A Stata-Based Analysis of the Non-Linear Relationship between International Expansion and Dual Innovation in Firms

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Abstract. This paper uses a sample of A-share listed companies in China's Shanghai and Shenzhen markets from 2011 to 2018 to develop a model and observe the multiple linear regression relationship. The non-linear relationship between international expansion of Chinese firms and dual innovation of firms is empirically tested, as well as the validation of the relationship by adding economic uncertainty as a moderating factor. It is found that: firstly, there is a non-linear effect in the multiple regression between international expansion and dual innovation for Chinese firms. Second, uncertainty in the economic environment enhances the non-linear relationship between international expansion and breakthrough innovation.

Keywords: multiple regression; firm internationalization; breakthrough innovation; incremental innovation; economic uncertainty

1 Introduction

In fact, after Schumpeter and March, Abernathy and Utterback (1978) introduced the concept of breakthrough innovation, followed by Dosi (1982), who not only introduced incremental innovation but for the first time combined breakthrough and incremental innovation in a unified framework.

Traditionally, there has been a preference for breakthrough innovation. This is because breakthrough innovation helps companies gain a technological threshold and market leadership [1], making it difficult for later competitors to break through. For example, the US is recognized as the world's strongest innovator, which has enabled it to maintain its prosperity for centuries. However, the advantages of incremental innovation are low risk, low investment, and easy market penetration. For emerging countries, incremental innovation may be the only option they have when they are unable to break the threshold of breakthrough innovation directly. This is because breakthrough innovation requires significant risky investment, which can trap firms in the "breakthrough innovation trap." However, excessive incremental innovation can lead firms into a "technology dependency trap," making it permanently difficult for latecomers to establish a competitive advantage. Therefore, at the firm level, it is difficult for them to use only one model as a sustainable competitive strategy, but rather a combination of "duals" to promote transformation and industrial upgrading.

2 Theoretical background and literature review

2.1 The relationship between international expansion and dual innovation in enterprises, and mechanisms of action

Studies do not separate breakthrough innovation from incremental innovation. In order to explore the relationship between internationalization strategy and dual innovation in firms, this paper proposes two ideas. First, under the theory of organizational learning, international markets provide a diverse environment and opportunities for multinational firms to learn new knowledge and skills. The differences between countries in terms of culture, innovation, and market demand open up new horizons for firms to expand their horizons in international markets and help to enrich their knowledge structures, thus promoting breakthrough and incremental innovation. Secondly, as the internationalization process expands, Chinese firms will gradually be subject to the attention and targeting of host country firms, which may make it difficult for them to translate their knowledge and reduce their dual innovation performance, and then they will have to shift their focus back to the domestic market and continue to promote dual innovation through the domestic circulation. This paper therefore proposes a research hypothesis. To test the hypothesis, we use multiple regression to build the model and observe the multiple linear regression relationship.

Hypothesis 1: The internationalization of Chinese firms has generally contributed to breakthrough innovation, but the mechanism of action is non-linear.

Hypothesis 2: The internationalization of Chinese firms has generally contributed to incremental innovation, but the mechanism of action is non-linear.

2.2 The moderating role of economic policy uncertainty

Economic policy uncertainty refers to the inability of economic agents to predict with certainty if, when, and how the government will change existing economic policies. [2] The majority of the literature supports economic policy uncertainty. Most of the literature supports the idea that economic policy uncertainty has a dampening or facilitating effect on firms' innovation performance, depending on their own perceptions and predictions of uncertainty. However, statistical studies from a sample of developed countries, such as the United States, have concluded that uncertainty in economic policy generally supports the positive effect of promoting firm innovation [3]. Most scholars studying the relationship between internationalization and innovation have considered the moderating role of economic policy uncertainty in the host country. And it has been found that economic policy uncertainty in the host country has a dampening effect on internationalization investment and also inhibits innovation, with the dampening effect increasing with higher policy uncertainty. [4] However, only a small number of articles have addressed this issue. However, only a relatively small number of articles have addressed the role of home country economic policy uncertainty in moderating the relationship between internationalization and dual innovation. Therefore, it can be inferred that economic policy uncertainty plays a moderating role in the non-linear effect of international expansion on dual innovation in Chinese firms, but the direction of the moderating role needs to be verified. To test the inference, we build the model with multiple regressions and look at the relationship between the regressions.

