The Journal of Comparative Economic Studies, Vol.14, 2019, pp. 121–140.

Independent or Collaborative Innovation: Evidence from Chinese Mobile Internet Firms

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Abstract: When do firms engage in collaborative innovation? Previous studies indicate that research and development (R&D) capabilities can influence a firm's decision to engage in collaborative innovation both positively or negatively. To understand these conflicting results, this study integrates the transaction cost theory and resource-based view, and introduces slack resources as a key moderator. Using data on patents and publicly listed mobile internet firms in China, we find that collaborative experiences, R&D capabilities, and slack resources can influence mobile internet firms' decision to engage in collaborative innovation. However, firms with high levels of R&D capabilities and abundant slack resources choose to innovate independently. In addition, firms' ownership structure and location can also influence their innovation decision.

Keywords: mobile internet firms, collaborative innovation, collaborative experiences, R&D capability, slack resources

JEL Classification Numbers: O36, O31, L86, M10

1. Introduction

The mobile internet industry relates to multiple interrelated fields, including mobile communication networks, the Internet, software development and application, information services, and mobile hardware manufacturing. On the one hand, the rapid development of information technology and the prosperity of online markets provide valuable development opportunities for the mobile internet industry. On the other hand, new technology and business models create constant challenges on this industry. Thus, related technology and resources continuously face reconfiguration and reallocation, changing the market positions of mobile internet firms.

China has a huge mobile internet market with 1.2 billion subscribers at the end of 2018. In the past few years, China's mobile internet industry has made remarkable achievements worldwide. The growth rate in mobile internet penetration reached 58% in 2018, which tripled over the course of a decade, influencing Chinese people's lives. They purchase more goods online, amplifying the country's already huge e-commerce market and reducing the prevalence of cash transactions.

However, the development of the mobile internet industry is full of hardships and challenges. In particular, due to high levels of uncertainty and variability, conducting technological innovation in the

mobile internet industry is very difficult for many firms. Such innovations not only require large amounts of investment in capital and talent but also demand the accumulation of experiences and technological capabilities over time. Moreover, since the mobile internet industry features a high level of integration, comprehensive cooperation between suppliers, manufacturers, and customers is necessary for its development. The products provided by mobile internet firms must meet the standards of the entire value-chain.

The mobile internet industry in China is composed of a large number of small and medium-sized firms. These firms have significant differences in terms of capabilities and resources. Some of them are rich in talent and expertise, while others are rich in capital. Especially small and micro firms, they often have limited access to funds, equipment, and marketing channels, among others. Even though these firms have new ideas and innovative technology, they are unable to produce and commercialise new products. Therefore, to innovate effectively and create value for stakeholders, these firms not only need to focus on improving their research and development (R&D) capabilities, but they also need to pay attention to building relations with other capable firms. In certain circumstances, some of these firms choose to conduct collaborative innovation with other mobile internet firms to obtain complementary resources and capabilities and finally achieve a win-win strategy for both sides.

As one important form of innovation, collaborative innovation has been studied by scholars in the field of strategic management on several aspects (Hagedoorn, 2002; Ketchen Jr., Ireland, and Snow, 2007; Arora, Athreye, and Huang, 2016). Some scholars argue that by forming collaborative innovation networks, firms are able to share knowledge and have access to advanced technologies, valuable knowledge, and resources (Inkpen and Tsang, 2005; Xie, Fang, and Zeng, 2016). Such networks can also help firms improve their product innovation performance (Belderbos, Carree, and Lokshin, 2004; Tsai, 2009). Some scholars advocate transaction cost theory and focus on cost minimisation. They think that firms can minimise the R&D cost by engaging in joint R&D activities with other partners (Hagedoorn, 2002). Other scholars adopt multiple theoretical perspectives and emphasise that the sharing of ideas, knowledge, expertise, and opportunities is important in collaborative innovation (Ketchen Jr., Ireland, and Snow, 2007). Therefore, many firm- and country-level factors have been found by scholars to influence the effectiveness and efficiency of collaborative innovation and the social spillover effect of collaborative innovation (Cassiman and Veugelers, 2002; Fritsch and Franke, 2004).

Among these factors, R&D capability is one important factor that scholars have studied in the field of collaborative innovation. In previous literature, some scholars argue that firms with strong R&D capability are more likely to engage in collaborative innovation because they can better absorb external knowledge and resources during the process of cooperation. However, this viewpoint is contradictory to the traditional innovation theory. According to this theory, firms that have strong R&D capability are more willing to conduct independent innovation because when they innovate independently, the patent or innovative products become exclusive, and they do not need to worry about important business information leaking out. Thus, only small enterprises with weak R&D capabilities seek external cooperation (Kleinknecht and

Reijnen, 1992).

Therefore, to better explain the antecedents of collaborative innovation, this study adopts the transaction cost theory and resource-based view to examine the impact of collaborative experiences, R&D capability, and slack resources on collaborative innovation. Based on the patent and financial data of publicly listed Chinese mobile internet firms from 2001 to 2013, we find that collaborative experiences and R&D capability have positive impacts on firms' collaborative innovation decision. However, slack resources have a negative impact on firms' decision to engage in collaborative innovation. Moreover, when firms have high levels of R&D capability and unabsorbed slack resources, they are more likely to conduct independent rather than collaborative innovation to protect their proprietary innovations. Furthermore, state ownership and the location of mobile internet firms also have a significant impact on firms' decision to engage in collaborative innovation.

This study has both theoretical and practical contributions. First, we directly supplement the literature on the drivers of collaborative innovation. We find that collaborative experiences, R&D capability, and unabsorbed slack resources have significant influence on mobile internet firms' decision to engage in collaborative innovation. Second, this study contributes to resource-based view and knowledge-based view. We find that even though R&D capability has a positive influence on collaborative innovation, when firms are capable of accumulating large amounts of slack resources, their likelihood of participating in collaborative innovation decreases. Finally, this study provides implications for managers who are in charge of improving mobile internet firms' innovative capability through collaborative innovations, as well as policymakers who formulate country-level innovation policies.

