

Article

The Effect of Open Innovation on Manufacturing Firms' Performance in China: The Moderating Role of Social Capital

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Abstract: Open innovation (OI) has great significance in innovation management. OI builds a bridge between firms and other organizations, which can help firms to quickly integrate into value chain innovation and discover the value stored in external resources, and thus can improve the performance of firms. The Chinese economy is accelerating its high-quality development. In this process, the importance of social capital is emphasized. However, less evidence is provided to discuss whether and how social capital from the resource perspective affects OI and firm performance. Therefore, we constructed a moderating model to deeply examine the mechanisms of the two models of the effects of inbound OI and outbound OI on firm performance and the impact of multidimensional social capital within it from the resource perspective. Our sample comprises 6899 observations of 1850 A-share listed manufacturing firms in China from 2016 to 2020. Considering the lag of resources into firm profitability, we decided to lag the firm performance by one year behind other indicators, so the sample data cover the period of 2016–2021. Then, we used Excel 2019 to complete the calculations of indicators and used multiple regression analysis of STATA17 to test the hypotheses. It is found that inbound and outbound OI have an inverted U-shaped relationship with firm performance. Institutional and technological social capital positively moderates the relationship between inbound and outbound OI and firm performance. Compared with the other two types of social capital, market social capital is the most widely owned among the sample firms, but its moderating effect is insignificant. The findings enrich and expand theoretical research on OI and firm performance and guide firms to implement OI, promoting their sustainable development.

Keywords: open innovation; social capital; inverted U-shaped performance; moderating role



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1. Introduction

The Chinese economy is accelerating its high-quality development and making every effort to enhance the status of enterprises as the main body of scientific and technological innovation. In the competitive market environment brought about by technological progress and the information explosion, the speed of technological innovation has accelerated. It has been difficult for enterprises to achieve absolute advantage in the market competition through closed innovation [1,2], so more and more enterprises are implementing open innovation (OI) to improve their competitive advantage [3]. Unlike closed innovation, OI crosses organizational boundaries and emphasizes extensive inter-organizational cooperation, which refers to an innovation model that accelerates internal innovation through the inflow of knowledge at organizational boundaries and uses the outflow of knowledge to expand external markets [4]. In the digital economy, most enterprises can only dominate one or a few value chain activities [2], and they need the help of other value chain activities to achieve value-added products or services. OI provides a link between enterprises and external organizations for communication, which can help enterprises to quickly integrate into value chain innovation and discover the value stored in external resources. Therefore, OI has a vital role in enterprises. Meanwhile, in promoting high-quality development, the

Chinese government actively guides the participation of social capital and emphasizes its importance. In this context, exploring the critical role of social capital and OI for Chinese enterprises is necessary.

Academics have conducted many studies on OI, including OI classification and relevance studies. In terms of OI classification, three significant schools of thought have been formed based on different perspectives: process [5,6], strategy [7], and characteristics [8]. Related studies mainly focus on closed innovation [9,10], dual innovation [11,12], human resources [13,14], and firm performance [15,16], and use empirical analysis [12], case studies [11], and simulations [10] to analyze the interplay between different factors. In terms of research objects, there are three primary levels: first, the macro level in the region, such as countries [17] and industries [18]; second, the specific middle level, such as enterprises [11,19] and universities [12,20]; and third, the micro level, such as projects [21]. After a closer reading of the above literature, we found that earlier scholars were more concerned with OI itself. However, establishing how to benefit from OI is firms' main focus, so recent research has shifted toward how OI is implemented. Meanwhile, the findings on how OI affects firm performance are still divergent. Some scholars argue that searching for and utilizing valuable external resources can shorten the development cycle, thus reducing firms' economic costs [16,22]. Others argue that while using valuable external resources can save economic costs, it increases the burden of management costs and reduces the ability to integrate resources. This leads to OI's negative impact on firm performance [23]. The divergence of the above findings suggests that studying the mechanism of action is indispensable to examining the relationship between OI and firm performance. This paper empirically analyzes the moderating path of OI to enhance firm performance.

