

# Research on the Impact of Technological Diversification on Manufacturing Enterprise Performance

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## ABSTRACT

This paper reviewed the literature on technological diversification and enterprise performance, and analyzed the effect of two types of technological diversification on enterprise performance, and put forward the relevant hypotheses on the basis of theoretical analysis. Based on the data collected from CSMAR database and the State Intellectual Property Office of 126 Shanghai and Shenzhen A-share manufacturing enterprises between 2015 and 2019, multiple regression analysis was carried out to test the hypotheses. The results show that related technological diversification has positive effect on financial performance, and unrelated technological diversification has negative effect on financial performance. Furthermore, relevant technology diversification and unrelated technology diversification all have positive relationship with innovation performance.

**Keywords:** *Related technology diversification, Unrelated technology diversification, Financial performance, Innovation performance.*

## 1. INTRODUCTION

Recently, science and technology have developed rapidly. New technologies and new products have emerged rapidly. Competition in all walks of life is intensifying, especially in technology-intensive manufacturing. As the most important and core resource of an enterprise, technological capability can determine the future development direction and sustainability of an enterprise. The complex market environment has brought many unpredictable risks to enterprises. If enterprises want to maintain their competitive advantages and keep core competitiveness in the fierce competition environment, they need to continuously improve existing products, and then seize the opportunity to launch new products to meet customer needs, while improving existing products or launching new products requires enterprises to have strong relevant and non-relevant technologies. More and more enterprises realize that only relying on a single technology and high-

quality products cannot maintain the long-term development of enterprises. Diversified technology strategy has become an important way for enterprises to deal with market changes, promote innovation process and obtain long-term competitive advantages. For enterprises, it is necessary to study how to layout the strategy of technological diversification and enhance the competitive advantage and performance of the enterprise.

## 2. LITERATURE REVIEW

From the perspective of theory, different theories explain the relationship between technological diversification and firm performance differently. From the perspective of empirical research, many scholars have studied the impact of technological diversification on corporate performance, but have not reached a relatively unified conclusion.

Some scholars have studied the impact of technological diversification on corporate financial performance and have come to different conclusions. Park, Yun and other scholars conducted empirical analysis and found that technological diversification positively affects the financial performance of enterprises [1][2][3][4]. Sang believes that increasing the degree of diversification in related technology fields plays a key role in improving corporate performance [6]. Yimin's research found that using different financial indicators to measure corporate performance will yield different results [7]. Appio's research found that there is an inverted U-shaped relationship between technological diversification and corporate performance ROA [8], while Zhang Qinglei's research found that technological diversification has no significant impact on corporate performance [9].

Some scholars have also studied the impact of technological diversification on enterprise innovation performance. He Yubing's research found that the synergy of RTD and UTD has a positive impact on continuous innovation [10]. Scholars such as Marhold and Zhang have studied the impact of technological diversification within enterprises on technological innovation [11][12][13], and reached different conclusions. Chen et al. found that there is an inverted U relationship between technological diversification and industrial innovation performance [14][15]. Sheng Yuhua used panel data of 435 high-tech enterprises and found that technological diversification is positively promoting the sustainability of technological innovation [16]. Du's research with negative binomial fixed effect regression method shows that RTD can help enterprises to strengthen R&D capabilities in related technical fields, and the relationship between UTD and TIP is an inverted U-shaped relationship [17]. The degree of positive impact is better than the positive impact of UTD on technical capabilities [18]. In order to study the relationship between technological diversification and innovation performance from a more comprehensive perspective, Pan completed his study from the perspective of strategic balance. The empirical results show that the relationship between technological diversification and its performance is an inverted U-shaped curve [19].

To sum up, due to different research objects and research methods, the current research on the relationship between technological diversification and corporate performance is still controversial.

Some studies do not subdivide the types of technological diversification, and different types of technological diversification have corresponding applicable conditions, and their effects on enterprise performance cannot be generalized.