2. Theory and hypothesis development

2.1. Collaborative innovation

Collaborative innovation is defined as the pursuit of innovations across firm boundaries by sharing ideas, knowledge, expertise, and opportunities (Ketchen Jr., Ireland, and Snow, 2007). Scholars have adopted several theories to investigate collaborative innovation, such as the social network theory, transaction cost theory, resource-based view, and knowledge-based view. They define collaborative innovation from multiple theoretical perspectives. According to social network theory, firms can obtain external information and resources by building relationship with innovative organisations outside the firm (Xie, Fang, and Zeng, 2016). These formal and informal relationships constitute firms' innovation networks and provide a foundation and platform for collaborative innovation between different firms (Nambisan and Sawhney, 2011). By selecting suitable partners within the network, and integrating and utilising the resources and knowledge from these partners, firms are able to carry out product or service innovation together. Then, they can spread and share the innovation results throughout the network and promote the development of the entire network (Freeman, 1991).

Meanwhile, the transaction cost theory investigates whether enterprises are more efficient in conducting

independent or collaborative innovation by focusing on cost during the process of collaboration (Baldwin and Von Hippel, 2011). Here, transaction costs include the time, effort, and expenses incurred in searching for information of an appropriate partner, bargaining and negotiating with other parties, reaching agreements, and signing and executing the contract (Ring and Van de Ven, 1994). Such costs can be in different forms, such as cash, financial capital, time, or effort. In Williamson's opinion (1981, 2010), with the increase of transaction uncertainty, asset specificity, and transaction frequency, transaction costs also increase. Moreover, under the condition of limited rationality and opportunism, communication cost, costs of negotiation and signing, and the high risk of cooperation failure can affect a firms' decision to engage in collaborative innovation.

Scholars supporting the resource-based view analyse why firms with special resources and certain capabilities are more likely to conduct internal R&D rather than collaborative innovation, and under what circumstances firms choose to carry out collaborative innovation to overcome their lack of internal resources and capabilities (Sakakibara, 1997; Johnson, 2008). Scholars supporting the knowledge-based view regard knowledge as a special type of resource and investigate how knowledge and experiences influence firms' innovation behaviour (Dell'Era and Verganti, 2010).

These theories have different logic. The social network theory studies the influence of firms' position in the network on its collaborative innovation performance from the perspective of collaborative innovation network. However, since data related to innovation network are difficult to obtain, scholars are unable to perform quantitative research. The transaction cost theory investigates the cost problem in the collaborative process, while the resource-based view further explains why transaction costs exist and how to reduce these costs by focusing on one factor that affects cost, which is resource. Thus, there are complementarities between the transaction cost theory and resource-based view. In this study, we combine these two perspectives to study mobile internet firms' collaborative innovation decision.

2.2. Firms' decision to engage in collaborative innovation

Why do firms choose to engage in collaborative innovation instead of internal R&D? What kinds of firms are more likely to cooperate with others to achieve technological breakthrough? Many scholars have tried to answer these questions. In previous research, scholars find that country-level policy, industry-related factors, and firm characteristics can influence firms' decision to engage in collaborative innovation. Based on a sample of R&D-active firms in the U.S. manufacturing sector, Link and Bauer (1987) find that market power is the principal determinant of firms' involvement in cooperative research. Sakakibara and Cho (2002) compare and evaluate Japanese and Korean industrial policies. They find that organisational and institutional structure are the main factors that influence the effective implementation of cooperative R&D. Bayona, Garcia-Marco, and Huerta (2001) show that the complexity of technology and the fact that innovation is costly and uncertain are the main reasons for firms to engage in cooperative R&D.

Other studies find that the main reason why firms choose to collaborate with other firms on R&D is that they want to acquire complementary technical knowledge and resources. In particular, tacit knowledge

can be acquired only through frequent communication and effective interaction between firms (Howard et al., 2016). Thus, forming collaborative networks is one of the most useful ways to transfer tacit knowledge (Van Burg, Berends, and Van Raaij, 2014). Furthermore, some studies find that a firm's absorptive capacity, competitiveness, R&D experiences, and age also affect its collaborative innovation decision (Lane and Lubatkin, 1998; Sakakibara and Cho, 2002). Moreover, to identify the establishment of collaborative relationships more clearly, some scholars use case studies to uncover the factors that influence collaborative innovation and investigate under what conditions the collaborative relationship becomes more effective (Aggeri, 1999; Davis and Eisenhardt, 2011).

Therefore, in this study, we adopt the transaction cost theory and resource-based view to study the firm-level antecedents of collaborative innovation. Based on the transaction cost theory, cost is one important aspect when conducting collaborative innovation. During the whole process of collaborative innovation, which includes searching for partners, negotiating with other parties, signing the contract, learning from other firms, and transferring knowledge between boundaries, firms need to invest a lot of time, effort, and money in their collaborative activities. Thus, the cost may be very high. However, firms can take some action to reduce these costs, for instance, by accumulating certain kinds of resources. In this study, we argue that experiences, knowledge, capabilities, and organisational slack are all important resources for firms. By owning these resources or designing a resource portfolio, firms may reduce transaction cost, and thus enhance their collaborative innovation decision. Therefore, the resource-based view complements the transaction cost theory in explaining the firm-level drivers of collaborative innovation decision.

2.3. Collaborative experiences

As one important type of resource, experiences has a profound impact on firms' decision-making process (Penrose, 1959). Compared with inexperienced firms, experienced firms are better at acquiring, absorbing, and accumulating knowledge, and can establish and manage synergies more effectively (Grant, 1996).

First, a firm's previous cooperation and alliance experiences can help it obtain related information more efficiently. Based on these experiences, firms can find new collaboration opportunities and distinguish qualified partners more accurately (Kogut, Shan and Walker, 1992). Therefore, we argue that firms with collaborative experiences can search opportunities and select partners at a lower cost, positively influencing their decision to engage in collaborative innovation.

Second, successful experiences can be regarded as a reflection of credibility. Enterprises with successful collaborative experiences are also considered reliable and trustworthy partners. Other enterprises that have intentions to collaborate are more willing to cooperate with these experienced firms (Gulati, Nohria, and Zaheer, 2000).

