Evaluating the Innovation Performance of Technology Mergers and Acquisitions in the Equipment Manufacturing Industry

Lu Huang[1], Yue Wang[1], Lining Shang[1], Ying Guo[1], Alan L. Porter[2,3]
[1]Beijing Institute of Technology, School of Management and Economics, Beijing - P.R.China
[2]Georgia Institute of Technology, Technology Policy & Assessment Ctr., School of Public Policy, Atlanta, GA - USA
[3]Search Technology, Inc., Norcross, GA - USA

Abstract--**Technology M&A has been an important way for companies acquiring knowledge resources to achieve rapid development externally, especially that aiming to obtain key technology capabilities. A big challenge that faces corporate managers and government policy makers is how to evaluate the innovation performance of post acquisition effectively. In this study, based on innovation process, we devise a method to evaluate the performance of the Tech M&A from the perspective of the technological innovation process, including R&D, patent and product sales. We present results in the numerical control machine tool industry in China.**

I. INTRODUCTION

Recently, more and more scholars believe that technology M&A (Tech M&A) has been an important way for companies acquiring knowledge resources to achieve rapid development externally [1,2,3]. Many world-class companies, especially those in the high technology industry, have leaped forward through M&A. Apple acquired fingerprint sensor maker AuthenTec and then added fingerprint recognition to the iPhone5S in 2013 [4]. The Chinese company Hanergy became the largest thin-film solar power company with the strongest technical expertise in the world after successfully making three acquisitions: in 2012, the German company Silbro, manufacturer of CIGS co-evaporation technology; and the US company MiaSolé, a CIGS module manufacturer; and in 2013, the US company GSE, a global leader in thin-film solar power manufacturing.

Since the 1980s, evaluating the performance of M&A has been a hot topic [5,6,7]. Throughout the 20th century, more and more scholars have focused on the performance of Tech M&A. Olimpia Meglio performed a systematic analysis of the literature on M&A performance evaluation and Tech M&A performance evaluation respectively. Meglio investigated how researchers measured acquisition performance, basing her research on papers selected from the top management and organization journals in the US and Europe. The results showed that, in the period of 1990-1999, only 21.45% of the papers on M&A performance studied Tech M&A performance, but the rate increased to 61.25% during 2000-2008 [8,9].

There are three main aspects in the research of Tech M&A performance: accounting performance [10], market-based performance [11] and innovation performance [12]. Studies could be divided into three stages:

In the first stage, scholars found that after acquiring small technology-based firms, the acquirer developed significantly faster than before [13].

In the second stage, researchers began to evaluate the performance of M&A, mainly from the perspective of finance. Scholars used multi-dimensional indexes and chose various time frames to evaluate the acquisition performance [14,15]. Some evidence suggested that shareholders of target firms derived significant value from acquisitions, but the value that shareholders of acquiring firms achieved from acquisitions was decidedly mixed [3,16].

Now at the third stage, the innovation performance evaluation, researchers' studies concentrate on the innovation performance or the technological performance, but most focus on examining the relationship between acquisitions and performance. Hitt et al. researched 191 acquisitions completed from 1970 to 1986 and found that acquisitions had negative effects on "R&D intensity" and "patent intensity" because of the rare presence of synergy and situations where executives may have traded investments in acquisitions for investments in internal R&D [17]. Ahuja et al. developed a framework relating acquisitions to a firm's innovation performance and discovered that, within technological acquisitions, the absolute size of the acquired knowledge base enhanced innovation performance while the relative size of the acquired knowledge base reduced innovation output. The relatedness of acquired and acquiring knowledge bases had a nonlinear impact on innovation output [12]. Lin tested an acquisition–learning–innovation framework and found that unrelated acquisitions also enhanced exploration in an era of technology fermentation [18]. Some studies examined the effect of acquisition on new products [19，20]. Research at this stage mainly focuses on the impact of M&A on firms' innovation, such as R&D, patent, knowledge transfer and process. The conclusions are variable. Some scholars attribute the inconsistent results to the different performance construct measurements and the fact that different areas have different characteristics [21，22].

Currently, China is an important part of the world M&A market. Since 2011, China has been second only to the United States as the largest market of M&A, accounting for 7.5% of the global total transactions value (Source: Thomson Financial, IMAA). Tech M&A has been the most significant part of the Chinese M&A market. In this paper, we seek to devise a whole process method to evaluate the performance of Tech M&A mainly from the perspective of the technological innovation process. We present the results in the field of numerical control machine tools in China, a core industry of equipment manufacturing.

II. CHALLENGES

Innovative performance, in its broader definition, is a process, as it encompasses outcomes from the conception of an idea all the way down to the introduction of an invention into the market. Innovative performance of M&A reflects the long-term gains through the invention of new process- and product-related technologies. These new technologies can eventually lead to improved profitability for companies if they are transformed into actual innovations. Also, as innovation performance is under the influence of various factors, it is difficult to define the innovation performance made by tech acquisition. A big challenge that faces corporate managers and government policy makers is how to evaluate the innovation performance of post acquisition effectively.