### 3. RESEARCH HYPOTHESIS

#### 3.1 *Technology Diversification and Financial Performance*

From the perspective of financial performance, the diversification of related technologies will, on the one hand, promote the knowledge spillover of the enterprise, promote the diversification of the core technologies of the enterprise, enhance the mutual coordination of multiple innovation activities, bring about the knowledge spillover effect, and bring about a great impact on the operation and production of the enterprise. It will also achieve economies of scale, indirectly improve the efficiency of corporate technological innovation activities, reduce unknown risks and costs, and promote corporate financial performance. When an enterprise carries out a related diversification strategy, it can focus on the core technology areas and find innovation points. It can mobilize the enthusiasm and creativity of employees through a clear direction and goal, improve the efficiency of technological innovation, and improve the efficiency of technological innovation. The core technology fields form scale effects and promote enterprise performance. Enterprises conduct reasonable research and evaluation of their diversified technical behaviors according to the complex and changeable environment, which can strengthen the improvement of related technologies and increase the speed of converting knowledge into technical capabilities. In addition, diversification of related technologies can enable enterprises to carry out R&D activities according to the familiar path in the past, reduce the risk of R&D activities, realize the synergy between new technologies and original technologies, and improve the financial performance of enterprises.

Relatively speaking, there are many risks for enterprises to carry out unrelated technology diversification. If an enterprise wants to expand unrelated technical fields, it needs to invest a lot of time, talents and resources. In this case, the resource utilization efficiency of the enterprise will decline, and as the degree of irrelevance increases, the cost will increase rapidly, which is difficult to estimate. Moreover, the resource capacity of the

enterprise is certain, which will affect other businesses of the enterprise. Even if enterprises have achieved certain results in unrelated technical fields, their ability to absorb heterogeneous technologies is limited, which may make it difficult for enterprises to make good use of technologies in new fields. The result may be that enterprises have strong innovation capabilities, but this translates into very little profit, reducing the financial performance of the business. On the other hand, the excessive degree of unrelated diversification increases the cost of coordination and communication between various organizational departments and limits the synergies between technologies. Therefore, this paper proposes the following assumptions:

- Hypothesis 1: There is a positive relationship between relevant technology diversification and firm financial performance.
- Hypothesis 2: Unrelated technological diversification is negatively related to firm financial performance.

### ***3.2 Technology Diversification and Innovation Performance***

Innovation performance refers to both the enterprise innovation process and the enterprise innovation results [20]. Innovation achievement refers to the process in which an enterprise invests technical resources and R&D funds to obtain technical patents and then develop innovative products. In the research, some scholars define innovation performance as the number and quality of new technology patents added by a company [21], and some scholars define innovation performance as the number of new products a company invest in the market. Some studies take the input-output efficiency of enterprise technology research and development as a measure of enterprise innovation performance. Some scholars consider the overall level of enterprise organization and believe that innovation performance refers to the investment of innovation resources, technological innovation, enterprise performance improvement and stimulating organization. Generally speaking, domestic and foreign scholars generally have three viewpoints on enterprise innovation performance: one is the ratio of input to output of technology research and development, and the efficiency ratio of investment in technological research and development to the efficiency of enterprise benefit output is used to

measure enterprise innovation performance; the second is technological innovation. The result is that the enterprise obtains new technology patents and develops new products through technological R&D innovation; the third is the whole process of stimulating organizational innovation thinking from the input of innovative resources, technological innovation and enterprise performance improvement. The financial benefits brought by technological innovation have a certain lag effect, and it is not even possible to determine a clear time point for the impact on financial performance.

From the perspective of innovation performance, for the related technology diversification strategy, the related technology diversification promotes the expansion of technology in the core areas, efficiently carries out innovation activities in the areas that you are more familiar with, and improves the conversion rate of technical knowledge. Investment improves innovation performance [22]. For the unrelated technology diversification strategy, the company conducts technology research and development innovation in non-core areas, which is convenient to break through technology lock-in, reduce the rigidity of core technology and the dependence on specific technology research and development routes, and improve the efficiency of technological innovation of enterprises; It expands the technological knowledge base of enterprises, increases the opportunities for enterprises to discover and excavate new technologies, disperses the risks of technological innovation, and improves the innovation performance of enterprises.

