An empirical study on the influence of institutional cross-shareholding on the innovation of listed companies

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Abstract: In this paper, we study the impact of cross-shareholdings of listed companies institutions innovation and mechanism of action, and use computer and related technology combined with econometrics, adopt OLS regression analysis and intermediary effect inspection and so on model, based on China's a-share listed companies from 2007 to 2020 data, cross-shareholdings of listed companies to institutional innovation influence the empirical analysis. It is found that institutional cross-shareholding mainly improves innovation input and output by alleviating financing constraints, and the conclusion is still robust after considering the endogeneity problem.

1. Introduction

Enterprise innovation is characterized by high investment, high risk, information asymmetry and great uncertainty (Holmstrom, 1989)[1]. From the perspective of social network (Aqsa Mehreen et al., 2019; Sven Horak et al. 2019)[2][3], some scholars believe that social network can provide new information for enterprise innovation and facilitate the introduction of capital for enterprise innovation. And then promote enterprise innovation. Institutional cross-shareholdings are defined as major institutional shareholders holding at least 5 per cent of two or more companies in the same industry(He and Huang, 2017)[4]. The listed company holds shares of many enterprises in the same industry, which can obtain diversified portfolio benefits(Lopez and Vives，2017)[5].

At present, big data and blockchain in computer science have had an unprecedented impact on the financial industry. The use of computer-related technology combined with econometrics can better deal with economic problems quantitatively[7]. Stata, as one of the three major measurement software, provides convenience for relevant personnel to apply big data for quantitative analysis and research[8]. This paper uses stata software for data processing and analysis.

2. Research hypothesis

Institutional cross-shareholding have the following two characteristics: 1. Institutional investors aim to maximize the total value of their portfolio. 2. As major shareholders,investors have the ability to promote the flow of information and resources in the same industry, enterprises and investors[9]. So how do cross-shareholding institutions affect enterprise innovation? They may increase corporate innovation investment by alleviating corporate financing constraints and thus[10]. In summary, the following hypothesis is proposed in this paper:

H1: Institutional cross-shareholding can increase corporate innovation inputs and outputs.

H2: Cross-holding institutional investors promote corporate innovation by easing financing constraints.

3. Study Design

3.1. Sample selection and data sources

This paper takes the 2007-2020 listed A-share main board and GEM of Shanghai and Shenzhen markets as the research samples and uses panel data to conduct empirical research, which are obtained from CSMAR database and Wind database. And the raw data are processed as follows: the financial listed companies are excluded; the ST* and ST company samples are excluded; the samples with missing key variables are excluded; and the continuous variables are treated with 1% tail shrinkage (Winsorize) in order to mitigate the influence of extreme values. Finally, 18,912 firm-annual observations were obtained.

3.2. Model design

Since cross-shareholdings of different listed companies by institutions are variable and adjusted, the experimental groups are not affected by cross-shareholdings at the same point in time, so a multi-period DID model is constructed by drawing on the

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study of Beck et al. (2010)[6], and to avoid multicollinearity, only cross-direction is introduced as the core dummy variable in this paper. Regression model (1) is constructed to test the effects of cross-shareholding on firms' innovation inputs and outputs.

$$Innov_{it} = \alpha + \beta D_{it} + \gamma \sum Controls_{it} + Industry_i + Year_i + \varepsilon_{it}. (1)$$

Among them, the explanatory variables are firm innovation indicators, innovation inputs (R&D expenses LnRDspends, R&D personnel LnRDperson) and innovation outputs (number of patent applications lnPatents), the main explanatory variable D_{it} represents the treatment variables in the multi-period DID model (i.e., double difference term), for the treatment group, if firm i is cross-owned by the institution at the end of time t, then take 1, otherwise take 0; the control group is never cross-owned by the institution, take 0. Controls represent the control variables, Industry and Year represent the industry and year fixed effects, i represents the firm, t represents the year fixed effects, otherwise take 0. is taken as 1 if firm i is cross-held by institutions within time t, otherwise it is taken as 0. Controls represent the control variables, Industry and Year represent the industry and year fixed effects, i represents the firm, t represents the year, and ε represents the residual term.

In order to test H2, the transmission path of institutional cross-holding on the improvement of firm innovation level, this paper analyzes from the perspective of firm financing constraints (KZ) to check whether financing constraints play a mediating effect between institutional cross-holding and firm innovation investment. The causal step method is used to test the mediation effect, in which the causal step method test procedure is as follows.

