UNIVERSITY OF WUPPERTAL
BERGISCHE UNIVERSITÄT WUPPERTAL

EUROPÄISCHE WIRTSCHAFT UND
INTERNATIONALE MAKROÖKONOMIK


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# Mergers and Acquisitions by Chinese Multinationals in Europe: The Effect on the Innovation Performance of Acquiring Firms


EIIW Diskussionsbeitrag 310
EIIW Discussion Paper 310

*Europäische Wirtschaft und Internationale Wirtschaftsbeziehungen*
*European Economy and International Economic Relations*

**ISSN 1430-5445**
**EIIW Discussion Papers are registered with RePEc-Econ Papers and in ECONIS**

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January 31st 2022

*Herausgeber/Editor: Prof. Dr. Paul J.J. Welfens, Jean Monnet Chair in European Economic Integration*

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**JEL classification:** O1, O3, F23
**Key words:** mergers and acquisitions, M&A, innovation performance, emerging market multinationals (EMNEs), learning, China, EU

**Summary:**

This study aims to investigate the effects of mergers and acquisitions (M&As) by Chinese multinational firm in the EU28 on the subsequent innovation performance of acquiring firms with different technological intensities and types of corporate ownership The study does so by applying the Zero-Inflated Negative Binomial estimation to analyze novel longitudinal firm-level data covering the period from 2010 to 2018. The empirical evidence suggests that Chinese acquiring firms are generally able to enhance their innovation performance after merging or acquiring firms from the EU28 countries. Furthermore, this study reveals that medium low- and low-tech firms significantly improved their innovation performance after undertaking M&As, but the same effect cannot be identified for firms in the high- and medium high-tech groups. Finally, strong evidence confirms the significant increase in innovation output of private-owned enterprises in the post-acquisition era compared with state-owned or -controlled enterprises.

**Acknowledgments:** I would like to thank Prof. Paul J.J. Welfens (EIIW/University of Wuppertal), Prof. Werner Bönte (University of Wuppertal), and Prof. Jens K. Perret (ISM International School of Management) for their valuable comments that greatly improved the manuscript. My thanks for helpful feedback and tremendous editorial support are due to David Hanrahan (EIIW/University of Wuppertal). The usual disclaimer applies.

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# 1. Introduction

Knowledge is well recognized as an essential element of factor-driven economic growth. With the development of globalization and technological advances, players from both developed and developing economies have more options and face new challenges in terms of generating new knowledge when operating on a global basis (Dunning & Lundan, 2008, p. 126). Multinational enterprises (MNEs), as one of the main contributors to knowledge creation and diffusion, often utilize international expansion functions as an essential mechanism that supplies the necessary global insights and experience (Luo & Tung, 2018) and which constitutes a new path for capabilities development (Chittoor et al., 2015). On the other hand, exploring and absorbing external knowledge can be costly and time-consuming due to the complexity and high risk of the process and the trade-off of related resources (Bertrand & Capron, 2015).

Since the late 1990s and the beginning of the 21st century, "soft" power has become more critical in strengthening the growth of companies and improving their international competitiveness (Papanastassiou et al., 2020). As late-comers to the global market, emerging-market multinational enterprises (EMNEs) are under increased pressure to improve their technological capabilities in a short period of time (Child & Rodrigues, 2005). Along with other primary motivations, there is clear evidence of an increasing tendency of EMNEs to appropriate their innovativeness by acquiring sophisticated technology and know-how from foreign firms or their subsidiaries in advanced economies (Amendolagine et al., 2018; Deng, 2009; Luo & Tung, 2007, 2018; Rui & Yip, 2008). This is frequently done by engaging in mergers and acquisitions (M&As), which is perceived as an effective channel for knowledge exploration, especially in areas in which such knowledge is difficult to acquire through trade or by way of imitation (Deng, 2009; Edamura et al., 2014). EMNEs have favored M&As due to the quick access to intangible assets for firms with no direct or relatively less experience (Fu et al., 2018; Y. Liu & Woywode, 2013).

The strong innovation needs of Chinese multinationals and the fast growth of internationalization activities by such firms in the EU serves as an interesting and representative case in practice. First of all, higher innovativeness and efficiency levels are required for the sustained growth of China's economy due to dual economic development pressures at home and abroad. While the Chinese economy was experiencing rapid growth in the past decades, a subset of industries continued narrowing the gap with the technological frontier. However, the general high-tech and modern service industries are still lagging, economic growth is overly dependent on energy and natural resource consumption, and the traditional conditions favorable to economic growth are fading (The State Council of the People's Republic of China [PRC], 2005). With the pressure of competing with firms from developed economies in the global market and avoiding the possibility of the middle-income trap, the innovation-driven economic growth strategy has been prioritized to maintain national competitiveness (CCCPC, 2016; World Bank & Development Research Center of the State Council [PRC], 2013).

In addition, China is currently the largest source country for outward foreign direct investment (FDI) worldwide (UNCTAD, 2021, p. 23). Cumulative bilateral FDI flows between the EU and China are almost balanced (European Commission, 2020). M&A purchases from Chinese investors in the EU experienced a significant increase and became the dominant market entry model in terms of transaction value or number of projects (Kratz et al., 2020). Moreover, Chinese multinationals proactively investing abroad have been significantly supported by the

Chinese government due to the expectation of benefiting from advanced external resources to progress further along global value chains (Fu et al., 2018; Kwok et al., 2018). However, since 2017 the Chinese government has started to tighten controls and even forbid certain types of outward FDI, especially in relation to investments grouped as "non-radical" activities (General Office of the State Council [PRC], 2017).

Last but not least, the global investment environment is becoming more complicated and challenging. In recent years, the continuously constrained domestic and international investment condition with regard to China has led to a decline of and new challenges to the internationalization via M&As of Chinese firms (UNCTAD, 2020, p. 32). The EU, predominantly Western European countries, is often regarded as an attractive investment destination for investors seeking knowledge and technological know-how because of the substantial knowledge reserves and the large variety of innovations on hand (Alvandi et al., 2015; Cozza et al., 2015). Nevertheless, major concern around losing domestic technology and labor to multinationals from emerging countries has contributed to a more restrictive economic and institutional environment (Giuliani et al., 2014). For example, a higher level of regulatory scrutiny in sensitive industries in the form of FDI screening regimes in most European economies (European Commission, 2017; UNCTAD, 2021), in which could affect the strategy and performance of firms (Peng et al., 2008).

Multinationals from emerging markets have constantly been changing the dynamics of outward FDI and the landscape of international expansion by learning from their acquisitions and partners; in turn, EMNEs also begin to upgrade their own innovation capabilities in a more proactive attitude to continually reshape the world economy (Luo & Tung, 2018; Papanastassiou et al., 2020). While EMNEs' technological knowledge base and capital intensity are still limited compared to developed MNEs, together with the growing challenge of a more dynamic and complex global investment environment, it is even more essential to obtain a comprehensive understanding of whether EMNEs have accomplished a higher innovation performance by utilizing M&As as an effective and efficient channel in matching and combining external asserts from advanced economies.

However, prior studies on this topic have focused primarily either on established MNEs from advanced regions and countries that are discrete in terms of experience and resources (Cloodt et al., 2006; Narula, 2017; Piperopoulos et al., 2018) or on the evidence regarding the relevant consequences which is still limited and inconsistent (Amendolagine et al., 2018; Anderson et al., 2015; Buckley et al., 2014; Cozza et al., 2015; Lin & Lin, 2010). Therefore, by studying the innovation performance of Chinese multinationals undertaking M&As in the EU28, this contribution to the research aims to further the discussion on whether outward M&As in developed economies serve as an effective method to facilitate innovation outcomes of EMNEs and, if so, in the process of innovation enhancing, whether and how the post-acquisition innovation performance differs across firms with different technological capabilities and corporate structures?

This research adds further evidence to the seminal studies in the area by focusing on the subsequent innovation performance of Chinese multinationals internationalized via M&As in the EU28 from 2010 to 2018. The contribution of this study is multifold. First, to make the analysis possible, the author constructed a unique longitudinal dataset containing comprehensive coverage of, and recent information on, the patent applications of Chinese multinationals and their effective M&A deals in EU countries by harmonizing data from several sources. Second, using the dataset constructed, this study provides additional evidence on the role of M&As in developing the innovation performance of Chinese multinationals concerning readily measured firm technological intensities and characteristics. Finally, several new insights have been revealed by applying the Zero-Inflated Negative Binomial estimation to analyze the data building upon the concept that not all investing companies generate innovations in the form of patents to control for the potential influence of the patenting behaviors from the firms on the measure of innovation performance.

The main results suggest that Chinese acquiring firms can expect a positive return vis-á-vis innovation performance by exploring developed foreign markets through M&As. However, significant consequences are concentrated amongst very few technological front-runners, and a significant improvement is invisible for the rest of the acquirers. Meanwhile, there is still a clear distinction between firms with different forms of corporate ownership. Private-owned enterprises (POEs) are clearly the main investors in the EU market and substantially benefit from M&As in terms of developing their innovation performance. On the other hand, the state-owned or -controlled enterprises (SOEs), who also undertake M&A activities in the EU market, obtain generally higher innovation outcomes than POEs but show no discernible differences in terms of innovation performance after having undertaken M&As. Thus, the empirical findings help address the current technology adoption approach and results using external knowledge from China, providing new perspectives for the deployment of existing and new policy instruments and future sustainable relationships when investing in the EU.

The paper is organized as follows: Section 2 reviews the theories and relevant aspects of the existing literature, followed by the development of hypotheses in Section 3. In Section 4, the process of sample and data selection and the model specification are explained. Section 5 takes a close look at the results of the empirical analysis. Section 6 incorporates the conclusions and presents a series of recommendations.

# 2. Background

## 2.1. Theoretical framework

According to the works of Joseph A. Schumpeter, innovation can be viewed as a step involving the implementation of new ideas and is normally associated with market commercialization (Schumpeter, 1942, 1947). Since then, micro-level technological progress has been recognized as an essential contributor in leading technological change and further affecting economic growth at the macro-level. New growth theories have explicated this process as being the result of making intentional investment decisions on productivity-driving factors, and the core factor was found to be the stock of knowledge capital (Lucas, 1988; Romer, 1986, 1990). The process of knowledge capital accumulation has primarily focused on the growth of human capital and new technologies. In general, humans can advance their knowledge and skills from education or experience, and the technological knowledge stock develops through continuous exploration, development, and implementation (Griliches, 1979; Grossman & Helpman, 1990).

Firms are corporate organizations with heterogeneous knowledge stocks that primarily aim for profit-maximization (Arrow, 1962; Pitelis & Teece, 2009). This nature leads firms to try to create and maintain sustained competitive advantages and thus play an essential role in the process of knowledge accumulation, creation, and diffusion (Barney, 1991). In order to maintain competitive advantages, firms actively use various knowledge capital inputs from internal and external resources within and across countries' borders via continuous interactive learning to reconfigure their resources and capabilities (Freeman, 1994, p. 468; Lundvall, 1995). From the organizational learning aspect, organizations can learn if any of its components acquire knowledge through a series of knowledge-enhancing investments or gain access to external knowledge bases (Argote, 2015; W. M. Cohen & Levinthal, 1989; Huber, 1991). Therefore, the external knowledge beyond firms' boundaries is crucial in obtaining a higher level of innovativeness because of the possibility of accessing diverse pools of knowledge and the opportunity to leverage the efficiency of internal research and development (R&D) activities (Cassiman & Veugelers, 2006). A firm's dynamic capabilities and key characteristics will also affect its approach to knowledge acquisition and the degree of knowledge to be progressed (W. M. Cohen, 2010, p. 195; W. M. Cohen & Levinthal, 1990).