- Hypothesis 3: There is a positive relationship between related technology diversification and firm innovation performance.
- Hypothesis 4: Unrelated technological diversification is positively related to firm innovation performance.

## **4. RESEARCH DESIGN**

### ***4.1 Samples and Data Sources***

This paper selects the Shanghai and Shenzhen A-share listed manufacturing enterprises with relatively complete information disclosure as the research sample, and the data period of the research is 2015-2019. In order to ensure the integrity and validity of the selected data, this study made the following considerations when selecting samples: (1) It only selects manufacturing A-share

companies. (2) ST and \*ST companies are excluded because they are not of general significance due to their deteriorating financial situation. (3) Companies with missing financial data and other data are eliminated. (4) In this study, patent data distribution is used to measure the degree of technological diversification. The data lag period is one year, and enterprises with zero patent application amount during the data period are excluded.

The sample data comes from two databases: (1) State Intellectual Property Office (SIPO). This study retrieve the number of patents belonging to different categories of each company from the patent search and analysis system, and the patent classification is in accordance with the international IPC classification standard. (2) CSMAR database. It is used to obtain the basic information, financial data and R&D data of each listed company. The sample data in this paper are all from public platforms, so the data obtained are true and reliable. After screening, a total of 126 companies met the requirements, and 630 groups of balanced data of sample companies from 2015 to 2019 were selected for analysis, mainly using Excel and Stata16.0 software to complete the processing.

## 4.2 Variable Selection

### 4.2.1 Dependent Variable

After screening, this paper adopts ROA as a measure of firm financial performance, with a lag period of one year [23], which can more objectively represent financial performance. In this paper, the number of enterprise patent applications plus one to take the natural logarithm to measure innovation performance [24], the lag period is one year, which can more objectively represent innovation performance.

### 4.2.2 Independent Variables

In this paper, based on Rene's research experience and the technical classification standard in the Patent Query and Analysis System of the National Patent Office, the Herfindahl index (HHI) is used to calculate the technological diversification [25]. The top 4 of IPC sub-categories are expressed as enterprise-related technical fields, and the top 3 of IPC categories are unrelated technical fields. Formula (1) calculates technical diversification TD, formula (2) calculates unrelated technical diversification UTD, formula (3) measures the

related technology diversified RTD, and the calculation formula is as follows:

$$TD = 1 - \sum P_i^2 \quad (1)$$

$$UTD = 1 - \sum P_j^2 \quad (2)$$

$$RTD = TD - UTD \quad (3)$$

$P_i$  refers to the number of patents filed in a certain IPC subclass  $i$  as a percentage of the total number of patents filed by the company in the current year. Patents are classified according to the first four classification numbers of the IPC category;  $P_j$  refers to the proportion of the number of patents filed under a certain IPC category  $j$  to the number of all patents filed by the company in the current year. It is classified according to the top three classification numbers of the IPC sub-category. The larger the RTD value, the higher the degree of diversification of related technologies, and the larger the UTD, the higher the degree of diversification of unrelated technologies.

### 4.2.3 Control Variables

Referring to the research of related scholars, this paper takes the age of the enterprise, the scale of the enterprise, and the R&D intensity as the control variables of the research.

## 5. EMPIRICAL TESTS

### 5.1 Correlation Analysis

Correlation analysis was carried out on the variables studied in this paper, and the results are shown in "Table 1" below. ROA is positively correlated with P, and the correlation coefficient is 0.112, which shows that when the financial performance of the enterprise is relatively good, more funds will be invested in technological innovation, which is in line with common sense. P has a significant positive correlation with UTD, and the correlation coefficient is 0.146, which indicates that when enterprises start to diversify unrelated technologies, they will explore more fields and apply for more patents that are different from the previous types. Another significant correlation with P is the scale of the enterprise, and the correlation coefficient is 0.242. This is well understood. The larger an enterprise is, the more income it receives, the more talents and funds it will invest in technological research and development, which will help improve technological innovation capacity and promote innovation performance. RTD and UTD

are significantly negatively correlated, and the absolute value of the correlation coefficient is as high as 0.628. When an enterprise is diversifying related technologies, its research field is familiar with the direction before, and the types of research patents are relatively concentrated in a few categories. So its unrelated technology

diversification will be relatively lower. That is the reason why the two are significantly negatively correlated. UTD is positively related to the age of the enterprise and the scale of the enterprise. The older and larger the company, the more likely it is to expand its technology and product areas and take the path of diversified development.

