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R&D Leap and Operational Efficiency: The Moderating Roles of Environmental Dynamism and Environmental Munificence

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Abstract. Based on the theory of ambidextrous innovation and dynamic capability, our study investigates into the relationship between R&D leap and operational efficiency. Thus, using panel data of 257 gem listed firms from 2011 to 2016, we show that R&D leap is negative to operational efficiency. In addition, environmental dynamism positively moderates the relationship between R&D leap and operational efficiency, and environmental munificence negatively moderates the relationship between R&D leap and operational efficiency. Our research is inspirational for managers to carry out proactive R&D management and to improve firm's operational efficiency.

1. Introduction

R&D is an important way for firms to gain competitive advantage. Mudambi and Swift [1] first defined one of the most extreme changes in R&D investment as the R&D leap, which is the most significant change in R&D investment that is inconsistent with historical trends. When the R&D investment is compact and significantly increased in a short term, it means that the firm move from exploitation to exploration; similarly, compact, significant decrease means a transition from exploration to exploitation. Based on the theory of punctuated equilibrium, the exploitation and exploration are alternated to improve performance [2], but from the perspective of ambidextrous innovation we find firm's conversion is risky, the resources and organizational routines required for exploration and exploitation are different. Thus, how should firms effectively use R&D investment to achieve corporate value? From the perspective of dynamic capability, we introduce two variables, environmental dynamism and munificence, to explore the moderating effect between R&D leap and operational efficiency, and to explore under what circumstances the risk can be reduced.

2. Theory and Hypotheses

2.1. Impact of R&D Leap on Operational Efficiency

Firms invest in R&D to create competitive advantage and firm value [3]. However, managing this R&D process is challenging, and switching between exploitation and exploration is risky [4]. First, the risk comes from the judgment of the timing of transition. If the firm shifts from exploitation to exploratory, and the existing capabilities are still valuable, then it will bring high opportunity costs. If the firm shifts from exploration to exploitation before creating new competitive advantages, they will not be able to obtain significant returns on R&D investment quickly [1]. Second, the risk comes from the degree of transition, and the larger the magnitude of R&D leap, the larger the organizational change. However, exploitation and exploration require different resource allocation, and the transition between them needs to overcome the organizational routines and path dependence problems [5]. There is a large sunk cost, and the operational efficiency is reduced. Hence:

Hypothesis 1: The magnitude of R&D leap negatively affects operational efficiency.

2.2. Moderating Effect of Environmental Dynamism

Environmental dynamism refers to the certain rate, instability and unpredictability shown by firms when they are faced with environmental changes [6]. Based on the concept of dynamic capabilities,

firms must have the ability to accommodate the dynamics of environment [7]. In a circumstance with high dynamism, opportunities appear fast and disappear quickly, so firms are required to mobilize resources to conduct R&D leap to quickly capture advantages. If the firm does not change in time in the case of high dynamism, it will miss new opportunities, resulting in huge opportunity costs that reduce operational efficiency[5]. Therefore, in a highly dynamic environment, the real-time conversion of track and regulation of R&D investment will help to capture fleeting opportunities, reduce opportunity costs, and achieve the firm's sustainable development. Hence:

Hypothesis 2: The environmental dynamism positively moderates the relationship between the magnitude of R&D leap and operational efficiency.

2.3. Moderating Effect of Environmental Munificence

The environmental munificence describes the adequacy of resources on the external market and the opportunities and capabilities of the external environment in which to support firm's growth and sustainable development [7]. The higher munificence provides firms with more external opportunities, and firms try to find a suitable environment or improve the richness of their environment to achieve better survival and development. In the case of a highly munificent environment, firms can choose more opportunities. By maintaining the existing path or making slight adjustment and keeping the existing capacity status, the stable development of the firm can be achieved, allowing lasting benefits [8]. The firms do not have large demand to increase the R&D leap extent. On the contrary, the transition does not necessarily bring significant benefits, and there is high opportunity cost, which reduces operational efficiency. Hence:

Hypothesis 3: The environmental munificence negatively moderates the relationship between the magnitude of R&D leap and operational efficiency.