Corollary 1: Economic policy uncertainty moderates the non-linear relationship between internationalization strategies and breakthrough innovation.

Corollary 2: Economic policy uncertainty moderates the non-linear relationship between internationalization strategies and incremental innovation.

2.3 Methods of regression analysis

Experiment data processing, empirical formulae, and factor analysis are all frequent applications of regression analysis. Regression analysis, like the final expressions, can be broken down further into the linear and non-linear subtypes. Univariate linear regression analysis is a type of linear regression that only uses one dependent variable and one independent variable. In multivariate statistics, multiple regression analysis is the gold standard. It constructs a regression model to discover the linear relationship between several independent and dependent variables. The A-test, the F-test, and the t-test were used to create the regression models. When the values of the appropriate explanatory variables are entered into the regression model, the projected values of the economic variables are obtained.

3 Data and methods

3.1 Data and models

This paper takes listed companies in China's Shanghai and Shenzhen A-shares as the research object, selects publicly available data of listed companies between 2011 and 2018 as the research sample, and further screens and processes the original sample. The listed company data used in this paper was obtained from the CSMAR database. The invention patent database used in this paper was obtained from the Wind database, Sina Finance, and CNRDS database, which were manually integrated. In order to prove the above hypothesis, the following model is presented in this paper:

$$Radical_{i,t} = a_1 Internation_{i,t}^2 + a_2 Internation_{i,t} + a_3 Control_{i,t} + \sum Year + \sum Industry$$

$$Incremental_{i,t} = \beta_1 Internation_{i,t}^2 + \beta_2 Internation_{i,t} + \beta_3 Control_{i,t} + \sum Year + \sum Industry$$

3.2 Definition of variables

In terms of variable selection this paper has been set out as follows. First, the explanatory variable: dual innovation. In this paper, the natural logarithm of the number of invention patent applications + 1 is used as a proxy for breakthrough innovation (radical), and the natural logarithm of the sum of the number of utility model and design patent applications + 1 is used as a proxy for incremental innovation (incremental), following the practice of Zhang Feng et al.

Secondly, the explanatory variable is the international expansion of the firm. This paper uses international customer concentration (ICC) to measure this, with the specific algorithm being

the ratio of overseas business revenue to operating revenue. The moderating variable is economic policy uncertainty (EPU). With reference to Gulen et al. [2] In this paper, the annual economic policy uncertainty is obtained using the annual mean of the monthly economic policy uncertainty index, which is then taken as the natural logarithm to avoid heteroskedasticity and reduced by a factor of ten to a uniform unit in order to verify its moderating effect. Control variables. Drawing on previous research [5] In this paper, we control for firm size, asset structure, gearing, ROA, enterprise value, age, Top1, and CFO, as well as year and industry dummy variables. (Industry)

3.3 Descriptive statistics of key variables

Table 2 reports the results of the descriptive statistics for the main variables. It can be seen that the mean value of radial is 1.838 and the maximum value is 5.844, while the mean value of incremental is 2.034 and the maximum value is 6.122. This shows that there is still a gap between the output of breakthrough innovation and that of incremental innovation, and the strength of breakthrough innovation is obviously not as strong as that of incremental innovation. The mean value of internationalization is 0.144, which indicates that the degree of internationalization of Chinese enterprises is not high. The standard deviation of internationalization is 0.212, which indicates that there is still a gap between the internationalization levels of enterprises.

Table 1. Descriptive statistics (self-drawn)

Variables	(1) N	(2) mean	(3) sd	(4) min	(5) max
Radical	15,536	1.838	1.425	0	5.844
Incremental	15,536	2.034	1.576	0	6.122
Internation	15,536	0.144	0.212	0	0.882
EPU	15,536	0.552	0.050	0.474	0.613
Size	15,536	22.03	1.251	19.94	26.06
Lev	15,536	0.391	0.201	0.0470	0.875
CFO	15,536	0.0437	0.0652	-0.142	0.225
Age	15,536	8.249	6.872	0	24
TOP 1	15,536	34.85	14.53	8.720	73.80
Turbinq	15,536	1.058	0.311	0.643	2.157
ROA	15,532	0.0489	0.0574	-0.168	0.217
Fix	15,536	0.210	0.145	0.00501	0.660

4 Baseline Regression Results and Analysis

The experimental data were analyzed using multiple regression analysis with Stata software. The results are presented below.