Third, during the process of negotiation, firms with collaborative experiences have more bargaining power, can ask for a better way to cooperate, and can secure a better position in the collaborative network. These experienced firms are also able to allocate resources more efficiently. Specifically, they can arrange the tasks more effectively based on each partner's resources and capabilities. Thus, complementarity can

be achieved. Furthermore, as the protection of proprietary assets is the most important issue during collaborative innovation, firms are afraid that their partners will imitate their valuable patents or technologies. We think that experienced firms can better protect their technology and intellectual property rights, thereby ensuring that their interests are not infringed upon by other firms (Kale, Singh, and Perlmutter, 2000).

Finally, during the process of collaboration, communication and trust are very important (Fawcett, Jones, and Fawcett, 2012). Especially when problems or conflicts occur, the frequency of communication increases, and a trusting relationship can help smooth the communication process. However, not all firms are good at communicating, problem-solving, and building mutual trust. Inexperienced and incapable firms may find it difficult to build mutual trust. They also meet many obstacles and have to invest more effort when trying to solve communication issues. Thus, the inherent cost becomes very high. On the contrary, experienced firms that previously have engaged in collaborative innovation are more knowledgeable in building a trusting relationship. When dealing with conflicts, this trusting relationship functions as a 'softener' for conflicts, ensuring the stability and long-term orientation of the collaborative relationship (Ring and Van de Ven, 1992). Thus, we propose:

Hypothesis 1: Collaborative experiences positively influence firms' decision to engage in collaborative innovation.

2.4. R&D capability

Previous research finds that firms in R&D-intensive industries are more likely to engage in collaborative innovation. This is because technological innovation requires large investment, and the risk is very high, while the output is quite uncertain. Therefore, many high-tech firms prefer to engage in collaborative innovation to share risks, as well as interests, with other firms. By doing so, firms can reduce the risk and increase the efficiency of their R&D.

We argue that firms with strong R&D capabilities enjoy more advantages in learning new technologies and knowledge. Compared with firms that have poor R&D ability, they can acquire knowledge from their partners more efficiently. They can also better absorb external knowledge and learn new technologies during the process of cooperation. Thus, such capable firms do not need to invest extra money and effort to ensure effective knowledge transfer and value creation.

Moreover, other firms are also more willing to cooperate with firms that feature strong R&D capabilities (Baum, Calabrese and Silverman, 2000; Bougrain and Haudeville, 2002) because firms that choose collaborative over independent innovation want to achieve technological complementarity. By cooperating with capable external organisations, they can access technologies that they cannot obtain through independent innovation (Hagedoorn, 1993).

An important goal of collaborative innovation is to create value for all participants. In the value creation process, firms extract, process, and develop new technology by exchanging, complementing, and sharing knowledge with others. Therefore, learning and creating firm value for shareholders based on shared

knowledge are vital for firms. When firms have strong R&D capabilities, they can learn and accumulate more knowledge during this process and thus, gain more innovation value (Brockhoff, Gupta, and Rotering, 1991).

Furthermore, previous studies have suggested that firms' R&D capacity relates to their absorptive capacity. Absorptive capacity can increase firms' return from external knowledge and resources (Miotti and Sachwald, 2003). Especially during the process of collaborative innovation, firms with strong absorptive capacity tend to gain more benefits due to their strong sensitivity and perception of external knowledge (Escribano, Fosfuri, and Tribó, 2009; Tortoriello, 2015). Thus, such firms participate in collaborative innovation more actively.

In addition, using data on German manufacturing enterprises, some scholars find that firms that maintain R&D cooperation relationship tend to be relatively large and have a high share of R&D (Fritsch and Lukas, 2001). Other scholars study Spanish firms and find that firms that engage in R&D and those that attempt to introduce higher-level innovation are much more likely to engage in co-operative arrangements for innovation (Bayona, Garcia-Marco, and Huerta, 2001). Thus, we propose:

Hypothesis 2: R&D capabilities positively influence firms' decision to engage in collaborative innovation.

2.5. Slack resources

According to the resource-based view, firms have different kinds of resources. Through an effective allocation of resources, they are able to achieve competitive advantages, leading to the creation of firm value (Barney, 1991). Research also shows that the richness of resources has a significant impact on firms' innovative activities and innovation output (Madhok and Tallman, 1998).

Within a firm, resources can be divided into two types. One type includes resources that are being consumed or used. The other type refers to resources that are idle or redundant, also called slack resources. Slack resources refer to the stock of excess resources available to an organisation during a given planning cycle (Sharfman et al., 1988; Nohria and Gulati, 1996). The presence of slack resources (e.g. unused capacity, employees, unexploited opportunities, and financial resources) enables firms to increase search, which generates opportunities for innovation and allows firms to pursue growth strategies (Tan and Peng, 2003).

There are many reasons for the existence of slack resources. On the one hand, firms are not always in the optimal operating condition. Thus, they are not able to take full use of the resources all the time. On the other hand, some firms accumulate slack resources in accordance with their own strategic intention. For example, when firms face environmental changes or want to make high-risk investments, slack resources function as a 'buffer' since these resources are idle, and using them will not interrupt daily operations (Iyer and Miller, 2008). O'Brien (2003) also finds that slack financial resources can facilitate investments in radical product innovations and protect organisations from potential depletion of resources if such efforts fail. Consequently, firms with abundant resources, especially abundant slack resources, can

deal with unexpected risks during the innovation process in a more timely and effective manner.

Regarding collaborative innovation, many firms engage in collaborative innovation because they want to reduce risk and R&D investment by cooperating with other firms. Especially small and medium-sized firms, due to shortage of funds and resources, they are not able to take on high-risk innovation all by themselves as they cannot afford the consequences of failure. Therefore, when they consider innovative activities or launch innovative products, they often choose to cooperation with other firms.

However, firms with abundant slack resources have a high level of risk tolerance and are not afraid of the failure brought by high-risk R&D activities, such as independent innovation. This is because even if the innovation project fails, slack resources can timely fill-in the resource gap (e.g. financing gap). The daily operation of the firm will not be negatively affected. Moreover, according to the transaction cost theory, slack resources can effectively reduce the cost of innovation failure. When firms have abundant slack resources, they are more likely to innovate independently, such that they have full ownership of the R&D results and do not need to worry about the disclosure of their own technology and trade secrets. Research also finds that with an increase in organisational slack, firms' intensity to conduct independent innovation increases (Greve, 2003), and their intention to explore and exploit increases (Voss, Sirdeshmukh and Voss, 2008). Therefore, we argue that firms with greater amounts of slack resources are more inclined to conduct independent, rather than collaborative, innovation when developing new technology or product. Therefore, we propose:

Hypothesis 3: Slack resources negatively influence firms' decision to engage in collaborative innovation.