We base our research on the following driving questions:

1. What is the innovation performance of Tech M&A? How do we define and evaluate the innovation performance made by tech acquisition?
2. What observable measures can be used to define innovation performance? One aspect only, such as R&D or patent, can't fully reflect innovation, so how do we use multi-dimensional indexes to evaluate innovation performance?
3. How do we use a quantitative method to measure the innovation performance of Tech M&A rather than just a subjective appraisal? What factors mainly impact the innovation performance of acquiring firms?

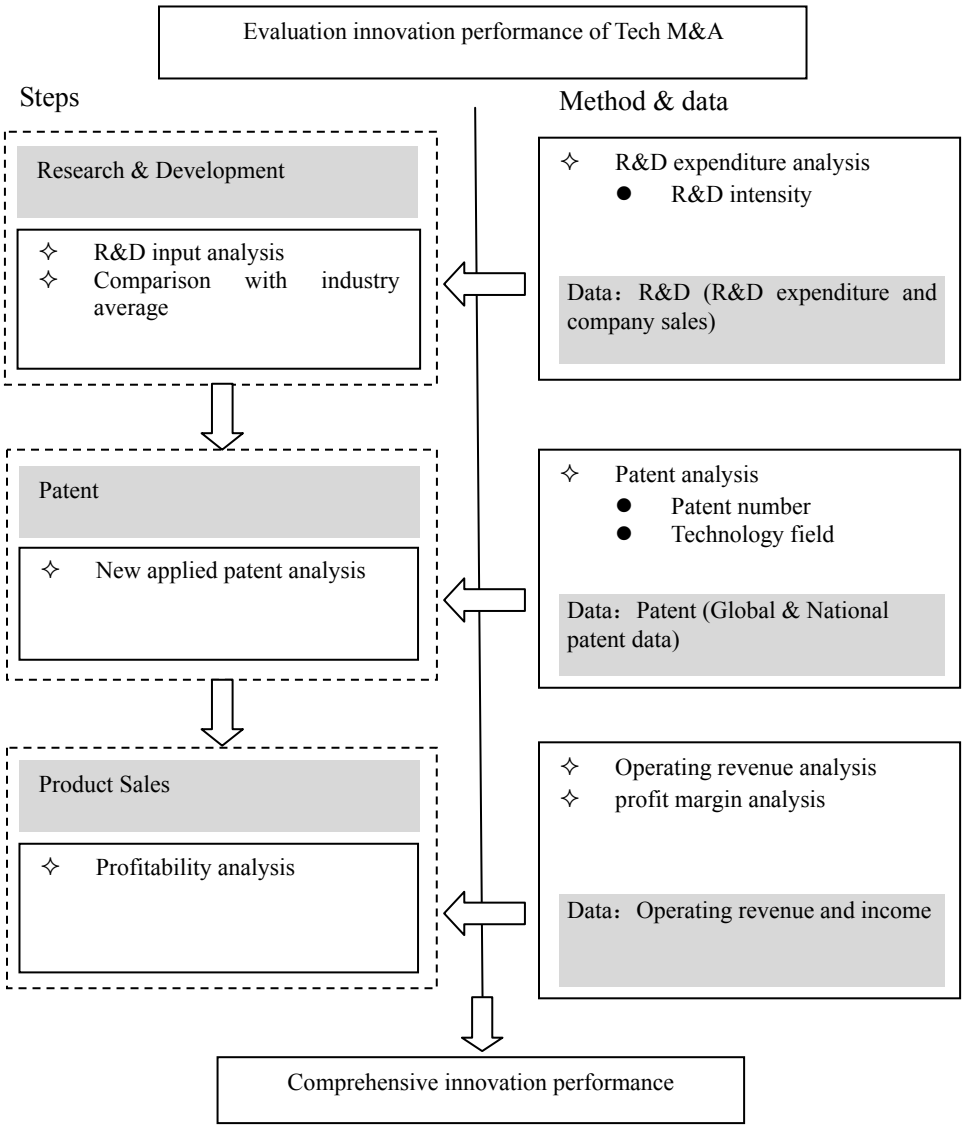

Fig. 1. Tech M&A Innovation Performance Evaluation Process

In this study, we devise a method for dividing the innovation process into three stages to evaluate M&A performance, focusing on R&D, patent and operating revenue. Figure 1 shows the process.

Step 1: Research & Development——The purpose of this step is to evaluate the R&D input performance of acquiring companies after M&A, which can be viewed as the first stage of innovation. First, R&D intensity analysis is used to analyze R&D expenditure intensity before and after M&A. Second, the R&D intensity of the acquirers is compared with the industry average to identify if they really increase investments in R&D.

Step 2: Patent——In step 2, patent analysis is used to evaluate the technology performance after M&A, which is frequently used as a valid indication of innovation. First, we analyze on a yearly basis the new applied patent numbers before and after M&A. Second, we measure the technology field of the acquirers to analyze if they have enforced their core technology or have entered into new technology fields through Tech M&A.

