Web Service Platforms, Social Networks, and Firms' Innovation Capability: Mediating Effects Model Based on Web Service Platform Synergies

Xiao Li
Ying Li
Weibo Zheng

Abstract

With the rise of new retail concepts, commodity trading has evolved from the traditional supply-to-consumer linear single-track relationship into a brand-new Internet platform-based S2b2c social networking system.[1] Despite this, over 90 percent of wood product enterprises have an extremely limited understanding and application of this new kind of web service platform-based marketing systems. To reveal the impact of web service platforms on the growth of wood product enterprises, this study proposes an analytical framework that integrates the web service platform synergy, the social network synergy, and the corporate innovation capability. Using this framework, the effects of social network and web service platform synergies on the corporate innovation capability are analyzed, with a particular focus on exploring the mediating role of web service platform synergy between the social network synergy and the corporate innovation capability. Based on the questionnaire survey data of 489 large, medium, and small-wood product enterprises in the Pearl River Delta and the Yangtze River Delta regions, the following empirical results are derived through a combination of stepwise regression and Sobel test: (1) Web service platform synergy has a significant positive impact on the corporate innovation capability; (2) Social network synergy has a significant positive impact on the corporate innovation capability; (3) Social network synergy has a significant positive impact on the establishment of web service platforms; and (4) Web service platform synergy has a partial intermediary relationship between social network synergy and innovation capability, accounting for 34.05 percent of the total effect. The results of this study indicate that like social networks, web service platforms are the strategic resources of enterprises. In the context of open innovation, it is essential for the wood product enterprises to deeply integrate with the social networks and web service platforms, which helps enhance their innovation capability.

Innovation capability, as an important part of core competitiveness for enterprises, has always been the focus of academic and industrial attention. To date, no theoretical consensus has been reached as to the connotative definition of innovation capability. Generally, scholars believe that innovation capability is the ability of an enterprise to develop new products and open new markets and channels (Benner and Tushman 2003, Jansen et al. 2006). It reflects corporate ability to create new values following the reorganization of production factors, as well as the synergy

[1] S2b2c is a new e-commerce marketing model that integrates suppliers and empowers distributors to jointly serve customers. It integrates quality upstream suppliers and introduces them to distributors so that they can offer comprehensive services to consumers. According to Zeng Ming, ''In the next five years, S2b will most likely be the leading business model'' (Zeng Ming Shu Yuan 2017a), and ''The real S2b is in fact S2b2c, in which S and b jointly serve c'' (Zeng Ming Shu Yuan 2017b).

The authors are, respectively, Lecturer, Zhaozhou No.1 Middle School, Daqing City, China and Northeast Forestry Univ., Harbin, China (zzyzhlx@163.com); Professor; Business School, Liaoning University, Shenyang, China (liying@lnu.edu.cn [corresponding author]); and Professor, School of Business & Administration, Hebei University of Economic and Business, Shijiazhuang, China (2726786225@qq.com). This paper was received for publication in November 2020. Article no. 20-00081.

Forest Prod. J. 71(2):188–197.
doi:10.13073/FPJ-D-20-00081

attained by integrating internal and external resources (Xuemei and Cheng 2014). To sum up, innovation capability is a comprehensive manifestation of such corporate abilities as strategic innovation, organizational innovation, technological innovation and market development, which is formed in the process of social network establishment. Social networks, as specific connections established among individuals, organizations, and between individuals and organizations during engagement in political and economic activities (Granovetter 1973, Neck et al. 2010), play a crucial role in enhancing corporate innovation capability. Although social networks have obvious agglomeration and small-world effects at both the micro and macro levels, the professional and spatial restrictions are also present, which shows their limited role in enhancing corporate innovation capability (Ping et al. 2016a).

As the implementation of the ''Internet +'' initiative deepens, the development of web service platforms is also constantly accelerating (Ning and Hongqi 2008). Currently, web service platforms have emerged as a new form of industrial organization, which has transformed traditional social networks into cross-temporal and spatial communication media that integrate the real and virtual societies owing to their comparative advantages, such as easy optimization and convenient online socialization and collaboration (Rujun Chen 2014, Huanli 2015). These platforms have also provided enterprises with an option to shift online from the offline socializing methods and business models. In some scholars' opinions, the digital revolution has changed the way people do business, and the sales and purchases via online service platforms have become an inseparable part of daily life among US consumers (Gazal et al. 2016). For modern enterprises, the web service platforms are a complete business strategy rather than a mere tool (Meng 2010). Web service platforms like e-commerce platforms and social media have changed the way of enterprise–consumer interaction, which not only increases the exposure of enterprises and brands, but more importantly helps enterprises understand consumer behaviors and preferences (Palmer and Koenig-Lewis 2009, Trusov et al. 2009, Kaplan and Haenlein 2010). Lin's Wood Industry, a Chinese wood product enterprise, has achieved transformation of its business model from a traditional closed operation to a brand-new S2b2c social system through deep integration with its customer web service platform and customized production system. The classic case of recording top sales in residential furniture industry on the whole network for 10 consecutive years is precisely the best proof of the above transformational achievements. Clearly, the web service platform-based synergistic innovation system has been formed among the leading enterprises in the wood product industry. Nevertheless, even though China has become the world's largest producer and exporter of wooden furniture since 2005 (Bo et al. 2008, Xin 2009), over 90 percent of China's small- and medium-sized enterprises among more than 80,000 wood product manufacturers sustain a traditional business model, where a substantial amount of manual work is still retained, without standardized production or specialized division of labor. In terms of information technology (IT) applications, the majority of enterprises remain at very low levels. Few of these enterprises have any manufacturing information platforms or internal management information networks, presenting information silos in the supply chains and marketing terminals. This is primarily attributed to the scarce research on the use of web service platforms by wood furniture manufacturers apart from the need to increase capital investment. Hence, by incorporating the web service platforms into the relationships between social networks and innovation capability of highly information driven small- and medium-sized wood product enterprises in the Pearl River Delta and the Yangtze River Delta regions, this study intends to reveal the mechanisms whereby the social networks and web service platforms affect the synergistic corporate innovation capability, with a view to facilitating the transformation and upgrading of these small- and medium-sized enterprises with the support of the ''Internet +'' initiative.