3. Method

3.1. Data

In this research, 259 GEM listed firms between 2011 and 2016 are used as objects. Given that the R&D leap has a lagging impact on operational efficiency, we take 1 year as the lag period, so the actual data used is from 2012 to 2016. After excluding missing data, the 257 firms and 1285 observation values were finally obtained. These data comes from CSMAR database, Wind database and Eastern Fortune database, from which the firms' R&D expenses, firm age, firm size and other indicator data are downloaded. The firms' annual reports and social responsibility reports are manually coded and verified based on the sample firms' websites.

3.2. Dependent Variable: Operational Efficiency

Operational efficiency means the ability of a firm to make profits by reasonably using various resources. Similarly to Lei [9], we measured it by the financial indicator that indicates a firm's operating capacity in its financial statements. Accounts receivable turnover is selected as the index. Accounts receivable turnover = operating income/accounts receivable average occupancy.

3.3. Independent Variable: R&D Leap

Similarly to Mudambi & Swift [1], Swift [4], Wu & Xiao[2], We measured it as maximum of the absolute values for all residuals for the firm from a Generalized Autoregressive Conditional Heteroskedastic (GARCH) time trend of R&D spending that the firm exhibits over the 20 quarters in total from 2011 to 2015. This method includes four steps. First, according to the autoregressive model calculate the residual u_{itn} of the autoregressive model of the i-th enterprise in the t year and the n quarter. During the observation period, we carried out partial correlation test on R&D investment of each firm. If the partial correlation is significant, the data will be autoregressive. Otherwise, autoregression is not performed. Second, calculate the GARCH model residual e_{itn} of the i-th firm in the t year and the n quarter. This is the extent to which the firm's R&D spending during the quarter deviated from its historical forecast of R&D trends. or changes in R&D spending. It also

means changes in R&D spending. Third, for the sake of comparison, we calculated the studentized residual e_{itn}(stud) of the GARCH model in the n quarter of the i-th enterprise. The formula refers to equation 1, where si=sqrt[variance (eitn)], hit=leverage (eitn). Fourth, We compared the absolute value of the studentized residuals for each quarter of each firm during the period 2011-2015 and find the maximum value of ei(max), which is the R&D leap of the i-th firm. The small ei(max) indicates that the changes of R&D investment is small and stable, and there is no R&D investment leap. The large ei(max) indicates that the R&D investment of the firm has changed greatly.

$$e_{itn}(\text{stud}) = \frac{e_{itn}}{s_i\sqrt{1-h_{itn}}} \ . \tag{1}$$

3.4. Moderator Variables

3.4.1. Environmental Dynamism

The measurement of environmental dynamism indicators is based on the calculation method of Boyd [10]. The basic idea is to exclude the stable income of operating income and normal income, and measure the variance of abnormal income. Next, using the least squares method (OLS) to calculate the abnormal operating income of each firm for the past 5 years. The formula refers to equation 2, where Sale represents operating income; Year is the year, and ε is the abnormal operating income, divided by the average of the past five years of operating income.

$$\text{Sale} = \alpha + \beta\text{Year} + \varepsilon. \tag{2}$$

3.4.2. Environmental Munificence

Environmental munificence describes whether environmental resources can support a firm's growth. According to Keats & Hitt [7], we measured it by the industry's average sales growth rate over the past five years. The larger the value, the higher the environmental munificence.

3.5. Control Variables

According to previous studies of scholars[1,4,5], the following variables are controlled in this paper: firm size, firm age, firm debt, ratio of independent directors(INDR), institutional investors' shareholding ratio (INST), ratio of state-owned shares and absorptive capacity.

4. Analysis and Findings

4.1. Descriptive Statistics

In this study, stata14.0 was used for descriptive analysis of uncentered variables. The means, standard deviations, and correlations for all the variables included in this study are shown in Table 1. As we can see, the mean of operational efficiency is 1.57, the mean of R&D leap is 0.24, the mean of environmental dynamism is 0.72, and the mean of environmental munificence is 3.18. The correlation coefficients between the variables are all less than 0.5, suggesting that there was no multicollinearity. Further, we conducted multicollinearity diagnosis for all variables, and all variance inflation factor VIF values were less than 2, indicating that there was no serious multicollinearity among variables in the model.