Step 3: Product Sales——When the new technologies transform into actual innovations, they can bring profits. In this step, profitability analysis is used to analyze the product performance made by the tech acquisition. First, we use operating revenue to analyze the product sales before and after M&A. Second, we measure the operating profit margin to reflect the profitability of the acquirers.

III. METHOD

In this study, we try to evaluate the innovation performance of Tech M&A in the numerical control machine tool (NCMT) industry in China by basing our research on the innovation process. We begin by searching commercial databases to find the listed companies in NCMT (Chinaventure, Wind, BVD etc). Eventually, we identify 42 companies in this industry. Among them, 39 companies are listed in China; 1 is listed in Singapore and 2 are listed in "Chinese new sanban". After searching the companies' M&A deals, we find that 30 companies are involved in M&A. 24 companies have made acquisitions in the years 2008-2012, acting as acquirers in those deals; the other 6 have been acquired by other companies as targets. Furthermore, we use two criteria based on Ahuja's theory to distinguish Tech M&A—acquisitions in which technology is a component of the acquired firm's assets—from all other acquisitions. First, we examine the news stories to establish if the acquiring firm reported technology as a motivating factor for the acquisition or if technology was a part of the transferred assets. We classify the acquisition as technological if either of these conditions is met. Second, we classify the acquisition as technological if the acquired firm has any patenting activity in the five years preceding the acquisition [12].

The goal of this research is to discover how Chinese companies successfully improve their innovation capability through Tech M&A. Therefore, our first criterion is to only focus on cases of successful M&A, both in terms of innovation and financial performance. Moreover, because the R&D data of Chinese listed companies is not published before 2007, and because it takes at least two years for the effects of Tech M&A on innovation to appear [23], we study just the M&A deals conducted in 2010 so as to compare the two years before and after M&A. Additionally, in order to make sure the effect on the innovation is from a single, specific M&A, the transaction should be the only Tech M&A conducted by the acquirer during the time investigated. Based on the three criteria mentioned above, four transactions are selected. We then develop datasets for R&D, patent and product sales in the years 2008-2012. R&D and new product sales data are obtained from annual reports and official websites; patents data are selected from the State Intellectual Property Office of the P.R.C (SIPO) and Derwent World Patents Index (WPI).

Tech M&A has gained importance as a strategy for enterprise development. Because of continuous product development and updates, many enterprises choose to acquire a company to obtain new technology. However, whether they achieve this goal or not is unclear. We believe that evaluating the innovation performance of acquiring companies will be helpful in formulating the Tech M&A strategy and managing the integration process after M&A. In this paper, we study the R&D intensity, patent and product sales after M&A to evaluate innovation performance of Tech M&A and find the main factors affecting the innovation performance. We structure the research in the following steps:

(1) First, we analyze the development of Tech M&A in the NCMT industry in China and select four cases. Through similarity and complementarity analysis, we classify the cases into different types based on the patents and products data. All in all, this step leads us to identify the characteristics of the four cases.
(2) Second, we analyze the innovation performance, including R&D, patent and product sales. R&D intensity is used to analyze the investment in the technology innovation of the acquirer after M&A. Patent is the direct indicator of innovation output, so we analyze the new applied patent numbers and the patent technology field after M&A. Furthermore, we use the product sales of the acquirer to analyze whether the innovations have been transformed into real profits.

IV. RESULTS

A. Trends and Cases

Our analysis begins by examining the trajectory of M&A deals in the NCMT industry from 2004 to 2012. From Fig. 2 we can conclude that the growth trend can be divided into three stages. During the first stage, from 2004 to 2006, a small number of M&A deals appear. Since 2004 the "National Medium and Long-Term Educational Reform and Development Program (2010-2020)" has issued a series of policy measures and special plans for scientific research to

improve research activities in technology for the machine tool industry. Then "Certain Suggestions of State Council on Supporting Promotion and Development of the Equipment Manufacturing Industry" (2006) pointed out that the development of the machine control tool industry should be given priority in the equipment manufacturing industry. The state established "The Special Planning for the Development of CNC Machine Tool Industry" in 2007. A steep incline in M&A deals occurs from this year forward, and, at this stage, the M&A deals maintain steady development. "Key Project Guide for High-End CNC Machine Tools and Basic Manufacturing Equipment" (2009) claimed an increasing development of CNC machine tools was required for the key industries. In 2010, the state published more policies for tax benefits and financial support to develop the CNC machine tool industry. Another rapid growth in M&A deals occurs in 2010 and maintains steady development. From the foregoing observations, we can easily conclude that Tech M&A has become a hotspot in the development of the numerical control machine tool industry in recent years.