Table 1. Variable correlation analysis

variable	mean	standard deviation	ROA	P	RTD	UTD	AGE	SIZE	R&D
ROA	0.039	0.050	1.000						
P	3.071	1.918	0.112 **	1.000					
RTD	0.094	0.082	0.100**	0.026	1.000				
UTD	0.764	0.153	-0.129***	0.146***	-0.628***	1.000			
AGE	18.071	4.896	-0.030	0.085*	-0.092*	0.171***	1.000		
SIZE	23.082	1.143	0.001	0.242***	-0.069	0.298 ***	0.268 ***	1.000	
R&D	0.051	0.039	-0.072 *	-0.043	0.136 ***	-0.071 *	-0.188 ***	-0.231 ***	1.000

a \*means p<0.1, \*\* means p<0.05, \*\*\* means p<0.01

## 5.2 Regression Analysis

This paper conducts regression analysis on panel data, and conducts Hausman test on the regression model to determine the choice of fixed-effect or random-effect model. The specific results are shown in "Table 2".

Model 1 is to test the relationship between financial performance (ROA) and control variables. The regression coefficient of R&D intensity (R&D) is -0.117 (t = -1.81), which is significant at the 10 % level, indicating that R&D intensity negatively affects corporate financial performance ROA. Model 2 is based on model 1 by adding independent variable related technology diversification RTD, and its regression coefficient is 0.074 (t = 3.07), which is significant at the 1% level, indicating that RTD positively affects ROA, so hypothesis H1 passes the significance test. Model 3 is based on model 1 by adding the independent variable unrelated technical diversification (UTD), and its regression coefficient is -0.035 (t = -2.64), which is significant at the 1% level, and the coefficient is negative, indicating that UTD negatively affects corporate performance, so hypothesis H2 passes the significance test. Model 4 is to test the total effect of independent variable RTD and UTD on ROA, the RTD regression coefficient is 0.056 (t = 1.82), at the level of 10 %. The regression coefficient of UTD is -0.016 (t = -0.94), which is not significant, indicating that RTD has a greater impact on corporate performance. Therefore, assumptions 1 and 2 hold.

Table 2. Regression analysis

variable	Financial Performance ROA				Innovation performance P			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
AGE	-0.088** ( -2.04 )	-0.073* ( -1.70 )	-0.070 ( -1.61 )	-0.069 ( -1.58 )	0.009 ( 0.87 )	0.011 ( 1.04 )	0.006 (0.56)	0.007 ( 0.62 )
SIZE	-0.079 ( -0.45 )	-0.091 ( -0.51 )	0.041 ( 0.22 )	-0.033 ( -0.18 )	0.485*** ( 10.79 )	0.483*** ( 10.77 )	0.462*** ( 9.99 )	0.426*** ( 9.06 )
R&D	-0.117* ( -1.81 )	-0.151** ( -2.32 )	-0.127** ( -2.00 )	-0.148** ( -2.26 )	0.067*** ( 4.17 )	0.063*** ( 3.85 )	0.069*** ( 4.29 )	0.059*** ( 3.66 )
RTD		0.074*** ( 3.07 )		0.056* ( 1.82 )		0.947* ( 1.82 )		2.74*** ( 3.56 )
UTD			-0.035*** ( -2.64 )	-0.016 ( -0.94 )			0.654* ( 1.93 )	1.60*** ( 3.75 )
R <sup>2</sup>	0.075	0.074	0.075	0.078	0.091	0.107	0.098	0.107
F	13.43 ***	10.07 ***	10.07 ***	8.04 ***	16.62 ***	14.87***	13.59***	11.90***
Hausman	18.94	20.88	20.78	21.04	60.48	62.12	66.17	68.25