In the process of promoting high-quality development in China, the participation of social capital is emphasized. In this context, exploring the mechanism of the role of social capital in the relationship between OI and firm performance is essential. Based on different perspectives, the concept of social capital has been summarized into three significant connotations: association, resource, and network. Scholars holding the association perspective define social capital as the relationship between an individual or group and society and the ability to use this association to obtain resources [24,25]. The resource perspective views social capital as resources embedded in social networks, which individuals or groups acquire and use through their actions [26,27]. The network view considers social capital as a dynamic network, and the information and resources that individuals or groups possess are determined by their position in the network [28,29]. Combined with China's national efforts to promote the status of enterprises as the main body of science and technology innovation and to create a favorable atmosphere conducive to enterprise technological innovation by actively enhancing the participation of social capital, this study takes the resource-based view that social capital exists in social networks and that enterprises can obtain relevant help or resources by taking active actions, such as receiving government subsidies through applications, getting help to solve technological innovation problems through consulting universities and research institutes, etc. After reading the relevant literature, we found that most studies on the relationship between social capital, OI, and firm performance have focused on the direct effects of either two of these factors [30,31]. Less evidence is provided to discuss whether and how social capital affects OI and firm performance in the Chinese context. Therefore, the focus is on examining the moderating role of social capital between OI and firm performance in the Chinese context and the limitations of the past literature.

The contribution of this paper may be that, first, the previous literature tends to explore the direct impact of social capital on OI and firm performance or the mediating role between OI and firm performance [32]. There is less research that considers social capital as a moderating variable. Although Yang et al. [33] considered social capital as a moderating variable, their study was based on the relational perspective. It explored the moderating role of structural, cognitive, and relational social capital. Unlike Yang et al., this paper is based on the resource perspective and explores the moderating role

of social capital in three dimensions: institutional, market, and technological. By doing this, this paper fills the gap in the research on the moderating role of social capital between OI and firm performance from the resource perspective. Second, the previous literature generally focuses on the impact of OI on firm performance but tends to use subjective perceptions such as managers or employees to measure firm OI. Less attention is paid to the effects of objective statistics. Guo et al. argued that subjective perceptions are not the only important factor when considering how OI affects firm performance; objective data are also essential [34]. This study further explores OI's impact on firm performance regarding technology purchase and joint patenting, which helps to provide new insights into the literature exploring OI.

The remainder of this paper is structured as follows: Section 2 explores related theories and lists the research hypotheses; Section 3 describes the data sources and regression model; Section 4 presents statistical results; and Section 5 discusses the findings, practical implications, limitations, and future research directions.

2. Theory and Hypotheses

2.1. Open Innovation and Firm Performance

In the early days, companies relied entirely on internal research and development (R & D) for innovation. They benefited from establishing many large R & D labs to create barriers to entry for potential competitors [35]. However, as technology iteration accelerated, knowledge fragmentation and risk increased, causing many firms to encounter bottlenecks in their innovation; they were driven to seek external collaborative R & D. By observing the behavior and innovation patterns of these large innovative firms, Chesbrough proposed the concept of OI [4], based on which many scholars have further extended and expanded its connotations [36], all of which are essentially examined based on the concept of resource flows. As a result, Chesbrough and Crowther classified OI into inbound OI and outbound OI according to the purposeful inflow and outflow of knowledge and technology between organizations [37].

(1) Inbound OI and firm performance. Inbound OI refers to integrating ideas, knowledge, and technology acquired from outside into the organization and using them for R & D. Its resource flow is an outward-to-inward process [4]. Firms can significantly improve performance through moderate inbound OI [15,16]. Inbound OI makes it possible for firms to access rich external resources. On the one hand, by searching for and utilizing valuable external resources, firms can bypass the early new product development steps and reach the new product implementation stage faster. This shortened development cycle will translate into economic returns for firms [38]. On the other hand, combining valuable external resources with the firm's existing intellectual property and products will further energize its existing resources and enhance its innovativeness, thus reducing the need to develop new products [39]. Effectively utilizing the firm's underutilized resources and reducing R & D activities improves the firm's financial performance [16,22]. However, over-reliance on external resources may lead to diminishing marginal utility [40]; as the level of innovation increases and the availability of more accessible information decreases, companies need to spend more on searching for valuable external information, strengthening communication with partners, and establishing close ties to obtain core resources to maintain the expansion of innovation in existing products [41]. Excessive search, judgment, coordination, and transaction costs, such as lawsuits for external resources, will significantly reduce the benefits of resource acquisition [42]. In addition, for firms that import without considering their absorptive capacity, such resources are meaningless [43], resulting in wasted costs that will further curb the increase in firm performance. Therefore, the following research hypothesis is proposed:

Hypothesis 1 (H₁): *The relationship between inbound OI and firm performance is an inverted U-shape.*