Theoretical Review and Research Hypotheses

Social networks are the embedded relationships between demand actors and demand fulfillers in the relational network of political and economic affairs. The degree of embeddedness decides the quantity and type of resources acquired, and thus decides the behavior and performance of the demand subjects (Uzzi 1997). Studies have shown that the intensity of relational embeddedness is a critical cause of difference in the corporate innovation capability that is attributed to resource integration factors (McEvily and Zaheer 1999, Xuemei and Cheng 2014). Meanwhile, a web service platform is a network information system designed to meet the user needs for cross-border information and flexible services (Shuying 2010), which can enhance the synergistic efficiency between political and economic affairs. Encompassing the meanings of interconnection and service, a web service platform has some attributes of social networks in the traditional sense, which has even replaced some functions of the social networks. So what role does the web service platform play in the social networks and the innovation system of wood product enterprises? What kinds of influence mechanisms exist? These issues are worthy of exploration.

Web service platforms and innovation capability of wood product enterprises

The inception of the Web service platform as an information tool plays a vital role in alleviating the difficulties of firms in getting information, as well as improving the development of supply and sales channels, intelligent production, service orientation of products, and market entry capability. Many researchers have conducted in-depth studies on the supportive effects of Web service platforms on supply chain innovation, promoting research to help Web service platforms transition from theory to practice, and facilitating theoretical improvements while achieving collaborative supply chain development. Rochet and Tirole (2006) and Parker and Van Alstyne (2005) believe that the Web service platform is an agent connecting platform service providers, business users, and supply chain nodes that increases firms' profitability while increasing the benefits to platform providers and users. Ying et al. (2016) believe that the Web service platform is an important tool in improving supply chain collaborative capability while cutting operating costs and achieving global resource allocation. Against the backdrop of open innovation, the Web service platform, as a carrier of information capital, is an important management tool and a strategic resource for

firms. It can improve the information capability of service methods and management techniques, optimize business flow and firm incubation, break through spatial limitations for nodes in the supply chain, provide real-time information services to firms, and facilitate the formation of social networks for entrepreneurs (Ning and Hongqi 2008, Rujun 2014). Therefore, this study proposes the following hypothesis:

H1: Network service platforms have a significant and positive impact on firms' innovation capability.

Network service platforms and innovation capability of wood product enterprises

Social networks have the functions of information transmission (Burt 1995, 1997), media connection (Oviatt and McDougall 1997) and resource allocation (Lin 1999). Apart from enabling enterprises to acquire market information dynamics and grasp market transaction opportunities, they also help enterprises find partners with comparative advantages, thereby reducing the corporate resource consumption and transaction costs, and improving efficient resource utilization (Haixi and Ying 2014). Research has indicated that the stronger the connection between enterprises and external social networks and the more active the information exchange, the better the enterprises' new product innovation performance (Xuemei and Cheng 2014). Accordingly, this study proposes the following hypothesis:

H2: Social networks have a significant positive impact on the innovation capability of wood product enterprises.

Role of web service platforms in the relationship between social networks and innovation capability of wood product enterprises

Web service platforms are an important part of innovation systems for emerging strategic industries and related industries of enterprises. On the premise of high integration between information and resources, they achieve resource sharing, technical exchanges, and benefit negotiation among industry, academia, and research institutes via network technology (Ping et al. 2016b). With the continuous popularization of web service platforms, such social network functions as information transmission, technological transfer, knowledge sharing, and resource integration have gradually been replaced by flatter digital service platforms. These analyses have shown that the network service platform as a cross-organizational information system can not only save time, reduce the communication costs of firms in obtaining information, and improve the efficiency of organizational relationships, but can also promote connectivity and interdependency in potential firm alliances, thus facilitating the formation of a solid social network for entrepreneurs. Based on this, this study proposes the following hypotheses:

H3-1: Social networks have a significant and positive impact on the formation of Web service platforms.

H3-2: Web service platforms' synergy plays a perfect intermediary role between social network synergy and firms' innovation capability.

H3-3: Web service platforms' synergy plays a partial intermediary role between social network synergy and firms' innovation capability.

Theoretical model

In innovation networks, the corporate production and operation are inseparable from their communication and synergy with the social networks and web service platforms. On the basis of the foregoing theoretical analyses and hypotheses, a theoretical model is put forward herein to reveal the influence mechanisms among the three. Based on the results of exploratory and confirmatory factor analyses, the social network SN is defined as three dimensions, the web service platform WP is defined as six dimensions, and the corporate innovation capability IN is defined as eight dimensions. Figure 1 depicts the influence mechanisms among various dimensions.

In the figure, the social network SN encompasses three dimensions, embeddedness (RE), closeness (CT), and content (CS); the web service platform WP encompasses six dimensions, information richness (IR), information exchange frequency (IE), technological transfer frequency (TT), capital flow frequency (CF), human resources exchange frequency (HR), and customer conversion rate (CR); and the innovation capability IN encompasses eight dimensions, market expansion (EI), brand building (BI), product update (PI), technological update (TI), administrative innovation (AI), quality innovation (QI), service innovation (SI), marketing innovation (MI), and a, b, c′ represent the path coefficients between variables.

Materials and Methods

Questionnaire development and data sources

Questionnaire development.—After consulting relevant mature questionnaires, the initial test items are defined based on the conceptual connotations of variables. The questionnaires for measuring social networks, web service platforms, and corporate innovation capability are compiled separately per the procedures of item purification, dimension generation, and questionnaire testing. During measurement, reverse questions and answers are designed for cross-validation, and the subjects are informed of the purpose of the questionnaire survey. While reducing the homology errors of questionnaires, social desirability biases are also minimized (Jiayuan 2012). After processes of prediction → inspection → correction → measurement → verification, formal questionnaires are finalized. During the measurement, the Likert five-point scale is used to score points ranging from strongly disagree (1) to strongly agree (5).