a \*means p<0.1, \*\* means p<0.05, \*\*\* means p<0.01

Model 5 is to test the relationship between innovation performance (P) and control variables. The regression coefficient of enterprise scale SIZE is 0.485 (t = 10.79), which is significant at the 1% level, indicating that the larger the enterprise scale, the better its innovation performance. The regression coefficient of R&D is 0.067 (t = 4.17), which is significant at the 1% level, indicating that R&D intensity positively affects the innovation performance of enterprises. Model 6 introduces independent variable RTD on the basis of model 5, and its regression coefficient is 0.947 (t = 1.82), which is significant at the 10% level, indicating that related technology diversification positively affects enterprise innovation performance P. Therefore, it is assumed that H3 passes the significance test. Model 7 is based on model 5 by adding the independent variable UTD, and its regression coefficient is 0.654 (t = 1.93), which is significant at the 10% level, indicating that unrelated technological diversification positively affects enterprises Innovation performance P, so Hypothesis 4 passes the significance test. Model 8 is to test the total effect of independent variables RTD and UTD on enterprise innovation performance. The RTD regression coefficient is 2.74 (t= 3.56), which is significant at the 1% level. The UTD regression coefficient was 1.60 (t= 3.75), which was significant at the 1 % level. This shows that the overall effect of both is positively promoting enterprise innovation performance, but the related technology diversification has a greater

impact on enterprise innovation performance. Therefore, assumptions 3 and 4 hold.

## 6. CONCLUSION

This paper draws the following conclusions. First, there is a positive correlation between the diversification of related technologies and the financial performance of enterprises. There is a negative relationship between unrelated technology diversification and corporate financial performance. Related technology diversification means that enterprises implement diversification in core technology fields. Enterprises enhance the mutual coordination of multiple innovation activities, which brings knowledge spillover effects and promote corporate financial performance. If an enterprise wants to expand unrelated technical fields, it needs to invest a lot of time, talents and resources, which can easily make the enterprise fall into a quagmire. Enterprises invest resources in a field with unknown and uncertain benefits for a long time. With the increase of the degree of irrelevance, the cost will increase at a faster pace. If the degree of irrelevance diversification is too high, the cost of coordination and communication between departments will increase and the synergistic effect between technologies will be limited. Second, about innovation performance. Related technology diversification has a positive relationship with corporate innovation performance; Unrelated technology diversification has a positive relationship with corporate innovation performance.

For the innovation performance of an enterprise, the diversification of related technologies and the diversification of unrelated technologies are the exploration of technological capabilities of the enterprise. By increasing the investment of human capital and other various investments to improve its core technological capabilities and non-core technological capabilities, enterprises create competitive advantages, so it will improve the innovation performance of enterprises. The diversification of related technologies promotes the expansion of technologies in core areas, and efficiently carries out innovation activities in areas that are familiar to them. It also improves the conversion rate of technical knowledge, and improves innovation performance with lower investment. For the unrelated technology diversification strategy, the company conducts technology research and development innovation in non-core areas, which is convenient to break through technology lock-in, reduce the rigidity of core technology and the dependence on specific technology research and development routes. Besides, it improves the efficiency of technological innovation of enterprises, and help improve the innovation performance of enterprises.

There are two limitations in this paper. First, the sample factor. In order to strengthen the robustness of the results of this paper, future related research can expand the sample size to test and supplement this paper. Second, variable factor. There are still many mediating variables and contextual factors that affect the performance of enterprises by technological diversification. It is hoped that the following research can expand the related variables.

## AUTHORS' CONTRIBUTIONS

Yiyuan Zhang was responsible for research design, Jianxin Zhao analysed data, Guangjian Zhang wrote the manuscript, and Pengbin Gao contributed to revising and editing.

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