In order to compare the innovation performance before and after M&A, we study the deals that occurred in 2010. At the same time, to make sure the effect on the innovation is coming from a single, specific M&A, the transactions should be the only Tech M&A conducted by the acquirers during 2008-2012. Table 1 lists the 24 companies' successful M&A transactions from 2008-2012. According to the above criteria, four cases are selected: Tianma Bearing Group Co., Ltd., Mesnac Co., Ltd., Siasun Robot & Automation Co., Ltd. and Shandong Weida Machinery Co., Ltd (see in Table 2).

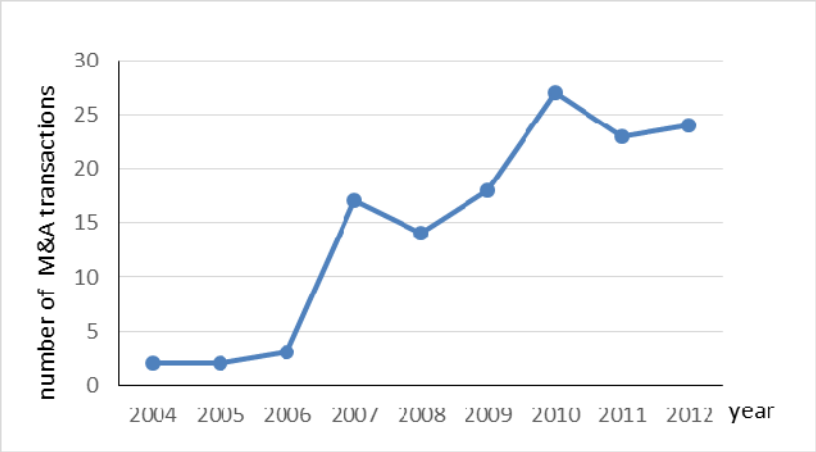

Fig. 2. Growth of Tech M&A Transactions in Numerical Control Machine Tool Industry

TABLE 1. TECH M&A TRANSACTION NUMBER DURING 2008-2010

Companies	2008	2009	2010	2011	2012
Hunan Valin Steel Co., Ltd.	3	1	1	3	3
Shenyang Machine Tool Co., Ltd.	2	4	1	3	2
China Erzhong Group (Deyang) Heavy Industries Co., Ltd.	0	1	0	1	1
Guangdong Dongyangguang Aluminum Co., Ltd.	0	1	2	0	3
Tianma Bearing Group Co., Ltd.	1	1	1	0	0
Huagong Tech Company Limited.	1	4	5	1	1
Mesnac Co., Ltd.	0	1	1	0	0
Shaanxi Qinchuan Machinery Development Co., Ltd.	1	1	2	2	0
Suzhou Victory Precision Manufacture Co., Ltd.	0	0	1	0	2
TONTEC Technology Investment Group Co., Ltd.	0	1	2	3	0
Zhe Jiang Kangsheng Co., Ltd.	0	0	3	0	1
Xuchang Yuandong Drive Shaft Co., Ltd.	0	0	0	1	1
Zhejiang Jinggong Science & Technology Co., Ltd.	2	0	1	0	0
Suzhou Dongshan Precision Manufacturing Co., Ltd.	0	0	4	1	1
Tianjin Motor Dies Co., Ltd.	0	1	0	1	1
Weihai Huadong Automation Co., Ltd.	1	0	0	0	0
Shenzhen Riland Industry Co., Ltd.	0	0	0	1	1
Siasun Robot & Automation Co., Ltd.	0	0	1	1	0
Shandong Weida Machinery Co., Ltd.	1	0	1	0	0
Shanghai KEN Tools Co., Ltd.	0	2	0	1	0
Wuhan Huazhong Numerical Control Co., Ltd.	0	0	0	4	1
Shandong Fin CNC Machine Co., Ltd.	1	0	0	0	3
Tongling Zonfa Trinity Technology Co., Ltd.	1	0	1	0	2
Dalian Zhiyun Automation Co., Ltd.	0	0	1	0	1

Though there is more than one Tech M&A transaction in each of these cases, the other acquisitions have little impact on the innovation performance. So, we still suppose the effect on the innovation is from the single, specific M&A in 2010. In case 1, MESNAC, a non-state enterprise, acquired 80% stock rights of Qingdao KeJie with 7.2 million in 2010. Though it acquired Dalian TianSheng in 2009 as well, the trade premium was very low. We suppose it has little effect on the innovation performance. In case 2, in order to develop the servo system (an important part of the NCMT industry), SIASUN invested 6 million in ShengHui CeKong and got 66.67% stock right. It also made another investment in 2011, but the stock right was too small to affect the innovation performance. In case 3, TIANMA acquired Qizhong ShuKong gradually from 2008 to 2010, a company that was the top enterprise in the numerical control system field. In case 4, WEIDA bought BaiCheng DianQi to acquire core technology in high-quality switch. The acquisition in 2008 was just a subsidiary listing of the WEIDA group.