Social network (SN) questionnaire.—With the rapid development of network technology, some functions of traditional social networks such as information transmission and media connection have been replaced by the flat web service platforms (Malone 1988, Brass et al. 2004). With reference to the classic questionnaires on social networks proposed by Zhang and Li (2008) and Weiqi et al. (2011), this study measures the synergistic level between enterprises and social networks using a SN questionnaire containing 24 items, which is based on the scores of collaboration frequency, relational closeness, and collaboration content of enterprises with parties or government agencies; industrial, commercial, and taxation sectors; industry authorities; banking authorities; and customers, suppliers, peers, and supporting enterprises.

Web service platform (WP) questionnaire.—Considering the role of web service platforms as the medium between enterprises and social networks, this study draws on the

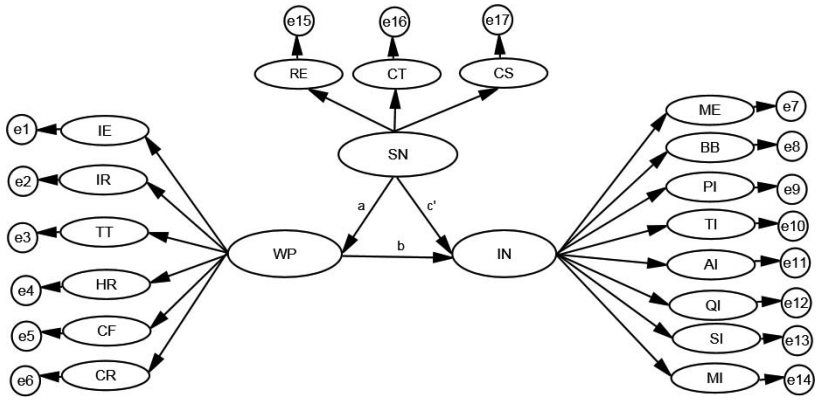

Figure 1.—Framework of theoretical hypothesis.

views of Collins and Hitt (2006), Hongxing and Xin (2011), and Xuemei and Cheng (2014) to measure the relational embeddedness between enterprises and web service platforms by compiling a 39-item WP questionnaire, which is based on the customer conversion scores for enterprise integration with e-commerce platforms (Tmall, JD, Alibaba, etc.), the human resources flow and technological transfer scores for enterprise integration with human resources platforms (Liepin, etc.) and technology patent platforms (Zhuanlibang, etc.), the scores for corporate synergy with financial service platforms (Mybank, etc.), as well as the information exchange and content scores between enterprises and all e-government and e-business platforms.

Corporate innovation capability (IN) questionnaire.—Corporate innovation activities are reflected in various aspects of production, operation, and management. With reference to research by foreign scholars (Govindarajan and Kopalle 2006, Subramaniam and Youndt 2005) and domestic scholars (Jiang and Lei 2014, Lei 2012), this study decomposes the innovation capability into weights of various capability aspects, and measures the corporate innovation capability by compiling a 34-item IN questionnaire, which is based on information about increases in the number, range, and share of new markets developed by enterprises; information about improvements in the investment, promotion, and popularity of brand culture; information about service consultations provided to customers and customer content of personalized services (product production cycle, distribution, installation, etc.); information about decreases in procurement and sales costs and increases in sales volume and procurement radius; information about technological import, patent use, and equipment update; information about quality inspection, environmental monitoring, and quality commitment; and information about corporate improvements in new institutional development, implementation, and new management concepts.

Data sources.—This study sampled general managers or heads of small- and medium-sized furniture manufacturers from 23 cities of the Pearl River Delta and Yangtze River Delta of China. From the directory of thousands of wood product enterprises in the regions, those with a high degree of information integration were selected for field research.

Throughout places in China such as Guangdong, Jiangsu, and Shanghai, a Member Representative Conference of Furniture Association & Economic Work Conference on Industrial Informatization Integration, with the help of the president of the furniture association, relevant staff, and the research team conducted a questionnaire survey among 255 enterprise representatives (the heads of enterprises) in the meeting place. After receiving the questionnaires, 182 valid questionnaires were counted. Meanwhile, through the recommendation of the heads of enterprises and the relevant personnel of China furniture association, the questionnaire electronic links (https://www.wjx.cn/m/8984963.aspx) were forwarded to their familiar furniture enterprises, and 239 valid questionnaires were submitted; in addition, 400 questionnaires were sent out by email, and 68 valid questionnaires were collected.

The enterprises were selected by snowball sampling, and the relevant personnel were entrusted to help contact the person in charge of the enterprises. The members of the research team personally distributed 255 copies of paper questionnaires, of which 182 valid questionnaires were returned. Another 400 questionnaires were distributed via mail to retrieve 68 valid questionnaires, while 239 valid questionnaires were collected from the Sojump online survey platform. In total, 489 valid questionnaires were collected using multiple data sources, with a recovery rate of lower than 35 percent. The samples are somewhat representative in terms of category distribution, geographic distribution, and informatization degree. Table 1 details the results of basic statistical data.

Methods

Structural equation model, as a sociological statistical approach combining qualitative and quantitative analyses, can not only handle the complex, nonlinear, and interactive system issues between directly observable (explicit) variables, directly unobservable (latent) variables, and interactive (endogenous) variables, but also allowed a systematic analysis of social issues. During investigation of the influence mechanisms among social networks, web service platforms, and corporate innovation capability, the formation of innovation capability involved multiple factors. Since these factors were interactive, complex, and not directly measurable, the formation of innovation capability was highly endogenous, so that the measurement of relevant variables conformed to the basic requirements of structural equation model analysis. Hence, the structural equation modeling software platforms SPSS 26.0 and AMOS 24.0 were used herein to measure and examine all variables.