(2) Outbound OI and firm performance. In contrast to inbound OI, resource transfer in outbound OI is an inside-out process, which refers to the commercialization of a firm by exporting part of its internal knowledge and technology to the external environment [4]. Because of the risk of leaking core technology and enhancing the competitiveness of other firms by transferring technology externally [44], many firms stay away from it. Still, it has been proven that moderate external OI can significantly increase firm performance [15,16,45]. By transferring technology through selling, licensing, outsourcing, or sharing, enterprises can, on the one hand, test the value and prospect of the technology through the market in the short term and have some insight into the future R & D direction of enterprises and commercializing the idle technology can also reduce sunk costs and boost economic growth (e.g., based on a survey of IBM manufacturers, Chesbrough found that in 2000, IBM obtained through technology licensing a lucrative economic income, accounting for about 20% of the net enterprise sales [46,47]). On the other hand, technology transfer may allow firms to gain strategic opportunities [48]; in a market with network externalities, revenue will increase with the number of users. As the technology is transferred outward, the user base expands, and the market share increases, and when the market share reaches a certain level, the technology will become the dominant design and industry standard. However, as the intensity of opening to the outside world increases, pinpointing business opportunities in the market, judging whether the technology performance improvement is displayed to the outside world, and identifying and determining the trusted sales targets will take a lot of time and energy for the enterprise. Additionally, if firms implement OI with the outside world without judgment and in an extreme manner, some technologies will be easily commercialized, which will result in the lack of future competitive advantage, the decline of their competitive position, and the rise of competitors, and may eventually lead to the continuous loss of their interests [49]—for example, some derivative products were previously sold by Xerox manufacturers, which led to the rise of companies such as Adobe and 3Com [4]. Therefore, the following research hypothesis is proposed:

Hypothesis 2 (H₂): *The relationship between outbound OI and firm performance is an inverted U-shape.*

2.2. The Moderating Role of Social Capital

In early research in this field, the term “social capital” was used to explore the impact of solid interpersonal ties within a community on the community’s ability to build cooperation, trust, and economic development [50]. Then, Bourdieu introduced it into sociology [51], based on which Nahapiet and Ghoshal proposed the definition of social capital at the firm level, where they considered it the sum of the resources that have and have not been obtained from a social network [52]. Since there are many different sources of social capital at the firm level—individuals, personal and social relationships [24], teams [25], etc.—scholars define it differently, resulting in its definition not being uniform, and to solve this problem, studies have been developed to classify it into different dimensions to carry out research according to relevant needs. Based on the conceptualization of social capital, Tsai and Ghoshal classified it into three dimensions: structural, relational, and cognitive [53]. Based on the direction of the firm’s connection with the outside, Bian and Qiu classified social capital into horizontal connection (other firms), vertical connection (government), and social connection (social interaction ability of corporate entities) [54]. According to different types of resources, studies have defined social capital in business, political, and technological dimensions [55,56]. Combining these propositions and considering the influence of different sources of capital on firm behavior, this study explores social capital in terms of institutional social capital (source government, etc.), market social capital (source customers and suppliers, etc.), and technological social capital (universities, research institutions, etc.) in a moderating role between OI and firm performance.

(1) The regulating role of institutional social capital. Institutional social capital refers to the various subsidies, technology, information, and other resources enterprises obtain

from the relationship network established with the government and institutions. Since there is a certain degree of uncertainty in enterprise innovation and operation, the high intensity of institutional social capital will provide important advantages [32]. Among them, various government subsidies and special funds can alleviate the financial pressure of OI and broaden the channels and ways of OI [57]. Additionally, policy support can stimulate information search, technology introduction, and technology commercialization dynamics. Technology and information support, on the other hand, help firms to quickly identify and avoid risks [58]. Thus, institutional social capital helps firms to increase their information search and transaction cost tolerance in the implementation of inbound OI, reduce the risk of core technology spillover in the process of outbound OI, and reduce the possibility of competitor competitiveness enhancement, thus enhancing firm profitability and improving firm performance. Therefore, this paper proposes the following:

Hypothesis 3 (H₃₁): *Institutional social capital has a significant positive moderating effect between inbound OI and firm performance.*

Hypothesis 3 (H₃₂): *Institutional social capital has a significant positive moderating effect between outbound OI and firm performance.*