Literature on innovation performance of Tech M&A suggested that strategic fit is an important factor driving the improvement of companies' innovation performance [3,12,24]. The strategic fit refers to relatedness, including technology relatedness and market or product relatedness. Quantitative research on technology relatedness is quite absent from the literature [25,26]. We apply Makri's theory and measurements in this paper. Technology relatedness involves technology similarity and technology complementarity. Technology similarity describes the degree to which the technological problem solving of two companies focuses on similar, narrowly defined areas of knowledge. Technology complementarity means to which degree the technological problem solving of the two companies focuses on different, narrowly defined areas of knowledge within a broadly defined area of shared knowledge. More importantly, to maximize benefits from Tech M&A, an adequate degree of technology relatedness needs to be measured [25].

The measures of technology similarity and complementarity are described as follows:

(1) Technology similarity:

$$\frac{\text{overlap all patent classes}}{\text{total patents A\&}T} \times \frac{\text{total A patents in common classes}}{\text{total A patents}}$$

A: acquirer T: target

(2) Technology complementarity:

$$\frac{\text{overlap all patent subcategories}}{\text{total patents A\&}T} - \left(\frac{\text{overlap all patent classes}}{\text{total patents A\&}T} \times \frac{\text{total A patent subcategories}}{\text{total A patents}}\right)$$

We use international patent classification (IPC) codes to measure technology relatedness. First, we want to illustrate technology similarity and complementarity with the help of IPC classes. For example, assume the IPCs of patents A, B, and C are B23Q19/05, B23Q19/18, and B23Q23/02. Patent A and patent B can be said to represent technology similarity as they are under the same subcategory: B23Q19. Meanwhile, patent A and patent C are from different subcategories, which demonstrates technology complementarity. Here we define B23 as a class and B23Q19 as a subcategory. In this way, we separately calculate the technology relatedness between the acquirer and the target in each of the four cases. The results are shown in Table 3.

According to literature on patterns of industrial innovation, different principal activities generate different technological trajectories [27,28]. While the NCMT industry belongs to the Production Intensive industry, product is one of the important factors affecting innovation patterns. In the cases presented in this paper, we also analyze the product relatedness of the acquirers and the targets. Product relatedness involves product similarity and product complementarity. Vertical M&A is viewed as product complementary and horizontal M&A is viewed as product similar. Table 4 classifies the technology and product relatedness for each of the cases. In case 4, although the technology similarity and technology complementarity are 0, the research fields of the acquirer and the target are all related to the production chain of numerical control machine tool, so we identify the relationship as technology complementary.

TABLE 2. FOUR SELECTED CASES

NO	Stock symbol	Company name	Company code	Found date	Size (number of employees)	Tech M&A (yuan)	Remarks	Motive of acquisition
1	002073	MESNAC CO., LTD.	MESNAC	2000.04.04	3105	Acquired 80% stock rights of Qingdao KeJie 7.2 million	Acquired Dalian TianSheng in 2009, but the trade is very little	To raise the automation level of enterprise and processing capacity of automation equipment by acquiring automatic technology of robots.
2	300024	SIASUN ROBOT & AUTOMATION CO.,LTD	SIASUN	2000.04.30	815	Invested 6 million in ShengHui CeKong and got 66.67% stock rights 6 million	Bought 4.29% stock rights of Xintai DianQi in 2011, but the deal has little effect on the innovation performance	To develop the servo system techniques (an important part of the numerical control tool industry).
3	002122	TIANMA BEARING GROUP CO., LTD.	TIANMA	2002.11.18	11018	Acquired Qizhong ShuKong gradually from 2008 to 2010 1.2 billion	Invested in the same company during 2008-2010	To combine the bearing and machine tool technology, make them interact with each other positively and diversify the product line.
4	002026	SHANDONG WEIDA MACHINERY CO., LTD.	WEIDA	1998.07.08	2122	Acquired BaiCheng DianQi 20 million	Acquired WEIDA cutting tool in 2008, but it is just listing subsidiary of the WEIDA group	To acquire the technology and intellectual properties in the design and manufacture of high-end switch from the target and develop industry chain

TABLE 3. ACQUIRER AND TARGET PATENT ACTIVITY

Case	Acquirer patents	Target patents	Technology similarity	Technology complementarity
1	192	2	0.000537	0.001302
2	82	1	0.002351	0.008710
3	57	69	0.000557	0.007380
4	107	14	0	0

