The Impact of Environmental Uncertainty on Corporate Innovation

Subjects: Management

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Innovation activity is a long-term investment activity with long cycles and high risk. When the external environment situation is serious, enterprises, in order to deal with emergencies that may result from environmental uncertainty, based on preventive motivation, usually tend to choose conservative investment strategies, reduce the capital of innovative investment, and maintain a high free cash flow to deal with market shocks and fierce market competition and ease the pressure of survival.

environmental uncertainty enterprise technology innovation

1. Introduction

A significant amount of research on the motivation of corporate technological innovation. Focusing on the external influencing factors of corporate technological innovation, such as financial policy, industrial policy and industry characteristics [1][2][3], and internal influencing factors, such as corporate governance structure, managers' shareholding ratio, executive incentive, corporation size, and nature of equity [4][5][6], a great deal of results have been achieved. However, most of the existing literature has not considered the risks faced by corporations and environmental uncertainty. The innovation investment decisions made by management are influenced by multiple factors, and any environmental uncertainty has risks, which in turn affects management's innovation investment decisions [7]. There are two important points in the literature about the influence of environmental uncertainty on technological innovation. One is the "opportunity-oriented effect" of environmental uncertainty on corporate technological innovation [8][9], and the other is the "risk avoidance effect" [10][11].

However, the current research mainly focuses on whether the relationship between them is linear or non-linear. On the one hand, it does not deeply explore the path and mechanism of "opportunity-oriented" or "risk-avoiding" caused by environmental uncertainty to corporate technological innovation. On the other hand, the existing literature mainly focuses on the situation of developed countries in Europe and the United States. The research on the environmental uncertainty of corporate technological innovation in emerging economies in the world needs to be enriched, and its institutional background should also be considered.

2. Descriptive Statistical Analysis

Table 1 shows the descriptive statistical results of each variable. It can be seen from the table that the average value of environmental uncertainty (EU) is 0.135, the minimum value is 0.013, and the maximum value is 0.961,

indicating that the uncertainties faced by enterprises have differences. The median of investment in technological innovation (R&D) is 17.999, and the average is 17.950, indicating that the overall innovation investment level of listed companies is acceptable. The minimum value of innovation output, the number of patents (Patents), is 0, the average value is 75.409, and the maximum value is 4282. The gap is large, indicating that the results formed by different enterprises after investing in innovation capital are quite different and input does not necessarily bring output. As a result, the effect of inter-enterprise achievement transformation needs to be improved. The median of government subsidy (SUB) is 16.616, the maximum is 22.172, and the minimum is 0, indicating that different companies receive a large difference in the intensity of government subsidies. The minimum value of information transparency (Trans) is 0.613, the maximum value is 1.430, and the standard deviation is 0.0687. There are differences in information transparency between different companies, but the difference is not significant.

Table 1. Descriptive statistics of each variable.

Main Variable	Sample Size	Mean	Median	Minimum	Maximum	Standard Deviation
LPatents	2645	2.8497	3.1781	0.0000	8.3624	1.8491
Patents	2645	75.4091	23.0000	0.0000	4282	260.8831
R&D	10,323	17.9500	17.9999	13.7090	21.4619	1.3312
EU	10,323	0.1346	0.1005	0.0133	0.9607	0.1151
SUB	10,323	16.5139	16.6161	0.0000	22.1719	1.8988
Trans	10,323	0.9940	0.9946	0.6125	1.4299	0.0687
Agency	10,323	0.0175	0.0100	0.0002	0.2446	0.0231
ROA	10,323	0.0392	0.0346	−0.2245	0.2080	0.0475
SIZE	10,323	22.2836	22.1819	19.5409	25.8882	1.0481
LEV	10,323	0.4254	0.4205	0.0491	0.9343	0.1825
TOB	10,323	2.1097	1.7587	0.8888	8.1375	1.1429
Dual	10,323	0.7575	1.0000	0.0000	1.0000	0.4286

3. Correlation Analysis

Table 2 is the regression table of the correlation between the main variables. The correlation coefficients of environmental uncertainty (EU), patents (Patents) and innovation input (R&D) are −0.008 and −0.058, respectively, indicating that environmental uncertainty (EU) has a negative impact on the innovation activities of the enterprise. The correlation coefficients between government subsidies (SUB), patents (Patents) and innovation input (R&D) are 0.182 and 0.358, respectively, indicating that government subsidy (SUB) has a positive impact on the innovation activities of enterprises. The correlation coefficients between agency, patents (Patents) and innovation input (R&D) are −0.055 and −0.117, respectively, indicating that the second type of agency problem between

enterprises negatively affects the technological innovation of enterprises. It can be seen from **Table 2** that the correlation coefficients between the variables are all lower than 0.5. Since the VIF value of all variables is less than 10, there is no multicollinearity problem among the variables.