(2) Moderating role of market social capital. Market social capital refers to the information, knowledge, and other resources companies obtain from established cooperation with customers, suppliers, and others. Based on trust, establishing long-term relationships with suppliers facilitates timely access to market information, the identification and location of current market opportunities, and complementary resources [59]. In contrast, establishing long-term relationships with customers is beneficial for pinpointing customer needs and reducing teething costs, thus increasing corporate sales and promoting financial performance [56], and communicating with users about new product development and other information is also beneficial for obtaining technological innovation ideas, improving existing products, and enhancing corporate innovation performance. Dahlander et al. stated that based on long-term trusting relationships, users' suggestions and ideas constitute an essential source of innovation for companies. Once adopted, they promote product innovation, increase users' understanding of new products, and improve loyalty [60]. As a result, in implementing OI in an environment of high trust, firms are more willing to communicate with each other to obtain complementary, explicit, or even implicit resources and obtain economic rewards. As a result, this study proposes the following:

Hypothesis 4 (H₄₁): *Market social capital has a significant positive moderating effect between inbound OI and firm performance.*

Hypothesis 4 (H₄₂): *Market social capital has a significant positive moderating effect between outbound OI and firm performance.*

(3) The regulating role of technological social capital. Technological social capital refers to the human, technical, and knowledge resources enterprises obtain from the relationship network between universities and research institutes. Since enterprises may encounter bottlenecks in the innovation process, and universities and research institutes, as units with high knowledge and following the frontier of technology, can effectively provide solutions to break through bottlenecks, maintaining close cooperation with these units will reduce obstacles to new product development and effectively solve some complex problems [61]. Currently, many enterprises are facing a shortage of R & D-oriented talents. Universities and other units can effectively improve the status quo of some enterprises with insufficient innovation, low management levels, and low overall quality by providing highly qualified and top-notch talents. At the same time, universities and other units, as strong time-sensitive and forward-looking information collection and dissemination centers, can provide various types of information on the status of market demand in time to

help enterprises make timely market judgments and accurately commercialize technologies, thus improving their profitability; therefore, this study proposes that:

Hypothesis 5 (H₅₁): *Technological social capital has a significant positive moderating effect between inbound OI and firm performance.*

Hypothesis 5 (H₅₂): *Technological social capital has a significant positive moderating effect between outbound OI and firm performance.*

3. Methods

3.1. Data and Sample

This study selected Chinese A-share-listed manufacturing companies as the sample for the following reasons. Firstly, considering the research context, it was more appropriate to use Chinese enterprise data. Secondly, for data accessibility, this study needed to collect a large sample of data. The data of domestic listed companies are abundantly available in the China Stock Market and Accounting Research Database (CSMAR), Chinese Research Data Services (CNRDS) database, etc., which enabled us to obtain relevant data to conduct the study.

To study the relationship between OI and firm performance and the moderating effect of multidimensional social capital on both, and to ensure that the data were authentic and reliable, A-share manufacturing listed companies of China were selected as the sample. The initial data were screened based on the following criteria: (1) selecting enterprises listed before 1 January 2016; (2) eliminating enterprises that were ST or PT; and (3) eliminating enterprises with missing and extreme values of relevant indicators. The final sample was obtained from 1132 enterprises in 2016, 1281 enterprises in 2017, 1354 enterprises in 2018, 1474 enterprises in 2019, and 1657 enterprises in 2020, with 6898 observations. Considering the profitability lag of resource transformation enterprises, the enterprise performance indicators lagged behind other indicators by one year, so the sample data covered the period from 2016 to 2021.

The sample data for conducting empirical analysis in this study were mainly from CSMAR, and the data of joint patent applications of sample enterprises were from the CNRDS database. The calculation of individual indicators and the merging of multiple indicators were implemented in Excel 2019. The statistical analysis of each variable and the regression analysis of each model hypothesis were processed in STATA17. The tailoring of explanatory variables with possible extreme values was completed. The following data results were obtained based on the above processing.

3.2. Measurement of Variables

3.2.1. Dependent Variable

The currently widely used return on total assets (ROA) measure of firm performance was selected. In the regression analysis, a one-year lag was taken to assess firm performance, i.e., financial data from 2017 to 2021 were used. This was followed by a robustness test of firm performance using gross operating margin (Maolilv), return on net assets (ROE), and net total assets margin (JROA).

3.2.2. Independent Variables

Based on the existing research results [62,63], OI was measured as follows: (i) Inbound OI (IOI), characterizing the intensity of resource inflow into the enterprise, was measured by the ratio of the enterprise's current technology purchase amount to its total assets at the beginning of the period. (ii) Outbound OI (OOI), characterizing the extent of technology and knowledge outflow, was expressed by the number of joint patents in the period, including joint applications for inventions, utility models, and designs, which affected the smoothness of this variable due to the excessive size of some data, and to weaken this effect, this variable was processed by adding one and taking the natural logarithm.

