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Technological diversification, absorbed slack and firm growth

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Abstract. Technological diversification and slack resources management are important means for enterprises to achieve endogenous growth. Based on the resource-based theory, this paper used the balanced panel data of 340 listed companies in China's manufacturing industries from 2014 to 2019 as samples and conducted the empirical test. The main findings are as follows: (1) Technological diversification has an N-shaped influence on firm growth, related technological diversification has a positive effect on firm growth, and unrelated technological diversification has an inverted U-shaped influence on firm growth. (2) The absorbed slack has a negative moderating effect on the relationship between technological diversification and firm growth.

Keywords: Technological diversification; absorbed slack; firm growth.

1. Introduction

Enterprises are the main body of technological innovation and the important foundation for promoting economic and social development. However, the situation is not as expected. According to the statistics of the State Administration for Industry and Commerce in China, the mortality rate of enterprises is high within 3-7 years after their establishment, and 60% of enterprises exit within 5 years, which makes the growth of enterprises face many challenges. At present, economic development is changing from high-speed growth to high-quality development in China, technological innovation is becoming increasingly important for enterprise growth. Technological innovation capability puts forward higher requirements for the development of enterprises. A single technology can no longer support the continuous innovation of enterprises, and the integration of diversified technologies has become one of the vital strategies for enterprises to increase their uniqueness and difference in competition[1]. Existing research on the relationship between technological diversification and firm growth is still controversial. Some scholars believe that diversified technologies can bring economies of scope and scale, which is conducive to the sustainable growth of enterprises. Some scholars also believe that technological diversification will disperse the limited resources and capabilities of enterprises, resulting in excessive management costs[2].

As the resource buffer of enterprises, organizational slack can be adjusted to adapt to internal or external changes and improve the enterprise's ability to adapt to the environment. Absorbed slack, as an important organizational slack, exists in the daily business activities of enterprises, and it is reflected in the cost of management expenses, sales expenses, and so on. Absorbed slack has an important impact on the technological diversification and growth of enterprises. The existing research on enterprise growth mostly focuses on the external environment on enterprise growth and seldom considers the influence effect from the perspective of enterprise resources. Therefore, it is necessary to consider the impact of technological diversification and absorbed slack on firm growth.

In response to the differences in existing research, this paper attempted to explore and answer two questions: (1) How do different types of technological diversification affect firm growth? (2) As an important slack resource, how does absorbed slack affect the relationship between technological diversification and firm growth? Therefore, this paper took 340 listed companies in China's manufacturing industries from 2014 to 2019 as research samples to test and analyze the impact of technological diversification on enterprise growth and the moderating effect of absorbed slack.

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2. Theoretical analysis and research hypothesis

2.1 Technological diversification and firm growth

For a long time, many theoretical studies have believed that the advantage of an enterprise is the core technological capability, and the development of non-core technological capability is a loss-making investment. However, with the complexity of the production process and the intensification of market competition, it is difficult for enterprises with a single technological capability to gain a long-term development in the market. Therefore, technological diversification has aroused the attention of scholars[3]. Technological diversification means that while maintaining the original core competitiveness, enterprises diversify their investment, and carry out innovation activities by applying different knowledge and technology fields[4]. In recent years, the trend of technological innovation is increasingly characterized by the cross-integration of multiple fields. Even if an enterprise produces a single product, it will use technologies from different fields to increase the innovation of the product to increase its competitiveness of the product in the market.

Technological diversification has two influences on the growth of enterprises: on the one hand, technological diversification contributes to the growth of enterprises. Technological diversification enables enterprises to expand their technological scope, and broaden the companies' options to deal with potential environmental changes by diversifying investment risks[5]. For example, BYD company utilizes its existing core technological advantages in the field of battery production to develop new energy vehicles and build the no.1 brand of electric vehicles in China. When the whole Chinese real economy is threatened by inflation, it can maintain stable development by using new products. On the other hand, technological diversification will also increase the cost of enterprises in coordination, integration, and communication. It will increase the management complexity of misallocation of resources and departmental and cultural conflicts[6], thus affecting the continuous innovation and growth of enterprises.