4.2. Results

The data in this paper are panel data, which may have heteroscedasticity, sequence correlation and cross-sectional correlation, etc., while the standard error estimated by driscoll-kraay is unbiased consistent and effective. Therefore, d-k standard error method is mainly used for estimation.

First, based on the control of firm size etc., we conduct a multiple regression analysis of core variables, the results are shown in table 2. As can be seen from model 2, the regression coefficient of R&D leap is -0.023($p<0.01$), $\Delta R^2=0.0031$, indicating that the R&D leap and operational efficiency are significant negatively, and Hypothesis 1 is supported.

Table 1. Correlations, means, and standard deviations of all variables

	Mean	Std. dev.	1	2	3	4	5	6	7	8	9	10	11
1 Operational efficiency	1.57	0.73	1										
2 R&D leap	0.24	0.55	-0.031	1									
3 Firm size	3.10	0.03	-0.016	0.028	1								
4 Firm debt	0.21	0.12	-0.077***	0.071**	0.329***	1							
5 Firm age	2.37	0.44	0.008	0.037	0.018	0.130***	1						
6 INDR	0.32	0.04	-0.03	-0.015	-0.088***	0.043	-0.013	1					
7 INST	2.46	1.02	0.111***	0.011	0.186***	0.033	0.088***	-0.086***	1				
8 State-owned shares	0.14	0.61	-0.03	-0.022	0.070**	-0.064**	0.037	-0.067**	0.112***	1			
9 Absorptive capacity	0.07	0.27	-0.025	-0.041	-0.011	-0.046*	-0.057**	-0.046*	0.050*	-0.018	1		
10 Env-dynamism	0.72	0.02	0.01	-0.079***	-0.054*	-0.041	-0.110***	-0.031	0.085***	0.045	0.005	1	
11 Env-munificence	3.18	0.51	0.032	-0.014	0.175***	0.084***	-0.008	-0.063**	0.049*	0.046*	-0.005	0.354***	1

N=1285. *significant at 10%; **significant at 5%; ***significant at 1%.

Second, we put environmental dynamism and munificence into the model to test their moderating effect. From the model 6, we can see the regression coefficient of the interactions between R&D leap and environmental dynamism, and munificence is 1.701($p<0.01$)and -0.058($p<0.01$), ΔR^2=0.0038. All interaction terms are significant, therefore Hypothesis 2 and 3 are supported.

Table 2. The result of hierarchical regression

	operational efficiency					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Firm size	-0.284**	-0.303**	-0.353**	-0.174**	-0.154*	-0.144*
Firm debt	0.05	0.067	0.068	0.057	0.061	0.067
Firm age	-0.273***	-0.269***	-0.279***	-0.259***	-0.259***	-0.262***
INDR	-0.396***	-0.407***	-0.386***	-0.381***	-0.383***	-0.392***
INST	0.014*	0.014*	0.014*	0.015*	0.014*	0.013*
State-owned shares	0.013***	0.012***	0.012***	0.013***	0.014***	0.016***
Absorptive capacity	0.039***	0.037***	0.037***	0.037***	0.039***	0.039***
R&D leap		-0.023***	-0.024***	-0.024***	-0.022***	-0.021***
Env dynamism			-0.493***	-0.682***	-0.634***	-0.677***
Env munificence				-0.072**	-0.069**	-0.069**
RDL* Dynamism					1.013**	1.701***
RDL* Munificence						-0.058***
R^2	0.0464	0.0495	0.0502	0.0525	0.0539	0.0577
ΔR^2	-	0.0031	0.0007	0.0023	0.0014	0.0038
F	2246.67***	561.29***	163.78***	286.04***	9.60E+08***	127.10***

N=1285. *significant at 10%; **significant at 5%; ***significant at 1%.