3.2.3. Moderating Variables

Social capital refers to the various resources obtained from the social network constructed by the enterprise, and according to the existing research results [56,64], it was measured as follows: (i) institutional social capital (ISC), characterizing the intensity of resources obtained by the enterprise from government and other authorities, was measured by the ratio of the current government subsidy amount to the enterprise's operating income at the end of the period. (ii) For market social capital (MSC), characterizing the intensity of resources obtained by the enterprise from partners such as suppliers, as customers and suppliers are equally important to enterprises, each indicator was assigned a value of 0.5 and summed to obtain the measure of social market capital, i.e., the sum of the annual percentage of sales from the top 5 customers multiplied by 0.5 and the annual percentage of purchases from the top 5 suppliers multiplied by 0.5 for the period. (iii) Technological social capital (TSC), characterizing the strength of the firm's access to resources from universities and other institutions, was measured by the number of executives with academic backgrounds.

3.2.4. Control Variables

Referring to existing studies [55] and combining their findings with the subject of this study, five variables were controlled: firm size (Size), measured by the natural logarithm of current firm book assets; gearing ratio (Lev), the ratio of current book liabilities to current book assets; firm intangible assets ratio (In_assets), the ratio of current total intangible assets to current total assets; and firm life cycle (Age), measured by measure the difference between the year and the time of enterprise establishment, and then add 1 to the difference and take the ln measure. Additionally, the control variables include the Year dummy variable.

3.3. Regression Model

In order to accurately examine the relationship between OI, social capital and firm performance, the following regression model was constructed by drawing on relevant studies:

$$ROA = \beta_0 + \beta_1 IOI + \beta_2 IOI^2 + \beta_3 Controls + \xi \quad (1)$$

$$ROA = \beta_0 + \beta_1 OOI + \beta_2 OOI^2 + \beta_3 Controls + \xi \quad (2)$$

$$ROA = \beta_0 + \beta_1 IOI + \beta_2 IOI^2 + \beta_3 Mod_i + \beta_4 Mod_i \times IOI + \beta_5 Mod_i \times IOI^2 + \beta_6 Controls + \xi \quad (3)$$

$$ROA = \beta_0 + \beta_1 OOI + \beta_2 OOI^2 + \beta_3 Mod_i + \beta_4 Mod_i \times OOI + \beta_5 Mod_i \times OOI^2 + \beta_6 Controls + \xi \quad (4)$$

In Models 1–4, Controls denotes control variables, consisting of Size, Lev, In_assets, Age, and Year. Mod_i denotes moderating variables, where $i = 1, 2$, and 3 , and when $i = 1$, Mod_1 denotes institutional social capital ISC; when $i = 2$, Mod_2 denotes market social capital MSC; and when $i = 3$, Mod_3 denotes technological social capital TSC.

Model 1 and Model 2 are benchmark regressions. Model 1 examines the role of inbound OI in the current period on firm performance in the next period. The squared term of inbound OI (IOI^2) is introduced in Model 1 to explore the nonlinear relationship between inbound OI and firm performance. Based on Model 1, Model 3 introduces the moderating variable Mod_i , the primary interaction term between the moderating variable and inbound OI ($Mod_i \times IOI$), and the secondary interaction term between the moderating variable and inbound OI ($Mod_i \times IOI^2$), which is used to explore the role of social capital on the relationship between inbound OI and firm performance. Model 2 and Model 4 were used similarly.

4. Discussion

4.1. Descriptive Statistics

The descriptive statistics of the main variables are shown in Table 1. Among the 6898 sample firms, the mean values of inbound OI (IOI) and outbound OI (OOI) are 0.004 and 0.92, respectively, with standard deviations of 0.039 and 1.33, respectively, and the median values are both 0, indicating that more firms in the observations did not adopt the OI model. Among the three dimensions of social capital, only technological capital (TSC) has a median of 0. In contrast, institutional capital (ISC) and market capital (MSC) have a median of 0.006 and 0.295, respectively, reflecting that the observed firms generally have institutional and market capitalization, and many do not have technological capital. Their standard deviations are 0.049, 0.152, and 1.082, respectively, which are small, reflecting that the intensity of resources owned by the observed firms from the society does not vary greatly.

Table 1. Descriptive statistical results.

