Impact of Mergers and Acquisitions on Innovation Performance in Listed Chinese Medicine Enterprise

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Abstract: Objective To provides a reference for the mergers and acquisitions activities of listed enterprises of Chinese medicine. Methods Taking listed Chinese medicine enterprise as the research object, the technical mergers and acquisitions occurred in 2010-2022 as the sample, proposed research assumptions based on literature research.. Subsequently, the empirical test was did on fixed effect model. Results The technical mergers and acquisitions had obvious promotion effect on the invention patents, sustainable inhibitory effect on the practical new patent, and no significant impact on the appearance patent and the total patent. Conclusion The technical mergers and acquisitions promoted the technological innovation of Chinese medicine enterprises. It was recommended that Chinese medicine enterprises should attach importance to the ability of integrating resources and the absorption of technical knowledge.

Keywords: Listed Chinese medicine enterprise; technical mergers and acquisitions; fixed effect model; innovation performance

1. Introduction

With the improvement of China's pharmaceutical R & D(research and development) innovation environment, the vitality of enterprise R & D innovation is increasing .Currently, the pharmaceutical industry in China faces increasingly strict regulatory policies and competition, with long drug development cycles, high risks, and escalating research and development costs. Pharmaceutical enterprises are experiencing growing pressure for growth. Concurrently, the active demonstration effect of domestic and international pharmaceutical industry mergers and acquisitions has increased the frequency and scale of such activities in China. In this context, mergers and acquisitions by Chinese medicine enterprises are also thriving. According to incomplete statistics, between 2010 and 2022, enterprises such as CR Sanjiu, Yunnan Baiyao, and Jilin Aodong, among others, carried out 35, 24, and 28 mergers and acquisitions, respectively. These mergers and acquisitions aimed to facilitate resource integration and strategic transformation to a certain extent. But did these mergers and acquisitions enhance the innovation performance of these enterprises?

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Research on the relationship between corporate mergers and acquisitions and innovation performance has achieved significant results. From major foreign studies, Ahuja and Katila (2001) conducted early research on the relationship between mergers and acquisitions and corporate innovation performance, suggesting that enhancing innovation capabilities is a critical motivation for enterprises to undertake mergers and acquisitions. Acquiring technological knowledge from target enterprises can enhance the acquiring enterprise's corporate value[1]-[2], particularly when acquiring innovative enterprises, which is an effective means[3] of acquiring technical knowledge. The impact of mergers and acquisitions on innovation performance is more pronounced[4] when the technical knowledge between enterprises is complementary. Geographic location also plays an important role[5] in the relationship between mergers and acquisitions and innovation performance. In the era of digital economy, acquiring digital technology enterprises can further drive innovation in the acquiring enterprise's digital technology[6]. In terms of domestic research, it has been found that mergers and acquisitions between enterprises with similar technologies and products in technology-driven mergers and acquisitions are more conducive to technical output[7]. Wang Wanqiu and others found from the perspectives of cross-border mergers and acquisitions and industry chain position that the maturity level of the acquiring enterprise, knowledge base, research and development investment, research and development collaboration capabilities, and financial resources have a significant promoting effect on innovation performance after mergers and acquisitions. Enterprises can acquire a complete set of patent technologies, product lines, or process flows through mergers and acquisitions, leading to breakthroughs in performance, appearance, functionality, and other aspects of new products[8].

Chinese medicine enterprises are a crucial component of China's pharmaceutical manufacturing industry. However, there is currently very limited research on the innovation performance of Chinese medicine enterprises resulting from mergers and acquisitions. This paper analyzes recent mergers and acquisitions by Chinese medicine enterprises and their technological innovation trends. It categorizes mergers and acquisitions into technical and non-technical types and empirically examines the impact of technical mergers and acquisitions on the innovation performance of Chinese medicine enterprises.