In the first step, the effect of whether the firm is cross-owned on the firm's R&D expenditure investment is verified.

$$\mathrm{Innov_{it}} = \alpha_1 + \beta_1 \mathrm{D_{it}} + \gamma_1 \sum \mathrm{Controls_{it}} + \mathrm{Industry_i} + \mathrm{Year_i} + \varepsilon_{\mathrm{it}}. (2)$$

In the second step, the effect of whether a firm is cross-owned on the mediating variable Mediation is verified.

$$\mathrm{Mediation_{it}} = \alpha_2 + \beta_2 \mathrm{D_{it}} + \gamma_2 \sum \mathrm{Controls_{it}} + \mathrm{Industry_i} + \mathrm{Year_i} + \varepsilon_{\mathrm{it}} . (3)$$

In the third step, whether the firm is cross-owned and the mediating variable are both used as explanatory variables, and the firm's R&D expenditure investment is used as the explanatory variable for validation.

$$\mathrm{Innov_{it}} = \alpha_3 + \beta_3 \mathrm{D_{it}} + \omega \mathrm{Mediation_{it}} + \gamma_3 \sum \mathrm{Controls_{it}} + \mathrm{Industry_i} + \mathrm{Year_i} + \varepsilon_{\mathrm{it}} . (4)$$

The test is carried out according to the above steps, and whether there is a mediating effect is judged according to the significance of the regression coefficient. The specific judgment criteria are: (1) if the regression coefficient β_1 is significant, the next test is conducted, and if it is not significant, it is considered that there is no mediation effect. (2) If β_2 and ω are significant, the mediating effect is considered to exist.

3.3.Variable definition

(1) Enterprise innovation indicators

The index of enterprise innovation includes innovation input and innovation output. In this paper, the R&D expenditure of the enterprise in the current year (LnRDperson) and the R&D staff of the enterprise in the current year (lnrdPerson) are used to measure the innovation input.Innovation output is measured by the number of patent applications filed by enterprises in that year.

(2) Institutional cross-shareholding

Institutional cross-holding (D_{it}). When institutional investors hold two or more enterprises in the same year, and they are all the top ten shareholders of listed companies, cross-shareholding will occur. The value is 1 if the firm is cross-owned by institutions during the year, and 0 otherwise.

(3) The remaining variables

The remaining variables include the mediating and control variables for the mediating effects test in the model setting, and the symbols and explanatory notes for the variables are shown in Table 1.

Table 1 Variable descriptions

Variable Types	Variable Symbols	Variable Name	Explanatory notes
Intermediate variables	KZ	KZ Index	The degree of financing constraint of the company, the larger the KZ the stronger the financing constraint
Control variables	Lnsize	Enterprise size	Total assets of listed companies at the end of the year
	Growth	Growth Capacity	Difference between the company's total assets for the current year and the previous year/total assets
	Lev	Leverage Level	Gearing ratio = total corporate liabilities / total corporate assets
	Topten	Shareholding Concentration	Shareholding of top ten shareholders
	Seperation	Separation rate of two rights	Degree of separation of ownership and control

Dual	Whether to hold two positions	If the chairman and general manager are the same person, take 1, otherwise take 0
Committee	Number of Committees	Number of company committees established
BIG4	Four major audits	If audited by a "Big Four" accounting firm, take 1, otherwise take 0
Outside	Whether the auditor is from abroad	If the accounting auditor is from abroad, take 1, otherwise take 0
Age	Company Years	Current year minus year of incorporation
Industry	Industry	Industry dummy variables
Year	Annual	Annual dummy variables

Note: The paper is logarithmic in the empirical regression process.

4.Empirical Results and Analysis

4.1. Descriptive statistics

Table 2 shows the results of descriptive statistics for the main variables. The mean value of institutional cross-holding is 0.19 and the standard deviation is 0.39, indicating that about 19% of the firms have cross-holding by institutional investors, and there is a large variation in cross-holding by institutions among different firms. It is observed that there is a significant difference between R&D input and output among different enterprises.

Table 2 Descriptive statistics

	N	Mean	Std. Dev.	min	Median	max	t-value
RDspends	18921	1.550e+08	359750297.96	581711.94	48641800	2.592e+09	59.28
RDperson	18921	348.45	825.44	0	93	6780	58.07
Patents	18921	23.94	304.70	0	0	15895	10.81
D	18921	0.19	0.39	0	0	1	65.74
Holdrate	18921	2.21	8.13	0	0	65.11	37.32
Lnsize	18921	22.07	1.27	19.9	21.89	26.05	2382.23
Growth	18921	-0.28	1.40	-8.9	.05	.94	-26.96
Lev	18921	0.4	0.20	.05	.4	.87	275.25
Topten	18921	58.73	14.78	24.13	59.56	90.26	546.66
Seperation	18921	4.6	7.40	0	0	28.29	85.59
Dual	18921	0.3	0.46	0	0	1	89.13
Committee	18921	3.93	0.43	2	4	5	1266.02
Big4	18921	.05	0.22	0	0	1	31.36
Outside	18921	.02	0.15	0	0	1	21.1
Age	18921	8.97	7.06	0	7	30	174.8

4.2. Baseline return

Table 3 reports the regression results of institutional cross-holdings and firm innovation. By adding no control variables and adding control variables, the D coefficient is significantly positive at the 10% level, indicating that institutional cross-holding has a significant positive relationship on firms' innovation inputs and outputs, which supports the H1 of this paper.