Variable	Min	Median	Mean	Max	Std. Dev.
IOI	0	0	0.004	1.866	0.039
OOI	0	0	0.92	8.970	1.33
ISC	0	0.006	0.013	3.096	0.049
MSC	0	0.295	0.318	1.081	0.152
TSC	0	0	0.707	14	1.082
ROA	−1.632	0.055	0.053	1.747	0.106
Size	7.978	9.569	9.621	11.964	0.506
Lev	0.008	0.391	0.401	3.221	0.21
In_assets	0	0.038	0.046	0.677	0.041
Age	1.386	2.944	2.944	4.143	0.286

4.2. Multiple Regression Analysis

The STATA 17 multiple regression analysis was used for hypothesis testing. Because of the introduction of interaction terms, the problem of multicollinearity may arise, which affects the final results. The two OI variables and three social capital variables were therefore decentered. Then, each interaction term was added to the base regression. Tables 2 and 3 show the final regression results. M1 and M3 contain control variables and first-order independent variables, based on which the inbound OI squared term is introduced to obtain M2, and the outbound OI squared term to obtain M4, and M5–M10 further introduce the first- and second-order interaction terms of the three social capital variables with the two OI variables, respectively.

Table 2. The effect of OI on firm performance.

Variable	ROA			
	M1	M2	M3	M4
IOI	0.0277 (1.23)	0.0570 (3.08)		
IOI ²		−8.2160 ** (−2.39)		
OOI			0.0005 (0.59)	0.0055 *** (2.69)
OOI ²				−0.0014 *** (−2.82)
Size	0.0170 *** (6.68)	0.0170 *** (6.69)	0.0164 *** (5.86)	0.0163 *** (5.82)
Lev	−0.1010 *** (−10.83)	−0.1020 *** (−10.85)	−0.1010 *** (−10.81)	−0.1010 *** (−10.80)
In_assets	−0.0684 ** (−2.50)	−0.0625 ** (−2.24)	−0.0635 ** (−2.31)	−0.0638 ** (−2.32)

Table 2. Cont.

Variable	ROA			
	M1	M2	M3	M4
Age	−0.0029 (−0.81)	−0.0031 (−0.86)	−0.0029 (−0.82)	−0.0031 (−0.87)
Constant	−0.0575 ** (−2.48)	−0.0570 ** (−2.46)	−0.0524 ** (−2.07)	−0.0520 ** (−2.06)
Adj-R ²	0.0565	0.0571	0.0564	0.0571
Year	Control	Control	Control	Control
F Value	26.43 ***	23.35 ***	26.52 ***	23.37 ***

Note: (1) **, $p < 0.05$; ***, $p < 0.01$. (2) Numbers in parentheses are t-values.

Table 3. The moderating effect of multidimensional social capital.

Variable	ROA					
	M5	M6	M7	M8	M9	M10
IOI	0.0598 *** (3.06)	0.0464 *** (3.28)	0.0038 (0.21)			
IOI ²	−6.408 * (−1.84)	−8.2262 * (−1.89)	−7.0790 * (−1.66)			
OOI				0.0016 (1.51)	0.0023 * (1.88)	0.0052 ** (2.57)
OOI ²				−0.0008 ** (−2.43)	−0.0013 *** (−2.62)	−0.0014 *** (−2.69)
ISC	−0.0782 (−0.95)			−0.0620 (−0.82)		
MSC		−0.0296 *** (−4.26)			−0.0286 *** (−3.84)	
TSC			0.0012 (1.40)			0.0019 ** (2.29)
ISC × IOI	0.887 (0.88)					
ISC × IOI ²	−1831.3 ** (−2.74)					
MSC × IOI		0.3830 (1.65)				
MSC × IOI ²		−0.1239 (−0.83)				
TSC × IOI			−0.1780 (−0.95)			
TSC × IOI ²			−0.0518 *** (−3.88)			
ISC × OOI				0.0149 (0.87)		
ISC × OOI ²				−0.1628 *** (−3.64)		
MSC × OOI					−0.0040 (−0.59)	
MSC × OOI ²					−0.0006 (−0.31)	
TSC × OOI						0.0016 (1.57)
TSC × OOI ²						−0.0003 ** (−2.18)
Adj-R ²	0.0613	0.0597	0.0572	0.0624	0.0593	0.0572
Year	Control	Control	Control	Control	Control	Control
F Value	17.69 ***	26.52 ***	18.47 ***	17.66 ***	17.77 ***	16.75 ***

Note: (1) *, $p < 0.1$; **, $p < 0.05$; ***, $p < 0.01$. (2) Numbers in parentheses are t-values.