Table 2. Correlation analysis of the main variables.

Variable	Patents	R&D	EU	SUB	Trans	Agency	ROA	SIZE
Patents	1							
R&D	0.322 ***	1						
EU	−0.008	−0.058 ***	1					
SUB	0.182 ***	0.358 ***	−0.01	1				
Trans	0.005	−0.059 ***	−0.011	0.004	1			
Agency	−0.055 ***	−0.117 ***	0.054 ***	−0.011	0.015	1		
ROA	0.086 ***	0.172 ***	−0.045 ***	0.049 ***	−0.303 ***	−0.132 ***	1.000	
SIZE	0.255 ***	0.473 ***	0.055 ***	0.389 ***	−0.067 ***	−0.005	0.036 ***	1.000

Note: *** represent significance at the levels of 1%, respectively.

4. Regression Analysis

4.1. Regression Analysis of Environmental Uncertainty and Enterprise Technological Innovation

(1) Innovation input in technology research and development stage

In order to explore the relationship between the two in depth, model (6) is used to test Hypothesis H1a to verify the relationship between environmental uncertainty and technological innovation investment. Column (1) of **Table 3** shows environmental uncertainty (EU) and technological innovation regression results in the technological development stage, and the regression coefficient between EU and technological innovation input (R&D) is −0.521, which is significantly negatively correlated at the 1% confidence level, indicating that EU has an inhibitory effect on innovation input (R&D). It can be seen that the greater the environmental uncertainty, the more significant the inhibitory effect on enterprises' investment in technological innovation, which verifies Hypothesis 1a.

Table 3. Regression analysis of environmental uncertainty and enterprise technological innovation.

Variable	(1) R&D	(2) LPatents	(3) Patents
EU	−0.521 ***	−0.612 *	−0.344 ***
	(−6.07)	(−1.89)	(−14.70)

Variable	(1) R&D	(2) LPatents	(3) Patents
ROA	2.791 ***	0.332	1.035 ***
	(10.86)	(0.36)	(15.42)
SIZE	0.789 ***	0.659 ***	0.976 ***
	(58.52)	(13.72)	(333.03)
LEV	0.666 ***	1.516 ***	2.696 ***
	(5.28)	(3.22)	(57.65)
TOB	0.061 ***	0.119 ***	0.247 ***
	(5.32)	(3.08)	(94.37)
Dual	−0.070 ***	−0.310 ***	0.045 ***
	(−2.97)	(−3.82)	(8.07)
Constant	−0.970 ***	−12.975 ***	−21.093 ***
	(−3.04)	(−11.52)	(−228.64)
Industry, Year		Control	
Observation	1023	2645	2645
Adjusted R^2	0.450	0.137	-
F	223.0	12.39	-

Among the control variables, it can be seen from column (1) of Table 3 that the regression coefficients of enterprise size (SIZE) and profitability index (ROA) are 0.789 and 2.791, respectively, which are both significantly positive at the 1% level, indicating that the larger the scale, the better the profitability. The better innovation foundation and innovation resources companies have, the more they invest in innovation activities. The regression coefficient of investment opportunity (TOB) is positive, indicating that the more investment opportunities a company has, the more likely it is to choose an innovative project to invest in, thereby promoting the company's input in technological innovation. The regression coefficient of the net business cycle (JYYZ) is significantly negative, which shows that the longer the net business cycle, the more unfavorable the company's innovation investment.

Note: ** and *** represent significant at the 10%, and 1%, confidence levels, respectively. The t value is in parentheses.

(2) Innovative output at the stage of achievement transformation

In order to explore the relationship between the two in depth, model (6) is used to test Hypothesis 1b to verify the impact of environmental uncertainty on the innovation output of the enterprise in the transformation stage of the results. The results of multiple regression are shown in **Table 3**. Column (2) of **Table 3** shows the regression results of environmental uncertainty (EU) and technological innovation in the achievement transformation stage, and innovation output (LPatents) is the natural logarithm of the number of patent applications, which is a continuous variable, using the OLS model test Hypothesis 1b. In column (2) of **Table 3**, the regression coefficient

between EU and innovation output (LPatents) is −0.612, which is significantly negative at the 10% confidence level, indicating that EU has an inhibitory effect on innovation output (LPatents). It can be seen that the greater the environmental uncertainty, the more unfavorable the technological innovation output of the enterprise, which verifies Hypothesis 1b.