5. Conclusion and Contribution

5.1. Research Conclusion

Our study analyzes and tests the impact of R&D leap on operational efficiency from the the theory of ambidexterity innovation and dynamic capability, and the moderating effect of firm's external environment. The research results show that: (1) the firm's R&D leap has a negative relationship with operational efficiency, for there are risks in the transition between R&D-based exploitative and exploratory; (2) the environmental dynamism positively moderates the relationship between R&D leap and operational efficiency, namely when the dynamism is higher, the external opportunities appear fast and disappear quickly, so the R&D leap will be more positive impact on operational efficiency; (3) the environmental munificence negatively moderates the relationship between R&D leap and operational efficiency, namely when the munificence is higher, there are more external opportunities, and making big leaps can take away vested interests and bring opportunity costs. So, the R&D leap will be more negative impact on operational efficiency.

5.2. Theoretical Contribution and Practical Significance

First, the research on the relationship between R&D leap and operational efficiency has been deepened and enriched. In the past, there were few studies on the relationship between them and most of the results show that R&D leap is conducive to the firm performance [1, 2]. Based on the theory of ambidexterity innovation, and we believed that not all R&D leaps are beneficial. Since the resources required for the two R&D are different, the behavior itself is risky. The exploration of the source of risk has further broadened the studies related to R&D leap.

Second, the moderating effect of environmental factors on the relationship between R&D leap and operational efficiency has been revealed. Previous studies mainly examined the impact of single characteristics of environment on performance. Based on the dynamic capability perspective, the firm shall have the ability to reconfigure resources to take the first-mover advantage in face of risks [5]. From the characteristics of the environmental dynamism and environmental munificence, the study has been investigated how can the firms improve the operational efficiency under risks and different environmental factors, and the research on them has been further exploited.

Third, a certain reference has been provided for firms to make R&D leap. The time node and the degree of transition are the main reasons for risks, which the firms should be able to clearly identify. In addition, the environment is an important influence factor in the development process of firms. Through the research on the two basic characteristics of environmental dynamism and environmental munificence, a certain reference has been provided in respect of operation of firms.

6. Limitation and Future Direction

With regard to sample data, some of them was obtained by manual coding of annual reports and social responsibility reports, and there was a certain deviation in the sample data. In the future, it is hoped to conduct further research on R&D leap from more perspectives.

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8. References

[1] Mudambi, R., Swift, T.. Knowing When to Leap: Transitioning between Exploitative and Explorative R&D [J]. Strategic Management Journal, 2014, 35(1): 126-145.

[2] Wu Jianzu, Xiao Shufeng. Innovation Attention Shift, R&D Spending Leap and Firm Performance: Evidence from China [J]. Nankai Business Review.2016,19(2):182-192(In Chinese).

[3] Hall B H, Jaffe A, Trajtenberg M. Market Value and Patent Citations: A First Look[J]. Social Science Electronic Publishing, 2005, 36(1):16-38.

[4] Swift, T.. The Perilous Leap between Exploration and Exploitation [J]. Strategic Management Journal, 2016, 37(8): 1688-1698.

[5] Jia Huiying, Wang Zongjun. R&D Investment Volatility and Firm Performance: The Moderating Roles of Industry Technological Dynamism and Organizational Absorptive Ability [J]. Nankai Business Review. 2018, 21(03): 130-141(In Chinese).

[6] Dess G G, Beard D W. Dimensions of organizational task environments [J]. Administrative Science Quarterly, 1984,29(1): 52-73.

[7] Keats B W, Hitt M A. A Causal Model of Linkages among Environmental Dimensions, Macro Organizational Characteristics and Performance[J]. Academy of Management Journal, 1988, 31(3):570-598.

[8] Yin Miaomiao, Ma Yanli. The relationship between resource combination and performance of new ventures under different environmental contexts[J]. Science Research Management, 2014, 35(8):110-116(In Chinese).

[9] Lei Haimin, Liang Qiaozhuan, Li Jiajun. Does the Firm's Political Governance Affect Its Operational Performance: A Non-parametric Test Based on Chinese Listed Companies [J]. China Industrial Economics. 2012,9(9):109-121(In Chinese).

[10] Boyd B K, Dess G G, Rasheed A M. Divergence between archival and perceptual measures of the environment: Causes and consequences[J].Academy of Management Review, 1993, 18(2): 204.