(1) Regarding the main effects test, Table 2 presents the results of the effect of the adoption of OI by firms in the current period on firm performance in the next period, from which it can be seen that the inclusion of quadratic regression M2 and M4 has a larger R^2 ($0.0571 > 0.0565$, $0.0571 > 0.0564$) compared to the primary term regression M1 and M3 with only inbound OI and outbound OI, indicating that the introduction of the quadratic term enhances the explanatory strength of the model. Meanwhile, M1 and M3 have a positive relationship between inbound and outbound OI and firm performance. Still, this relationship is not significant, indicating a non-linear relationship between OI and firm performance.

In M2 and M4, after controlling for the relevant variables, the primary and quadratic terms of inbound OI and firm performance are positively and negatively correlated, respectively. Both are significant, with regression coefficients of 0.0570 and -8.216 , respectively, which reflect a significant inverted U-shaped relationship between inbound OI and firm performance, and H_1 is supported. Similarly, the primary term of outbound OI is positively related to firm performance. In contrast, the quadratic term is negatively related to firm performance, and both are significant with regression coefficients of 0.0055 and -0.0014 , respectively, which indicates a significant inverted U-shaped relationship between outbound OI and firm performance, and H_2 is supported.

(2) Testing for moderating effects, Table 3 reports the moderating effects of social capital. First, the moderating effect of institutional social capital is tested. Adding institutional social capital and the interaction term of institutional social capital to M2 and M4 forms M5 and M8. In M5, the primary ($\beta = 0.0598$, $p < 0.01$) and quadratic terms of inbound OI remain significant ($\beta = -6.408$, $p < 0.1$), and the quadratic term of inbound OI and the interaction term of institutional social capital negatively affect firm performance and are significant ($\beta = -1831.3$, $p < 0.05$), indicating that institutional social capital significantly and positively moderates the inverted U-shaped relationship between inbound OI and firm performance. Therefore, H_{31} is supported. In M8, the outbound OI quadratic term remains significant ($\beta = -0.0008$, $p < 0.05$), and the interaction term between the outbound OI quadratic term and institutional social capital negatively affects firm performance. This effect is also significant ($\beta = -0.1628$, $p < 0.01$), which shows that institutional social capital also significantly and positively regulates the inverted U-shaped relationship between outbound OI and firm performance, and thus, H_{32} is supported.

The process of testing the moderating effect of social market capital is consistent with the process of testing the moderating effect of institutional capital above. M6 and M9 add the social market capital and the interaction term of market social capital to M2 and M4, respectively. Among them, both the quadratic term of inbound and outbound OI and the interaction term of market social capital negatively affect firm performance. The regression coefficients are -0.1239 and -0.0006 , respectively. Still, they are insignificant, so H_{41} and H_{42} are not supported.

M7 and M10 add the technological social capital and the interaction term of technological social capital to M2 and M4, respectively. Among them, both the quadratic term of inbound and outbound OI and the interaction term of technological social capital have a significant negative relationship with firm performance ($\beta = -0.0518$, $p < 0.01$; $\beta = -0.0003$, $p < 0.05$), indicating that there is a significant positive moderating effect of technological social capital on the inverted U-shaped relationship between inbound and outbound OI and firm performance. Therefore, H_{51} and H_{52} are supported. The results of the control variable regressions are not presented due to space limitations.

4.3. Robustness Tests

Since firm performance has multiple measures, considering that different measures may have an impact on the final results, the robustness of the study findings is examined by replacing firm performance indicators and choosing the gross operating margin (Mao-lilv), return on net assets (ROE), and net margin on total assets (JROA) as measures of performance, and regressing the main effects and moderating effects again. The test results

differed somewhat from the above regression results regarding significance levels and regression coefficients, but the main findings remained consistent. Thus, the findings of this study have a high degree of robustness. The regression results are not presented due to space limitations.

5. Discussion and Conclusions

5.1. Research Conclusions

Although there have been many research findings addressing the relationship between OI and firm performance, they tend to use the subjective perceptions of firm employees to measure OI and less often use objective data to examine the relationship between OI and firm performance, and lack a resource-based perspective to examine the mechanism of the role of social capital on the relationship between OI and firm performance in the Chinese context. This paper uses data from CSMAR and CNRDS for 2016–2021 to construct a research framework on OI and firm performance under the moderating role of multidimensional social capital based on a literature review and obtains the following main findings.

