Broadband Deployment and M&A Activities: Evidence from Listed Firms in China

Xueyang Liu

Advisor: Joan Calzada

Universitat de Barcelona

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Abstract

This paper explores the causal effect of broadband deployment on mergers and acquisitions (M&A) using data from Chinese-listed firms between 2011 and 2022. Leveraging the "Broadband China" policy as an exogenous source of variation, we employ a staggered Differences-in-differences methodology to analyze how access to broadband Internet affects the decision of firms to engage in M&A transactions and its impact on firm performance. Our findings indicate that broadband deployment significantly increases the probability of firms initiating M&A transactions and finishing them successfully. These results are mainly driven by transactions that involve the complete acquisition of targeted firms, and that occur between firms of the same city or the same province. Our analysis reveals that broadband-driven M&As do not significantly impact the firms' total factor productivity, but we do find that they lead to a decrease in labor productivity and an increase in employment. The positive impact on employment occurs in all industries, whereas the reduction in labor productivity is significant only in some regulated activities such as electricity, heat, gas, and water production industries.

JEL Classification: D24, D83, G34, L96

Keywords: Broadband, M&A, ICT, Productivity, Employment, China

1. Introduction

Broadband Internet connections have experienced rapid development in China since the end of the 1990s. The length of fiber optic lines has expanded from 1.2 million kilometers in 2000 to 64.3 million kilometers in 2023. In parallel to the deployment of this infrastructure, the number of Internet users has soared from 8.9 million in 2000 to 1.092 billion in 2023, and the number of domain names ending in ".cn" experienced a strong increase from 48,695[1] in 2000 to 20.1 million[2] by the end of 2023. These changes have very relevant implications for the organization and performance of Chinese firms, as access to high-speed internet helps them to better communicate with their providers and clients, and to collect information that is useful to improve their production, operations, and management (Grimes et al., 2012; Akerman et al., 2015; Cambini et al., 2023).

One important research question that so far has received very little attention from the economic literature is whether the increase in information and the competitive pressure generated by the Internet has led firms to engage more in M&A transactions to increase their scale, reduce cost, and expand their sales to other regions. M&As can be used by firms to increase their market share and to enter new industries and markets (Stigler, 1950; Zhang et al., 2022). It is expected that after these transactions take place, the acquirer firm will gain knowledge, technology, and assets from the targeted firm, which can increase its productivity and scope (Hanelt et al., 2021).

Broadband connections can help firms gather information that is essential to successfully complete the M&A transaction. Acquirers can find information about the targeted firms, reducing the risks associated with information asymmetries. It also offers the acquirer and the targeted firms tools for real-time communication, facilitating the decision-making process. In addition, after the acquisition, the existence of good broadband connections can help the managers of the firms to better integrate the resources and the activities of the two entities.

This paper contributes to the literature on M&As by offering a detailed analysis of the effects of broadband deployment on the incentives of Chinese firms to engage in M&A transactions and on the impact on their productivity and performance. While some previous papers have examined the probability that firms engage in more M&As activities after potentially gaining access to broadband connections (Zhang et al., 2022), we examine which type of acquisitions

[1] Statistical Report on China's Internet Development from China Internet Network Information Center (CNNIC), published in January 2001. (only Chinese version)

[2] 53rd Statistical Report on China's Internet Development, published in March 2024.

are incentivized by the new technology and which are the consequences in the organization of the firms and their performance. The analysis of the Chinese case is especially relevant to study this research question, due to the staggered rollout of broadband fiber lines across its large cities in the last years, and to the consolidation process that is experiencing most of their economic activities.

To address these research questions, we combine an M&A dataset from the Chinese Research Data Services (CNRDS) and information on the characteristics of listed firms obtained from the China Stock Market Accounting Research (CSMAR) database. Specifically, we consider an unbalanced panel of firms for the period 2011-2022. The panel includes 2111 firms in 2011 and 4774 firms in 2022 and has 29,756 pair firm-year observations in total. In addition to this, we use information on the "Broadband China" program to identify the specific years in which broadband technology was available for the listed firms. One potential difficulty in identifying the impact of broadband deployment on firms' mergers and organizational decisions is that telecommunications operators can invest more in new technologies in those cities in which there is a higher demand for the Internet and more economic activity. To account for this situation, we exploit the quasi-exogenous variation in the deployment of the fiber technology generated by a public program of the Chinese government. In 2013, the government launched the "Broadband China" policy, to accelerate broadband infrastructure construction. Between 2014 and 2016, 120 pilot cities were selected for this initiative and received additional resources for the deployment of fiber networks. One important characteristic of the program is that cities were selected according to policy objectives and not for commercial reasons. We use this policy as an exogenous source of variation and employ staggered Differences-in-Differences (DiD) to investigate the impact of broadband deployment on M&A activities.