2.6. R&D capability and slack resources

R&D capability and slack resources have different effects on firms' decision to engage in collaborative innovation. As such, how do firms with both strong R&D capability and abundant slack resources make collaborative innovation decision? We argue that when mobile internet enterprises have a high level of slack resources and R&D capabilities, they are more likely to carry out independent innovation. This is because when a firm does not have slack resources, although it has strong R&D capability, it may be constrained by limited resources, such as lack of financial capital, equipment, factory, etc. This means that it is not able to apply its new ideas to new products because factories are at full capacity in manufacturing current products. If managers decide to use non-slack resources for R&D purposes, this may cause the firm irreversible damage if the R&D project fails, and the daily operations may also be disrupted. Thus, under these circumstances, firms are more likely to cooperate with others to pursue resource complementarity and make sure that, with the help of their partner, all the innovative activities go smoothly. Therefore, we argue that firms with strong R&D capability but limited slack resources are more likely to engage in collaborative innovation.

For firms that have rich slack resources, we argue that R&D capability positively influences their decision to conduct independent innovation. First, firms with strong R&D capability can better allocate

and manage their resources, enabling them to conduct independent innovation more effectively. Second, capable firms that have abundant slack resources do not need to rely on others to commercialise their patents or products, and they do not need to worry that innovation failure will affect their normal operations. Especially for large and leading firms, because they have abundant resources and strong capabilities, they can do all the innovative activities and launch new products independently. Thus, they have less incentive to cooperative with others. Third, many small mobile internet firms with valuable patents or innovative ideas are often unable to launch their products independently. Some of them choose to cooperate with other enterprises to commercialise their products. Others may choose to participate in the innovation platform provided by large enterprises. Therefore, we hypothesise that firms with abundant slack resources and strong R&D capabilities are less likely to engage in collaborative innovation.

Hypothesis 4: Slack resources negatively moderate the relationship between R&D capabilities and firms' decision to engage in collaborative innovation.

3. Methodology

3.1. Sample and data collection

Data for this study mainly come from two sources. One is the patent data provided by the state intellectual property office of China. This database contains information on all patents applied for by firms or individuals, such as the date of patent application, patent number, basic information of patent applicants, and patent content, etc. The other source is the China Stock Market Accounting Research (CSMAR) database, which includes all the financial information of publicly listed Chinese firms. Before performing our analysis, we matched the patent data to the data of publicly listed firms, and identified all the patents that were applied for by publicly listed Chinese firms every year.

The research targets of this study are all mobile internet firms in China. Based on the industry code of publicly listed companies provided by CSMAR, we classify enterprises in the telecommunication, media, and technology industry as mobile internet firms. The final sample size is 1,660, and the research span is from 2001 to 2013. All the firms in our sample are publicly listed firms; thus, according to the Chinese Corporation Law, they must have operated for more than three years. The distribution of firms in each year is shown in Table 1. From this table, we see that the number of firms that carry out collaborative innovation increased rapidly during the years 2001 to 2012, but decreased slightly in 2013.

We choose 2001 to 2013 as our research period for several reasons. First, the wireless local area network (WLAN) was enabled in China in 2001. As such, the year 2001 was regarded as the starting point of the mobile internet industry. Since 2001, with the popularisation of WLAN, many mobile internet firms entered into a period of great development. Second, in 2014, the central cyberspace security and leading informatisation group was established in China. Thus, the development of the mobile internet industry entered a new era in 2014. Third, we find from our database that before 2001, there was no mobile internet firm that engaged in cooperative innovation. Therefore, in this study, we focus on the collaborative

innovation of mobile internet firms during the period from 2001 to 2013.

Table 1: Year Distribution of Sample

Year	2001	2002	2003	2004	2005	2006	2007
Number of Firms	34	39	52	61	67	72	98
Collaborative Innovation	3	8	12	19	20	25	29
Percentage	8.82%	20.51%	23.08%	31.15%	29.85%	34.72%	29.59%
Year	2008	2009	2010	2011	2012	2013	Total
Number of Firms	105	135	198	242	287	270	1660
Collaborative Innovation	35	44	71	77	105	77	525
Percentage	33.33%	32.59%	35.86%	31.82%	36.59%	28.52%	31.63%

3.2. Measures

a. Dependent variable

Collaborative innovation. This study investigates firms' decision to engage in collaborative innovation by analysing their patent application behaviour. This variable is a dummy variable. If a firm cooperates with others to apply for patents in the focal year, we code Co-innovation as 1. If a firm applies for all the patents independently in the focal year, we code this variable as 0. The dependent variable is lagged by one year.

b. Independent variables

Collaborative experiences. Collaborative experiences is a dummy variable. Based on patent data, if a firm has applied previously for patents with other firms, we code Experience as 1. If a firm has never before applied for a patent with other firms, we code this variable as 0.

R&D capability. R&D investment is a commonly used measurement for R&D capability. However, because many mobile internet firms do not disclose R&D investment information, using such measurement leads to too many missing observations. Therefore, we adopt the number of patent applications in the previous year to measure a firm's R&D capability.

Slack resources. Slack resources are divided into three types: absorbed, unabsorbed, and potential slack resources. Absorbed slack resources are measured by the ratio of sales, management, and general expenses to sales revenue. Unabsorbed slack resources are measured by the ratio of quick assets (cash and tradable securities) to total liabilities. Potential slack resources are measured by the ratio of total liabilities to total owners' equity. These measurements have been widely used by many scholars (Bourgeois, 1981; Greve, 2003; Iyer and Miller, 2008). All the related data are collected from the CSMAR database.

c. Control variables

Firms' decision to engage in collaborative innovation is also affected by other firm-level and macro-level factors. Thus, we control for these factors as well.

State ownership. Research reveals that some Chinese firms' behaviour is greatly influenced by government policy. Thus, we control for the state ownership of firms. When the focal firm is state-owned, we code Ownership as 1 and 0 otherwise.