First, an inverted U-shaped relationship between inbound and outbound OI and firm performance verifies the “openness paradox” [40]. That is, the OI model adopted by firms to introduce or import knowledge, technology, and resources can indeed promote firm performance improvement. However, the related search and identification costs increase with the introduction of output increase. When the costs increase to the extent that they exceed the benefits brought about by the introduction or output of resources, the OI hurts the enterprise’s performance. Guo et al. found that technology purchase, collaborative R & D, and firm performance have an inverted U-shaped relationship [34]. This study provides empirical evidence from statistical data for the inverted U-shaped relationship between inbound OI, outbound OI, and firm performance. Thus, this model should be adopted moderately to maximize value from inbound and outbound OI and improve firm performance.

Second, institutional social capital significantly moderates the relationship between inbound OI, outbound OI, and firm performance. Institutional social capital reflects the interaction between firms and institutions such as the government and the intensity of their access to resources. High levels of institutional capital can provide effective channels and a trusting environment along with other support for firms to obtain value from OI while mitigating the adverse effects such as increased difficulty in identifying and acquiring invisible knowledge due to high levels of OI, thus promoting the further development of firms.

Third, there is no significant positive effect of market social capital on the relationship between inbound and outbound OI and firm performance. Compared with the other two kinds of social capital, this kind of capital is the most widely owned. As mentioned earlier, firms obtain complementary resources, such as advanced production chains, from upstream suppliers through inbound OI and receive product demand from downstream users through outbound OI, which is manifested as explicit knowledge and makes it difficult to highlight the advantages of the accepted firms because these resources can also be provided to other firms. Therefore, the moderating effect of inbound and outbound OI on firm performance is insignificant.

Fourth, technology social capital significantly moderates the relationship between inbound OI, outbound OI, and firm performance. A high level of technological capital can provide firms with scarce resources such as human resources and technology, effectively provide solutions to complex problems, and break through technological bottlenecks, thus reducing obstacles to new product development, shortening the time to commercialize the technology, and subsequently improving firm profitability.

5.2. Theoretical Implications

The theoretical implications of this study are as follows.

First, no studies explore the moderating role of social capital between OI and firm performance based on the resource perspective. Based on the resource perspective, this study divides social capital into three dimensions: institutional, market, and relational, and explores the relationship between OI and firm performance, which fills the gap in the research on the moderating role of social capital between OI and firm performance from the resource perspective.

Second, the previous literature tends to measure corporate OI using subjective perceptions of managers or employees, such as external frequency of knowledge and idea acquisition, the establishment of external partnerships, and the initiative of outward knowledge flow through the firm [65] and other individual subjective cognitive dimensions, and less often examines their impact on firm performance from objective data such as firm technology purchases and joint patent development. This study uses both technology purchases and joint patents to objectively explore their impact on firm performance, which helps to provide new insights into the literature exploring OI by providing new insights.

5.3. Managerial Implications

The following management insights can be drawn based on the above findings and discussions.

First, companies should proceed to adopt inbound and outbound OI models and keep them at moderate levels. Although OI has been proposed in the innovation field for a long time, the data show that only a few sample firms have adopted OI. Firms should change their innovation mindset, follow the development of society, and gradually adopt OI to improve their firm performance. It is worth noting that inbound OI and outbound OI do not sustainably improve firm performance; they have an inverted U-shaped relationship with performance, so companies should not blindly introduce resources or commercialize technologies to improve performance and should keep the adoption of this model at a moderate level.

Second, companies should pay attention to forming and maintaining scarce social capital. Since the social network built by social capital facilitates the acquisition of valuable resources more conducive to further development, companies should strive to acquire and maintain existing social capital, especially some scarce social capital. This study examines the moderating role of institutional social capital, market and technological social capital between inbound and outbound OI, and firm performance. It is found that the sampled firms have less institutional social capital and technological social capital, with an important moderating role.

5.4. Limitations and Directions for Future Research

The limitations are as follows: first, this study constructs a theoretical framework of OI and firm performance under the moderating role of social capital and examines social capital in three dimensions: institutional social capital, market social capital, and technological social capital. In the future, we can use other classifications of social capital to test further whether the theoretical framework is universally applicable. Second, to investigate the relationship between OI and firm performance, the existing literature mainly uses a single sample of high-tech, innovative, or technology service industries. We used data from manufacturing enterprises, but using a single type of enterprise may limit the universality of the research findings. In the future, sample data from multiple types of enterprises can be organically combined to understand the relationship between OI and firm performance more deeply.

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