The results of our analysis show that broadband deployment increases the likelihood of firms participating in M&A transactions. We find that broadband not only increases the number of M&A transactions initiated by the firms but also the number of operations that finish successfully. Interestingly enough, this result is observed in the case in which firms completely acquire the targeted firm, but we do not find a significant effect in operations in which firms just want to acquire a share of the targeted firm. In addition to this, we find that broadband has a significant impact on M&A where both the acquirer and the targeted firms are located in the same city, the same province, or in different cities in the same province. By contrast, broadband does not affect the probability of transactions between firms located in different provinces. These results suggest that broadband does not completely eliminate the relevance of the distance for the firms' decisions. Broadband connections might facilitate the acquisition process and the integration of the acquired firms after the merger, but this is not enough to engage in transactions with firms located in other provinces, at least not in the years that follow the rollout of the new technology. Finally, in order to verify the validity of our results we conduct two placebo tests. First, we consider 'false' policy implementation years, which are set one and two years before the actual policy implementation years. Second, we generate a random treatment variable to assess its effect on M&A activities, which should not have significant effects. Both placebo tests indicate that our results are attributable to broadband implementation rather than other factors.

The last part of the paper examines the impact of broadband Internet on the productivity and employment of firms, focusing on those directly affected by an M&A transaction. We find that broadband deployment does not have a significant effect on firms' total factor productivity (TFP) and labor productivity, but it does significantly increase firms' employment. We next examine whether M&A is a mechanism through which broadband Internet impacts firms' performance. We obtain that the joint effect of broadband access and participation in an M&A transaction does not have a significant impact on TFP. However, we do find a positive impact on employment in those firms that after the deployment of the broadband participated in M&A activities. We also find that this generates a reduction in labor productivity. Our economic intuition for these results is that after the completion of an M&A, firms expand and need additional personnel to integrate the acquired firm. The increased information flow generated by the new broadband connections and the adoption of ICT might also require hiring more employees, even though some employees might become redundant during this process. Consequently, M&A acts as a mechanism through which broadband promotes employment growth. Additionally, resources and efforts devoted to managing integration and new hires might temporarily reduce labor productivity.

The remainder of this paper is structured as follows: Section 2 reviews the existing literature on the impact of broadband Internet and the relationship between broadband and M&A; Section 3 describes the implementation of the "Broadband China" policy; Section 4 describes the data; Section 5 outlines our empirical strategy; Section 6 presents the results on the impact of broadband deployment on M&As; Section 7 explores the role of M&A to amplify the effect of broadband Internet on firms' productivity and employment; and Section 8 concludes the paper.

2. Literature Review

This paper is connected to three different strands of the literature. First, it contributes to the recent studies that examine the effects of information and communications technology (ICT) on economic activities and the performance of firms. Second, it is related to the papers that analyze the direct effect of broadband deployment on the firms' productivity. Finally, it contributes to a new and still very scarce literature examining the effects of broadband deployment on the merger activity of firms.

Effecs of ICT on the economic activity - Broadband and the underlying infrastructure can be regarded as ICT (Harris, 1998). There is a large number of papers that have explored the economic impact of ICT. Several papers have shown that the ICT affects the economic growth(Jorgenson & Stiroh, 2017; Czernich et al., 2011), international trade (Grossman & Helpman, 1993; Akerman et al., 2022), the labor market (Autor et al., 2003; Hjort & Poulsen, 2019),among others. ICT can increase economic growth by generating and transmitting ideas. According to the endogenous growth theory, the generation and dissemination of ideas and information are pivotal drivers of economic growth (Lucas Jr, 1988; Romer, 1990; Aghion et al., 1998). Pohjola (2002) examines the 'New Economy', which is characterized by the rapid expansion of ICT, focusing on how ICT investments correlate with economic growth across different countries. Jorgenson & Stiroh (2017) demonstrates that ICT contributed to the acceleration of economic growth in the United States in the late 1990s. Czernich et al. (2011) examine the effect of broadband deployment on the economic growth in OECD countries from 1996 to 2007, and show that a 10% increase in broadband penetration raises annual per capita growth by 0.9 to 1.5%.