The internationalization process of firms can sufficiently assist knowledge accumulation by creating great learning potentials and practices (Johanson & Vahlne, 1977; Pearce, 1999). Overseas investments not only allow companies to exploit economies of scale and scope offered by new markets but also provides direct access to effective resources, which can support companies in increasing their knowledge base in day-to-day operations and enhance their dynamic capability to continuously explore, integrate, and reconfigure efficiency gains (Caves, 1989; Meyer et al., 2009; Teece et al., 1997; Teece, 2014). M&As, in particular, allow two or more firms to benefit from synergies and complementarities by transferring and leveraging each other's knowledge and resources, thereby further enhancing the firms' capabilities to facilitate the appropriation of new knowledge appropriating and the generation of innovations (Cassiman et al., 2005; Mudambi & Swift, 2011; Vermeulen & Barkema, 2001). Moreover, M&As have proven to be an effective mechanism for accessing and sourcing a firm's strategic assets, which has been defined by Amit and Schoemaker (1993, p.36) as ‘‘a set of difficult to trade and imitate, scarce, appropriable and specialized resources and capabilities that give a company the competitive advantage". Therefore, acquisitions might not only provide companies with opportunities to explore and utilize codified knowledge in the foreign market, but also facilitate the diffusion of tacit know-how (Fu et al., 2018; Kogut & Zander, 1993). This feature is especially attractive to and beneficial for less innovative multinationals aiming to broaden and deepen their knowledge base, shorten the learning curve through replication and reconstruction of product development, and thus improve their ability to develop new knowledge at the early stage of development, and even prepare for the introduction and development of other new technologies in the future, so as to overcome the late-comer disadvantage in global competition.

Even though there are great learning opportunities and resources from investing and operating internationally, the innovation enhancing-effect from outward M&As still faces considerable challenges, and the learning process can be very complicated. Firstly, the outcome might vary depending on the nature of the knowledge and the accumulation process (W. M. Cohen, 2010, p. 165). Secondly, it requires adequate resources and capabilities on the part of acquiring firms to continuously explore or exploit the embodied knowledge through various channels (W. M. Cohen & Levinthal, 1989; March, 1991). Finally, the adequate strategies and dynamic capabilities required to co-evolve within the internal and external institutional environments are also essential for firms to survive long-term (Cantwell et al., 2010; Nelson & Winter, 1982). Overall, even if the aforementioned demands are fulfilled, the expected effectiveness of knowledge acquisition cannot be guaranteed due to the possibility of either no noticeable improvement being realized or even the inadequacy of the acquired knowledge (Huber, 1991).

EMNEs are generally seen as being different from developed economies' MNEs mainly due to the different resources and experience available, and the possibility of strong government involvement at home (Buckley et al., 2014; Cuervo-Cazurra & Genc, 2008; Goldstein, 2009, p. 74). The "hard" technical skills and "soft" capacities of EMNEs are generally weaker, especially in terms of technological know-how, brand names, and management capabilities in comparison to advanced MNEs (Awate et al., 2012; Buckley et al., 2014; Madhok & Keyhani, 2010; Ramamurti & Singh, 2009). Thus, EMNEs might require an early internationalization strategy in order to access the assets necessary to compensate for competitive disadvantages or to escape from the domestic institutional disadvantages (Child & Rodrigues, 2005; Luo & Tung, 2007; Rui & Yip, 2008). It is noteworthy that EMNEs are also embedded in societies. The different home- and host-country governmental environments will also influence the knowledge learning and generating processes directly or indirectly. For instance, EMNEs might enjoy potential capital and policy support from the state to encourage their internationalization activities (Ramamurti & Singh, 2009, p. 82) or even be disciplined to accelerate their learning process (Mathews, 2002). However, they may also face credibility deficits and thus face low incentives for collaboration in the host countries due to possible ambiguous home-country political and social practices (Amendolagine et al., 2018; Gao et al., 2017).

Due to the aforementioned reasons, EMNEs have a strong incentive to improve competitiveness in the global market with constrained resources and competencies to learn from the trial-and-error process and face mixed pressures from dynamic internal and external institutional environments. The possibility of achieving a higher knowledge base via outward M&As or, eventually, struggling in the integration process and losing the ability and opportunity to innovate, makes the study essential and provides evidence on whether M&As affect the ex-post innovation performance of acquiring firms from emerging economies by taking account to economic and political factors.

## 2.2.Literature review

Since the 2000s, benefiting from more research and detailed evidence, there has been an increase in valuable insights offered into the firm performance of EMNEs (Papanastassiou et al., 2020). New players from emerging countries are increasingly involved in the global organization of innovation, and the evidence available shows that this is favored by EMNEs pursuing knowledge-seeking investment overseas (Ai & Tan, 2020; Papanastassiou et al., 2020). However, in the existing relevant literature, the main valuable insights still concern the investment motivations and determinant factors (Child & Rodrigues, 2005; Gubbi & Elango, 2016; Lu et al., 2014; Luo & Tung, 2007, 2018; Ramasamy et al., 2012; Rui & Yip, 2008). Less emphasis has been placed on understanding the consequences of FDI, especially of M&As in the context of EMNEs in developed economy markets (Ai & Tan, 2020; Amendolagine et al., 2018; Buckley et al., 2014; Papanastassiou et al., 2020). In addition to the relatively scant research, researchers have tended to focus on the general productivity or trade performance (W. Chen & Tang, 2014; Cozza et al., 2015), while only a relatively limited number of studies have investigated the impact on the innovation performance (Fu et al., 2018). Furthermore, theoretical and empirical studies on the relationship between international acquisition activities and innovation performance from EMNEs appear to have inconsistent outcomes (Anderson et al., 2015; Lin & Lin, 2010).

In the existing literature, a few findings have suggested an adverse outcome in improving the innovation performance of EMNEs via cross-border M&A activities. A primary concern is the typically high level of uncertainty and cost for firms to explore and integrate foreign knowledge, as well as the challenge of discontinuing duplicate R&D in the post-acquisition period (Bertrand & Capron, 2015; Fu et al., 2018). Despite facing common difficulties and challenges in regard to M&As and knowledge integration, EMNEs are often seen as lacking the competence to leverage and transfer the value of the acquired resources and to combine them optimally with their domestic assets (Luo & Tung, 2018; Yakob et al., 2018). Researchers argue that resulting from limited ownership advantages, weak international experience, and lacking in absorptive capacity, EMNEs are 'unlikely to be able to integrate acquired assets successfully' (Narula, 2012), or it will take a considerably long time to enhance their firm-specific advantages (FSAs) via the international acquisition of technology (Rugman, 2009; Rugman & Li, 2007). Therefore, EMNEs will most likely struggle to recognize and learn from the valuable knowledge and experience of acquired companies. Instead, they are most likely to rely on their country-specific advantages (CSAs), such as cheap natural resources and labor, to operate in the global market (Ramamurti & Singh, 2009, p. 157; Rugman & Li, 2007).

More recent research tends to have mixed conclusions. Several case studies have reached a similar conclusion, i.e. that EMNE's innovation performance will not be significantly affected by cross-broader investments. Hansen et al. (2016) provide a detailed case study of a Chinese multinational from the biomass power plant industry which invested in Denmark via acquisitions to obtain necessary technology and knowledge assets. The authors identify insufficient innovation capability building and argue that this is largely associated with distrust of the Chinese parent company and IP protection, as well as difficulties in managing differences in working practices and long-distance communication. The findings of Spigarelli et al. (2013) display that the expected knowledge-enhancing effect of operating in advanced countries is often postponed or reduced because of the lack of synergies and significant cultural differences alongside the acquirer's weak competitive advantages and managerial skills by studying an

SOE in the machinery and electrical industry from China which acquired a small Italian firm in 2005.

A series of empirical analyses discovered limited effects under certain conditions. Using an event study methodology, Anderson et al. (2015) research firms' innovation activities at both home and in host countries between 1998 and 2012. They find that the granting of patents to the domestic Chinese investors significantly increased in the wake of strategic asset-seeking acquisitions in the developed markets, such as the US, Japan, and Europe, but the innovation performance of acquired firms do not show a significant change, and the absorptive capacity of SOEs and POEs do not significantly differ from each other. By analyzing the M&As undertaken by Chinese and Indian medium- and high-tech companies in the EU28 and the US from 2003 to 2011, Amendolagine et al. (2018) reveal that EMNEs have higher innovation outputs after investing in the region with higher innovative capacity, but that the outcome is not straightforward in most innovative hubs. They further explain that a higher innovation performance after acquisition primarily relies on the knowledge base status of the acquiring EMNEs rather than how innovative the target firm or location is.

Other studies have concluded a positive influence of internationalization activities in generating new knowledge. A theoretical research contribution (Y. Liu & Woywode, 2013) proposes a 'light-touch' integration strategy be applied by Chinese investors as an efficient tactic to stimulate intra-group knowledge exchange by giving considerable autonomy to the local acquired firms, especially with rich technological competencies in the post-acquisition phase. This finding echoes the results of Karabag et al. (2018), Schüler-Zhou & Schüller (2013) and Tsai (2002) on a higher intra-group knowledge exchange due to increased motivations and initiatives. The empirical findings of the study by Edamura et al. (2014), which used propensity score matching and a difference-in-difference estimator to investigate the effects of M&As from Chinese MNEs in the developed market on firms' performance, suggest that the intangible assets of the acquiring firms have increased after outbound M&A transactions, and that the unaffected R&D intensity implied a complementarity relationship between acquiring and acquired firms. Another similar study that extended the sample to include outward FDI activities was undertaken in 2015. Cozza et al. claim a positive and significant influence from M&A on EMNEs' productivity could be expected, but the positive influence from M&As is smaller than for greenfield investments, and the former is more used for qualitative improvement. Piperopoulos et al. (2018) identify that outward FDI could enhance the innovation performance of Chinese EMMEs' subsidiaries in high-tech industrial sectors. Moreover, the positive effect will be more substantial when the investments are geared towards developed countries. Applying a Tobit model with random effects to analyze first-hand data collected from firms via a purpose-designed survey from Guangdong province in China, Fu et al. (2018) find that outward direct investment leads to an increase in the innovation performance of Chinese acquirers, although the impact is shaped by internal and external factors such as firm characteristics and investment destinations. Furthermore, they hold the "innovation springboard" view of the motivation for Chinese investment in developed countries and find that outward FDI and in-house R&D are overlapping for Chinese multinationals.

In general, the relevant research methods and data have improved considerably, from the aforementioned analysis of single case studies to further selected specific industries to more comprehensive studies. In comparison to the previous literature, more recent studies tend to conclude a positive impact of outward direct investment on the innovation performance of acquiring firms for EMNEs. Furthermore, the empirical studies focusing on certain industries or generalized groups discovered a more successful story. Nevertheless, most studies mainly focus on an aggregated country-level analysis, a single industry with high technological intensity, or a few selected leading technology firms. General investigations covering all types of investors using micro-level data are considerably limited. Findings emphasize that an innovation improvement through M&As is a complicated process, the positive outcomes depend upon the incentive and capability of continuous learning, the existence of an absorptive capacity, and the institutional differences between different investing companies.

# 3. Hypotheses

Based on the theoretical guidance and empirical evidence presented in Sections 2.1 and 2.2, the following hypotheses are put forward concerning the effects of cross-border M&As on the innovation performance of acquiring firms considering the manufacturing technological intensity and corporate ownership.

Notwithstanding that most previous studies have argued that outward M&As can have multi-faceted impacts on the innovation performance of EMNEs under different circumstances, M&As are still regarded as an effective channel to reach new or complementary resources with lower entry barriers to provide new technical and organizational components for firms (Ai & Tan, 2020; Vermeulen & Barkema, 2001). For instance, the subsidiaries of EMNEs can access frontier knowledge and advanced technological capacity by engaging in local networks, which allow for the exploration and/or exploitation of specialized knowledge on a daily basis (Kafouros et al., 2012). Such opportunities and strategy implementations contribute the most to knowledge transfer and experience accumulation by allowing more control of acquired strategic assets and familiarization with the external knowledge bloc from new customers, suppliers, competitors, and governments (Johanson & Vahlne, 2009; Luo & Peng, 1999; von Hippel, 1988). Additionally, EMNEs can enjoy extra gains by expanding in the existing developed markets. In developed markets, the target regions have broader absolute knowledge bases and more extensive market demands, which offer higher learning opportunities with intensive information and knowledge exchanges (Amendolagine et al., 2018). Host countries with a high share of R&D expenditure in the manufacturing sector are generally attractive for Chinese investment (Amighini et al., 2013). This could assist EMNEs in meeting the mainstream international standards within a short time and enable EMNEs to gain in terms of attractiveness and bargaining power in utilizing technological resources and collaborating in the international invention (Ai & Tan, 2020; Child & Rodrigues, 2005).