Taking into account the data characteristics of the number of patent applications in China, the explained variables of the model are converted from continuous variables to the number of patent applications to explain. As patent data have many values of 0, the Poisson model is more consistent with the number features, and multiple regression models make the regression results more robust. From column (3) of **Table 3**, it can be seen that the regression coefficient between environmental uncertainty (EU) and technological innovation output (Patents) is −0.344, which is a significant negative correlation, indicating that EU's influence on innovation output (Patents) has an inhibitory effect. It can be concluded that the greater the environmental uncertainty, the more unfavorable the technological innovation output of the enterprise, which verifies Hypothesis 1.

4.2. Regression Analysis of Environmental Uncertainty, the Second Type of Agency Problem and Enterprise Technological Innovation

In the technology research and development stage, models (6)–(9) were used to test Hypothesis 2 to verify the relationship between environmental uncertainty and technological innovation input and the mediating effect of the second type of agency problem on environmental uncertainty and technological innovation input. From column (1) of **Table 4**, it can be seen that the regression coefficient between environmental uncertainty EU and technological innovation input (R&D) is −0.521, which is significantly negatively correlated at the 1% confidence level, indicating that EU's contribution to innovation input (R&D) has an inhibitory effect. Further testing the mediation effect, from column (2) of **Table 4**, it can be seen that the correlation coefficient between agency and innovation input (R&D) is −2.693, which is significantly negative at the 1% confidence level, indicating that the second type of agency problem is common among enterprises and affects enterprises' input in technological innovation and inhibits innovation. From column (3) of **Table 4**, it can be seen that the regression coefficient between agency and the environmental uncertainty EU is 0.006, which is significantly positive at the 1% level, that is, the higher the environmental uncertainty, the more serious the enterprise's second type of agency problem. From column (4) of **Table 4**, we can see that in model (9), the coefficients of agency, Environmental Uncertainty (EU) and the company's technological innovation input (R&D) are −2.606 and −0.505, respectively, which are both significantly positive at the 1% level. Combining the regression results of the previous models, we show that the greater the environmental uncertainty, the more significant the inhibitory effect on the enterprise's technological innovation investment. In addition, it exacerbates the second type of agency problem, which has a negative impact on enterprises' investment in technological innovation indirectly. This verifies Hypothesis 2.

Table 4. Regression analysis of environmental uncertainty, the second type of agency problem and innovation input.

Variable	(1) R&D	(2) R&D	(3) Agency	(4) R&D
EU	−0.521 ***		0.006 ***	−0.505 ***
	(-6.07)		(3.35)	(−5.88)
Agency		−2.693 ***		−2.606 ***
		(−6.02)		(−5.83)
ROA	2.791 ***	2.771 ***	−0.010 *	2.764 ***
	(10.86)	(10.78)	(−1.84)	(10.77)
SIZE	0.789 ***	0.781 ***	−0.003 ***	0.782 ***
	(58.52)	(57.67)	(−9.22)	(57.85)
LEV	0.666 ***	0.697 ***	0.013 ***	0.701 ***
	(5.28)	(5.52)	(4.80)	(5.56)
TOB	0.061 ***	0.065 ***	0.001 ***	0.064 ***
	(5.32)	(5.63)	(4.31)	(5.57)
Dual	−0.070 ***	−0.062 ***	0.002 ***	−0.066 ***
	(-2.97)	(−2.65)	(3.03)	(−2.80)
Constant	−0.970 ***	−0.820 **	0.078 ***	−0.766 **
	(−3.04)	(−2.55)	(11.14)	(−2.39)
Industry, Year		Control		
Observation	10,323	10,323	10,323	10,323
Adjusted R^2	0.450	0.450	0.112	0.451
F	223.0	222.9	35.22	218.8

Note: *, **, and *** represent significance at the 10%, 5%, and 1% confidence levels, respectively. The t value is in parentheses.

In the achievement transformation stage, using models (3) (3) to test Hypothesis 2 to verify the effect of environmental uncertainty on firms' innovation output and the mediating effect of the second type of agency problem between environmental uncertainty and technological innovation output. The results of the multiple regressions are shown in **Table 5**. Column (1) of **Table 5** shows the regression results of environmental uncertainty (EU) and technological innovation in the achievement transformation stage. Innovation output (LPatents), which is the natural logarithm of the number of patent applications, is a continuous variable, and the OLS model was used to test Hypothesis 1. In column (1) of **Table 5**, the regression coefficient of EU and innovation output (LPatents) is −0.612, which is significantly negative at the 10% confidence level, indicating that EU has an inhibitory effect on innovation output (LPatents). Further testing the mediating effect, in column (2) of **Table 5**, the correlation coefficient between agency and innovation output (LPatents) is −3.934, which is significantly negative at the 5% confidence level, indicating that the second type of agency problem is prevalent among firms, which affects their

technological innovation output and plays an inhibitory role on innovation. As can be seen in column (3) of **Table 5**, the regression coefficient between Agency and EU is 0.006, which is significantly positive at the 1% level, that is, the higher the environmental uncertainty, the more serious the second type of agency problem of firms. In column (4) of **Table 5**, it can be seen that in model (9), the coefficient of agency with firms' technological innovation output (LPatents) is −3.804, which is significantly negative, and the coefficient of environmental uncertainty (EU) with firms' technological innovation output (LPatents) is -0.586, which is significantly negative at the 10% level. Combining the regression results of the previous models, it can be concluded that the greater the environmental uncertainty, the more unfavorable the technological innovation output of the firm, and also, it indirectly has a negative impact on the technological innovation output of the firm by exacerbating the second type of agency problem. This verifies Hypothesis 2.