Table 1.—Sample characteristics description.

Industry attribute and classification	Number of companies (%)
Material	
Solid wood furniture	162 (33.13)
Panel furniture	182 (37.22)
Upholstered furniture	112 (22.90)
Bamboo furniture	13 (2.66)
Rattan furniture	8 (1.64)
Steel-wood furniture	12 (2.45)
Function	
Office furniture	131 (26.79)
Home suite	160 (32.72)
Living room furniture	102 (20.86)
Bedroom furniture	22 (4.50)
Study furniture	19 (3.89)
Children's furniture	14 (2.86)
Dining room	55 (11.25)
Brand	
International brand	18 (3.68)
Famous brands in China	55 (11.25)
Regional brand in China	109 (22.29)
Common brand in China	307 (62.78)
Grade	
Top grade	81 (16.56)
Medium top grade	103 (21.06)
Medium grade	142 (29.04)
Medium lower grade	88 (18.00)
Lower grade	75 (15.34)
E-commerce platform	
Yes	424 (86.71)
CRM management platform	
No	65 (13.29)
Mobile application	
Yes	131 (26.79)
No	357 (73.01)
Ownership	
State-owned	2 (0.41)
Non-state-owned	473 (96.73)
Sino-foreign jointly owned	14 (2.86)
Number of employees/people	
Less than 20	61 (12.47)
21–50	175 (35.79)
51–100	180 (36.81)
101–200	52 (10.63)
201–1000	21 (4.29)
Duration time (year)	
Less than 3	39 (7.98)
3–5	113 (23.11)
6–10	124 (25.36)
11–15	138 (28.22)
More than 15	75 (15.34)
Annual sales (million Yuan RMB)	
Less than 5	77 (15.75)
5–10	144 (29.45)
10–20	163 (33.54)
More than 20	104 (21.27)
Geographical distribution	
Shanghai	31 (6.34)
Jiangsu province	84 (17.18)
Zhejiang province	95 (19.43)
Guangdong province	279 (57.06)

Exploratory factor analysis.—Through exploratory factor analysis, dimensionality reduction computations were performed on the data from social network SN, web service platform WP, and innovation capability IN questionnaires using SPSS 26.0 software. By comprehensively treating multiple groups of highly correlated and semantically overlapping observation variables into a few potential independent factors, the intrinsic relationships between observation variables and potential independent factors can be reproduced. After removing invalid observation items, recoding was performed to obtain a formal 24-item SN questionnaire, a formal 39-item WP questionnaire, and a formal 30-item IN questionnaire. Principal components with eigenvalues of greater than 1 were extracted to separately complete the questionnaire correction and dimension division.

Confirmatory factor analysis.—The results of exploratory factor analysis were validated with a first-order structural equation model, and the degrees of agreement of various questionnaire structural dimensions with actual evaluations were determined according to the model fitting indices. To reduce the endogenous errors resulting from the overlap of social networks and web service platforms, it was necessary to attempt fitting test with second-order model on the basis of first-order validation. While determining whether the SN, WP, and IN questionnaires can holistically evaluate respective connotations, this also provided simpler and clearer independent variables for mining the influence mechanisms among the three. The measurement equation was as follows:

$$Y = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \ldots\ldots \\ \\ \\ x_n \end{bmatrix} = \begin{bmatrix} \lambda_{x11} & 0 & & 0 \\ \lambda_{x12} & 0 & & \ldots \\ \lambda_{x13} & 0 & \ldots & \\ \ldots & & & 0 \\ 0 & & 0 & \\ 0 & & 0 & \\ 0 & \ldots & 0 & \lambda_{xnm} \end{bmatrix} \cdot \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \ldots \\ \\ \\ \xi_m \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_1 \\ \delta_1 \\ \ldots \\ \\ \\ \delta_n \end{bmatrix} \quad (1)$$

where Y is endogenous variable, x is the observed variable, λ is factor loading, ξ is model potential exogenous variables, and δ is error term of exogenous variable, n and m are the number of elements in the matrix.

Hierarchical regression analysis and Sobel mediation test.—To clarify the complex relationships among web service platforms, social networks, and corporate innovation capability, the scores of control variables (age, nature, and size of enterprise), as well as SN, WP, and IN variables were standardized to generate corresponding variables, with which a hierarchical regression model was built. Mediator variables were determined, and their mediating effect in theoretical model was calculated as per the test procedure of Wen and Ye (2014) using the Sobel test tool (http://quantpsy.org/sobel/sobel.htm) provided by Kristopher J. Preacher and Geoffrey J. Leonardelli. The aforementioned theoretical hypotheses were estimated.

Results and Discussion

Results and discussion of exploratory factor analysis

During formal measurement, reliability test and Bartlett's sphere test are first performed on the corrected 24-item SN

Table 2.—Exploratory factor analysis of questionnaires.

First-order factor	Second-order factor	Load mean	Explained variation (%)	Cumulative contribution rate (%)	Cronbach's α coefficient	
Social network (SN)	Relational embeddedness (RE)	0.710	26.205	74.27	0.896	0.896
	Closeness (CT)	0.652	24.849		0.860	
	Content (CS)	0.610	23.216		0.828	
Web service platform (WP)	Information richness (IR)	0.633	14.66	71.16	0.892	0.937
	Information exchange frequency (IE)	0.649	15.25		0.900	
	Technological transfer frequency (TT)	0.646	11.34		0.820	
	Capital flow frequency (CF)	0.751	7.45		0.797	
	Human resources exchange frequency (HR)	0.782	12.11		0.834	
	Customer conversion rate (CR)	0.768	10.35		0.813	
Innovation capability (IN)	Market expansion (EI)	0.800	20.295	76.08	0.868	0.962
	Brand building (BI)	0.682	14.775		0.863	
	Product update (PI)	0.825	13.891		0.862	
	Technological update (TI)	0.698	7.411		0.871	
	Administrative innovation (AI)	0.802	6.913		0.865	
	Quality innovation (QI)	0.685	4.576		0.862	
	Service innovation (SI)	0.767	4.192		0.878	
	Marketing innovation (MI)	0.764	4.031		0.908	

questionnaire, the 39-item WP questionnaire, and the 30-item IN questionnaire. Table 2 lists the specific computational results.