As a late-comer, Chinese multinationals generally have a strong incentive and are under a certain time pressure to catch up and become one of the leading players in the industry (Fu et al., 2018; Mathews, 2002). Nevertheless, they are also continuously catching up by improving their technological ability and expanding upon their international organizational experience. Research has found that Chinese investors typically invest in the main sectors of expertise that each EU country specializes in and tend to pursue a long-term investment strategy aimed at substantial production and innovation development through cooperation with European subsidiaries (Alvandi et al., 2015, pp. 24–25; Cozza et al., 2015). Meanwhile, certain "home-country advantages" can support firms' learning process and ability to recognize relevant and valuable resources in the host country by enhancing the home country's knowledge base and technological specialization, such as a sustained increase in technical education and investment in science and technology, and sufficient support in developing innovative abilities through policy guidance and financial support from home-country institutions (Rabbiosi et al., 2012; Rui & Yip, 2008).

Accordingly, due to applying an effective channel targeting innovative locations along with a solid technological-oriented investment incentive and increasing innovation and organizational capacity in general, the innovation performance of Chinese acquiring firms is predicted to benefit from the M&As:

***Hypothesis 1. The subsequent innovation output of Chinese acquiring enterprises is positively associated with M&As undertaken in the EU.***

However, the proposed innovation enhancement effect of M&As is not uniform and is somewhat shaped by many other determining factors. One essential determinant is the different levels of technology intensity. The high-technology-intensive firms (hereinafter "high-tech firms") are generally considered to be "more innovative, more efficient, pay higher wages, and are more successful than low-technology-intensive firms" (Zawislak et al., 2018). Therefore, the high-tech firms are expected to exhibit a higher ability to recognize the value of new and external information, to exploit and acquire knowledge via external learning, and to assimilate it and extend it to its own internal systems to generate innovations (W. M. Cohen & Levinthal, 1990). Mathews (2002) points out that due to the character of licensed product designs, opening knowledge spillovers in high technology clusters, as well as the possibility of purchasing start-ups and receiving the technical support from specialized consulting firms, the barriers around "tacit knowledge" are minimalized. For these reasons, the late-movers, such as most companies in high-tech industries from China, can replicate and imitate the products with a relatively more accessible and possibly cheaper production process. Therefore, they benefit from avoiding sunk investments in old technologies and leapfrogging to new technologies (Awate et al., 2012).

However, one should consider the nature of the high-tech industry, it involves intensive technological content, fierce competition, high degrees of uncertainty and risk, while - at the same time - the knowledge distance between the majority of Chinese high-tech firms and the western technological frontier is still existing (Fu et al., 2018). A significant amount of investment in advance is required, and the learning process will be "more complex, more time consuming and full of risks" (Cloodt et al., 2006). Furthermore, knowledge transfer is closely tied to the willingness to cooperate and trust between the participants, and ongoing communication and interpretation are emphasized (Johanson & Vahlne, 2009). However, due to host governments' increasing concern for national market security protection and the desire to maintain the target company's competitiveness, high-tech industries are often associated with sensitive sectors with high entry and transfer barriers (Alvandi et al., 2015; Hennart, 2012). Last but not least, a matched international experience and organizational expertise is required to achieve continuous learning from M&As (Luo & Tung, 2018). A series of research contributions suggest that Chinese acquiring firms intend to have less control or give full autonomy to the target firms in high-tech sectors or with strong technological competencies, while at the same time are less likely to have local partners if the institutional distance is large (Alvandi et al., 2015; Beule et al., 2014). In any case, Chinese acquirers shoulder higher costs and uncertainty to develop adaptive and transformative approaches to integrate knowledge from external sources and to create innovations. Thus, the following hypothesis is formed:

***Hypothesis 2a. In the high-technology sector, the subsequent innovation output of Chinese acquiring enterprises is negatively influenced by M&As undertaken in the EU.***

Accordingly, innovation will also occur in and be important for low-technology-intensive firms (hereinafter "low-tech firms"). A firm being grouped in the lower technological intensity industry does not mean that it has low innovative frequencies or opportunities (Reichert et al., 2016). Despite the widely held belief that lower-tech firms passively experience the evolution of technology, there are a group of firms that actively contribute to the change of technological breadth and depth, more importantly, they are distributed across a wide range of industries (Mendonça, 2009). At the same time, with less intensive technological content and a smaller technology gap, it is more likely that the low-tech sector will catch up through external technology acquisition and consume fewer resources compared to high-tech sectors, this would further increase the possibility that the technological followers from China could achieve the offsetting of the competitive advantages of the technological leader (Fu et al., 2018).

In the face of an increasing global technological diversification and crossover of firms' technology portfolios, the strategic flexibility of the firms in the low-tech industries, due to their market-driven features, may allow them to have a high awareness and absorptive ability vis-á-vis external technologies and knowledge, thus to be able to effectively generate or improve product/process innovations that can be transferred to economic uses (Mattes et al., 2015). A good combination of different types of capabilities that are relevant to innovation/non-formal R&D-based capabilities can help less technology-intensive firms to achieve innovation success (Reichert et al., 2016), and this is especially true for firms from developing countries (Zawislak et al., 2018). On the other hand, as mentioned in the research of Hirsch-Kreinsen et al. (2006) and Reichert et al. (2016), most low-tech firms rely on externally developed technologies. Also, they are key users of innovative products and technologies generated in high-tech industries, and there is a strong interdependence between these types of firms (Santamaría et al., 2009). Thus, the supplier-led characteristics enable low-tech firms to utilize advanced manufacturing technologies, and their superior dynamic capabilities allow them to efficiently acquire appropriate technologies from external sources and effectively function in a new environment. For the above reasons, the author proposes that:

***Hypothesis 2b. In the low-technology sector, the subsequent innovation output of Chinese acquiring enterprises will be positively influenced by M&As undertaken in the EU.***

In the meantime, home-country characteristics play an integral role in the investment behavior and learning process of Chinese EMNEs (Amighini et al., 2013; Buckley et al., 2007; Rabbiosi et al., 2012). Among several factors, firm ownership can reflect the mixed moderating effects of resources and capacities on firm innovation outcomes (Genin et al., 2020).

The intention of promoting innovation through internationalization activities is strong for SOEs. A supportive finding (Ramasamy et al., 2012) shows that it is more prevalent among SOEs in order to acquire strategic assets, such as technology, brands, and know-how, to compete in the global market and maintain domestic market share. Also, SOEs are seen as the primary vehicle for implementing government programs and will therefore actively invest in innovation resources in response to the government's call to build up an innovation-oriented economy (Zhou et al., 2017). Moreover, although the innovation performance of SOEs is generally believed to be lower than that of POEs in the market, the high concentration of resources and the reorganization of recruitment help SOEs to perform well in allocating scarce resources and attracting talent, as well as to avoid the typical agent problem (Kroll & Kou, 2019). In addition, the innovation competencies of SOEs can be facilitated by the linkages to organs of state governance (Li et al., 2018). In emerging economies, SOEs often operate in strategically essential sectors, and they still enjoy privileged access to financial and regulatory support, such as receiving investment subsidies and/or tax reductions from the government (Fu et al., 2018; Song et al., 2011; Zhou et al., 2017). Despite gaining valuable substantive resources, access to policy information can lead to even more opportunities to stimulate (inter-)organizational coordination, which can help reduce investment risk and innovation barriers (Amighini et al., 2013; Howell, 2017).

Despite enjoying the government-related advantages, SOEs also receive institutional pressure to reflect multiple objectives when making investment decisions (Genin et al., 2020; Ramamurti & Hillemann, 2018). They need to follow the national guidance and pursue political mandates or commercial interests when participating in the design of globalization strategies or claiming credit for the organizations (Child & Rodrigues, 2005; Song et al., 2011). These goals, which are irrelevant to the development of corporate innovation, will disrupt the learning motivation and opportunities for SOEs, weaken the organizational resources for technological innovation, and hinder the integration of external resources (Li et al., 2018; Zhou et al., 2006). Furthermore, due to complex organizational structures and a higher reliance on government resources, SOEs have been found to have weak incentives to engage in innovation and are less efficient at transferring acquired critical inputs into innovation outputs than POEs or foreign enterprises (Ayyagari et al., 2011; Cui & Jiang, 2012; Kroll & Kou, 2019). Therefore, even though the main players, especially in the manufacturing sector, are still SOEs in China (Zhou et al., 2017), and they have certain advantages in managing scare resources and often enjoy certain privileges with regard to financial support or information access, the lower productivity, multi-investment strategies, and complicated organizational system can lead to unfavorable effects on the exploitation and exploration of external resources. Along with the aforementioned evidence on Chinese SOEs in particular, SOEs often face a perceived legitimacy deficit and higher institutional pressures in the host region, especially if the government of the target country worries that acquisitions by Chinese MNEs could lead to the wholesale transfer of technology and job positions to China (Meyer et al., 2018, p. 214). The following hypothesis summarizes the discussions:

***Hypothesis 3a. The M&As that Chinese enterprises undertake in the EU will adversely influence the post-acquisition innovation output of SOEs.***

Interestingly, the study shows (Ramasamy et al., 2012) that the incentive of Chinese POEs to seek knowledge and technology through outward FDI is not apparent. At the current stage, the technical advantages of the host economy do not seem to be attractive to POEs, who are instead more driven by market expansion (Ramasamy et al., 2012). Besides, the constrained capital-raising environment in the domestic market for the POEs might also affect the motivation for investing abroad in order to gain access to capital (Xiao, 2004). Also, it is worth noting that Chinese private firms have only been allowed to invest abroad since 2003 (Buckley et al., 2007), so they have less learning experience compared to SOEs and foreign enterprises. As late-comers in the market, they may suffer more from ‘newness’ and ‘smallness’ (Liang et al., 2012). Thus, the POEs will bear more pressure to manage “ambidextrously”, meaning that firms need to exploit not only their FSA but also overcome competitive disadvantages (Liang et al., 2012; Luo & Rui, 2009).

In fact, the POEs from China generally follow the traditional way of investing abroad to exploit their firms' specific advantages further and enhance their organizational capacities (Lu et al., 2011). When investing in OECD countries, POEs are even more attracted by host country strategic assets than SOEs when investing in higher-income countries (Amighini et al., 2013). Many researchers find evidence that Chinese POEs generally have higher productivity levels (Dougherty et al., 2007; Morck et al., 2008). They are not necessarily less capable of absorbing acquired strategic assets than SOEs which receive more support (Anderson et al., 2015). Unlike SOEs, Chinese POEs do not have highly internalized production systems, over-employment, or social responsibilities. The higher level of flexibility allows them to have advantages in organizational capacity to identify opportunities in international markets quickly, pursue a rapid decision-making process, and effectively adapt to new environments and knowledge (Liang et al., 2012). On the other hand, POEs are also facilitated by the liberalization of regulations and supported by the government when investing abroad, benefitting from the "Going abroad" strategy since 2001, and the constraints to POEs in terms of financial support and the administrative process has been largely reduced (Luo et al., 2010). More importantly, POEs are perceived to be more transparent and effective, and generally show a long-term orientation and a stronger willingness to learn (Y. Liu & Woywode, 2013). Thus, the following hypothesis:

***Hypothesis 3b. The M&As that Chinese enterprises undertake in the EU will have a favorable influence on the post-acquisition innovation output of POEs.***

The recent innovation strategy "Made in China 2025" prompted ten major development industries aiming to systematically promote the improvement of advanced technology industries in the hope of transforming China from a large manufacturing country with low added value to a manufacturing powerhouse (The State Council [PRC], 2015). Following the reform of the state-owned sector, and in keeping with the so-called principle of "grasping the big and releasing the small", state-owned businesses have been increasingly concentrated in a few large state-supported business groups (Yiu, 2011). At the same time, most of the companies selected to become key R&D forces in China are required to have strong innovation and technology capabilities as well as strategic assets, but this group is still mostly composed of SOEs (Yiu, 2011). On the other hand, POEs from technology-intensive industries are found to be more active in conducting strategic asset-seeking FDI and proactively engaged in organizational learning via outward FDI (Lu et al., 2011). In this case, although both POEs and SOEs have a higher likelihood to be motivated by knowledge-seeking when investing in the high-tech manufacturing industry in developed economies, and they obtain specific advantages in terms of resources and capacities, SOEs are more likely to have greater access and resources to handle larger and more demanding knowledge-seeking M&A cases. This is because they have more resources and capabilities to recognize and manage strategic asset-rich acquisitions, and they often have the critical resources and are able to maintain large and higher risk investments with strong incentives to acquire strategic assets when investing in developed economies. Thus, the interdependence of learning opportunity and capacity through acquisition might affect the innovation outcomes, which leads to the following hypothesis:

***Hypothesis 4. In the high-technology sector, the innovation output of SOEs will benefit more than POEs after having M&As in the EU*.**

# 4. Methodology

## 4.1. Sample

To empirically investigate the consequences of the undertaking of M&As by EMNEs in developed economies in the context of the relationship with the level of innovation outcome of the acquiring companies, I constructed a data sample consisting of 230 Chinese acquiring firms that had undertaken M&A transactions in the EU28 countries from 2010 to 2018 as reported by Bureau van Dijk's (BvD) Orbis and Zephyr databases, as well as SDC Platinum (Thomson Reuters).