Firm size. Previous studies show that employees' knowledge diversity can increase firm-level openness, thereby influencing firms' innovation behaviour (Bogers, Foss, and Lyngsie, 2018). In this study, firm size is measured by the total number of employees in the focal firm. In the regression, we include the natural logarithm of the employee number.

Firm age. Previous studies show that firm age can influence firms' decision to collaborate. Some scholars think that age has a positive influence on firms' decision to collaborate (Sakakibara and Cho, 2002). Other scholars argue that only start-up firms want to cooperate with others for innovation (Shan, Walker and Kogut, 1994) because they have limited resources. Thus, mature firms with accumulated resources are more likely to conduct innovation independently (Tether, 2002). Therefore, we include firm age as a control variable.

Total assets. This variable is calculated by the natural logarithm of the focal firm's total assets. Data on total assets come from the CSMAR database.

Firm Location. In China, mobile internet firms often choose to locate their headquarters or offices in developed cities because in these cities, it is easier for the firms to find potential partners, and the transaction costs are lower. Thus, we include firm location as a control variable. If a firm is located in Beijing, Shanghai, Guangzhou, or Shenzhen, which are big cities in China, we code this variable as 1 and 0 otherwise.

Year. To control for latent time effect, year dummies are included in the regression model.

3.3. Analytical methods

Because the dependent variable in this study is dichotomous (i.e. whether the focal firm choose to engage in collaborative innovation), we use logistic regression to analyse firms' decision to engage in collaborative innovation. In the regression model, we centralise all the explanatory variables.

4. Results and findings

We report the summary statistics of all variables in Table 2 and their correlations in Table 3. The sample size is 1,660. The mean value of the dependent variable, collaborative innovation, is 0.316. This means that 31.6% of mobile internet firms in our sample choose to engage in collaborative innovation. Moreover, 46.1% of these mobile internet firms are located in developed cities, while 41.4% are state-owned enterprises.

In the correlation table, except for potential slack resources, all the explanatory variables are significantly correlated with the dependent variable. As hypothesised, collaborative experiences and R&D capability are positively correlated with collaborative innovation. Absorbed and unabsorbed slack resources are negatively correlated with firms' decision to engage in collaborative innovation. Among the control

variables, ownership, size, age, and total assets are positively correlated with firms' decision to engage in collaborative innovation. Moreover, we observe that correlations between all the variables are below the commonly used cut-off threshold of 0.7, suggesting that multicollinearity is not a severe problem in any of the models.

Table 2: Descriptive statistics

Variables	Abbreviation	Mean	S.D.	Min	Max
Collaborative innovation	Co-innovation	0.316	0.465	0	1
Collaborative experiences	Experience	0.434	0.496	0	1
R&D capability	R&D	44.275	136.275	1	3651
Absorbed slack resources	A-slack	0.220	0.253	-0.153	5.253
Unabsorbed slack resources	U-slack	2.027	3.961	0.011	25.956
Potential slack resources	P-slack	0.219	0.914	-1.381	5.649
State ownership	Ownership	0.414	0.493	0	1
Firm size	Size	1.397	1.126	1.126	1.946
Firm age	Age	13.160	0.453	3	73
Total assets	Assets	21.271	1.032	15.577	26.998
Firm Location	Location	0.461	0.499	0	1

Table 3: Correlation table

	1	2	3	4	5	6	7	8	9	10	11
1. Co-innovation	1										
2. Experience	0.382**	1									
3.R&D	0.233**	0.200**	1								
4.A-slack	-0.092**	-0.038	-0.042+	1							
5.U-slack	-0.134**	-0.168**	-0.094**	0.153**	1						
6.P-slack	0.063	0.077*	0.122**	-0.054*	-0.305**	1					
7.Ownership	0.215**	0.195**	0.192**	-0.094**	-0.265**	0.215**	1				
8.Size	0.070*	0.057*	0.041+	-0.062*	0.133**	-0.056*	-0.033	1			
9.Age	0.060*	0.106**	0.136**	0.047+	-0.125**	0.241**	0.141**	-0.091**	1		
10.Assets	0.156**	0.097**	0.306**	-0.228**	-0.303**	0.271**	0.258**	-0.051*	0.073*	1	
11.Location	0.228**	0.223**	0.391**	-0.166**	-0.225**	0.295**	0.341**	0.085**	0.074*	0.755**	1

Note: Significance levels: + $p<0.1$; * $p<0.05$; ** $p<0.01$

We present the regression results in Table 4. Model 1 is the baseline model. Models 2, 3, and 4 separately incorporate the effect of collaborative experiences, R&D capability, and slack resources. Model 5 incorporates all the three independent variables. Model 6, which is also the full model, incorporates the interaction term of R&D capability and slack resources. All the models have higher R-squared than the baseline model, which indicates that our independent variables contribute to increased explanatory power.

In Model 1, we include all the control variables. Results show that state ownership has a significant impact on firms' decision to engage in collaborative innovation. In other words, state-owned enterprises are more willing to collaborate with other firms. Moreover, firms in big cities and those with abundant

assets are also more likely to engage in collaborative innovation. However, for mobile internet firms, age and the number of employees have no influence on their collaborative innovation decision.

Table 4: Estimation results of logistic regression

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables						
Experience		1.558**			1.449**	1.434**
		(0.125)			(0.129)	(0.130)
R&D			0.006**		0.005**	0.008**
			(0.001)		(0.001)	(0.003)
A-slack				-0.560+	-0.595+	-0.273
				(0.326)	(0.324)	(0.306)
U-slack				-0.092**	-0.048*	-0.060*
				(0.026)	(0.023)	(0.027)
P-slack				-0.097	-0.096	-0.063
				(0.073)	(0.074)	(0.082)
Moderating effects						
R&D * A-slack						0.001
						(0.001)
R&D * U-slack						-0.017*
						(0.007)
R&D * P-slack						-0.001
						(0.001)
Control variables						
Ownership	0.876**	0.601**	0.746**	0.787**	0.457**	0.454**
	(0.128)	(0.134)	(0.131)	(0.129)	(0.138)	(0.138)
Size	-0.041	0.066	-0.067	-0.120	-0.018	-0.023
	(0.077)	(0.082)	(0.079)	(0.080)	(0.086)	(0.087)
Age	0.001	0.001	-0.002	0.001	-0.001	-0.001
	(0.008)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)
Assets	0.397**	0.228*	0.240*	0.421**	0.125	0.122
	(0.089)	(0.094)	(0.093)	(0.092)	(0.100)	(0.100)
Location	0.255*	0.246*	0.274*	0.281*	0.256*	0.257*
	(0.115)	(0.122)	(0.118)	(0.117)	(0.124)	(0.125)
Year	Included	Included	Included	Included	Included	Included
Constant	-11.460**	-8.750**	-7.797**	-11.081**	-5.558*	-5.527**
	(1.645)	(1.707)	(1.740)	(1.690)	(1.858)	(1.841)
N of observations	1 660	1 660	1 660	1 660	1 660	1 660
LR chi2	168.91	333.94	221.61	193.92	379.40	387.21
Log likelihood	-951.424	-868.905	-925.071	-938.919	-846.178	-842.270
Pseudo R^2	0.082	0.161	0.107	0.094	0.183	0.187