According to the calculations in Table 2, the Cronbach's α coefficients for the SN, WP, and IN questionnaires are 0.896, 0.937, and 0.962, respectively, while the KMO values are 0.912, 0.851, and 0.962, respectively. This indicates that all three questionnaires have good internal consistency reliabilities, which are suitable for factor analysis. Factors with eigenvalues of greater than 1 are separately extracted. For the SN questionnaire, three dimensions of RE, CT, and CM are extracted; for the WP questionnaire, six dimensions of IR, IE, TT, CF, HR, and CR are extracted; and for the IN questionnaire, eight dimensions of EI, BI, PI, TI, AI, QI, SI, and MI are extracted. The minimum Cronbach's α coefficient for various dimensional subscales in the questionnaires is $0.797 > 0.7$, which indicates excellent reliability of questionnaire development. The cumulative variance contribution rates of the questionnaires are 74.27, 71.16, and 76.08 percent, and the single factor contribution rate of each questionnaire is lower than 30 percent, suggesting good construct validity of the questionnaires. The above measurements are statistically reasonable.

Results and discussion of confirmatory factor analysis

To further verify the relationships between factors and observation items, confirmatory factor analysis is performed on the 489 sample data using AMOS 24.0. Table 3 lists the computational results of the first- and second-order structural equation models.

As shown in the results in Table 3, the three-dimensional construct of social networks, the six-dimensional construct of web service platforms, and the eight-dimensional construct of corporate innovation capability model have all passed the tests. Comparison of first- and second-order model NNFIs (non-normed fit indexes) finds better fit of second-order model, indicating that the three evaluation models allow evaluation of the overall corporate innovation capability in addition to the synergistic level evaluation of enterprises with social networks and web service platforms according to dimensions. The second-order model is closer to the reality.

Results and discussion of reliability, validity, and correlation analyses

For a statistical verification of the rationality of relationships between social networks, web service platforms, and corporate innovation capability, all the questionnaires are examined for reliability and validity using SPSS 26.0 and AMOS 24.0. Table 4 details the test results. Cronbach's α and CR values are both higher than 0.70, and the average factor extractions are both greater than the test standard of 0.50, suggesting good reliability and convergent validity of the questionnaires. The square roots of AVE (average variance extracted) are all greater than the correlation coefficient of related variables, which indicates good discriminative validity of the questionnaires.

Results and discussion of hypothesis tests

H1, H2, and H3-1 are tested with hierarchical regression models, and Table 5 lists the model results. Models 1, 3, 5, and 6 use IN as the dependent variable, Model 2 uses SN as the dependent variable, and Model 4 uses WP as the dependent variable. Among them, Model 1 is a benchmark model that only incorporates control variables. It can be seen from the R^2 values that all equations exhibit VIF (variance inflation factor) independent variable values of less than 10, and the F values are significant at a 0.001 level, indicating that the variables are independent and the theoretical models hold. The Model 5 results show that the regression coefficient of WP is 0.538 ($P < 0.001$), suggesting a significant positive impact of WP on IN, so H1 is supported. According to the Model 3 results, the regression coefficient β of SN is 0.386 ($P < 0.001$), which suggests that SN has a significant positive impact on IN, so H2 is supported.

The results of Models 2 and 4 show that SN has a significant predictive effect on WP ($\beta = 0.233$, $P < 0.001$), so H3-1 is supported. On the basis of Model 3, Model 6

Table 3.—Fit indices for first- and second-order confirmatory factor analysis models.

NNFI	SN fit value		WP fit value		IN fit value		Fitting criteria	Fitting result
	First-order	Second-order	First-order	Second-order	First-order	Second-order		
CMIN/DF	2.304	1.753	2.857	1.024	3.624	1.931	<5: The smaller the value, the better the model fit	Excellent
RMSEA	0.037	0.022	0.033	0.029	0.039	0.032	<0.1: The smaller the value, the better the model fit	Ideal
RMR	0.034	0.031	0.023	0.019	0.042	0.026	<0.05: The smaller the value, the better the model fit	Ideal
TLI	0.975	0.979	0.964	0.982	0.986	0.991	>0.9: The closer to 1, the better the fit	Excellent
GFI	0.991	0.994	0.993	0.995	0.993	0.997	>0.9: The closer to 1, the better the fit	Excellent

Table 4.—Results of questionnaire reliability and validity test, variable correlation test, and AVE square roots.

Variable	Cronbach's α coefficient	AVE	CR	Mean	SD	SN[a]	WP[a]	IN
SN	0.812	0.659	0.853	3.745	0.601	0.812		
WP	0.918	0.744	0.946	4.023	0.754	0.509***	0.863	
IN	0.947	0.896	0.982	4.312	0.679	0.563***	0.642***	0.947

[a] * = $P < 0.1$, ** = $P < 0.05$, *** = $P < 0.001$.

Table 5.—Relationship test results between web services platforms, social networks and corporate innovation capability.