## 4.2. Variables

### *4.2.1. Patent*

The number of patent applications has been used to measure the innovation performance of selected Chinese acquirers. The source of the patent data is the European Patent Office (EPO) Worldwide Patent Statistics Database (PATSTAT), provided by Orbis. I utilized the unique firm identity number from the sample to search for patents in the regional, international, and national patent offices of the EPO[1], World Intellectual Property Organization (WIPO), and EU-28, respectively. The duplicate patent applications published in different patents offices have been removed. In order to integrate the patent data, patents carry the priority date as the reference date because the priority date will reflect the proper period of the discovery of both domestic and foreign inventions (OECD, 2009, p. 53). However, if the priority date is not available, the publication date is used to proxy the priority date based on the general estimation that the application is published 18 months after it is filed (OECD, 2009, p. 19).

In this study, the focus will be on innovation output as a means to gain an understanding of the innovation performance of Chinese acquiring firms. Patent frequency has been widely recognized as a good indicator for measuring innovation performance in terms of innovation outputs (Pakes & Griliches, 1984). Using patent frequencies in this way has both notable strengths and weaknesses (Smith, 2009, pp. 158–160). Patent data usually do not suffer from retrospective bias and success bias since they are collected continuously and systematically (Dahlin & Behrens, 2005). As a measure of technological novelty, they represent a valid and close link to important inventions (Griliches, 1990; Schmookler, 1966, p. 18). Patent statistics cover a broad range of technologies and are fairly consistent within industries (W. Cohen et al., 2000; OECD, 2009, p. 27). In addition, Ahuja and Katila (2001) summarize several findings which claim that patents indeed have an economic significance due to the property rights conferred to the assignee, and that they are also closely related to other measures such as new products and innovation counts. Therefore, patent data are believed to be the best choice in indicating firms' innovation performance for this study. It should, however, be noted that some inventions may not be patentable, and that inventions that are patented can differ greatly in terms of economic value or be skewed across technical fields and industries (Griliches, 1990; Trajtenberg, 1990).

[1] The EPO is a regional office with 32 members in 2007 which searches and examines patent applications on behalf of European countries.

#### 4.2.2. M&A

The variable of primary interest, M&A, is measured by dummies. The post-acquisition period, which starts one year after an acquisition took effect, is equal to one, otherwise, it is zero. The data was collected from two M&A databases, namely Zephyr and SDC Platinum, using the following approach. Firstly, the author filtered those M&A transactions, which have a share acquisition of at least 10 percent, in EU28 countries with an effective date between 1 January 2010 and 31 December 2018. Secondly, those transactions in which the acquirers' parent company was not located in China were excluded. The information was cross-checked using data from the Orbis database and the firms' official websites and annual reports. Thirdly, after having dropped transactions with duplicated or incomplete information, acquirers being individuals rather than corporate entities, and affiliates that were either acquired or dissolved over the analysis period, 467 cross-border M&A deals by 357 companies were observed. Finally, only those firms that had undertaken M&As between 2012 and 2016 were retained for the analysis to allow the observation of innovation outputs from acquiring firms at least two years before and after the acquisition. Therefore, the final sample contains 230 firms with 321 M&A deals.

#### 4.2.3. Technological intensity classifications

The present study employs the sectoral approach[2] of the European Commission in order to classify the economic sectors of firms into different groups based on their level of technological intensity (measured by the ratio of R&D expenditure to value-added) in accordance with the statistical classification of economic activities of the European Community (NACE Rev.2) at a 2-digit level. Firms from various manufacturing (MFG) industries can be aggregated into four categories: high-, medium high-, medium low-, and low-technology industries, henceforth referred to as H-tech, MH-tech, ML-tech, and L-tech. In this research, both H-tech and MH-tech are treated as high-technology sectors and the ML-tech and L-tech industries are aggregated as low-technology sectors. Firms in the service sector were grouped as knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS) using the same criteria.

#### 4.2.4. Corporate ownership

A binary variable has been used to indicate the type of corporate ownership, 1 refers to SOE, and 0 is POE. The information on firms' ownership was harmonized using Orbis and SDC Platinum data, which was cross-checked against publicly available sources. These sources include the official websites and annual reports of companies and Chinese state agencies, such as the State-owned Assets Supervision and Administration Commission of the State Council (SASAC)[3]. In doing so, the accuracy and integrity of the ownership information have been largely enhanced due to a higher chance of including both listed and non-listed Chinese MNEs and cross-checking the details from multiple reliable sources.

[2] A detailed explanation of the classification and calculations can be found on the website of the European Commission via, https://ec.europa.eu/eurostat/cache/metadata/en/htec_esms.htm, accessed on 18.10.2020.

[3] A list of 97 central state-owned enterprises is available on the website of SASAC http://www.sasac.gov.cn/n2588035/n2641579/n2641645/index.html, accessed on 21.11.2020.

#### *4.2.5. Control variables*

In this research, several control variables are taken into account to keep other possible explanatory factors of an acquiring firm's innovation output and investment decision constant.

The size of the Chinese acquirers has been controlled for by taking a log transformation of the number of employees. A relative consensus view derived from abundant studies is that larger firms are more likely to associate with and benefit from incremental innovations because of higher profitability and organizational ability from monopolistic activities and cost-spreading advantages (W. M. Cohen, 2010, p. 140; W. M. Cohen & Klepper, 1996). Large firms are anticipated to be able to re-invest in more R&D and their workforce, thereby, enjoying a higher production and additional bargaining power to exploit economies of scale and scope (Klepper & Simons, 2005). Several studies show a decline of R&D productivity as a company grows larger, or a closer U-shape relationship between R&D productivity and firm size (Lerner, 2006; Pavitt et al., 1987; Scherer, 1965). For Chinese multinationals investing in the EU market, a positive moderating effect of the firm size is expected to assist firms to better engage in organizational learning and have more substantial financial and organizational capabilities to adapt to new environments, thereby promoting innovation.

Similar expectations apply to firms' experience, which reflects the knowledge intensity of an organization. This variable is proxied using the number of years since the establishment of the acquiring firm in this study. Prior literature demonstrates that firms with greater experience enjoy increasing returns to scale of information and network externalities, which in turn allow for the development of management and coordination capabilities (Amendolagine et al., 2018; Cozza et al., 2015). A higher level of maturity can influence a firm's ability and willingness to take risks when making investment decisions (V. Z. Chen et al., 2014). However, an adverse influence can be expected for Chinese acquirers. The findings from Luo & Tung (2007; 2018) suggest a different impact due to the finding that Chinese MNEs may seek access to strategic resources in developed countries rather at an early stage of the firms' development, this could lead to Chinese firms gaining early access to accumulating international experience and R&D resources.

At the same time, a firm's financial performance (measured by an acquirer's revenue to total assets) is included due to its influence on profitability (Amendolagine et al., 2018). Also, it is considered as a standard feature together with firm size in order to control for potential spillover effects (X. Liu & Buck, 2007). Furthermore, the technological intensity level of target firms is taken into account, if a target firm belongs to the high-technology sectors or KIS cluster, the dummy value is equal to 1, otherwise 0. This is because there is a high likelihood that those firms contain stronger strategic and knowledge-intensive assets, which reflect a possibly more complex and longer learning process. Additionally, it can also capture the possible "light-touch" effect.

In the end, year dummies and industry-fixed effects are included to control for common shocks, business cycle fluctuations, and technological opportunities. The selected variables are described in the following **Table 1**:

**Table 1: The description of the variables**

| *Variables* | *Symbol* | *Description* | *Expected sign* | *Source* |
|---|---|---|---|---|
| Innovation performance | y | The number of patents of an acquiring firm | | Orbis PATSTAT |
| M&A | L_M&A | Value 1 for lagged one-year acquisitions for all years after the year the M&A was initially made, otherwise 0 | + | Orbis Zephyr & TR |
| Acquirers' Technological intensity category | MFG tech: H-tech, MH-tech, ML-&L-tech | Value 1 if an acquiring firm is H-tech, value 2 if an acquiring firm is MH-tech, value 3 if an acquiring firm is ML- & L-tech | +/- | Orbis Zephyr, TR, & EC |
| Acquirers' ownership type | SOE | Value 1 if an acquiring firm is state-owned or controlled, value 0 if an acquiring firm is privately-owned | + | Orbis Zephyr & TR |
| Acquirers' size | Size | Log (The number of employees) | + | Orbis Zephyr & TR |
| Acquirers' experience | Age | The number of years since the establishment of the acquiring firm | +/- | Orbis Zephyr & TR |
| Acquirers' financial performance | Fin | The return on assets (acquirer's revenue to total assets) | + | Orbis Zephyr & TR |
| Targets with upper intermediate technological intensity and knowledge-intensive assets | Tar U-tech \| KIS | Value 1 if a target firm belongs to the group of the H-tech, MH-tech, or KIS, otherwise, 0 | +/- | Orbis Zephyr, TR, & EC |
| Acquirers with high technological intensity and knowledge-intensive assets | Acq H-tech \| KIS | Value 1 if an acquiring firm belongs to the group of the H-tech or KIS, otherwise, 0 | +/- | Orbis Zephyr, TR, & EC |

*Source: Author's own elaboration*

## 4.3. Empirical method

This study aims to understand the effect of M&As undertaken by emerging country acquirers in developed markets on their innovation performance. The concept of the knowledge production function will be applied to understand innovation as the stock of valuable economic knowledge of firms and the relationship between inputs and outputs (Griliches, 1990; Pakes & Griliches, 1980).

The outcome of interest is measured by patent applications ($y_{it}$). Since no patent applications are found for around half of the companies in the searched patent office databases during the sample selection, there is a risk of selection bias in the estimates if missing data are omitted; when this is the case, the inference can be misleading (Baltagi, 2021, p. 310; Heckman, 1979). A two-part model and a Heckman two-step selection model are applied to test the existence of possible sample selection bias (Cameron & Trivedi, 2013, p. 389). Detailed explanations of the estimations used and the results generated are reported in the Appendix in **Table 5**. A similar regression outcome suggests that the null hypothesis that the equation of interest and selection equation are uncorrelated cannot be rejected. In other words, the selected sample would be equally applicable to the entire population despite a loss of efficiency (Heckman, 1979).

According to the statistics summarized in **Table 3**, and the frequency distribution of the outcome variable in **Figure 2** in the Appendix, patent counts were only taken as non-negative integer values with the variance significantly exceeding the sample mean; the values cover a wide range with around half of the counts being zero and with a long right tail. Thus, the dependent variable indicates a possible discrete and significant overdispersion (Cameron & Trivedi, 2009, p. 555, 2013, p. 89). Additionally, the possibility of having "excess zeroes" might exist with the patent counts due to some firms not having made patent applications, not because they had no patent-worthy discoveries, but because they decided against filing a patent for other reasons, such as considering the cost of obtaining a patent to be too expensive, the company wanting to keep innovations as a trade secret, or because the application was prima facie rejected by the patent office (Kanwar & Singh, 2018, p. 37). For the aforementioned reasons, despite applying the Poisson regression model (PRM) to analyze the count data, the models for Negative Binomial (NB) data and Zero-Inflated data are jointly compared, resulting in an advance in handling data with a highly skewed distribution and zero inflation (Cameron & Trivedi, 2013, p. 80, 2013, p. 139; Hausman et al., 1984; Lambert, 1992; Mullahy, 1986).

**Table 6** in the Appendix provides a series of goodness-of-fit statistics to diagnose the optimum models. The Pearson dispersion statistic is significantly greater than 1, indicating the data is likely to be Poisson over-dispersed (Cameron & Trivedi, 2013, p. 358). A lower log-likelihood value and smaller measures from the information criteria fit tests based upon the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) specify that the NB models and Zero-Inflated Negative Binomial (ZINB) model are generally preferred over the PRM and Zero-Inflated Poisson (ZIP) model (Cameron & Trivedi, 2009, p. 346). Moreover, the positive and significant statistics from the Vuong test support the view that the ZINB model and ZIP model are superior to the NB model and Poisson model, respectively (Greene, 2012, p. 863; Vuong, 1989). A consistent result is also suggested by the likelihood ratio test statistics, which show the ZINB specification significantly improves the overall fitting for the data compared to the NB specification. (Blonigen, 1997; Cameron & Trivedi, 2013, p. 357; Hausman et al., 1984). Overall, given the consistent results of the applied tests, the ZINB model with heteroscedasticity-robust standard errors is considered to be most efficient among the selected estimations.