Another group of papers has explored the effects of ICT on international trade. Freund & Weinhold (2004) have shown how the Internet reduces trade costs and increases international trade by facilitating information flow between buyers and sellers. Websites, e-commerce platforms, and digital marketing allow firms to reach foreign customers without the need to physically contact them. Clarke & Wallsten (2006) examine how Internet adoption has led to increased trade, highlighting the role of ICT in enhancing market access for both developed and developing countries. More recently, Akerman et al. (2022) find that broadband access in Norway reduces the information friction and enlarges the choice set of exporters and importers.

Several papers have examined the effects of ICT in the labor market. It is considered that

ICT leads to the creation of new jobs, but also to the displacement of workers. Autor (2015) discusses the complementarity between technology and labor, arguing that automation does not merely replace labor but also creates new tasks and jobs, thereby sustaining or even increasing employment. Acemoglu & Restrepo (2019) also examine automation, finding that ICT reduces the labor share if the worker replacement effect from the automated tasks exceeds the increased demand for created nonautomated tasks. Some literature has also discussed whether is more beneficial for skilled workers since they can more easily learn and adapt to new technologies (Bresnahan et al., 2002; Autor et al., 2003; Akerman et al., 2015). These studies conclude that broadband and other technologies help skilled workers execute nonroutine complicated tasks but replace unskilled workers if they can just handle routine work.

This paper is more connected to the literature that examines the causal effect of ICT on firms. Most studies started to explore the impact of ICT on firm performance since the famous quote by Solow (1987), "*You can see the computer age everywhere but in the productivity statistics*". The productivity paradox is explained by the time lag between technology adoption and the increase of productivity (David, 1990; Bresnahan & Trajtenberg, 1995; Brynjolfsson & Hitt, 1996; Jorgenson & Stiroh, 2017), and measurement error (Griliches, 2009). David (1990); Bresnahan & Trajtenberg (1995); Brynjolfsson & Hitt (1996) show that the slow realization of productivity gains from electric power and early computer technology originates from the lack of organizational adaptation and complementary innovations. ICT improves efficiency by automating routine tasks and reducing the time and labor required for manual processes. This allows firms to allocate resources more effectively and focus on strategic activities. In addition, ICT enhances data management and analysis, providing firms with critical insights to optimize operations and identify new opportunities. Moreover, ICT supports innovation by providing tools and platforms for developing new products and services, thus driving competitive advantage.

Broadband deployment and firm's productivity - Broadband telecommunications lines are an integral part of ICT and represent an important channel to increase productivity. Broadband lines increase the capacity to transmit information rapidly and reliably, which reduces information asymmetry. Access to broadband telecommunications lines offers firms the opportunity to access real-time data and to communicate instantaneously with their stakeholders, leading to more informed decisions and efficient market operations. Several papers have shown that broadband has a positive effect on firm productivity. Grimes et al. (2012) show that in New Zealand, firms with high-speed internet connections experience higher productivity than those without. Akerman et al. (2015) demonstrate that in Norway broadband internet complements skilled labor, leading to increases in firm productivity and performance, specifically for firms intensive in skilled labor. Cambini et al. (2023) exploit Italian firm data in 2013-2019 and municipality-level data on the diffusion of ultra-fast broadband, using the distance between each municipality and the closest optical packet backbone node as an instrument. They find that the deployment of ultra-fast broadband increases the firm productivity, which is related to structural changes at the workforce level. There are also some studies showing that broadband does not have a statistically significant effect on firm productivity. Colombo et al. (2013) find that the adoption of basic broadband applications does not increase firms' productivity in Italy. De Stefano et al. (2014) use a static fuzzy regression discontinuity to examine the effect of ADSL on firm performance in the UK, while they do not find a significant effect. DeStefano et al. (2018) use the distance of the cable distance to the local telephone exchange as an instrument, but also obtain that ADSL does not have a significant effect on firm performance. Finally, some papers have also examined the effect of broadband on firm performance in the case of China. Zhang et al. (2022) use the exogenous "Broadband China" policy, finding that broadband infrastructure has a significant positive effect on firm productivity. Fernandes et al. (2019) investigate the impact of broadband on the export performance of Chinese firms before the widespread influence of Alibaba and similar e-commerce platforms. They use firm-level production data and province-level information on internet penetration, finding that broadband improves the overall firm performance.