Model	Model 1[a] IN	Model 2[a] SN	Model 3[a] IN	Model 4[a] WP	Model 5[a] IN	Model 6[a] IN
Enterprise age	0.039*	0.011	0.023**	0.019	0.025**	0.024**
Enterprise nature	0.061*	0.024	0.046**	0.043	0.051**	0.042**
Size	0.174***	0.131***	0.175***	0.162***	0.175***	0.158***
SN	—	—	0.386***	0.233***	—	0.241***
WP	—	−0.034***	—	—	0.538***	0.564***
R^2	0.322	0.079	0.466	0.281	0.434	0.492
Adjusted R^2	0.291	0.067	0.447	0.262	0.417	0.490
F value	16.784***	6.660***	24.331***	12.278***	23.245***	25.014***

[a] * = $P < 0.1$, ** = $P < 0.05$, *** = $P < 0.001$; the coefficients in the table are standardized. SN = social network, WP = web service platform, and IN = corporate innovation capability.

incorporates the mediator variable WP. The adjusted R^2 is 0.490, and the explained variation increases by 49.0 percent, indicating that the WP plays a significant positive role in enhancing IN ($\beta = 0.262$, $P < 0.001$). Despite the significant impact of SN on IN, it shows a slight decrease ($\beta = 0.231$, $P < 0.001$). Accordingly, web service platforms play a significant role in mediating the impact of social networks on corporate innovation capability. Hence, H3-2 is rejected, while H3-3 is supported.

Results and discussion of mediating effect analysis

According to the computational results of Models 1 to 6, the coefficients for paths a, b, and c′ in the theoretical models are 0.233, 0.564, and 0.241, respectively, showing significant impacts at a level of $P < 0.001$. For Model 3 in Table 5, the correlation coefficient of social networks with corporate innovation capability is c = 0.386, revealing a significant impact at the $P < 0.001$ level. The theoretical H3-2 fails the test, while H3-3 (web service platforms play a partial mediating role between social networks and synergistic corporate innovation capability) passes the test. Hence, the mediating effect of mediator variable in the theoretical model is calculated using the Sobel test tool (http://quantpsy.org/sobel/sobel.htm) to the effect (wp) = ab/c = 0.233 × 0.564/0.386 = 0.3405, with a variance of sqrt (0.490 − 0.447) = 0.2074. That is, under an analytical framework of integration among social networks, web service platforms and innovation capability for wood product enterprises, the mediating effect of web service platforms accounts for 34.05 percent of the total effect in the synergistic innovation capability model, which explains a 20.74 percent variance of the corporate innovation capability. Thus, H3-2 (web service platforms play a complete mediating role between social networks and synergistic corporate innovation capability) is rejected, while H3-3 (web service platforms play a partial mediating role between social networks and synergistic corporate innovation capability) is accepted. The mediating effect accounts for 34.05 percent of the total effect.

Conclusions

Research conclusions

In this study, through verification of the impacts of social networks and web service platforms on the innovation

capability of wood product enterprises, the following conclusions are drawn.

The results of exploratory and confirmatory factor analyses show that (1) in today's rapid development of platform service network technologies, various node units in the social networks act as the providers of such functional services as information transmission, knowledge transfer, and resource allocation, which have promoted the synergistic efficiency of wood product industry in three dimensions of synergistic frequency, closeness, and content. (2) The synergistic collaboration between web service platforms and wood product enterprises is reflected in significant enhancements in the following six aspects: information exchange frequency, technological transfer frequency, capital flow frequency, human resources exchange frequency, customer conversion rate in the collaboration process, and the information richness of web service platforms. (3) Corporate innovation capability is reflected in eight dimensions of market expansion, brand promotion, product update, technological update, administrative innovation, quality innovation, service innovation, and marketing innovation.

The test results of theoretical models for social networks, web service platforms, and corporate innovation capability indicate that (1) social networks and web service platforms are significantly influential to enhancing corporate innovation capability; (2) social networks have a significant positive impact on the web service platforms; (3) in the process of social network synergy with entrepreneurial innovation activities, the mediating role of web service platforms accounts for 34.05 percent of the total effect.

Implications

Through empirical analysis of the relationships among social networks, web service platforms, and innovation capability of wood product enterprises, this study draws the following implications:

The results of Models 1 to 6 demonstrate the following. (1) Age and size of wood product enterprises have significant positive impacts on the corporate innovation capability, a result consistent with the finding of Xuemei and Cheng (2014). The longer the establishment of an enterprise and the larger its size, the stronger its innovation capability. Moreover, enterprise size exerts a greater effect on the enhancement of corporate innovation capability. (2) The regression coefficient of social network synergy against web service platform synergy reaches 0.233***. This suggests that the appeal for corporate synergy with social networks has promoted the emergence of Internet service platforms, forcing enterprises to shift their traditional business transactions to the time-saving and efficient web service platforms with relational, platform, and market attributes for daily e-government, business processing, and external resources acquisition. (3) The regression coefficients of social network synergy and web service platform synergy against the innovation capability of wood product enterprises are 0.386*** and 0.538***, respectively, which agree with the conclusions of Jiang and Lei (2014), Ning and Hongqi (2008), Rochet and Tirole (2006) and Parker and Van Alstyne (2005), et al. Traditional political and commercial network synergies and web service platform synergies play a prominently positive role in enhancing the innovation capability and performance of wood product enterprises. By integrating comparative advantages of various regions such as professional service resources and service time flexibility, the web service platforms can also help enterprises reduce costs of production, management, and sales, and improve the collaborative efficiency between node enterprises in the industry chain. Meanwhile, prompted by the cross-border resource integration function of web service platforms, enterprises shift their traditional business transactions onto these web platforms with relational, platform, and market attributes, which helps them break through the time and space boundaries to acquire external resources and achieve strategic allocation of global resources, thereby facilitating the ''Enterprise + Internet'' process. Hence, various local government departments are recommended to develop appropriate web service platforms, which not only broadens the corporate social networks, but also provides fundamental guarantees for corporate transformation and upgrade.