A zero-inflated model assumes that there are two possible unobserved cases for each observation (Long & Freese, 2014, p. 535). In the latent group A ("always 0"), a firm does not have patents; in the other group –A ("not always 0"), a firm might have the probability to produce positive output, but obtains no patent applications. Thus, these possibilities are included as a binary process using the logit model to identify which group an observation belongs to. Let $\varphi_{it}$ stand for the probability of an individual being in group A, then the probability for the other case is $1 - \varphi_{it}$, the overall probability of 0 is a mixture of two types of 0s is shown in equation (1). For those observations which have counts including zeros, the probability of each count is assumed to follow a gamma distribution is shown in equation (2):

$$\Pr(y_{it} = k_{it}) = \begin{cases} \varphi_{it} + (1-\varphi_{it})\Pr(y_{it} = 0 \mid x_{it}, A_i = 0) & if\ k_{it} = 0 \quad (1) \\ (1-\varphi_{it})\Pr(y_{it} = k_{it} \mid x_{it}, A_i = 0) & if\ k_{it} > 0 \quad (2) \end{cases}$$

The equation used for estimating the density of expected counts as a mixture of the above two components can be expressed as:

$$\begin{aligned} E(y_{it} \mid x_{it}, z_{it}) &= \exp(x_{it}^{'}\beta)(1-\varphi_{it}(z_{it}^{'}\gamma)) \\ &= \exp(\beta_0 + \beta_1 Size_{it} + \beta_2 Age_{it} + \beta_3 Fin_{it} + \beta_4 \delta_i^{TarU-tech/KIS} + \beta_5 \delta_i^{MFGtech} + \beta_6 \delta_i^{SOE} + \beta_7 \delta_{it}^{M\&A} \\ &\quad + \beta_8 \delta_i^{SOE} \times \beta_7 \delta_{it}^{M\&A} + year_i + industry_i + \varepsilon_{it})(1-\varphi_{it}(z_{it}^{'}\gamma)) \end{aligned}$$

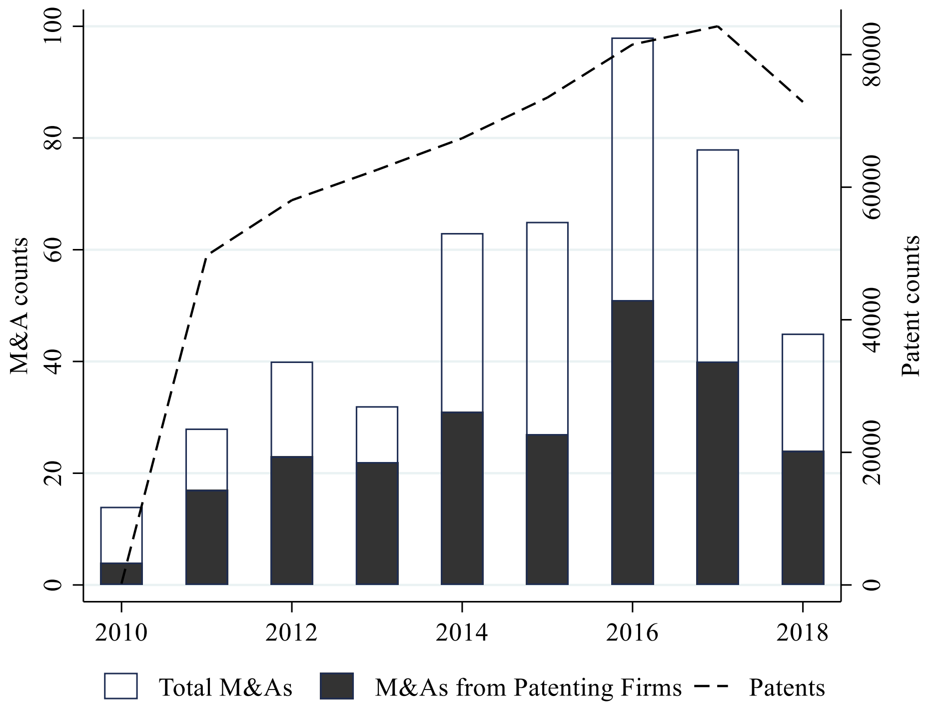
Where $y_{it}$ indicates the number of patents for firm $i$ in year $t$. The vector $x'_{it}$ contains the covariates specified in explanatory variables, and β stands for the corresponding coefficients to be estimated. A set of variables that reflect a firm's characteristics are included, they are $Size_{it}$, $Age_{it}$, $Fin_{it}$, and $Tar\ U - tech/KIS_i$ referring to the firm's size, age, financial performance, and the technology intensity of target firms, respectively. The categorical variable $MFGtech_i$ represents the manufacturing industry classifications of acquirers, 1 to 3 is for H-tech, MH-tech, and ML-&L-tech, respectively. $SOE_i$ denotes the ownership of acquirers, 1 if a firm is an SOE, 0 if a firm is a POE. $M\&A_{it}$ refers to the Chinese firms' M&A activities, 1 if a firm has undertaken a M&A and after, 0 otherwise. The probability of the logistic link function is denoted as $\varphi_{it}(z'_{it}\gamma)$, given the covariate vector of inflation variables $z'_{it}$, γ is the parameter vector. The factors that might inflate the number of zeroes are considered as firm age, firm size, financial performance, and if the acquiring firm belongs to the H-tech or KIS group (yes=1, no=0). The time effects and industry effects in the sample will be captured by $year_i$ and $industry_i$. $\varepsilon_{it}$ is the error term to capture the residual variation.

# 5. Results

## 5.1.Descriptive analysis

**Figure 1** displays the general development of M&As by Chinese acquiring firms in the EU from 2010 to 2018 (lhs) using the sampled dataset. According to the trend demonstrated by the bar charts in the graph, the number of M&As undertaken by Chinese MNEs in the EU increased significantly since 2010 until peaking in 2016, followed by a rapid drop in the following two years. This trend is in line with the general findings from research on Chinese outward M&A transactions in the EU (Kratz et al., 2020), which can, in one aspect, reflect the reliability of the study sample. The total number of M&A activities and the M&As from Chinese acquirers who applied for at least one patent during the time (in black) share a similar growth trend among all years. M&As by firms that file patent applications for their innovation outcomes make up a considerable share of the total number of M&A activities, accounting for roughly 50% on average. The number of patent applications of the acquirers who had M&A deals in the EU28 between 2012 – 2016 is also illustrated (rhs). The line graph shows that these acquirers' total number of patents rose gradually from 2010 to 2017 and again declined after 2017.

**Figure 1: Cumulative M&A deals and patents applications of Chinese acquirers in the EU**




*Source: Bureau van Dijk and Thomson Reuters. Author's own elaboration*

The following two-way table shows the summarized statistics of individual MFG technological intensity classifications and firms' ownership types (**Table 2**). The first row presents the observations of the categorical variables, while the second row includes the means of patent applications. In general, it is noticeable that MH-tech firms or POEs undertake a major share of the M&A investment. The results in the last column show that the MH-tech group accounts for almost half of the total observed frequency (558/1125) amongst the four classifications, followed by the H-tech, L-tech, and ML-tech groups. The average patent applications of each MFG-tech group allow us to see that the H-tech group occupies the absolute leading position in receiving patents among the groups. Surprisingly, although the number of firms from the ML-tech or L-tech groups is less than the MH-tech group, the average patents received from the former two groups are not very different from the latter. The results in the last row (Total) show that the frequency of POEs is almost double the frequency of SOEs, but the average patents received for the POEs is approximately half the ratio for SOEs. The results in the center part of the table indicate that the major innovative power is H-&MH-tech SOEs.

**Table 2: The matrix of Chinese acquirers by MFG technology classifications and acquirer's ownership**

| | *Acquirer's Ownership* | | |
|---|---|---|---|
| *MFG Technology* | *SOE* | *POE* | *Total* |
| **H-tech** | **72** | **207** | **279** |
| | *171.54* | *141.29* | *149.10* |
| **MH-tech** | **225** | **333** | **558** |
| | *227.60* | *74.03* | *135.95* |
| **ML-tech** | **36** | **72** | **108** |
| | *145.11* | *84.53* | *104.72* |
| **L-tech** | **72** | **99** | **171** |
| | *52.06* | *73.86* | *64.68* |
| **Total** | **405** | **711** | **1116** |
| | *179.09* | *94.65* | *125.29* |

*Notes: The first row presents frequencies, while the second row contains the means of patent applications*

*Source: Bureau van Dijk, Thomson Reuters, European Commission, official websites and annual reports of companies, and Chinese state agencies. Author's own elaboration*

## 5.2.Main results

The data sample for hypotheses testing excludes HUAWEI TECHNOLOGIES CO., LTD. and MIDEA GROUP CO., LTD. due to the receptions of a considerably high number of patent applications. The descriptive statistics and pairwise correlations of the selected variables for the regression analysis are reported in the following **Table 3**. In general, the correlations between variables exhibit the expected signs and present low correlations among the regressors, together with computed results of variance inflation factors, which are all below the acceptable level of 10 (Neter et al., 1985), specify that multicollinearity should not be a serious concern.

**Table 3: Descriptive statistics and pairwise correlations of selected variables**

| | Variable | Obs | Mean | Std. Dev. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | Patents | 2052 | 132.3 | 467.6 | 1.00 | | | | | | | | |
| (2) | Size | 1132 | 8.09 | 2.05 | 0.38* | 1.00 | | | | | | | |
| (3) | Age | 1872 | 16.12 | 8.39 | -0.01 | 0.02 | 1.00 | | | | | | |
| (4) | Fin | 1200 | 0.55 | 0.43 | 0.02 | 0.00 | -0.18* | 1.00 | | | | | |
| (5) | Tar U-tech \| KIS | 2052 | 0.57 | 0.49 | 0.10* | 0.02 | -0.05* | -0.07* | 1.00 | | | | |
| (6) | MFG tech | 1116 | 2 | 0.71 | -0.07* | 0.05 | 0.08* | 0.00 | 0.30* | 1.00 | | | |
| (7) | SOE | 2052 | 0.39 | 0.49 | 0.06* | 0.13* | 0.11* | 0.07* | -0.06* | 0.13* | 1.00 | | |
| (8) | L M&A | 2052 | 0.39 | 0.49 | 0.10* | 0.10* | 0.23* | -0.11* | -0.01 | 0.08* | 0.02 | 1.00 | |
| (9) | Acq H-tech \| KIS | 2052 | 0.38 | 0.49 | -0.02 | 0.00 | -0.07* | -0.13* | 0.07* | 1.00* | -0.02 | -0.04 | 1.00 |
| | Mean VIF = 1.81 | | | | | 1.14 | 1.25 | 1.11 | 1.22 | 3.84 | 1.10 | 1.17 | 3.66 |

*Notes: Correlations are measured via Bravais-Pearson, and Cramer's V statistics are taken for dummies. * shows significance at the .05 level*

The hypotheses are tested with regard to the results presented in **Table 4**. The output variable is the number of patents per year for all regressions. The upper part of the results, labeled as count on the top left, shows coefficients for the change in the expected count for the firms that obtained patents. The lower part, labeled as inflate, corresponds to the binary process. Model 1 was included as the baseline model and contained only control variables. The MFG technological classifications and firm's ownership type are individually added in models 2 and 3, respectively. The variable of primary interest L_M&As is included in model 4, and together with the former two variables in model 5. Models 6 to 10 are presented based on the sub-samples to test the hypotheses. The positive results of the natural logarithm of the dispersion parameters (lnalpha) in all models indicate overdispersion in the data. Robust standard errors are included in parentheses.