Table 3 Institutional cross-holdings and firm innovation inputs and outputs

	(1) LnRDspends	(2) LnRDspends	(3) LnRDperson	(4) LnRDperson	(5) Lnpatent	(6) Lnpatent
D	0.380***	0.176***	0.258***	0.144***	0.110***	0.0469*
	(14.98)	(8.64)	(10.99)	(6.17)	(4.09)	(1.65)
Lnsize		0.884***		0.489***		0.181***
		(100.35)		(48.42)		(14.65)

Growth		0.00157		0.000438		-0.0113
		(0.27)		(0.07)		(-1.38)
Lev		-0.714***		-0.361***		-0.287***
		(-15.32)		(-6.75)		(-4.40)
Topten		-0.000919		-0.0028***		-0.00206**
		(-1.50)		(-4.00)		(-2.40)
Seperation		0.00335***		0.00470***		0.00209
		(3.28)		(4.02)		(1.47)
Daul		0.0410**		0.0279		-0.0186
		(2.45)		(1.45)		(-0.79)
Committee		-0.0160		0.00656		-0.0299
		(-0.93)		(0.33)		(-1.24)
Big4		0.271***		-0.215***		-0.103**
		(7.23)		(-5.00)		(-1.96)
Outside		0.0816		0.0608		-0.00149
		(1.55)		(1.00)		(-0.02)
Equity		-0.0110		-0.00750		-0.184***
		(-0.73)		(-0.44)		(-8.74)
lnage		-0.166***		-0.114***		-0.0551***
		(-12.87)		(-7.70)		(-3.05)
_cons	15.32***	-2.674***	-0.452***	-10.29***	0.324*	-2.805***
	(92.93)	(-11.99)	(-2.96)	(-40.27)	(1.85)	(-8.98)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	18921	18921	18921	18921	18921	18921
Adj.R^2	0.2557	0.5822	0.8174	0.8428	0.0453	0.0636

t statistics in parentheses $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

4.3. Intermediation effect test

In this paper, we select the financing constraint indicator KZ as the mediating variable for the mediating effect test, and the results are shown in Table 4 , the coefficients β_1 and β_2 of the cross term D in regression model (1)(2) are significant, and the coefficients ω and β_3 of KZ in regression model (4) are significant, and $\omega < \beta_1$; From the negative sign of the indirect effect, it is clear that institutional cross-shareholding can promote corporate innovation investment by alleviating corporate financing constraints, and in summary, hypothesis 2 is verified to hold.

Table 4 Mediation effect test

	(1)	(2)	(3)
	LnRDspends	KZ	LnRDspends
D	0.176***	-0.200***	0.168***
	(8.64)	(-6.63)	(8.27)
KZ			-0.0387***
			(-7.86)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes

Year	Yes	Yes	Yes
N	18921	18921	18921
Adj.R^2	0.5822	0.5056	0.5835

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4. Robustness tests

Figure 1 is a multi-period DID parallel trend test graph. The horizontal coordinate is the number of years since the company was first cross-owned by institutional investors, and the values range from -2 to 5. From the second to the fifth year of cross-ownership, the company's innovation improves significantly with a certain lag. On the whole, institutional cross-holding has a significant enhancement effect on corporate innovation of listed companies, which supports the basic hypothesis 1 of this paper.

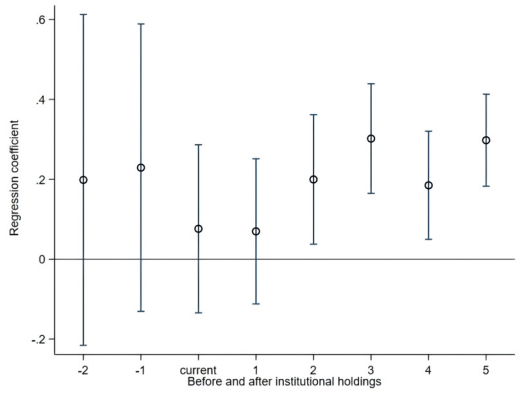

Figure 1 Multi-period DID parallel trend test

5. Conclusion and Insights

The empirical results of this paper show that institutional cross-shareholding can significantly increase enterprise innovation investment and innovation results. The test of action mechanism shows that the innovation input of enterprises can be improved mainly by alleviating the financing constraints of companies.

The research of this paper has important theoretical and practical significance. Theoretically, this paper makes an in-depth analysis of the impact of institutional cross-shareholding on enterprise innovation, enriches the relevant literature on the economic consequences of cross-shareholding institutions, and expands the research on the influencing factors of enterprise innovation activities from the perspective of institutional cross-shareholding. In the practical sense, it can provide policy suggestions for the regulatory layer. That is, we should give full play to the positive role of cross-shareholding institutions in the capital market, let institutional investors participate in market transactions and corporate governance through cross-shareholding, and give full play to the function of the capital market in serving the innovation of the real economy.

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