Among the 489 wood product enterprises surveyed, 424 have settled on the e-commerce platforms (proportion 0.8571), 65 have implemented customer relationship management (CRM; proportion 0.1329), and 131 have sales records via mobile applications (proportion 0.2679). The overall performance of the wood product industry chain is as follows: node enterprises are not highly informatized and insufficiently powerful in terms of size, industry information channels are not smooth, independent R&D capabilities are not strong, and systematic scientific and technological supports are lacking. Thus, wood product manufacturers are required to comprehend the meanings of wood product industry + Internet, Internet + wood product industry, and other related concepts through Internet thinking and redefine their development paths. By establishing a ''wood product industry + Internet'' strategic relationship, these enterprises are also required to realize the resource integration of excellent upstream suppliers in the industry chain, optimize the production processes, and focus on empowering distributors and retailers. It is necessary for them to break through the traditional business model and surpass the factory fences by combining the characteristics of the wood product industry and of consumer upgrading and transformation, and to meet individual demands, private customization, and whole-house customization needs by applying multiple e-commerce models like B2C, C2B, C2M, and O2O, ultimately realizing transformation and upgrading from the traditional to the new retail S2b2c model.

Hypothesis test results of theoretical models integrating social network synergy, web service platform synergy, and innovation capability of wood product enterprises suggest that like social networks, the web service platforms are the strategic resources of enterprises, which are also an important corporate administrative tool and a vital medium for information capital acquisition. In the context of open innovation, the social network and web service platform synergies are essential in enhancing the corporate innovation capability.

This study expands the application of the network embedding and collaborative innovation theories by Jiang and Lei (2014), which measures the complex relationships between the major elements of synergistic innovation and demonstrates the positive role of web service platforms in the relationship between social networks and synergistic innovation capability of wood product enterprises. In this way, the study closely links the web service platforms to the corporate innovation capability, which enriches the research

perspective of collaborative innovation management and also provides theoretical support for innovation capability enhancement and practice transformation and upgrade of wood product enterprises.

Limitations and prospects of research

Owing to its limited conditions, this study has certain inevitable limitations: (1) The external validity of the research conclusions remains to be examined. This study chose firms that have a presence on or are about to register on e-commerce platforms from China's Yangtze River Delta and Pearl River Delta regions as research subjects to explore and examine the influence mechanism of Web service platforms and social networks on innovation capability. Although the furniture manufacturers in the two regions were representative of China, future study is needed to verify the applicability of the research results in regions such as northeastern China to improve the generalization capability and universality of the research results. (2) The selection of research objects can be further extended to include manufacturers that have not yet registered on e-commerce platforms. Owing to limitations of time and research conditions, this study collected 489 valid questionnaires issued to furniture manufacturers from China's Yangtze River delta and Pearl River delta regions to carry out measurement and analysis. Subsequent studies could extend the range of selection to regions across China and further expand the sample coverage. (3) Owing to difficulties in obtaining data such as R&D investment of firms, this study used a cross-section of questionnaire data to verify its theoretical hypotheses. To obtain more reliable statistics, future research should use longitudinal panel data to carry out research design and verify the theoretical framework.

Acknowledgments

The authors acknowledge the foundation programs supporting this research, including the National Natural Science Foundation of China (NSFC 71373039) and the New Century Supporting Foundation for Excellence, Ministry of Education of China (NCET-13-0712). We thank International Science Editing (http://www.internationalscienceediting.com) for editing a draft of this manuscript.

References

Benner, M. J. and M. L. Tushman. 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. *Acad. Manag. Rev*. 28:238–56. http://dx.doi.org/10.5465/AMR.2003.9416096

Bo, W., Z. Chunxia, and D. Yongwu. 2008. Analysis of change of world export trade of wood furniture. *J. Fujian Agric. Forestry Univ.: Philos. Sci*. 11(3):64–68. http://en.cnki.com.cn/Article_en/CJFDTOTAL-FJLY200803015.htm

Brass, D. J., J. Galaskiewicz, H. R. Greve, and W. Tsai. 2004. Taking stock of networks and organizations: A multilevel perspective. *Acad. Manag. J*. 47:795–817. https://doi.org/10.2307/20159624

Burt, R. S. 1995. Structural holes: The social structure of competition. Harvard University Press, Cambridge, MA. https://www.mendeley.com/catalogue/0d988b52-7b42-3e92-ac44-6d6333e9a358

Burt, R. S. 1997. The contingent value of social capital. *Administrative Sci. Q*. 42:339–365. https://doi.org/10.2307/2393923

Collins, J. D. and M. A. Hitt. 2006. Leveraging tacit knowledge in alliances: The importance of using relational capabilities to build and leverage relational capital. *J. Eng. Technol. Manag*. 23:147–167. https://doi.org/10.1016/j.jengtecman.2006.06.007

Gazal, K., I. Montague, R. Poudel, and J. Wiedenbeck. 2016. The forest products industry in a digital age: Factors affecting social media adoption. *Forest Prod. J*. 66. https://doi.org/10.13073/FPJ-D-15-00007

Govindarajan, V. and P. K. Kopalle. 2006. Disruptiveness of innovations: Measurement and an assessment of reliability and validity. *Strategic Manag. J*. 27:189–199. https://doi.org/10.1002/smj.511

Granovetter, M. S. 1973. The strength of weak ties. *Am. J. Sociol*. 78:1360–1380. https://doi.org/10.2307/2776392

Haixi, J. and J. Ying. 2014. Social network theory new economic sociology review. *J. Hebei Univ. Econ. Bus*. 150–158. https://doi.org/10.3969/j.issn.1007-2101.2014.06.031

Hongxing, Z. and G. Xin. 2011. How does the entrepreneurs' social capital impact on operating performance—A study based on the mediate effect of dynamic capability. *J. Shandong Univ. (Philos. Social Sci.)* 106–113. https://doi.org/10.3969/j.issn.1001-9839.2011.04.015

Huanli, H. 2015. Analysis of realistic social relation network and relation search technology. Agricultural Univ. of Hebei, Baoding. http://d.wanfangdata.com.cn/thesis/Y2874653

Jansen, J. J. P., F. A. J. Van den Bosch, and H. W. Volberda. 2006. Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. *Manag. Sci*. 52:1661–1674. https://doi.org/10.1287/mnsc.1060.0576

Jiang, W. and X. U. Lei. 2014. Dual embeddings of knowledge network, knowledge integration, and innovation capabilities of clustered firms. *J. Management Sci. China* 34–47. https://doi.org/10.3969/j.issn.1007-9807.2014.02.003