TABLE 4. CLASSIFICATION OF CASE STUDIES

Case	Technology Relatedness	Product Relatedness
1	Similar The research fields of the buyer and the target are equipment automation and automatic system, which are mainly used to produce equipment and molds. Acquisition enforces buyer's technologies in mechanical automation.	Complementary Acquirer: rubber equipment, chemical equipment and batching system Target: robotic hand and its accessories, robot and robot system To raise the automation level of enterprise and processing capacity of automation equipment by acquiring automatic technology of robots.
2	Similar The buyer and the target are both involved in numerical control system; their technologies are mainly used to produce high-end CNC machine tools, electro mobile and elevator. Acquisition strengthens the technologies in numerical control system.	Similar Acquirer: industrial robot, automatic production line of assembling and testing, automatic logistics and storage equipment Target: servo driving controller and servo motor system To improve the intelligence level of numerical control system and the pieces of equipment by using servo control technology.
3	Complementary Different research fields: The target's field concentrates on machine tool and automation control. The buyer's field focuses on precision manufacturing of bearing. Acquisition broadens upstream technologies and improves the capacity of production of automation equipment.	Similar Acquirer: machine manufacturing industry including machine tool, bearing and round steel Target: numerical control machine tool To improve the capacity of acquirer in precision manufacturing of bearing and machine tool.
4	Complementary Different research fields: The target's technology is mainly on electric switch and relay and the buyer's is on turning and boring technologies. Acquisition broadens upstream technologies and high-quality switch technologies.	Complementary Acquirer: accessories of machine tools such as saw blade, band-saw blade and chuck Target: mechanical and electrical equipment and electronic switch To expand businesses in electric tool industry through acquisition.

B. R&D

Literature on the effects of Tech M&A on the post-acquisition R&D investment of the acquirer is mixed. Hitt et al. (1991) argued that managers tended to forgo other investment opportunities, mostly R&D projects, given the limited resources remaining for managerial allocation. Thus, firms may substitute innovation for acquisitions. The authors support this argument by analyzing data from a sample of 191 US M&A events showing a negative relationship between M&A and R&D input [17]. Veugelers and Cassiman (2005) argued that R&D input may decrease after M&A because of the elimination of duplicated R&D, but it may increase due to the fact that economies of scale and/or scope in R&D may be achieved after M&A, which motivates firms to perform more R&D projects [24].

In this paper, we analyze the effects on post-acquisition investment in R&D in the Chinese NCMT industry. Table 5 shows Tech M&A knowledge base combinations and their effects on post-acquisition investment in R&D. The results indicate that the R&D expenditure of the acquirer increases after M&A as a whole. Considering the size of different companies, we calculate the acquirer's R&D intensity (R&D expenditure divided by sales) and compare it with the industry average. Table 6 shows the results. For further analysis, we find that when the product of the acquirer and target is similar, the acquirer increases investment in R&D in 2010 and decreases R&D investment after M&A. This can be seen for the acquirer SIASUN in case 2 and TIANMA in case 3. However, when product is complementary, the acquirer decreases investment in R&D in 2010 and increases R&D investment after M&A This can be seen for the acquirer MESNAC in case 1 and WEIDA in case 4. We can see the development trend in Fig 3. In all, product relatedness has a more significant effect on post-acquisition investment in R&D than technology relatedness. And the R&D intensity after M&A is evidently higher than the industry average in acquisitions of complementary product, while in acquisitions of similar product, the R&D intensity two years after M&A is not significantly different.

TABLE 5. TECH M&A KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON POST-ACQUISITION INVESTMENT IN R&D

Case	Relatedness		R&D expenditure of acquirer（million yuan）				
	Technology	Product	2008	2009	2010	2011	2012
1	similar	complementary	406.51	598.23	572.59	750.22	1342.29
2	similar	similar	161.49	165.28	251.12	339.62	371.36
3	complementary	similar	1546.42	764.96	1078.42	452.61	846.71
4	complementary	complementary	121.79	140.40	149.56	219.86	291.16

TABLE 6. TECH M&A KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON POST-ACQUISITION R&D INTENSITY

Case	Relatedness		R&D intensity of acquirer				
	Technology	Product	2008	2009	2010	2011	2012
1	similar	complementary	4.45%	5.30%	3.82%	3.93%	8.29%
2	similar	similar	4.17%	3.54%	4.55%	4.33%	3.56%
3	complementary	similar	4.87%	2.35%	3.01%	1.46%	3.38%
4	complementary	complementary	3.23%	3.92%	3.41%	3.43%	4.51%
	Industry average		2.32%	2.49%	2.41%	3.12%	4.11%