Broadband deployment and firm's M&A activities - M&A activities increase the productivity of firms by enabling them to access new technologies (Hanelt et al., 2021), accumulate knowledge (Hoenig & Henkel, 2015; Svahn et al., 2017), increase international trade (Bertrand & Zuniga, 2006; Hijzen et al., 2008), and enter new markets (Berger et al., 2004). Firms use M&A to acquire the technology assets of the targeted firms, which can include proprietary software, patents, specialized equipment, and R&D capabilities (Hoenig & Henkel, 2015). Loebbecke & Picot (2015) show that this mechanism allows firms to increase their productivity. M&A is also an instrument to access digital platforms, which allow acquirers to manage massive data that can Cross-border M&A helps parent firms enter the international market and facilitates the reallocation of resources across borders (Berger et al., 2004). Firms benefit by increasing the scale of their operations, which allow them to lower production costs, access to raw materials, and profit from favorable regulatory environments in different countriesenhances efficiency (Bertrand

& Zuniga, 2006).

Broadband Internet connections play a significant role in facilitating M&A activities. Broadband telecommunications lines allow firms to communicate and transmit information in a more efficient way during M&A negotiations. Broadband connections reduce information asymmetries and help managers to make their decisions. M&A transactions imply a mental burden to managers because the possibility of a failure might affect their professional careers(Amihud & Lev, 1981). Indeed, acquirers might have doubts about the sellers' financial situations and the purpose of the transactions. In this situation, access to broadband Internet can reduce the psychological pressure affecting the managers and increase the possibility of a successful M&A. The decisions of managers are also affected by the shareholders' attitudes, which depend on the communication between managers and shareholders (Baker & Wurgler, 2004). When shareholders expect a successful M&A, they would invest more in the firm, which incentivizes managers to be more active during the negotiations. In this context, access to high-speed broadband lines provides a communication tool for shareholders and firms, making it more likely to start an M&A.

Broadband also increases the M&A success rate during negotiations. In the transaction process, multiple rounds of negotiations are typically required. Prior to each negotiation, executives from both parties can monitor the dynamics of the counterpart's company through social media platforms such as Twitter (Ang et al., 2021). Consequently, broadband facilitates better decision-making for both parties involved in the M&A transactions. Broadband enables the use of video conferencing, instant messaging, and other real-time communication tools, which are essential for coordinating geographically dispersed M&A parties (Das et al., 2005). Effective communication facilitated by broadband technology minimizes delays and misunderstandings by ensuring that the interests of all parties are aligned and by accelerating the resolution of issues.