Jiayuan, Y. 2012. Statistical remedies. Abstracts of the 15th National Conference on Psychology. Guangzhou, Guangdong, China. http://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZGXG201211001059.htm

Kaplan, A. M. and M. Haenlein. 2010. Users of the world, unite! The challenges and opportunities of social media. *Business Horizons Bloomington*. https://doi.org/10.1016/j.bushor.2009.09.003

Lei, X. 2012. The mechanism of the knowledge network dual embeddedness and the upgrading of innovation capability. Zhejiang University, Hangzhou. http://cdmd.cnki.com.cn/Article/CDMD-10335-1012446262.htm

Lin, N. 1999. Building a network theory of social capital. *Connections* 22:28–51. https://www.researchgate.net/publication/253594521_A_Network_Theory_of_Social_Capital

Malone, T. W. 1988. Modeling coordination in organizations and markets. Readings in Distributed Artificial Intelligence 33:151–158. https://doi.org/10.1287/mnsc.33.10.1317

McEvily, B. and A. Zaheer. 1999. Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Manag. J*. 12, http://dx.doi.org/1133-1156.10.1002/(SICI)1097-0266(199912)20:123.0.CO;2-7

Meng, X. 2010. Study on combining of E-commerce and E-marketing. *Software* 5:546–553. http://dx.doi.org/10.4304/jsw.5.5.546-553

Ming, Z. 2017a. In the next five years, S2b will most likely be the leading business model. *Zeng Ming Shu Yuan*. https://www.sohu.com/a/144792854_206868

Ming, Z. 2017b. ''The real S2b is in fact S2b2c, in which S and b jointly serve c''. *Zeng Ming Shu Yuan*. https://www.sohu.com/a/151318340_343156

Neck, H. M., G. D. Meyer, B. Cohen, and A. C. Corbett. 2010. An entrepreneurial system view of new venture creation. *J. Small Bus. Manag*. 42:190–208. https://doi.org/10.1111/j.1540-627X.2004.00105.x

Ning, A. and W. Hongqi. 2008. Research on incubator network service platform construction of science and technology parks in China. *Ind. Technol. Econ*. 27(7):68–70. https://doi.org/10.3969/j.issn.1004-910X.2008.07.021

Oviatt, B. M. and P. P. McDougall. 1997. Challenges for internationalization process theory: The case of international new ventures. *MIR: Management International Review* 37:85–99. https://www.jstor.org/stable/40228434

Palmer, A., and N. Koenig-Lewis. 2009. An experiential, social network-based approach to direct marketing. *Direct Marketing: Int. J*. 3:162–176. https://doi.org/10.1108/17505930910985116

Parker, G. and M. W. Van Alstyne. 2005. Two-sided network effects: A theory of information product design. *Social Sci. Electronic Publish-*

ing 51:1494–1504. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1177443

Ping, H., L. Lei, and W. Yao. 2016a. The study on characteristic and structures of the collaborative innovation network in Beijing. 70–78. http://www.cnki.com.cn/Article/CJFDTotal-KXXG201602008.htm

Ping, Y., W. Gang, and S. Zhengdong. 2016b. Research on the construction mode of regional collaborative innovation system based on network public service platform. *Technology Wind* 10:90–92. http://dx.doi.org/10.3969/j.issn.1671-7341.2016.10.078

Rochet, J. C. and J. Tirole. 2006. Two-sided markets: A progress report. *Rand J. Econ*. 37:645–667. https://doi.org/10.1111/j.1756-2171.2006.tb00036.x

Rujun, C. 2014. The relation between network society and real society and its management. *China Sci. Technol. Exp*. 90–91.

Shuying, W. 2010. Research on architecture of collaborative work platform for industrial-chain enterprises cluster. *J. Comput. Appl*. 30:1363–1366. http://www.cnki.com.cn/Article/CJFDTotal-JSJY201005064.htm

Subramaniam, M. and M. A. Youndt. 2005. The influence of intellectual capital on the types of innovative capabilities. *Acad. Manag. J*. 48:450–463. http://dx.doi.org/10.1055/s-2001-15824

Trusov, M., R. E. Bucklin, and K. Pauwels. 2009. Effects of word-of-mouth versus traditional marketing: Findings from an internet social networking site. *J. Mark*. 73:90–102. https://doi.org/10.2139/ssrn.1129351

Uzzi, B. 1997. Social structure and competition in interfirm networks: The paradox of embeddedness. *Adm. Sci. Q*. 42:35–67. http://dx.doi.org/.10.2307/2393808

Weiqi, D., L. Qiao, and W. Jiang. 2011. Inside and outside the cluster network embedded with the company business: An empirical study from four industrial clusters in Zhejiang province. *Studies Sci. Sci*. 571–581. http://en.cnki.com.cn/Article_en/CJFDTOTAL-KXYJ201104013.htm

Wen, Z. and B. Ye. 2014. Analyses of mediating effects: The development of methods and models. *Adv. Psych. Sci*. 22:731–745. https://doi.org/10.3724/SP.J.1042.2014.00731

Xin, L. 2009.Comparative analysis on the international competitiveness of Chinese furniture. *J. Int. Trade* 1:47–53. http://en.cnki.com.cn/Article_en/CJFDTOTAL-GJMW200901008.htm

Xuemei, X. and L. Cheng. 2014. Social networks and new product innovation performance: Moderating effects model based on synergies of knowledge and technology. *Sci. Sci. Manag. of S. & T*., 7. http://www.cnki.com.cn/Article/CJFDTOTAL-KXXG201406007.htm

Ying, L., W. Chenyou, Y. Chen, and L. Xiao. 2016. A review on public service platforms of collaborative industry chain. *Computer Eng. Sci*. 38:1111–1117. http://www.cnki.com.cn/Article/CJFDTotal-JSJK201606008.htm