Table 5. Regression analysis of environmental uncertainty, the second type of agency problem and innovation output 1.

Variable	(1) LPatents	(2) LPatents	(3) Agency	(4) LPatents
EU	−0.612 *		0.006 ***	−0.586 *
	(−1.89)		(3.35)	(−1.81)
Agency		−3.934 **		−3.804 **
		(−2.14)		(−2.07)
ROA	0.332	0.335	−0.010 *	0.280
	(0.36)	(0.37)	(−1.84)	(0.31)
SIZE	0.659 ***	0.646 ***	−0.003 ***	0.647 ***
	(13.72)	(13.36)	(−9.22)	(13.39)
LEV	1.516 ***	1.581 ***	0.013 ***	1.617 ***
	(3.22)	(3.35)	(4.80)	(3.42)
TOB	0.119 ***	0.122 ***	0.001 ***	0.121 ***
	(3.08)	(3.15)	(4.31)	(3.13)
Dual	−0.310 ***	−0.301 ***	0.002 ***	−0.297 ***
	(−3.82)	(−3.71)	(3.03)	(−3.65)
Constant	−12.975 ***	−12.726 ***	0.078 ***	−12.705 ***
	(−11.52)	(−11.23)	(11.14)	(−11.21)

Variable	(1) LPatents	(2) LPatents	(3) Agency	(4) LPatents
Industry, Year	Control			
Observation	2,645	2,645	10,323	2,645
Adjusted R^2	0.137	0.138	0.112	0.139
F	12.39	12.42	35.22	12.19

Note: Y and control represent significance at the 10%, 5%, and 1% confidence levels, respectively. The t value is in parentheses.

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and innovation output (Patents) is −4.682, which is significantly negative, indicating that the second type of agency problem generally exists between different companies and affects the company's output of technological innovation, inhibiting innovation. In column (3) of **Table 6**, the regression coefficient between agency and EU is 0.006, which is significantly positive, that is, the higher the environmental uncertainty, the more serious the second type of agency problem of the enterprise. In column (4) of **Table 6**, using model (9) to test, the coefficient of agency and firm's technological innovation output (Patents) is −4.603, which is significantly negative. At the 1% confidence level, the environmental uncertainty EU and the technological innovation output (Patents) of the enterprise are significantly negative with a regression coefficient of −0.321. Combining the regression results of the previous models and using the principle of mediating the effect test, it is found that the greater the environmental uncertainty, the more unfavorable the technological innovation output of the enterprise. In addition, it also indirectly negatively affects the technological innovation output of enterprises by exacerbating the second type of agency problem. This verifies Hypothesis 2.

Table 6. Regression analysis of environmental uncertainty, the second type of agency problem and innovation output 2.

Variable	(1) Patents	(2) Patents	(3) Agency	(4) Patents
EU	−0.344 ***		0.006 ***	−0.321 ***
	(−14.70)		(3.35)	(−13.66)
Agency		−4.682 ***		−4.603 ***
		(−26.93)		(−26.43)
ROA	1.035 ***	0.992 ***	−0.010 *	0.992 ***
	(15.42)	(14.85)	(−1.84)	(14.79)
SIZE	0.976 ***	0.968 ***	−0.003 ***	0.969 ***
	(333.03)	(329.01)	(−9.22)	(328.79)
LEV	2.696 ***	2.723 ***	0.013 ***	2.757 ***

Variable	(1) Patents	(2) Patents	(3) Agency	(4) Patents
	(57.65)	(58.54)	(4.80)	(59.11)
TOB	0.247 ***	0.248 ***	0.001 ***	0.246 ***
	(94.37)	(94.81)	(4.31)	(93.90)
Dual	0.045 ***	0.053 ***	0.002 ***	0.051 ***
	(8.07)	(9.61)	(3.03)	(9.22)
Constant	−21.093 ***	−20.892 ***	0.078 ***	−20.881 ***
	(−228.64)	(−225.78)	(11.14)	(−225.60)
Industry, Year	Control			
Observation	2645	2645	10,323	2645

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