Note: Standard errors in parentheses; significance levels: + p<0.1, * p<0.05, ** p<0.01.

DV=Collaborative innovation

Hypothesis 1 tests the effect of collaborative experiences on collaborative innovation. As Model 2 in Table 4 shows, after including all control variables, collaborative experiences is positively associated with

firms' decision to engage in collaborative innovation (β=1.558, $p<0.01$). The result indicates that past successful collaborative experiences can increase firms' decision to engage in collaborative innovation in the following year. Thus, Hypothesis 1 is supported.

In Model 3, we include the second independent variable, R&D capability. After including all control variables, R&D capability is positively associated with collaborative innovation, and the effect is significant (β=0.006, $p<0.01$). Thus, Hypothesis 2 is supported. As expected, firms with strong R&D capabilities are more likely to engage in collaborative innovation.

Model 4 includes the three variables of slack resources, namely absorbed, unabsorbed, and potential slack resources. The effect of absorbed slack resources is negative and significant (β=-0.560, $p<0.1$), while that of unabsorbed slack resources is also negative and significant (β=-0.092, $p<0.01$). However, the effect of potential slack resources is not significant (β=-0.097, $p>0.1$). Therefore, Hypothesis 3 is partially supported. Only absorbed and unabsorbed slack resources negatively influence firms' decision to engage in collaborative innovation.

In Model 5, all the independent variables are included. In this model, the effects of collaborative experiences, R&D capabilities, and slack resources are robust. The effects of collaborative experiences (β=1.449, $p<0.01$) and R&D capabilities (β=0.005, $p<0.01$) are positive and significant. Thus, Hypotheses 1 and 2 are supported. The effects of absorbed slack resources (β=-0.595, $p<0.1$) and unabsorbed slack resources (β=-0.048, $p<0.05$) are negative and significant, partially supporting Hypothesis 3.

In Model 6, we add the interaction terms of R&D capability and slack resources to the regression model. The results show that unabsorbed slack resources negatively moderates the relationship between R&D capability and collaborative innovation (β=-0.017, $p<0.05$). However, the moderating effects of absorbed and potential slack resources are not significant. Thus, Hypothesis 4 is partially supported. Mobile internet firms that have strong R&D capability and abundant unabsorbed slack resources are less likely to engage in collaborative innovation.

5. Discussion and conclusion

Using data on patents and publicly listed firms in China, this study examines why and under what circumstances mobile internet firms choose to engage in collaborative rather than independent innovation. Results show that collaborative experiences, R&D capability, and unabsorbed slack resources have significant impact on mobile internet firms' collaborative innovation decision. Firms that have strong R&D capability and those that have previously carried out collaborative innovation are more likely to engage in collaborative innovation in the future. However, firms with abundant absorbed and unabsorbed slack resources are more likely to conduct innovation independently. Moreover, firms that have strong R&D capability and abundant unabsorbed slack resources choose to carry out independent rather than collaborative innovation to protect the exclusivity of their innovation achievements.

First, in the mobile internet industry, past successful collaborative experiences provide valuable

knowledge that can help firms cooperate with their partners more effectively. With the accumulation of collaborative experiences, firms can better choose an appropriate partner with which they can share information and from whom they can acquire knowledge. Moreover, experienced firms are also good at building trusting relationships and managing inter-firm knowledge transfer. Therefore, firms that have rich collaborative experiences are more willing to participate in collaborative innovation.

Second, previous research on R&D capability shows that firms' R&D capability has a positive impact on both independent and collaborative innovation, which brings some confusion in explaining firms' decision to engage in collaborative innovation. To deal with these conflicting findings, slack resources are introduced as one important moderator. Results show that when firms have strong R&D capability and abundant unabsorbed slack resources, they prefer to conduct independent innovation. However, when firms have strong R&D capability but insufficient slack resources, they tend to cooperate with other firms to make up for their shortcomings.

Third, when analysing slack resources, we find that the moderating effects of absorbed and potential slack resources are insignificant. This is because the fluidity, flexibility, and risk of absorbed and potential slack resources are different from those of unabsorbed slack resources. Absorbed slack resources are not very flexible and ready to use. Using these resources may expose a firm to a high level of risk. Most of absorbed slack resources have specific usage, such as management expenses, remuneration paid to employees, processed products, and idle production equipment (Sharfman et al., 1988). Thus, the characteristics of absorbed slack resources may limit the possibility of these resources being used for other purposes. Meanwhile, potential slack resources are associated with firms' debts and liabilities. Thus, the risk of using these resources is relatively high and the outcome is often uncertain. In the future, more research is necessary to be done to investigate the role of slack resources.

Fourth, we find that state ownership has a significant impact on firms' decision to engage in collaborative innovation. In other words, state-owned enterprises are more willing to participate in collaborative innovation. This may be related to the policy and institutional orientation of the government and the socially responsible activities of state-owned enterprises. For many industries, the government actively promotes the development of the whole industry. For example, collaborative innovation is one of the important topics of China's 13th Five-Year Plan, which is a momentous country-level plan launched by the State Council. Based on this plan, firms in many industries of China, such as the mobile internet, banking, and petroleum industries, should try their best to cooperate with each other to achieve synergy. In particular, leading state-owned enterprises are required by the Chinese government to actively cooperate with some small and medium-sized firms and drive the innovation of those firms. By doing so, the progress of the whole industry can be promoted.