In models 1 to 5 using full data samples, among those firms who obtain patents, the coefficients of firm size, age, and financial performance are positive and statistically significant in all estimations. In other words, acquiring firms with a larger scale, more experience, or a better financial performance, are expected to be positively associated with the probability of generating more patents. However, by viewing the lower set of coefficients, both the size and the age of a firm significantly influence the odds of not having patents but with adverse effects. As the size of a firm increases, the higher the chance that a firm receives a patent, for the age of the company; on the contrary, it increases the likelihood of not having a patent. The coefficients of the control variables in model 1 show the expected signs. The regression results in column 2 indicate that the MH-tech firms produce notably more patents than ML-tech and L-tech firms, but a similar result cannot be determined for the H-tech group, holding everything else constant. In column 3, SOEs are seen to have better innovation performance than POEs by observing the positive coefficient of the ownership variable, the difference, however, is insignificant.

Hypothesis 1 expected that the subsequent innovation output of Chinese acquiring enterprises is positively associated with M&As undertaken in the EU. The positive coefficient of the L_M&A variable in both models 4 and 5 only partially supports this hypothesis. All else equal, Chinese acquirers, which have the opportunity to apply for patents, are estimated to have a higher expected innovation output by 26% [exp(0.229)-1]% after acquisition (model 4). If we include the MFG technological classification and the ownership type in the model, as shown in model 5, being post-acquisition increases the expected innovation output of Chinese acquiring firms by 21% [exp(0.193)-1]%, but the effects are not significant at the 5% level, holding other variables constant.

Hypothesis 2a states that in the high-technology sector, the post-innovation output of Chinese acquiring enterprises is negatively influenced by M&As undertaken in the EU market. Based on the regression results reported in column 6, the estimated coefficient of the lagged M&A is positive for H-&MH-tech firms, which indicates that firms in the high-technology sector can obtain a higher expected patent count in the post-acquisition era among those who file patents. However, this result is statistically insignificant at the given significant levels, which partially rejects Hypothesis 2a.

## Table 4: ZINB analysis on acquirers’ innovation outcomes

| | | (1) Controls | (2) | (3) | (4) | (5) | (6) H-&MH-tech | (7) L-&ML-tech | (8) SOE | (9) POE | (10) H-&MH-tech |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Count | Size | 0.426*** | 0.482*** | 0.422*** | 0.424*** | 0.475*** | 0.468*** | 0.448*** | 0.525*** | 0.428*** | 0.470*** |
| | | (0.03) | (0.03) | (0.03) | (0.03) | (0.04) | (0.04) | (0.08) | (0.04) | (0.05) | (0.04) |
| | Age | 0.058*** | 0.069*** | 0.059*** | 0.057*** | 0.068*** | 0.071*** | -0.029 | -0.020 | 0.084*** | 0.072*** |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.03) | (0.01) | (0.02) | (0.01) |
| | Fin | 0.918*** | 0.502** | 0.870*** | 0.924*** | 0.470** | 0.347 | -0.307 | 1.324*** | 0.777*** | 0.356 |
| | | (0.20) | (0.20) | (0.21) | (0.20) | (0.21) | (0.23) | (0.41) | (0.34) | (0.24) | (0.23) |
| | Tar U-tech \| KIS | -0.010 | 0.058 | 0.001 | -0.010 | 0.050 | 0.067 | -0.660 | 0.229 | 0.123 | 0.096 |
| | | (0.14) | (0.15) | (0.14) | (0.14) | (0.15) | (0.19) | (0.44) | (0.29) | (0.21) | (0.19) |
| | H-tech | | 0.127 | | | 0.144 | | | | | |
| | | | (0.19) | | | (0.19) | | | | | |
| | MH-tech | | 0.691*** | | | 0.661*** | | | | | |
| | | | (0.19) | | | (0.19) | | | | | |
| | SOE | | | 0.134 | | 0.105 | 0.302* | -0.907** | | | 0.185 |
| | | | | (0.13) | | (0.14) | (0.15) | (0.43) | | | (0.23) |
| | L_M&A | | | | 0.229 | 0.193 | 0.269 | 0.958* | -0.020 | 0.777*** | 0.165 |
| | | | | | (0.18) | (0.19) | (0.18) | (0.54) | (0.17) | (0.26) | (0.25) |
| | L_M&A × SOE | | | | | | | | | | 0.210 |
| | | | | | | | | | | | (0.28) |
| | Constant | -4.432*** | -4.977*** | -4.399*** | -4.388*** | -4.890*** | -4.337*** | -2.214* | -4.943*** | -4.552*** | -4.345*** |
| | | (0.58) | (0.60) | (0.59) | (0.58) | (0.61) | (0.69) | (1.15) | (0.85) | (0.72) | (0.68) |
| Inflate | Size | -0.410*** | -0.466*** | -0.410*** | -0.410*** | -0.466*** | -0.458*** | -0.599*** | -0.398*** | -0.399*** | -0.459*** |
| | | (0.05) | (0.08) | (0.05) | (0.05) | (0.08) | (0.09) | (0.18) | (0.07) | (0.08) | (0.09) |
| | Age | 0.060*** | 0.056*** | 0.060*** | 0.060*** | 0.056*** | 0.036 | 0.050** | 0.081*** | 0.058*** | 0.036 |
| | | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.03) | (0.02) | (0.03) | (0.02) | (0.03) |
| | Fin | 0.249 | -0.986** | 0.248 | 0.250 | -0.984** | -1.158** | -0.772 | 0.711** | -0.042 | -1.161** |
| | | (0.25) | (0.47) | (0.25) | (0.25) | (0.47) | (0.55) | (0.65) | (0.36) | (0.41) | (0.55) |
| | Acq H-tech \| KIS | -0.243 | -1.133*** | -0.248 | -0.242 | -1.127*** | -0.621** | | -0.100 | -0.431* | -0.621** |
| | | (0.17) | (0.27) | (0.17) | (0.17) | (0.27) | (0.28) | | (0.27) | (0.25) | (0.28) |
| | Constant | 1.663*** | 2.567*** | 1.660*** | 1.666*** | 2.570*** | 2.513*** | 4.413*** | 0.814 | 1.737*** | 2.516*** |
| | | (0.45) | (0.60) | (0.45) | (0.45) | (0.60) | (0.73) | (1.44) | (0.81) | (0.55) | (0.73) |
| | lnalpha | 0.474*** | 0.361*** | 0.474*** | 0.471*** | 0.357*** | 0.316*** | 0.394** | 0.089 | 0.597*** | 0.316*** |
| | | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.17) | (0.10) | (0.13) | (0.09) |
| | Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Industry dummy | Yes | No | Yes | Yes | No | No | No | Yes | Yes | No |
| | Observations | 953 | 712 | 953 | 953 | 712 | 534 | 178 | 389 | 564 | 534 |
| | Log lik. | -4000.4 | -3271.2 | -3999.9 | -3999.7 | -3270.4 | -2635.8 | -618.5 | -1802.5 | -2146.9 | -2635.4 |
| | Wald Chi-sq | 439.2*** | 430.7*** | 433.4*** | 436.5*** | 427.2*** | 354.8*** | 104.3*** | 307.7*** | 348.6*** | 375.6*** |
| | AIC | 8048.9 | 6584.4 | 8049.7 | 8049.4 | 6586.7 | 5313.6 | 1276.9 | 3655.0 | 4343.9 | 5314.9 |

*Notes: Robust standard errors in parentheses. Significance levels:* * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 2b, according to which the subsequent innovation output of Chinese acquiring enterprises in the low-technology sector will be positively influenced by M&As undertaken in the EU, is tested using the sub-sample in model 7. Among the firms who applied for patents, a higher innovation outcome for acquirers is evidenced after undertaking M&A activities in the EU in comparison to the pre-acquisition period, with the expected number of patents increased by a factor of 2.60 [exp(0.958)]. However, the change in effect is statistically significant only at the 10% level, which provides weak support for Hypothesis 2b.

Hypothesis 3a predicts that the M&As that Chinese enterprises undertake in the EU will have an adverse influence on the post-acquisition innovation output of SOEs. In column 8, it can be seen that an additional number of patents from Chinese SOEs are expected according to the results from the count equation. However, the result is not significantly different after merging with or acquiring companies from the EU, even at the 10% significance level. Thus, Hypothesis 3a can be partially rejected by the finding.

In contrast, Hypothesis 3b states that the innovation output of POEs will increase after having M&As in the EU. Within model 9, the coefficient of L_M&A shows that the expected number of patents increased by a factor of 2.17 [exp(0.777)] when a firm goes from the pre-M&A period to the post-M&A period, holding other variables constant, which is consistent with Hypothesis 3b. The change in effect is highly significant and provides empirical support for Hypothesis 3b. This result suggests that a strong positive effect of M&As on the firms' innovative performance can be identified for POEs among those which file patents.

Hypothesis 4 assumes that in the high-technology sector, the innovation output of SOEs will benefit more than POEs after having M&As in the EU. The interaction term of M&A and ownership type is added to test the hypothesis. In the count model, the positive but insignificant coefficient of the interaction term in column 10 does not suggest that SOEs are more likely to generate additional higher innovation output in comparison to POEs in the upper intermediate technology industry after having M&A activities in the EU, holding other covariates constant.

## 5.3.Robustness check

The author tested the results for a potential endogeneity problem by replacing the regressors lagged for one to two years to check the robustness. The results are persistent in the tests according to the outcomes included in the appendix (**Table 7** and **Table 8**). Furthermore, two outlier companies, HUAWEI TECHNOLOGIES CO., LTD. and MIDEA GROUP CO., LTD. were re-included into the data sample. According to the test results shown in **Table 9**, similar results are presented in testing hypotheses 2b to 4. However, we observe an enormous impact on the parameter of the L_M&A variable after adding the two companies. The effect of M&As became positive and highly significant with regard to the increase of patents received after having undertaken M&A activities in the EU. Therefore, it is necessary to treat these two firms carefully.

# 6. Conclusion and Discussion

## 6.1. Conclusion

This study is mainly interested in whether EMNEs can enhance their innovation performance after having undertaken M&A deals in developed markets. In more detail, how the firms' innovative performance changes with respect to different technological intensity and ownership types. To address these questions, this research has investigated Chinese acquiring firms with M&As in EU28 countries over the period of 9 years from 2010 to 2018.

This research contributes to the existing literature in several ways. Due to detailed data on Chinese M&As in the EU being very limited, in this study, the author constructed a comprehensive firm-level dataset by crosschecking various data sources to research the change of innovation performance of Chinese MNEs undertaking M&As in the EU28. Meanwhile, this research adopted a Zero-Inflated Negative Binomial estimation method to account for the overdispersion and zero inflation in the data. The results of several goodness-of-fit tests suggest that this specification significantly improves the fitting of the data. With reference to the empirical findings, while supporting the idea that the behavior of not filing patent applications exists and should be considered when using patents as an indicator of innovation, several new insights and practical implications have been provided on the performance of Chinese multinationals' innovation output by acquiring external resources using cross-border M&As in developed economies.

This study found that having M&As in the EU market will enhance the innovation outcomes of Chinese acquiring firms over the sample period. However, an overall significant improvement is invisible from the obtained observations. This positive finding aligns with the evidence from the literature that Chinese acquirers can improve their innovativeness via M&A activities in developed markets (Fu et al., 2018; Piperopoulos et al., 2018). With respect to a learning perspective, on the one hand, M&As can be viewed as an effective channel for acquirers to reach additional resources and learning opportunities for knowledge accumulation and transformation. On the other hand, Chinese multinationals are generally able to acquire and manage the acquired knowledge and technology from developed economies to reinforce their innovation performance. Nevertheless, the resultant improvement in innovation performance is different among diverse groups of firms in terms of technical intensity and ownership type.

The enhancement of the innovation performance can be identified for H-&MH-tech firms after investing in the EU market through M&As, but the effect is insignificant, except when including the two giant innovation hubs. Multiple reasons can exist which could explain these findings. It may be due to the intrinsic features of innovations with high added value, which are often related to high uncertainty and risk and long-term investment needs; thus, an apparent increase in innovation outcomes of high technological intensive Chinese MNEs is not directly visible. Alternatively, the lack of technological capacity and international organizational experience could be the reason for those firms failing to mobilize external resources to fulfill the needs and upgrade their advantages. It is also possible that the H-&MH-tech firms are aiming for a higher quality level of innovation.

Notwithstanding, a consistent weak improvement in innovation has been evidenced for the ML-&L-tech acquirers after purchasing or merging with firms from the EU market. Hence, the idea that M&As can provide additional opportunities and necessary resources to the ML-&L-tech companies to advance their innovation performance is supported. Companies with a lower technological intensity also contribute to the breadth and depth of technological development covering a wide range of industries. Together with the market-driven characteristics, ML-&L-tech firms might be able to recognize and absorb external technology and know-how to enhance their innovativeness at a relatively fast speed. However, the experience and financial performance of ML-&L-tech firms are found to be negatively associated with the number of patents. This finding might reflect previous findings such as (Cozza et al., 2015) that acquisitions are favored by firms who desire early access to intangible assets or search for financial support.