2. Research Design

2.1 Research Hypotheses

Sevilir and Tian (2012) found that mergers and acquisitions have a significant positive effect on a enterprise's future patent output level, individual patent citation counts, and subsequent innovation[9]. Xie Wei, Sun Zhongjuan, Li Peixin, and others (2011) examined mergers and acquisitions in the Chinese medicine industry and concluded that mergers within this industry, which share similar characteristics, have a higher success rate in converting acquired knowledge into technological innovation because of their shared goals[10]. Therefore, this paper proposes Hypothesis 1.

Hypothesis 1: Technical mergers and acquisitions promote the innovation performance of listed Chinese medicine enterprises.

Zhou Chengxiong et al. (2016) verified that, among 34 industries participating in mergers and acquisitions on the A-share market, enterprises experienced a significantly higher growth rate in innovation capability starting from the third year after the merger compared to those that did not participate in mergers and acquisitions, indicating a sustained impact of mergers and acquisitions on innovation performance[11]. Qi Ying et al. (2022) argued that the long-term impact of technical mergers and acquisitions on innovation performance arises from the internalization and absorption of technological resources acquired through mergers and acquisitions, a process that occurs over an extended period[12], which continuously strengthens a enterprise's long-term technological capabilities. Based on this, Hypothesis 2 is proposed.

Hypothesis 2: Technical mergers and acquisitions have a long-term impact on innovation performance.

2.2 Sample Selection and Data Sources

The Chinese medicine enterprises studied in this paper fall under the category of Pharmaceutical Manufacturing (C27) as per the "Guidelines for the Classification of Listed Enterprises" revised by the China Securities Regulatory Commission in 2012. Sample selection criteria are as follows: 1) The time frame is from January 1, 2010, to December 31, 2022; 2) Enterprises listed on the Shanghai and Shenzhen stock exchanges with A-shares in the Chinese medicine industry are included, while enterprises in circulation, delisted enterprises, and those not listed in 2010 are excluded; 3) Samples with missing data are excluded; 4) Mergers and acquisitions events involving listed Chinese medicine enterprises, including asset or equity acquisitions, are selected, and failed merger and acquisition events are excluded. Data sources: Patent data are sourced from the National Intellectual Property Administration's patent retrieval system, while financial and merger and acquisition data are obtained from corporate annual reports and relevant transaction announcements. The final sample size is 338.

2.3 Variable Measurement

2.3.1 Dependent Variable

Innovation performance is often measured through technological innovation, primarily focusing on the number of patents as an indicator, such as the number of patent applications and the number of patents held, to assess a enterprise's ability to absorb and innovate in technology. This paper uses the number of patents as the standard for measuring innovation performance. Considering that technological innovation after mergers and acquisitions takes time, this paper uses the number of patent applications in the year of the merger and the subsequent year (a total of two years) as the data for the dependent variable. Patent applications are further categorized into invention patent applications, utility model patent applications, design patent applications, and total patent applications.

2.3.2 Independent Variable

Based on the motives behind corporate mergers and acquisitions, two types of mergers and acquisitions are distinguished: technical mergers and acquisitions and non-technical mergers and acquisitions. Technical mergers and acquisitions are characterized by large enterprises acquiring small or medium-sized enterprises primarily for the purpose of gaining technological capabilities, or by acquiring enterprises aiming to absorb the technological resources of the

target enterprise[13], falling under the category of technology-driven mergers and acquisitions. Non-technical mergers and acquisitions, on the other hand, do not have the acquisition of technological knowledge and the improvement of technical expertise as their primary objective[14] ,or do not aim to acquire patents. To determine whether mergers and acquisitions by Chinese medicine enterprises fall into the category of technical mergers and acquisitions, the approach used by Wen Chengyu (2011) is applied, which employs two criteria: 1) Examination of merger and acquisition enterprise announcements, which mention the acquisition of knowledge assets such as technology, patents, new products, and technical talent; 2) Assessment of whether the target enterprise possessed patent technology within the five years prior to being acquired[15]. Meeting either of these criteria classifies the merger and acquisition as a technical merger and acquisition. If a technical merger and acquisition occurs, it is coded as 1; otherwise, it is coded as 0.