In addition, a firm's location also has an important impact on its collaborative innovation decision. Mobile internet firms that are located in big cities are more inclined to participate in collaborative innovation. In big cities, these firms can more easily search for new partners, and the geographical proximity reduces the communication cost during the process of collaboration. This also helps explain

why firms in various industrial parks are more likely to cooperate.

Finally, this study has implications for managers who make strategic cooperation decisions in mobile internet enterprises. When making decisions related to collaborative innovation, managers in mobile internet firms should first consider their own resources and capabilities. Then, based on a comprehensive understanding of their status, they can choose an appropriate partner and try their best to achieve resource complementarity. In addition, this study also has implications for policymakers in the Chinese government. The government should actively support innovative enterprises, especially some small and medium-sized mobile internet firms. These firms often have novel ideas of products and new thoughts about the market frontier, but they are unable to apply these ideas to new products due to insufficient capital and equipment. Under these circumstances, the government should consider providing some financial support to these firms. The government or some powerful enterprises can also provide an innovation platform to connect these innovative firms. By doing so, all these firms may form a collaborative innovation ecosystem wherein they can exchange new ideas and search for suitable partners. Therefore, a healthy development of the whole mobile internet industry can be achieved.

Even though this study highlights some interesting findings, it still has some limitations. First, the research sample is limited to publicly listed firms, which may influence the generalisability of this study. In the future, scholars can conduct surveys and collect data from private firms to extend our findings. Second, because of data limitation, we are unable to distinguish with what type of firm (local or a foreign firm) the focal firms collaborate. In future studies, scholars need to collect more fine-grained data regarding the collaborator for a better understanding of the mechanism of collaborative innovation. Finally, the government plays a very important role in facilitating the development of Chinese mobile internet firms. We suggest future studies to pay more attention to the influence of government policies and the impact of the overall market trend in China.

Acknowledgements

This paper was supported by the National Natural Science Foundation of China (71902027) and Beijing Natural Science Foundation (9194030). This paper was prepared with the financial support of the KIER Joint Usage and Research Centre Project 'International Political Economy of Chinese and Russian Multinationals' and KIER Foundation.

References

Aggeri, F. (1999) "Environmental policies and innovation: a knowledge-based perspective on cooperative approaches", *Research Policy*, Vol. 28, No. 7, pp. 699-717.

Arora, A., Athreye, S. and Huang, C. (2016) "The paradox of openness revisited: Collaborative innovation and patenting by UK innovators", *Research Policy*, Vol. 45, No. 7, pp. 1352-1361.

Baldwin, C. and Von Hippel, E. (2011) "Modeling a paradigm shift: From producer innovation to user and open collaborative innovation", *Organization Science*, Vol. 22, No. 6, pp. 1399-1417.

Barney, J. B. (1991) "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17, No. 1, pp. 99-120.

Baum, J. A., Calabrese, T. and Silverman, B. S. (2000) "Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology", *Strategic Management Journal*, Vol. 21, No. 3, pp. 267-294.

Bayona, C., Garcia-Marco, T. and Huerta, E. (2001) "Firms' motivations for cooperative R&D: An empirical analysis of Spanish firms", *Research Policy*, Vol. 30, pp. 1289-1307.

Belderbos, R., Carree, M. and Lokshin, B. (2004) "Cooperative R&D and firm performance", *Research policy*, Vol. 33, No. 10, pp. 1477-1492.

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.

Bougrain, F. and Haudeville, B. (2002) "Innovation, collaboration and SMEs internal research capacities", *Research Policy*, Vol. 31, No. 5, pp. 735-747.

Bourgeois Iii, L. J. (1981) "On the measurement of organizational slack", *Academy of Management Review*, Vol. 6, No. 1, pp. 29-39.

Brockhoff, K., Gupta, A. K. and Rotering, C. (1991) "Inter-firm R&D co-operations in Germany", *Technovation*, Vol. 11, No. 4, pp. 219-229.

Cassiman, B. and R. Veugelers. (2002) "R&D cooperation and spillovers: Some empirical evidence from Belgium", *American Economic Review*, Vol. 92, No. 4, pp. 1169-1184.

Davis, J. P. and Eisenhardt, K. M. (2011) "Rotating leadership and collaborative innovation: Recombination processes in symbiotic relationships", *Administrative Science Quarterly*, Vol. 56, No. 2, pp. 159-201.

Dell'Era, C. and Verganti, R. (2010) "Collaborative strategies in design-intensive industries: Knowledge diversity and innovation", *Long Range Planning*, Vol. 43, No. 1, pp. 123-141.

Escribano, A., Fosfuri, A. and Tribó, J. A. (2009) "Managing external knowledge flows: The moderating role of absorptive capacity", *Research policy*, Vol. 38, No. 1, pp. 96-105.

Fawcett, S. E., Jones, S. L. and Fawcett, A. M. (2012) "Supply chain trust: The catalyst for collaborative innovation", *Business Horizons*, Vol. 55, No. 2, pp. 163-178.

Freeman, C. (1991), "Networks of innovators: A synthesis of research issues", *Research Policy*, Vol. 20, No. 5, pp. 499-514.

Fritsch, M. and Franke, G. (2004) "Innovation, regional knowledge spillovers and R&D cooperation", *Research Policy*, Vol. 33, No. 2, pp. 245-255.

Fritsch, M. and Lukas, R. (2001) "Who co-operates on R&D?", *Research Policy*, Vol. 30, No. 2, pp. 297-312.

Grant, R. M. (1996) "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17, No. S2, pp. 109-122.

Greve, H. R. (2003) "A behavioral theory of R&D expenditures and innovations: Evidence from shipbuilding", *Academy of Management Journal*, Vol. 46, No. 6, pp. 685-702.

Gulati R., Nohria N. and Zaheer A. (2000) "Strategic networks", *Strategic Management Journal*, Special Issue 21, No. 3, pp. 203-215.

Hagedoorn J. (1993) "Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences", *Strategic Management Journal*, Vol. 14, No. 5, pp. 371-385.