To sum up, the relationship between technological diversification and firm growth is complicated. This paper argued that the impact of technological diversification on firm growth has a stage characteristic, and shows a nonlinear positive N-shaped curve relationship: When enterprises just began to implement the technology diversification strategy, the exploration of technology often starts from their core areas, focusing on the accumulation of capabilities in the core areas is conducive to the optimization and innovation of their key products. With the accumulation of technical capabilities in multiple fields, enterprises improve their knowledge absorption capacity, which is conducive to integrating the technical knowledge of different fields and improving their management efficiency and innovation ability[7]. When the field of technological diversification continuously expands, the costs of R&D, personnel management, and resource coordination will increase greatly, and the cost of technological diversification will rise more than its benefits[8]. At the same time, the excessive dispersion of technical resources into different fields may increase system risks, which harms the growth of enterprises[9]. As the degree of technological diversification of enterprises increases to a suitable range, the cross-penetration of diversified technologies and stable relations can disperse the investment risks of enterprises, and bring the dynamic and static scale economy, scope economy, speed, and spatial economic[10]. It can make enterprises produce low adaptation costs, promote organizational learning and knowledge spillover, and help to improve the competitive advantage of enterprises. Based on this, the following hypothesis was proposed:

Hypothesis 1: There is an N-shaped curve relationship between technological diversification and firm growth.

Based on the research of Chen and Chang[11], this paper divided technological diversification into related technological diversification and unrelated technological diversification. Related technological diversification means that the technical knowledge of the enterprise is distributed in the technical fields with a high degree of knowledge correlation[12]. While unrelated technological

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diversification refers to the technical knowledge that enterprises possess in the non-related technology fields, which has a low correlation degree and great difference.

2.1.1 Related technological diversification and firm growth.

Technical knowledge in related technical fields has similar scientific and technological basic principles[13]. Enterprises' R&D investment in similar science and technology fields is conducive to a higher cumulative effect, accelerating resource agglomeration and promoting the formation of economies of scale[14]. In addition, due to the small difference and high degree of association, the technological fusion and reorganization among these fields are easy to occur and take low risk, which can improve the R&D efficiency and promote the growth of enterprises. Based on this, the following hypothesis was proposed:

Hypothesis 2: There is a positive correlation between related technological diversification and firm growth.

2.1.2 Unrelated technological diversification and firm growth.

The unrelated technological diversification indicates that the knowledge base is quite different and the degree of heterogeneity is high. Compared with related technological diversification, in the initial stage of unrelated technological diversification, the resource input is more dispersed, and the coordination and allocation of resources required by different fields are limited, which increases the uncertainty of R&D investment[15]. When the field of unrelated technological diversification expands to an appropriate width, it is beneficial for enterprises to reduce the lock-in effect of enterprises in a specific technology field and promote mutual inspiration among heterogeneous knowledge[16]. The multi-technology field innovation of enterprises can improve the innovation ability of enterprises, and the market competitiveness of enterprises, which is conducive to the growth of enterprises. Based on this, the following hypothesis was proposed:

Hypothesis 3: There is a U-shaped curve relationship between unrelated technological diversification and firm growth.

2.2 The moderating effect of absorbed slack

Technological diversification is a way of technological resource combination[1]. The effects of other resources should also be considered. This paper considered the moderating effect of absorbed slack on the relationship between technological diversification and firm growth. Absorbed slack refers to the resources that have been utilized by an organization, but can be reused when the organization is faced with special circumstances. When enterprises adopt the strategy of technological diversification, they need to coordinate the limited resources, while the competition for resources is intensified with the increase of technological diversification. Absorbed slack has poor liquidity and flexibility, and its applicable scenarios are limited. Faced with opportunities for technological innovation, enterprises are difficult to quickly excavate and utilize absorbed slack, and react slowly to the rapidly changing external technological environment[17]. In addition, if the technological field does not bring the expected benefits to the enterprise, the absorbed slack will further increase the sunk cost, making the enterprise's capital turnover slow and increasing the burden on the enterprise. Based on this, the following hypotheses were proposed:

Hypothesis 4: Absorbed slack has a negative moderating effect on the relationship between technological diversification and firm growth.

Hypothesis 5: Absorbed slack has a negative moderating effect on the relationship between related technological diversification and firm growth.

Hypothesis 6: Absorbed slack has a negative moderating effect on the relationship between unrelated technological diversification and firm growth.