2.3.3 Control Variables

Following the practices[16-17], this paper uses profitability and enterprise market value as control variables. Profitability is represented by the annual total asset turnover of the acquiring enterprise. Enterprise market value is measured based on the market value of the acquiring enterprise for each year, using the market value on the last day of each year as the reference as shown in Table1.

Table 1: Conceptualization and Measurement of Variables in the Econometric Model

Variable Types	Variable Names	Variable Definitions	Variable data description
Dependent variable	NIP	invention patent application quantity	Natural logarithm of the annual number of invention patent applications + 1
	NUM	Number of Utility Model Patent Applications	Natural logarithm of the annual number of utility model patent applications + 1
	NAP	Number of Design Patent Applications	Natural logarithm of the annual number of design patent applications + 1
	TNP	Total Patent Applications	Natural logarithm of the annual total number of patent applications + 1
Independent Variable	TMA	Technical Mergers and Acquisitions	Binary variable indicating whether technical mergers and acquisitions occurred during the year, 1 for yes, 0 for no
Control Variables	MVF	Firm Size	Natural logarithm of the annual market value of the firm
	ROA	Profitability	Profit margin on total assets of the firm

Note: Total annual patent applications are the sum of invention patent applications, utility model patent applications, and design patent applications.

3. Empirical Study

3.1 Variable Stationarity Test

In this study, data stationarity tests were conducted for the dependent variable, independent variables, and control variables. Considering the nature of short panel balanced data, the IPS method was applied for panel unit root tests. The results indicate that all the variables, including the dependent variable, independent variables, and control variables, passed the 5% significance test, suggesting that the sample data is stationary.

3.2 Regression Analysis

Chinese medicine listed enterprises acquire target enterprises' resources through merger and acquisition activities and integrate these resources after the merger, reducing merger and acquisition risks and enhancing the scale of the enterprise's technological knowledge. This, in turn, strengthens the level of technological innovation. In this study, a panel fixed-effects model is employed to examine whether technical mergers and acquisitions by Chinese medicine listed enterprises result in positive technological innovation. Considering the lagged nature of patents relative to the research and development process, i.e., the number of patents in a given year is influenced by variables from the previous year or several previous years, the model is constructed as follows:

$$NIP_{i,t-n} = \alpha_1 + \beta_1 * TMA_{i,t-n} + \beta * Controls_{i,t-n} + \varepsilon_{it} \quad (1)$$

$$NUM_{i,t-n} = \alpha_1 + \beta_1 * TMA_{i,t-n} + \beta * Controls_{i,t-n} + \varepsilon_{it} \quad (2)$$

$$NAP_{i,t-n} = \alpha_1 + \beta_1 * TMA_{i,t-n} + \beta * Controls_{i,t-n} + \varepsilon_{it} \quad (3)$$

$$TNP_{i,t-n} = \alpha_1 + \beta_1 * TMA_{i,t-n} + \beta * Controls_{i,t-n} + \varepsilon_{it} \quad (4)$$

Where NIP represents the number of invention patents for Chinese medicine listed enterprises, NUM represents the number of utility model patents, NAP represents the number of design patents, TNP is the total number of patents for listed enterprises, TMA is a dummy variable representing merger and acquisition activities by Chinese medicine listed enterprises within the year, and Controls encompass a series of control variables for Chinese medicine listed enterprises during the year, including MVF (enterprise size) and ROA (profitability). N represents the lag period, with values of 1, 2, and 3.

Table 2 and Table 3 present the empirical results regarding the relationship between technical mergers and acquisitions and innovation. Controlling for annual effects, when N=1, the regression coefficient for technical mergers and acquisitions on invention patents is 0.297, significant at the 5% level. This indicates that merger and acquisition activities by Chinese medicine listed enterprises have a significant impact on invention patents. Examining the impact of technical mergers and acquisitions on utility model patents, when N=1, the regression coefficient is -0.131, significant at the 5% level, suggesting that technical mergers and acquisitions have a negative effect on utility model patents, hindering their generation. The influence of technical mergers and acquisitions on design patents and total patents is not significant, indicating that technical mergers and acquisitions do not affect design patents and total patents. From the perspective of corporate merger motives, Chinese medicine listed

enterprises pursue innovation through fundamental technological changes rather than alterations in product shape, structure, manufacturing methods, or appearance, and aim to enhance their technological capabilities in the short term. Therefore, mergers and acquisitions by Chinese medicine listed enterprises increase the number of invention patent applications, aligning with the fact that these enterprises introduce technology through mergers and acquisitions, thus validating Hypothesis 1.