Hagedoorn, J. (2002) "Inter-firm R&D partnerships: An overview of major trends and patterns since 1960", *Research Policy*, Vol. 31, No. 4, pp. 477-492.

Howard, M., Steensma, H. K., Lyles, M. and Dhanaraj, C. (2016) "Learning to collaborate through collaboration: How allying with expert firms influences collaborative innovation within novice firms", *Strategic Management Journal*, Vol. 37, No. 10, pp. 2092-2103.

Inkpen, A. C. and Tsang, E. W. (2005) "Social capital, networks, and knowledge transfer", *Academy of Management Review*, Vol. 30, No. 1, pp. 146-165.

Iyer, D. N. and Miller, K. D. (2008) "Performance feedback, slack, and the timing of acquisitions", *Academy of Management Journal*, Vol. 51, No. 4, pp. 808-822.

Johnson, W. H. (2008) "Roles, resources and benefits of intermediate organizations supporting triple helix collaborative R&D: The case of Precarn", *Technovation*, Vol. 28, No. 8, pp. 495-505.

Kale P., Singh H. and Perlmutter H. (2000) "Learning and protection of proprietary assets in strategic alliances: Building relational capital", *Strategic Management Journal*, Special Issue 21, No. 3, pp. 217-237.

Ketchen Jr, D. J., Ireland, R. D. and Snow, C. C. (2007) "Strategic entrepreneurship, collaborative innovation, and wealth creation", *Strategic Entrepreneurship Journal*, Vol. 1, No. 3-4, pp. 371-385.

Kleinknecht, A. and Reijnen, J. O. N. (1992) "Why do firms cooperate on R&D? An empirical study", *Research Policy*, Vol. 21, No. 4, pp. 347-360.

Kogut B., Shan W. and Walker G. (1992) "The make-or-cooperate decision in the context of an industry network", In Nohria N, Eccles R (eds), *Networks and Organizations: Structure, Form, and Action*, Harvard Business School Press: Boston, MA, pp. 348-365.

Lane P. J. and Lubatkin M. (1998) "Relative absorptive capacity and interorganizational learning", *Strategic Management Journal*, Vol. 19, No. 5, pp. 461-477

Link A. N. and Bauer L. L. (1987) "An economic analysis of cooperative research", *Technovation*, Vol. 6, No. 4, pp. 247-260.

Madhok, A. and Tallman, S. B. (1998) "Resources, transactions and rents: Managing value through interfirm collaborative relationships", *Organization Science*, Vol. 9, No. 3, pp. 326-339.

Miotti L. and Sachwald F. (2003) "Co-operative R&D: why and with whom? An integrated framework of analysis", *Research Policy*, Vol. 32, No. 8, pp. 1481-1499.

Nambisan, S. and Sawhney, M. (2011) "Orchestration processes in network-centric innovation: Evidence from the field", *Academy of management perspectives*, Vol. *25*, No.3, pp. 40-57.

Nohria, N. and Gulati, R. (1996) "Is slack good or bad for innovation?", *Academy of Management Journal*, Vol. 39, No. 5, pp. 1245-1264.

O'Brien, J. P. (2003) "The capital structure implications of pursuing a strategy of innovation", *Strategic Management Journal*, Vol. 24, No. 5, pp. 415-431.

Penrose E. T. (1959) "*The Theory of the Growth of the Firm"*, New York: Wiley.

Ring, P. S. and Van de Ven, A. H. (1992) "Structuring cooperative relationships between organizations", *Strategic Management Journal*, Vol. 13, No. 7, pp. 483-498.

Ring, P. S. and Van de Ven, A. H. (1994) "Developmental processes of cooperative interorganizational relationships", *Academy of Management Review*, Vol. 19, No. 1, pp. 90-118.

Sakakibara, M. (1997) "Heterogeneity of firm capabilities and cooperative research and development: An empirical examination of motives", *Strategic Management Journal*, Vol. 18, No. S1, pp. 143-164.

Sakakibara, M. and Cho, D. S. (2002) "Cooperative R&D in Japan and Korea: A comparison of industrial policy", *Research Policy*, Vol. 31, No. 5, pp. 673-692.

Shan, W., Walker, G. and Kogut, B. (1994) "Interfirm cooperation and startup innovation in the biotechnology industry", *Strategic Management Journal*, Vol. 15, No. 5, pp. 387-394.

Sharfman M. P., Wolf G., Chase R. B. and Tansik D. A. (1988) "Antecedents of Organizational Slack", *Academy of Management Review*, Vol. 13, No. 4, pp. 601-614.

Tan, J. and Peng, M. W. (2003) "Organizational slack and firm performance during economic transitions: Two studies from an emerging economy", *Strategic Management Journal*, Vol. 24, No. 13, pp. 1249-1263.

Tether, B. (2002) "Who co-operates for innovation, and why. An empirical analysis", *Research Policy*, Vol. 31, No. 6, pp. 947-967.

Tortoriello, M. (2015) "The social underpinnings of absorptive capacity: The moderating effects of structural holes on innovation generation based on external knowledge", *Strategic Management Journal*, Vol. 36, No. 4, pp. 586-597.

Tsai, K. (2009) "Collaborative networks and product innovation performance: Toward a contingency perspective", *Research Policy,* Vol. 38, No. 5, pp. 765-778.

Van Burg, E., Berends, H. and Van Raaij, E. M. (2014) "Framing and interorganizational knowledge transfer: A process study of collaborative innovation in the aircraft industry", *Journal of Management Studies*, Vol. 51, No. 3, pp. 349-378.

Voss, G. B., Sirdeshmukh, D. and Voss, Z. G. (2008) "The Effects of Slack Resources and Environmental threat on Product Exploration and Exploitation", *Academy of Management Journal*, Vol. 51, No. 1, pp. 147-164.

Williamson, O. E. (1981) "The economics of organization the transaction cost approach", *American Journal of Sociology*, Vol. 87, No. 3, pp. 548-577.

Williamson, O. E. (2010) "Transaction cost economics the natural progression", *Journal of Retailing*, Vol. 86, No. 3, pp. 215-226.

Xie, X., Fang, L. and Zeng, S. (2016) "Collaborative innovation network and knowledge transfer performance: A fsQCA approach", *Journal of Business Research*, Vol. 69, No.11, pp. 5210-5215.