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3. Empirical study design

3.1 Sample

This paper selected listed enterprises in manufacturing from 2014 to 2019 as research samples for empirical research. The sample enterprises are required to operate continuously during this period without delisting, disclose various information clearly, and the patent application is continuous and maintained at a stable level. After the strict screening, effective samples of 340 listed manufacturing enterprises were obtained. The patent application information of sample enterprises (including parent companies and subsidiaries) comes from the WIND database, and the basic data and financial data of enterprises come from the CSMAR database.

3.2 Variable measurement

Dependent variable. This paper took firm growth as the dependent variable. This variable was measured by Tobin's Q ratios (TBQ).

Independent variable. This paper took technological diversification as the independent variable. This variable was measured by patent application data and the entropy index method. Considering the general characteristics of an innovation project duration cycle of more than one year, this paper combined the patent data of two years. The degree of technological diversification (TD) was calculated as follows:

$$TD_t = \sum_{i=1}^{n} \left(\frac{N_{it}}{N_t} \times Ln \frac{N_t}{N_{it}} \right)$$

Where Nt represents the total number of patents of the enterprise in year t and year t-1, Nit represents the number of patents of the enterprise in the ith technology fields in year t and year t-1, and n represents the total number of technology fields involved in patents of the enterprise in year t and year t-1. Technical fields are distinguished by the first four digits of the IPC main classification number. The larger TD value is, the wider the technology fields involved by the enterprise and the higher the degree of technology diversification.

In terms of the measurement of related and unrelated technological diversification, this paper adopted the first three patent classification numbers as the measurement standards of unrelated technological diversification and also combined the data of two years[9,19]. Related technological diversification(RTD) and unrelated technological diversification (UTD) were calculated as follows:

$$UTD_t = \sum_{j=1}^{n} \left(\frac{M_{jt}}{N_t} \times Ln \frac{N_t}{M_{jt}} \right); \quad RTD_t = TD_t - UTD_t$$

Where Nt represents the total number of patents of the enterprise in year t and year t-1, Mjt represents the number of patents of the enterprise in year t and year t-1 in the jth technology field (distinguished by the first three of the patent main classification number), and n represents the total number of technology fields involved in patents of the enterprise in year t and year t-1.

Moderating variable. This paper took absorbed slack as the Moderating variable. This variable was measured by the cost-income ratio(ESR)[18].

ESR = (Operating Expenses + Management Fees + Financial Costs)/Sales Revenue.

Control variables. Enterprise size (SCA) was measured by the natural logarithm of the total assets of enterprises. Enterprise age (AGE) referred to the observation time of the enterprise minus the interval of the establishment of the enterprise. Industry (IN) was classified according to the sub-industry classification standard of the China Securities Regulatory Commission (CSRC) for the manufacturing industry in 2012. Enterprise nature (FP) was measured by dummy variables (1= state-owned enterprise, 0= other). Return on assets (ROA) was an indicator to measure the overall operating status of an enterprise.

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3.3 Research model

According to the above theoretical analysis, the following model was constructed. Considering that the independent variable has a certain degree of lag effect on the dependent variable, the independent variable was used to conduct statistical analysis on the one-year lagged data of each model. Among them, ε 0 is the error term.

Model 1: $TBQ_{nt} = \beta_0 + \beta_1 TD_{nt-1} + \beta_2 TD_{nt-1}^2 + \beta_3 TD_{nt-1}^3 + \beta_4 X_{nt} + \varepsilon_0$

Model 2: $TBQ_{nt} = \beta_0 + \beta_1 RTD + \beta_2 X_{nt} + \varepsilon_0$

Model 3: $TBQ_{nt} = \beta_0 + \beta_1 UTD_{nt-1} + \beta_2 UTD_{nt-1}^2 + \beta_3 X_{nt} + \varepsilon_0$

Model 4: $TBQ_{nt} = \beta_0 + \beta_1 TD_{nt-1} + \beta_2 TD_{nt-1}^2 + \beta_3 TD_{nt-1}^3 + \beta_4 ESR_{nt} + \beta_5 ESR_{nt} \times TD_{nt-1} + \beta_6 ESR_{nt} \times TD_{nt-1}^2 + \beta_7 ESR_{nt} \times TD_{nt-1}^3 + \beta_8 X_{nt} + \varepsilon_0$

Model 5: $TBQ_{nt} = \beta_0 + \beta_1 RTD_{nt-1} + \beta_2 ESR_{nt} + \beta_3 ESR_{nt} \times RTD_{nt-1} + \beta_4 X_{nt} + \varepsilon_0$