Meanwhile, all of the results of this paper strongly support the hypothesis that POEs can largely improve their innovation performance after having undertaken M&As in the EU market. Although POEs are considered to have less international M&A experience in comparison to their global counterpart and bear the later-comer disadvantage, they are nevertheless the major and active investment players who can successfully leverage and acquire external resources to benefit their technological advantages. Therefore, financial support for POEs, especially medium and small POEs, and the simplification of the administrative regulation process should be further improved to provide necessary and convenient policy services for POEs to invest abroad and integrate into the international market.

## 6.2.Recommendations

Since the possibility of having higher innovativeness indeed exists for Chinese firms undertaking M&As in the EU, it is essential to ensure a modest investment environment to secure a continuous investment incentive from the Chinese multinationals. Particularly in the current weak domestic and international economic conditions. From the perspective of cross-border investment, the deepening of the Comprehensive Agreement on Investment (CAI) could offer a good opportunity to reduce investment friction by providing a regulatory framework for investors and strengthening governmental communication and coordination between China and the EU. From the domestic market perspective, the facilitation of outward investment, such as simplifying the administrative procedures and optimizing financial service reform, should be continuously promoted, especially for POEs.

In order to encourage firms to internalize their assets, especially intangible assets, in an efficient, effective, and sustainable manner, appropriate stimulation should be provided targeting different groups. For high-tech manufacturing firms, a continuous openness to external information and resources is essential. For instance, continuous and rational increases in R&D capital and workforce investment and observation of innovation performance are effective ways to increase firms' knowledge stocks and improve learning capabilities. Providing executives with specialized training programs, acquiring experienced management personnel, and developing suitable corporate development strategies can benefit firms' innovation and competitiveness. Additionally, firms should develop their main strengths and characteristics through rational investment, maintain a healthy financial capability, and have a clear understanding of the target environment to improve their ability to explore and utilize external resources effectively.

## 6.3. Limitations and future research

The limitations of this study can also provide several valuable ideas for future research. Firstly, although China is a very representative case in the study of outward investment from emerging economies, the findings should not be overgeneralized. Future research could be extended to other emerging economy countries, and comparative analysis could be conducted. Secondly, the reasons behind the insignificant change of innovation performance after engaging in M&As can be further explored in detail especially for H-tech firms and SOEs. It might provide more comprehensive suggestions in improving innovation outcomes for those firms on various knowledge paths. Thirdly, while in this paper firms are distinguished on the basis of corporate ownership, some researchers (Cheng et al., 2019) have argued that it is not only the type of corporate ownership but also the political connections which play an essential role. This might indeed provide a different picture but is not considered in this article. Finally, future research could identify whether there are more international collaborations between EMNEs and developed MNEs in generating higher innovative outputs due to M&As. Whether or not more researchers from emerging economies are participating in international R&D after M&As would be a particularly important avenue for future research to identify the international knowledge spillover effect.

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# Appendix

*Two different estimations are applied to test whether or not the selected sample suffers from the problem of sample selection bias. Despite including the main variables discussed in section 4.2 (for descriptive statistics, see **Table 3**), two additional variables are selected. The R&D intensity of firms has been used as an alternative variable to the MFG tech, and the accumulated number of M&A deals in the EU for each firm is added to control for a firm's internationalization experience.*

*The estimated results of using the two-part model are included in columns 1 and 2. The first part is a probit regression, in which the dependent variable takes 1 if a firm has been identified to have patents, 0 otherwise. The second part has the number of patents as the outcome variable, and is estimated by an NB specification. Columns 3 and 4 list the regression results using Heckman two-step estimates. The dependent variable in the selection regression (column 4) is again a binary variable. The response variable in the outcome regression (column 3) is the natural logarithm of the number of patents.*

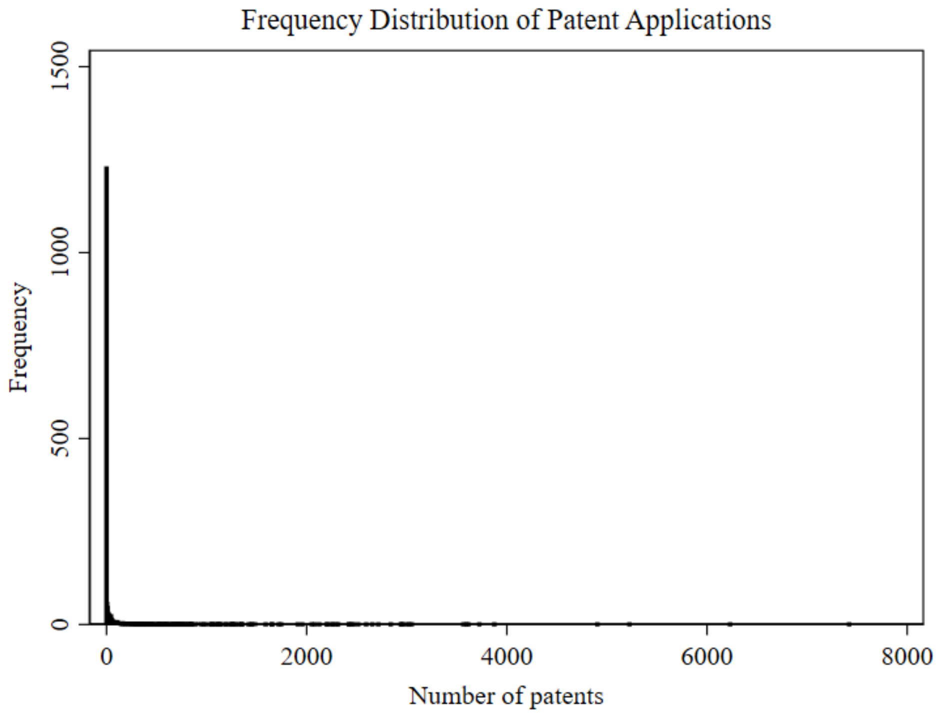
*A similar outcome is generated using different estimations. Additionally, the inverse Mills ratio (lambda) is not significantly different from zero given the p-value. Since lambda is the covariance between the errors in the equation of interest and the selection equation, the null hypothesis that the two models are independent cannot be rejected.*

**Table 5: Sample selection regression results**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | | | Heckman Two-step estimates | |
| VARIABLES | Probit | NB | Outcome | Selection |
| Size | 0.326*** | 0.782*** | 0.773*** | 0.336*** |
| | (0.037) | (0.073) | (0.070) | (0.037) |
| Age | -0.054*** | 0.013 | 0.018 | -0.052*** |
| | (0.008) | (0.015) | (0.016) | (0.008) |
| Fin | | 0.875*** | 0.717*** | |
| | | (0.220) | (0.199) | |
| Tar U-tech \| KIS | | 0.912*** | 0.759*** | |
| | | (0.151) | (0.151) | |
| M&A EU28 | -0.028 | | | -0.023 |
| | (0.107) | | | (0.114) |
| R&D intensity | 0.113*** | | | 0.122*** |
| | (0.021) | | | (0.018) |
| Constant | -1.674*** | -7.823*** | -5.950*** | -2.900*** |
| | (0.352) | (0.782) | (0.880) | (0.382) |
| lambda | | -0.176 | | -0.445 |
| | | (0.385) | | (0.326) |
| Observations | 894 | 485 | 446 | 792 |
| Year Dummy | YES | YES | YES | YES |
| Industry dummy | YES | YES | YES | YES |
| Wald chi2 | 117.5*** | 978.4*** | 411.3*** | |
| Log Lik | -501.8 | -2751 | | |
| rho | | | -0.385 | |

*Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1*

**Figure 2: Frequency distribution of patent applications**




*Source: Orbis*

**Table 6: The model comparison using pooled Poisson, NBRM, ZIP, and ZINB**

| Model | Pearson dispersion statistic | Log likelihood | AIC | BIC | LR test |
|---|---|---|---|---|---|
| Poisson | 1763086* | -140822.11 | 281674.20 | 281737.80 | |
| NB | | -3083.57 | 6199.14 | 6266.98 | |
| ZIP | | -140649.60 | 281355.30 | 281474.00 | |
| ZINB | | -3173.09 | 6372.17 | 6427.29 | |
| XTPoisson | | -15821.38 | 31674.76 | 31742.60 | |
| XTNB | | -2748.26 | 5530.52 | 5602.60 | |
| NB nested in XTNB | | | | | 670.19* |
| NB nested in ZINB | | | | | 36.40* |
| XTNB nested in ZINB | | | | | -633.80 |

*Notes: * shows significance at the .01 level*

# Table 7: Robustness test with all individual variables lagged by one year

| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Controls | | | | | H-&MH-tech | L-&ML-tech | SOE | POE | H-&MH-tech |
| Count | L_Size | 0.353*** | 0.378*** | 0.348*** | 0.352*** | 0.373*** | 0.346*** | 0.627*** | 0.347*** | 0.418*** | 0.349*** |
| | | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.06) | (0.05) | (0.05) | (0.04) |
| | L_Age | 0.051*** | 0.058*** | 0.052*** | 0.051*** | 0.057*** | 0.058*** | -0.091*** | 0.002 | 0.068*** | 0.057*** |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.03) | (0.02) | (0.02) | (0.01) |
| | L_Fin | 1.056*** | 0.664** | 0.969*** | 1.068*** | 0.589** | 0.492 | -0.296 | 1.432*** | 0.665** | 0.457 |
| | | (0.24) | (0.26) | (0.24) | (0.24) | (0.26) | (0.30) | (0.38) | (0.41) | (0.29) | (0.30) |
| | Tar U-tech \| KIS | -0.062 | 0.083 | -0.053 | -0.061 | 0.057 | 0.019 | -0.283 | -0.058 | -0.075 | -0.008 |
| | | (0.15) | (0.17) | (0.15) | (0.15) | (0.17) | (0.21) | (0.42) | (0.33) | (0.22) | (0.21) |
| | H-tech | | 0.203 | | | 0.236 | | | | | |
| | | | (0.20) | | | (0.20) | | | | | |
| | MH-tech | | 0.699*** | | | 0.645*** | | | | | |
| | | | (0.18) | | | (0.19) | | | | | |
| | SOE | | | 0.213 | | 0.218 | 0.409** | -1.048*** | | | 0.504** |
| | | | | (0.14) | | (0.15) | (0.17) | (0.37) | | | (0.24) |
| | L_M&A | | | | 0.321 | 0.322 | 0.338 | 1.293*** | 0.093 | 1.015*** | 0.412 |
| | | | | | (0.20) | (0.21) | (0.21) | (0.38) | (0.20) | (0.28) | (0.27) |
| | L_M&A× SOE | | | | | | | | | | -0.152 |
| | | | | | | | | | | | (0.29) |
| | Constant | 0.805* | 0.625 | 0.823* | 0.831* | 0.667 | 1.459*** | 1.098* | 1.484** | 0.249 | 1.450*** |
| | | (0.43) | (0.51) | (0.43) | (0.44) | (0.53) | (0.54) | (0.67) | (0.76) | (0.56) | (0.54) |
| Inflate | L_Size | -0.420*** | -0.471*** | -0.420*** | -0.420*** | -0.471*** | -0.470*** | -0.593*** | -0.432*** | -0.392*** | -0.469*** |
| | | (0.06) | (0.08) | (0.06) | (0.06) | (0.08) | (0.10) | (0.19) | (0.08) | (0.08) | (0.10) |
| | L_Age | 0.057*** | 0.051*** | 0.058*** | 0.057*** | 0.051*** | 0.024 | 0.051** | 0.090*** | 0.049*** | 0.024 |
| | | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.03) | (0.02) | (0.03) | (0.02) | (0.03) |
| | L_Fin | 0.072 | -1.209** | 0.070 | 0.0725 | -1.219** | -1.357** | -0.851 | 0.563 | -0.325 | -1.363** |
| | | (0.26) | (0.47) | (0.26) | (0.26) | (0.48) | (0.53) | (0.61) | (0.38) | (0.42) | (0.54) |
| | Acq H-tech \| KIS | -0.263 | -1.072*** | -0.269 | -0.262 | -1.069*** | -0.614** | | -0.126 | -0.404* | -0.615** |
| | | (0.17) | (0.26) | (0.17) | (0.17) | (0.26) | (0.28) | | (0.28) | (0.24) | (0.28) |
| | Constant | 1.894*** | 2.848*** | 1.893*** | 1.894*** | 2.850*** | 2.925*** | 4.440*** | 1.037 | 2.017*** | 2.925*** |
| | | (0.45) | (0.62) | (0.45) | (0.45) | (0.62) | (0.74) | (1.54) | (0.86) | (0.55) | (0.74) |
| | lnalpha | 0.403*** | 0.325*** | 0.401*** | 0.398*** | 0.316*** | 0.278*** | 0.209 | 0.095 | 0.508*** | 0.277*** |
| | | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.18) | (0.11) | (0.12) | (0.09) |
| | Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Industry dummy | Yes | No | Yes | Yes | No | No | No | Yes | Yes | No |
| | Observations | 832 | 622 | 832 | 832 | 622 | 467 | 155 | 338 | 494 | 467 |
| | Log lik. | -3700.0 | -3057.3 | -3698.6 | -3698.5 | -3054.6 | -2473.8 | -558.5 | -1676.0 | -1983.9 | -2473.7 |
| | Wald Chi-sq | 234.2*** | 167.5*** | 258.4*** | 230.5*** | 199.0*** | 174.9*** | 150.8*** | 201.6*** | 199.7*** | 175.6*** |
| | AIC | 7446.0 | 6154.7 | 7445.2 | 7444.9 | 6153.3 | 4987.6 | 1155.1 | 3400.0 | 4015.9 | 4989.3 |