Table 2. Analysis of non-linear effects (self-drawn)

VARIABLES	(1) Radical	(2) Incremental	(3) Radical	(4) Incremental
$Internation^2$	-2.844***	-2.271***	-2.824***	-2.262***
	(-14.54)	(-9.73)	(-14.43)	(-9.64)
$Internation$	2.284***	1.951***	2.273***	1.948***
	(16.50)	(12.23)	(16.42)	(12.18)
$economi$			-1.817***	-6.810***
			(-4.24)	(-13.96)
$Internation^2$ *economi			-8.032**	0.718
			(-2.11)	(0.16)
$Internation$*economi			5.469**	-1.951
			(2.08)	(-0.65)
Control	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	15,532	15,532	15,532	15,532
R-squared	0.293	0.292	0.293	0.292

The relationship between internationalization and dual innovation is clearly positive, and when combined, it supports a positive relationship between internationalization and innovation, but why would scholars suggest that there is a non-linear relationship between the two? 6 presents the results of estimating the effect of internationalization on radical and incremental innovation. In column (1), the quadratic term of internationalization on radial innovation is -2.844 and is significant at the 1% level, suggesting that the relationship between internationalization and radial innovation is inverted U-shaped, which proves hypothesis 1. The threshold here is 0.009623 after the threshold effect test, so the following breakthrough innovation threshold is distinguished by whether the internationalization strategy is greater than 0.009623. As in column (2), the estimated coefficient of the secondary term of internationalization on incremental innovation is -2.271 and is significant at the 1% level. This suggests that there is an inverted "U" shape between internationalization and incremental innovation. Hypothesis 2 is proved.

As shown in Table 2, after the threshold, economic uncertainty has a positive moderating effect on the relationship between internationalization strategy and breakthrough innovation, as shown in column (3), where the coefficient of internationalization strategy on breakthrough innovation is -2.844, while the coefficient of the cross product of the two is -8.032 as shown in column (1) and is significant at the 1% level, thus inference 1 is proved. As shown in column 4, economic uncertainty does not play a moderating role, so corollary 2 cannot be proved. This may be because policymakers do not over-innovate when the domestic environment is uncertain. Instead, as Chinese companies expand internationally, policymakers will try to reduce their risk by bringing in new ideas that are a step forward.

5   Key Conclusions and Insights

5.1   Summery

This paper examines the impact of corporate internationalization strategy on breakthrough innovation and incremental innovation by matching data of non-financial A-share listed companies in Shanghai and Shenzhen from 2011 to 2018. The study found that, firstly, there is an inverted "U"-shaped relationship between firms' internationalization strategies and their dual innovation. Second, economic uncertainty weakens the inverted U-shaped relationship between internationalization strategy and breakthrough innovation.

5.2   Conclusion

As China's "One Belt, One Road" and "Go Global" strategies push Chinese companies to develop international strategies, it is crucial to promote corporate innovation, especially breakthrough innovation. However, companies should be aware that international expansion is more important for incremental innovation. Moreover, both breakthrough and incremental innovation are constantly facilitated by a firm's international expansion but can also be inhibited by higher levels of international embedding, which in turn can inhibit the continued growth of both types of innovation capabilities. Therefore, while the promotion of dual innovation by international expansion should be seen, its negative inhibiting effects should also be considered prospectively. For example, the current internationalization strategy based on the policy of "domestic and international circulation" is of great importance for Chinese companies.

Multiple linear regression analysis is used to predict economic indicators. This statistical method is used to make sense of the data and the relationships it contains. This combination with economics makes a lot of sense. However, we should not only consider the one-sided impact but also think about whether this theoretical issue can be applied in practice.

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