Model 6: $TBQ_{nt} = \beta_0 + \beta_1 UTD_{nt-1} + \beta_2 UTD_{nt-1}^2 + \beta_3 ESR_{nt} + \beta_4 ESR_{nt} \times UTD_{nt-1} + \beta_5 ESR_{nt} \times UTD_{nt-1}^2 + \beta_6 X_{nt} + \varepsilon_0$

4. Data analysis

4.1 Descriptive statistics and correlation analysis

The descriptive statistical analysis and correlation coefficient matrix are shown in Table 1. Analysis results show that the correlation coefficients of other variables are relatively small except for the high correlation between different modes of technological diversification, so there is no multicollinearity problem.

Table1: Descriptive statistical analysis and correlation coefficient matrix

variable	The mean	The standard deviation	TBQ	TD	RTD	UTD	ESR	SCA	AGE	IN	FP	ROA
TBQ	1.897	1.142	1.000	-0.271***	-0.124***	-0.281***	0.133**	-0.415***	-0.072***	-0.064***	-0.126***	0.179***
TD	2.500	0.820	-0.271***	1.000	0.666***	0.929**	-0.168***	0.479***	0.019	0.247***	0.175**	-0.037*
RTD	0.536	0.322	-0.124***	0.666***	1.000	0.344**	-0.067***	0.356***	-0.005	0.228***	0.135**	0.023
UTD	1.964	0.651	-0.281***	0.929***	0.344***	1.000	-0.179***	0.427***	0.026	0.198***	0.154**	-0.058***
ESR	0.178	0.195	0.133***	-0.168***	-0.067***	-0.179***	1.000	-0.123***	0.001	-0.085***	-0.084***	-0.128***
SCA	22.996	1.213	-0.415***	0.479***	0.356***	0.427**	-0.123***	1.000	-0.005	0.022	0.205**	0.120***
AGE	20.685	4.338	-0.072***	0.019	-0.005	0.026	0.001	-0.005	1.000	-0.014	0.047*	0.039*
IN	20.327	6.890	-0.064***	0.247***	0.228***	0.198**	-0.085***	0.022	-0.014	1.000	-0.023	-0.155***
FP	0.553	0.497	-0.126***	0.175***	0.135***	0.154**	-0.084***	0.205***	0.047**	-0.023	1.000	-0.072***
ROA	0.033	0.075	0.179***	-0.037*	0.023	-0.058***	-0.128***	0.120***	0.039*	-0.155***	-0.072***	1.000

Note: * p<0.10, ** p<0.05, *** p<0.01.

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4.2 Hypothesis testing

4.2.1 Regression analysis results of the relationship between technological diversification and firm growth.

The regression analysis results of the relationship between technological diversification and firm growth are shown in Table 2. In model 1, The cubic regression coefficient of "technology diversification - firm growth" is positive, the remarkable relationship between technological diversification and firm growth is the N-type curve, therefore the H1 was founded. In model 2, the regression coefficient of "related technological diversification - firm growth" is significantly positive, indicating that related technological diversification is significantly positively correlated with firm growth, thus H2 was valid. In model 3, the "unrelated technological diversification - firm growth" quadratic regression coefficient is positive, showing the relationship between the related technology diversification and firm growth to a significant U-shaped curve relationship, so the H3 was valid. Thus, the relationship between technological diversification and firm growth is complex, enterprises should coordinate the resources reasonably to promote enterprise development and growth. Due to space limitations, the regression results of control variables are not listed here but can be obtained from the author if necessary.

Table2: Regression analysis results

	Model 1	Model 2	Model 3
TD_{-1}	0.694^{**} (0.327)		
TD^2_{-1}	-0.460^{***} (0.152)		
TD^3_{-1}	0.075^{***} (0.022)		
RTD_{-1}		0.145^{*} (0.076)	
UTD_{-1}			-0.538^{***} (0.153)
UTD^2_{-1}			0.104^{**} (0.041)
R^2	0.241	0.234	0.242
Adjusted R^2	0.238	0.232	0.239
F value	80.750^{***}	103.530^{***}	92.508^{***}
N	2040	2040	2040

Note: the regression coefficients listed in the table are the standard error of the coefficients in parentheses.