*Notes: Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

## Table 8: Robustness test with all individual variables lagged by two years

| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Controls | | | | | H-&MH-tech | L-&ML-tech | SOE | POE | H-&MH-tech |
| Count | L2_Size | 0.353*** | 0.353*** | 0.343*** | 0.355*** | 0.345*** | 0.318*** | 0.678*** | 0.364*** | 0.351*** | 0.324*** |
| | | (0.03) | (0.04) | (0.04) | (0.03) | (0.04) | (0.04) | (0.07) | (0.06) | (0.04) | (0.04) |
| | L2_Age | 0.037*** | 0.038*** | 0.036*** | 0.035*** | 0.036*** | 0.036*** | -0.135*** | 0.001 | 0.040** | 0.034** |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.03) | (0.02) | (0.02) | (0.01) |
| | L2_Fin | 1.030*** | 0.744*** | 0.952*** | 1.025*** | 0.686*** | 0.612** | -0.298 | 1.393*** | 0.678*** | 0.540** |
| | | (0.23) | (0.23) | (0.22) | (0.23) | (0.23) | (0.25) | (0.37) | (0.44) | (0.26) | (0.24) |
| | Tar U-tech \| KIS | -0.024 | 0.181 | -0.027 | -0.012 | 0.155 | 0.029 | -0.267 | -0.328 | -0.074 | -0.053 |
| | | (0.17) | (0.19) | (0.17) | (0.17) | (0.19) | (0.24) | (0.50) | (0.45) | (0.23) | (0.24) |
| | H-tech | | 0.257 | | | 0.285 | | | | | |
| | | | (0.21) | | | (0.22) | | | | | |
| | MH-tech | | 0.626*** | | | 0.549*** | | | | | |
| | | | (0.18) | | | (0.19) | | | | | |
| | SOE | | | 0.228 | | 0.221 | 0.443** | -1.563*** | | | 0.686*** |
| | | | | (0.16) | | (0.16) | (0.18) | (0.43) | | | (0.22) |
| | L2_M&A | | | | 0.367* | 0.391* | 0.420* | 1.734*** | -0.066 | 1.054*** | 0.648** |
| | | | | | (0.22) | (0.22) | (0.22) | (0.46) | (0.24) | (0.26) | (0.28) |
| | L2_M&A× SOE | | | | | | | | | | -0.468 |
| | | | | | | | | | | | (0.29) |
| | Constant | 1.231** | 1.083** | 1.286** | 1.243** | 1.159** | 1.905*** | 1.511** | 1.765** | 1.413** | 1.901*** |
| | | (0.50) | (0.53) | (0.51) | (0.50) | (0.55) | (0.56) | (0.75) | (0.90) | (0.68) | (0.56) |
| Inflate | L2_Size | -0.398*** | -0.442*** | -0.399*** | -0.398*** | -0.441*** | -0.456*** | -0.475** | -0.432*** | -0.360*** | -0.455*** |
| | | (0.06) | (0.08) | (0.06) | (0.06) | (0.08) | (0.10) | (0.19) | (0.09) | (0.07) | (0.10) |
| | L2_Age | 0.050*** | 0.045*** | 0.051*** | 0.050*** | 0.045*** | 0.013 | 0.042 | 0.098*** | 0.038** | 0.013 |
| | | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.03) | (0.03) | (0.03) | (0.02) | (0.03) |
| | L2_Fin | -0.0318 | -1.286** | -0.0329 | -0.0318 | -1.288** | -1.403** | -0.990 | 0.613 | -0.419 | -1.406** |
| | | (0.28) | (0.51) | (0.28) | (0.28) | (0.51) | (0.55) | (0.71) | (0.41) | (0.40) | (0.55) |
| | Acq H-tech \| KIS | -0.264 | -1.001*** | -0.269 | -0.262 | -0.996*** | -0.582** | | -0.101 | -0.379 | -0.582** |
| | | (0.18) | (0.27) | (0.18) | (0.18) | (0.27) | (0.29) | | (0.31) | (0.25) | (0.29) |
| | Constant | 1.929*** | 2.767*** | 1.929*** | 1.929*** | 2.768*** | 3.083*** | 3.612** | 0.852 | 2.081*** | 3.081*** |
| | | (0.48) | (0.65) | (0.48) | (0.48) | (0.65) | (0.77) | (1.50) | (0.93) | (0.56) | (0.77) |
| | lnalpha | 0.344*** | 0.285*** | 0.339*** | 0.335*** | 0.271*** | 0.204** | 0.171 | 0.103 | 0.372*** | 0.194** |
| | | (0.08) | (0.09) | (0.08) | (0.08) | (0.09) | (0.09) | (0.18) | (0.11) | (0.12) | (0.09) |
| | Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Industry dummy | Yes | No | Yes | Yes | No | No | No | Yes | Yes | No |
| | Observations | 703 | 529 | 703 | 703 | 529 | 398 | 131 | 282 | 421 | 398 |
| | Log lik. | -3117.9 | -2598.2 | -3116.5 | -3115.8 | -2594.9 | -2091.8 | -480.1 | -1414.0 | -1669.9 | -2090.5 |
| | Wald Chi-sq | 193.6*** | 130.4*** | 202.2*** | 204.3*** | 156.9*** | 147.8*** | 144.3*** | 138.7*** | 181.3*** | 161.0*** |
| | AIC | 6279.8 | 5234.3 | 6279.0 | 6277.5 | 5231.9 | 4221.6 | 996.3 | 2873.9 | 3385.7 | 4220.9 |

*Notes: Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

# Table 9: Robustness test by including outliers

| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Controls | | | | | H-&MH-tech | L-&ML-tech | SOE | POE | H-&MH-tech |
| Count | Size | 0.473*** | 0.539*** | 0.474*** | 0.466*** | 0.534*** | 0.540*** | 0.448*** | 0.525*** | 0.456*** | 0.542*** |
| | | (0.03) | (0.04) | (0.03) | (0.03) | (0.04) | (0.04) | (0.08) | (0.04) | (0.05) | (0.04) |
| | Age | 0.092*** | 0.110*** | 0.092*** | 0.088*** | 0.105*** | 0.105*** | -0.029 | -0.02 | 0.106*** | 0.106*** |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.03) | (0.01) | (0.01) | (0.01) |
| | Fin | 1.391*** | 0.959*** | 1.400*** | 1.380*** | 0.949*** | 0.808*** | -0.307 | 1.324*** | 1.125*** | 0.819*** |
| | | (0.22) | (0.21) | (0.23) | (0.22) | (0.21) | (0.22) | (0.41) | (0.34) | (0.26) | (0.22) |
| | Tar U-tech \| KIS | 0.196 | 0.314** | 0.191 | 0.201 | 0.297* | 0.320* | -0.660 | 0.229 | 0.371* | 0.343* |
| | | (0.15) | (0.16) | (0.15) | (0.15) | (0.16) | (0.18) | (0.44) | (0.29) | (0.19) | (0.18) |
| | H-tech | | 0.296 | | | 0.299 | | | | | |
| | | | (0.20) | | | (0.20) | | | | | |
| | MH-tech | | 0.701*** | | | 0.698*** | | | | | |
| | | | (0.21) | | | (0.21) | | | | | |
| | SOE | | | -0.034 | | -0.047 | 0.097 | -0.907** | | | -0.009 |
| | | | | (0.12) | | (0.13) | (0.14) | (0.43) | | | (0.22) |
| | L_M&A | | | | 0.519*** | 0.394** | 0.408** | 0.958* | 0.0195 | 1.042*** | 0.314 |
| | | | | | (0.18) | (0.19) | (0.19) | (0.54) | (0.17) | (0.22) | (0.24) |
| | L_M&A× SOE | | | | | | | | | | 0.192 |
| | | | | | | | | | | | (0.28) |
| | Constant | -5.735*** | -6.751*** | -5.736*** | -5.600*** | -6.592*** | -6.035*** | -2.214* | -4.943*** | -5.427*** | -6.044*** |
| | | (0.57) | (0.59) | (0.57) | (0.56) | (0.58) | (0.61) | (1.15) | (0.85) | (0.69) | (0.60) |
| Inflate | Size | -0.428*** | -0.466*** | -0.428*** | -0.427*** | -0.467*** | -0.456*** | -0.599*** | -0.398*** | -0.424*** | -0.456*** |
| | | (0.05) | (0.08) | (0.05) | (0.05) | (0.08) | (0.10) | (0.18) | (0.07) | (0.08) | (0.10) |
| | Age | 0.053*** | 0.061*** | 0.053*** | 0.052*** | 0.060*** | 0.040 | 0.050** | 0.081*** | 0.049*** | 0.040 |
| | | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.03) | (0.02) | (0.03) | (0.01) | (0.03) |
| | Fin | 0.214 | -0.992** | 0.213 | 0.213 | -0.975* | -1.155** | -0.772 | 0.711** | -0.170 | -1.156** |
| | | (0.26) | (0.50) | (0.26) | (0.26) | (0.50) | (0.57) | (0.65) | (0.36) | (0.44) | (0.57) |
| | Acq H-tech \| KIS | -0.261 | -1.175*** | -0.259 | -0.260 | -1.172*** | -0.676** | | -0.100 | -0.452* | -0.677** |
| | | (0.17) | (0.29) | (0.17) | (0.17) | (0.29) | (0.30) | | (0.27) | (0.26) | (0.30) |
| | Constant | 1.875*** | 2.433*** | 1.877*** | 1.891*** | 2.450*** | 2.385*** | 4.413*** | 0.814 | 2.087*** | 2.384*** |
| | | (0.43) | (0.60) | (0.43) | (0.43) | (0.60) | (0.73) | (1.44) | (0.81) | (0.53) | (0.73) |
| | lnalpha | 0.594*** | 0.487*** | 0.593*** | 0.578*** | 0.476*** | 0.414*** | 0.394** | 0.089 | 0.671*** | 0.414*** |
| | | (0.07) | (0.07) | (0.07) | (0.07) | (0.07) | (0.07) | (0.17) | (0.10) | (0.11) | (0.07) |
| | Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Industry dummy | Yes | No | Yes | Yes | No | No | No | Yes | Yes | No |
| | Observations | 967 | 721 | 967 | 967 | 721 | 543 | 178 | 389 | 578 | 543 |
| | Log lik. | -4186.1 | -3393.6 | -4186.1 | -4182.3 | -3391.3 | -2750.1 | -618.5 | -1802.5 | -2314.5 | -2749.9 |
| | Wald Chi-sq | 568.6*** | 545.9*** | 573.7*** | 608.0*** | 552.7*** | 582.3*** | 104.3*** | 307.7*** | 622.9*** | 598.7*** |
| | AIC | 8420.3 | 6829.2 | 8422.2 | 8414.6 | 6828.7 | 5542.2 | 1276.9 | 3655.0 | 4678.9 | 5543.7 |

*Notes: Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

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