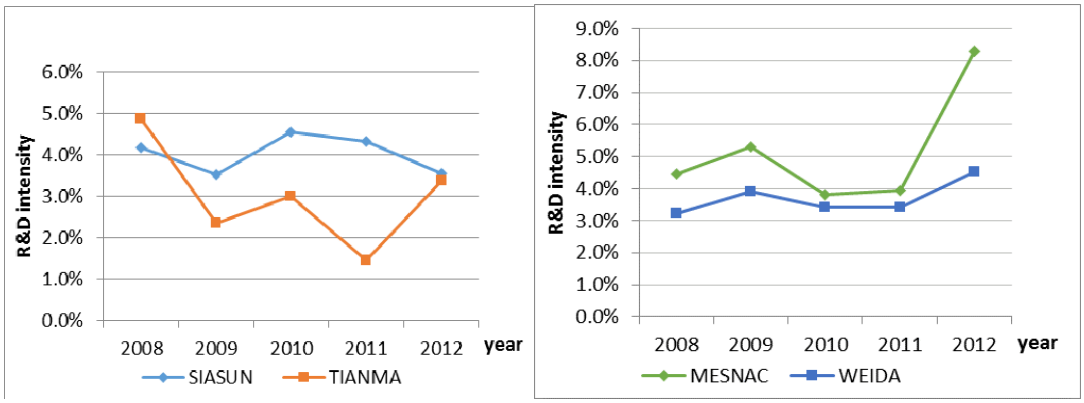

Fig. 3. Development Trend of R&D Intensity after M&A

C. Patents

Though Hitt et al. (1991) found a negative relationship between firms' acquisitions and R&D output (patent intensity measured by number of patents divided by sales) [17], most studies [12,29], which also focused on the impacts of M&A on patents, found a positive relationship between M&A and patents. From the previous literature we can see that M&A events could have either positive or negative impacts on innovation. The result depends on the specific knowledge base context and the way in which firms manage M&A.

In this paper, we also analyze Tech M&A knowledge base combinations and their effects on patents activity in the Chinese NCMT industry. Table 7 shows the results. We find that the number of new applied patents of the acquirer increased in 2010 and decreased after M&A in case 1 and case 2, while the other two cases are just the opposite. MESNAC's patents in case 1 are focused on B29D30, the technology field, before and after M&A; SIASUN's patents, in case 2, are focused on B25, mechanical arm, which is an important part of the machine tool industry. However, in case 3, TIANMA applied more patents in B23, which are used for machine tool; in case 4, WEIDA first applied a patent in G05B19 after M&A, which was applied on numerical control system (the core technology of numerical control tool). In conclusion, acquisitions of similar technology can help companies continue ongoing research activities, allowing them to apply more patents in a short time. Acquisitions of complementary technology can lead acquirers to enter new technology fields and provide technological diversification that is helpful to keep up with rapid technological development; though the patent activity is impaired in the acquisition year, it will be strengthened after the Tech M&A.

TABLE 7. TECH M&A KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON PATENTS ACTIVITY

Case	Relatedness		Patent activity of acquirer				
	Technology	Product	2008	2009	2010	2011	2012
1	similar	complementary	69	51	54	52	30
2	similar	similar	23	14	42	26	86
3	complementary	similar	11	12	10	11	14
4	complementary	complementary	2	9	4	1	7
	Industry average		15.25	20.54	22.04	23.75	15.25

D. Product Sales

When the new technologies are transformed into actual innovations, they can bring profits. Profitability analysis is used to show the product performance made by tech acquisition. We analyze the operating revenue of acquirers. Table 8 shows the results. The revenue of acquirers increases in the acquisition year and varies after M&A. In Fig. 4, the revenues of MESNAC, in case 1, and TIANMA, in case 3, show a sharp decline after M&A. However, SIASUN, in case 2, shows rapid growth after M&A, and WEIDA maintains steady development.

In order to analyze the profitability of acquirers, we show the operating profit margins in Table 9. We can see that in cases 1, 2 and 3 the operating margins increase in 2010 and then decrease after M&A, while the operating margins of case 4 keep growing within the period investigated. In addition, because of the depression of the downstream industry, the profits decline sharply in 2012. In conclusion, we find that when the technology and product are both similar or both complementary in acquisition, the sales of the acquirer keep increasing after the Tech M&A; acquisitions combining similar technology with complementary product or similar product with complementary technology have a negative impact on profitability.

By combining the three parts, we can classify the Tech M&A cases into four types. The results are shown in Table 10. **Technology- and products-updating:** after combining similar knowledge bases, the acquirer immediately increases investments in R&D and patent activity and then uses enforced technology to update products. **Products-enhancing:** in this acquisition, the acquirer reduces duplicate R&D investment and diversifies the product line through complementary product. **Technology-enhancing:** the acquirer enters a new technology field through complementary technology and then increases R&D investment in the core technology field. **Technology- and products-enhancing:** by learning from the target's complementary technology and product, the acquirer increases investment in R&D to enhance technology and products, and the sales keep growing.

TABLE 8. TECH M&A KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON OPERATING REVENUE

Case	Relatedness		operating revenue of acquirer（billion yuan）				
	Technology	Product	2008	2009	2010	2011	2012
1	similar	complementary	9.12	11.28	15.00	22.15	16.19
2	similar	similar	3.87	4.66	5.52	7.84	10.44
3	complementary	similar	31.75	32.62	35.83	30.99	25.04
4	complementary	complementary	3.85	3.85	4.82	6.40	6.45