4.2.2 Regression analysis results of the moderating effects of absorbed slack.

The regression analysis results of the moderating effects of absorbed slack are shown in Table 3. In model 4, "TD × ESR" of the coefficient is -6.149 ($p<0.01$), in contrast to the "TD" coefficient of symbol, and "TD2 × ESR" and "TD3 × ESR" has not been through the test of significance, H4 was not. In model 5, the coefficient of "RTD × ESR" is -1.829 ($P<0.001$), which is opposite to the coefficient sign of related technological diversification, indicating that absorbed slack negatively moderates the relationship between related technological diversification and firm growth, and H5 was valid. In model 6, the coefficient of "UTD × ESR" is -7.079 ($p<0.001$), contrary to the coefficient sign of unrelated technological diversification, the coefficient of "UTD2 × ESR" is 1.949 ($p<0.001$), Contrary to the quadratic coefficient sign of unrelated technological diversification, indicating that absorbed slack negatively regulates the relationship between unrelated technological diversification and firm growth, and H6 was valid. Due to space limitations, the regression results of control variables are not listed here but can be obtained from the author if necessary.

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Table3: Regression analysis results of absorbed slack moderating

	Model 4	Model 5	Model 6
TD_{-1}	1.892***(0.570)		
TD^2_{-1}	-0.766***(0.265)		
TD^3_{-1}	0.093**(0.038)		
RTD_{-1}		0.449***(0.112)	
UTD_{-1}			0.713***(0.263)
UTD^2_{-1}			-0.217***(0.069)
ESR	7.146***(1.887)	1.717***(0.311)	6.466***(1.014)
TD_{-1}×ESR	-6.149**(2.894)		
TD^2_{-1}×ESR	1.528(1.421)		
TD^3_{-1}×ESR	-0.066(0.217)		
RTD_{-1}×ESR		-1.829***(0.494)	
UTD_{-1}×ESR			-7.079***(1.193)
UTD^2_{-1}×ESR			1.949***(0.334)
R^2	0.263	0.251	0.265
Adjusted R^2	0.259	0.248	0.261
F value	60.393***	84.984***	72.984***
N	2040	2040	2040

4.3 Robustness test

To make the regression analysis more stable, a robustness test was carried out in this paper. The high-tech industry is a collection of enterprises engaged in the research, development, production, and technical services of one or more high-tech and its products based on "high-tech". Enterprises in this industry are quite different from other enterprises in terms of strategic choice and resource allocation. It may be controversial whether the technological diversification strategy has the same influence on firm growth as other enterprises. Based on the robustness test, according to the Guidelines for Industry Classification of Listed Companies published by the China Securities Regulatory Commission (CSRC) in 2012 and High-tech Industry (Manufacturing) Classification (2017) published by the National Bureau of Statistics in 2017, partially duplicate manufacturing enterprises are excluded. A total of 119 enterprises are involved in the data regression, and the results are consistent with the original text. The robustness test of this paper was passed. Due to space limitations, it is not listed, but can be obtained from the author if necessary.

5. Conclusion

Based on the panel data of listed manufacturing enterprises from 2014 to 2019, this paper explored the impact of technological diversification on firm growth and the role of absorbed slack in the process of technological diversification on firm growth. The results show that:

(1) The impact of technological diversification on firm growth is characterized by three stages, showing a significant positive N-shaped curve relationship, that is, with the improvement of the degree of technological diversification, the relationship between technological diversification and firm growth changes from positive correlation to negative correlation, and finally to a positive correlation. Among them, related technological diversification has a significant positive impact on firm growth. Due to the small difference in knowledge base between technical fields, related technological diversification can reduce the cost of organizational learning and easily produce knowledge accumulation, to improve the success rate of new technology research and promote the growth of enterprises. While the impact of unrelated technological diversification on firm growth has a two-stage characteristic, which is a significant positive U-shaped curve. That is, with the improvement of the degree of unrelated technological diversification, its relationship with firm growth changes from a negative correlation to a positive correlation.

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(2)Absorbed slack has a negative moderating effect on the relationship between related technological diversification, unrelated technological diversification, and firm growth. Technological diversification is the optimization of enterprise resource allocation, but absorbed slack is a resource with poor liquidity and flexibility. The increase of absorbed slack will inhibit the implementation of enterprise technological diversification strategy, and stir up negativity toward enterprise innovation.

The results of this study show that blindly pursuing the expansion of the technological field can not maintain the long-term stable growth of enterprises, but in different periods to change the corresponding strategy.

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