When N=2 and N=3, representing lags of 2 and 3 periods, the impact of technical mergers and acquisitions on invention patents is not significant. This suggests that technical mergers and acquisitions do not have a long-term and sustained impact on invention patents for Chinese medicine listed enterprises. The technology introduced through mergers and acquisitions only enhances the technological capabilities of enterprises in the short term. To achieve long-term technological innovation and stable profit-generating capabilities, relying solely on merger and acquisition activities is insufficient. Examining the impact of technical mergers and acquisitions on utility model patents reveals that technical mergers and acquisitions suppress the number of utility model patents. This aligns with the motivation of Chinese medicine listed enterprises to pursue core technology through merger and acquisition activities, and this suppression effect persists over time, validating Hypothesis 2.

Table 2: Empirical Results of Technology-Oriented Mergers and Innovation(1)

dependent variable	NIP			NUM		
	N=1	N=2	N=3	N=1	N=2	N=3
TMAt-n	0.297** (0.133)	0.213 (0.141)	0.236 (0.145)	-0.131** (0.066)	-0.193*** (0.069)	-0.190** (0.075)
MVFt-n	0.209** (0.084)	0.226** (0.089)	0.214** (0.094)	0.117 (0.042)	0.125*** (0.044)	0.151*** (0.048)
ROAt-n	0.124 (0.102)	0.133 (0.111)	0.164 (0.122)	0.096 (0.051)	0.110** (0．055)	0.057 (0.063)

Note:*, ＊＊ and ＊＊＊ respectively indicate significance levels of 10%, 5%, and 1%. The numbers within parentheses represent standard errors.

Table 3: Empirical Results of Technology-based Mergers and Innovation(2)

dependent variable	NAP			TNP		
	N=1	N=2	N=3	N=1	N=2	N=3
TMAt-n	0.006 (0.102)	-0.108 (0.108)	0.006 (0.114)	0.152 (0.112)	0.027 (0.119)	0.095 (0.123)
MVFt-n	0.110* (0.064)	0.122* (0.069)	0.121 (0.074)	0.200*** (0.071)	0.216** (0.075)	0.220* (0.080)

ROAt-n	0.100	0.107	0.146	0.143*	0.154	0.170
	(0.078)	(0.085)	(0.095)	(0.086)	(0.093)	(0.103)

Note: *, * * and * * * respectively indicate significance levels of 10%, 5%, and 1%. The values within parentheses are standard errors.

4. Conclusion and Recommendations

This study, using merger and acquisition events involving Chinese medicine listed enterprises that occurred between 2010 and 2022 as samples, employed a panel data fixed effects model to examine the relationship between technical mergers and acquisitions and innovation performance of Chinese medicine enterprises. The following conclusions are drawn:

Firstly, innovation performance, measured by four indicators: the number of invention patents, utility model patents, design patents, and total patents, was found to be influenced differentially by technical mergers and acquisitions. Technical mergers and acquisitions have a significant positive effect on invention patents, a significant negative effect on utility model patents, and no significant impact on design patents and total patents.

Secondly, the innovation performance resulting from mergers and acquisitions exhibits a degree of sustainability. Technical mergers and acquisitions in the previous year continue to exert a suppressing effect on utility model patents.

Chinese medicine listed enterprises can stimulate short-term innovation in invention technology through technical mergers and acquisitions, which aligns with their acquisition objectives. However, technical mergers and acquisitions do not generate a sustained positive impact on technological innovation. Therefore, Chinese medicine listed enterprises should prioritize post-merger resource integration and the capacity to absorb technical knowledge, thereby creating synergistic effects for resource integration and absorption. Furthermore, they should seek merger targets that align with their development strategies and innovation directions.

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