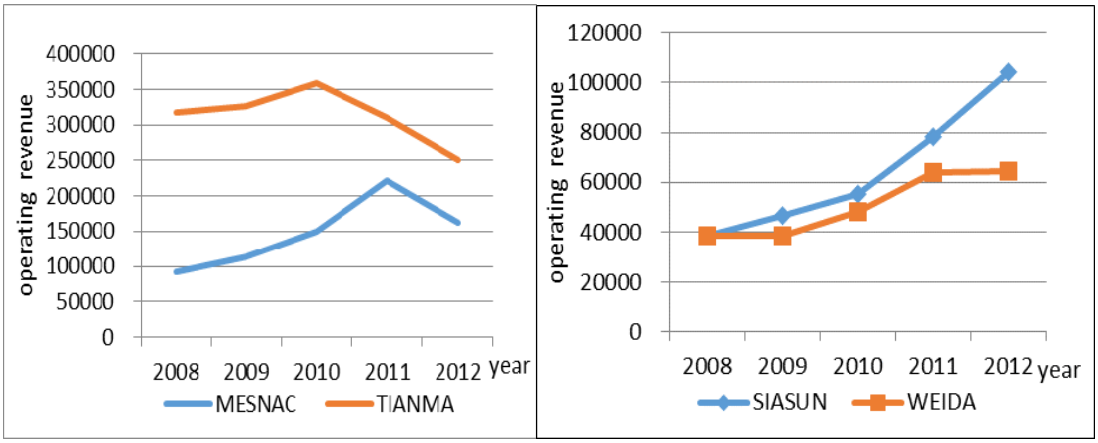

Fig. 4 Develop Trends of Operating Revenue after M&A (Ten Thousand Yuan)

TABLE 9. TECH M&A KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON PROFITABILITY

Case	Relatedness		profit margin of acquirer				
	Technology	Product	2008	2009	2010	2011	2012
1	similar	complementary	21.02%	23.22%	24.03%	23.56%	8.48%
2	similar	similar	11.18%	15.17%	17.51%	16.01%	14.19%
3	complementary	similar	19.08%	19.15%	20.73%	15.20%	8.33%
4	complementary	complementary	8.75%	9.39%	10.55%	11.27%	11.20%

TABLE 10. KNOWLEDGE BASE COMBINATIONS AND EFFECTS ON POST-ACQUISITION INNOVATION PERFORMANCE

Technoloy	Product	
	Similar	complementary
similar	**Technology- and products-updating** R&D intensity and patents activity first increase and then decrease; Product sales keep growing	**Products-enhancing** R&D intensity first decreases and then increases; Patents activity and product sales first increase and then decrease
complementary	**Technology-enhancing** R&D intensity and product sales first decrease and then increase; Patents activity firstly increase and then decrease	**Technology- and products-enhancing** R&D intensity and patents activity first decrease and then increase; Product sales keep growing

V. CONCLUSIONS

This paper provides a method, based on innovation process, to evaluate the innovation performance of Tech M&A. We take the numerical control machine tool industry as an example. The paper follows technology relatedness and product relatedness methods and outlines the R&D intensity, patents and profitability analysis process.

This study has a few limitations. Some doubt remains regarding the reliability of patent data. Sometimes patent data cannot reflect the core technology of a company because some patent-based indicators could be obscured by strategic behaviour, which means sometimes an emerging technology is not yet permitted for patenting. Another limitation is the extent to which this framework may be applicable to other industries, especially other product-intensive sectors such as other machinery and instruments industries. Firms in these sectors also have complex knowledge bases and products requiring integration across disciplines and functional areas of expertise. Within these limitations, the paper seeks to analyze the characteristics of Tech M&A with technology similarity/complementariy and examine the innovation performance from the view of R&D, patents and profitability.

The R&D analysis results suggest that the acquirer's R&D expenditure increases after M&A, but R&D intensity is different. Compared with technology relatedness, product relatedness has a more significant effect on post-acquisition R&D investment. In acquisition of similar product, R&D intensity increases in the acquiring year and then decreases after M&A. However, when product is complementary, the acquirer's R&D intensity decreases in the acquiring year and increases after M&A. In addition, the R&D intensity after M&A is evidently higher than the industry average in acquisition of complementary product, while in the acquisition of similar product, the R&D intensity two years after M&A is not significantly different from before.

We then examine the patent activity and technology field after Tech M&A. As shown, acquisitions of similar technology can help companies continue ongoing research activities, so they apply more patents in a short time. Acquisitions of complementary technology can lead acquirers to enter new technology fields and patents in new and core technology fields are applied. Though the patent activity is impaired in the acquisition year, it is strengthened after the Tech M&A.

At the same time, we also analyze the effect on post-acquisition product sales. The results show that when technology and product are both similar or are both complementary in acquisition, the sales of the acquirers keep increasing after the Tech M&A; acquisitions combining similar technology with complementary product or similar product with complementary technology have a negative impact on profitability.

In conclusion, we can classify the Tech M&A cases into four types. Technology- and products-updating: after combining similar technology and products, the acquirer immediately increases investments in R&D and patent activity and then uses enforced technology to update products. Products-enhancing: after acquiring complementary product and similar technology, the acquirer reduces duplicate R&D investment and diversifies the product line through complementary product. Technology-enhancing: the acquirer enters a new technology field through acquiring complementary technology and similar products and then increases R&D investment in the core technology field. Technology- and products-enhancing: by learning from the target's complementary technology and product, the acquirer increases investment in R&D to enhance technology and products, and the sales keep growing.

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