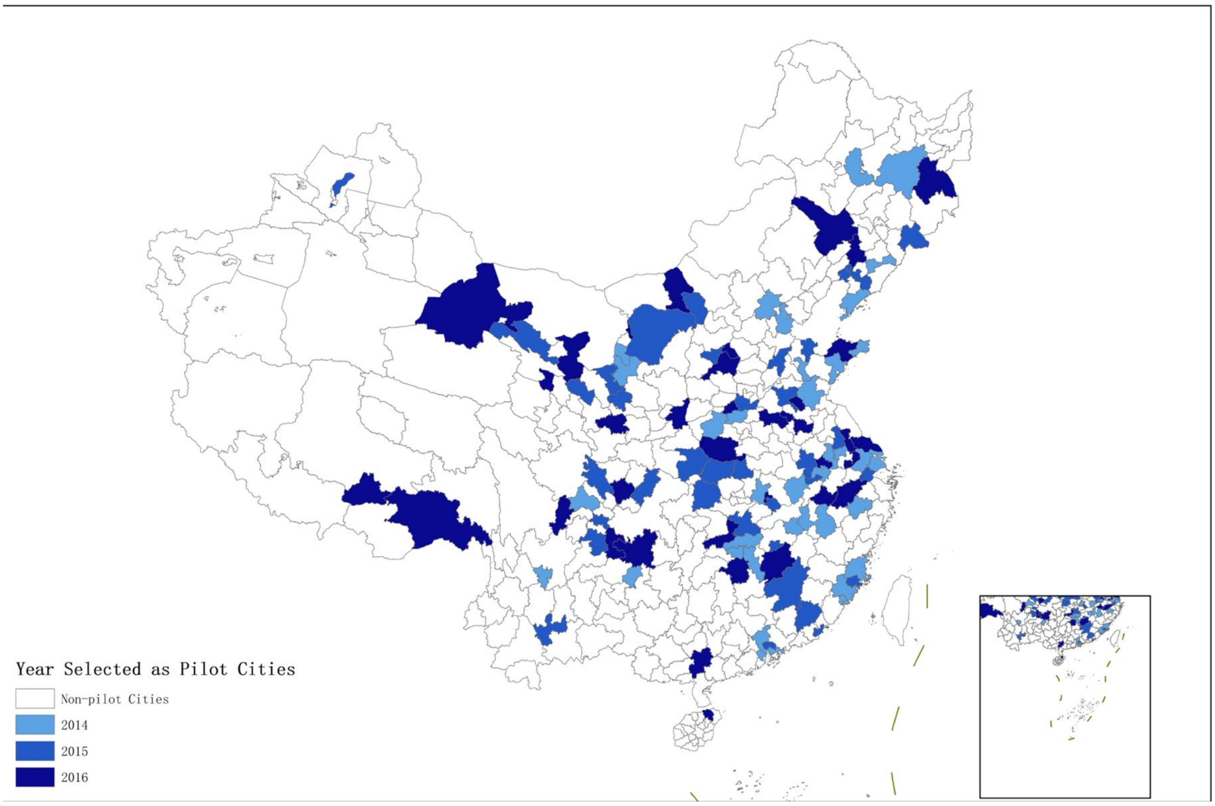
Finally, access to high-speed communications technologies is also crucial for resource consolidation after M&A. Once an M&A is completed, both parties need time to integrate resources (Coates, 2015). Broadband technologies facilitate the integration of IT systems between merging entities, ensuring operational continuity. This integration is crucial for consolidating financial systems, human resource procedures, and other operational components that are essential for the newly formed organization.

The contribution of this paper is to find the relationship between broadband deployment and M&A activities. We classify M&A activities comprehensively, examining M&A probability, progress, proportion, and the geographical locations of firms involved. Furthermore, we analyze the impact of broadband-driven M&A on firm productivity and employment.

3. Broadband Market and Fiber Deployment in China

China entered into the Internet era in the early 1990s. In the late 1990s, the Internet in China was primarily accessed through dial-up connections, which required users to connect their computers to a telephone line via a modem. The modem would dial a number provided by the Internet Service Provider (ISP) to establish a connection. China Telecom was one of the first ISPs to offer dial-up services to the public. Other early players in the telecommunications market were China Unicom and local ISPs that provided services in some specific regions. ISPs usually charged for dial-up Internet access on a per-minute basis, similar to how telephone calls were billed. This pricing model made Internet usage relatively expensive, limiting extensive use by the general population. In these years, only universities, government departments, and a small group of highly educated individuals had access to the Internet. Moreover, dial-up connections were slow and unreliable. The maximum speed of dial-up connections in China was 56 Kbps, which is far lower than modern broadband speeds. This limited bandwidth meant that only small amounts of data could be transferred at a time, which led to limited applications such as text-based activities like email and simple web browsing. By the mid-2000s, Asymmetric Digital Subscriber Line (ADSL) technology began to replace dial-up connections. ADLS provides faster and more reliable Internet access than dial-up connections. The first ADSL services were introduced in major Chinese cities around 2000. China Telecom and China Netcom were among the first to offer ADSL services. Deployment initially focused on urban areas where the demand for faster Internet was higher. ADSL requires a special modem and a splitter to separate voice and data signals, allowing users to use the telephone and the Internet simultaneously without interference. The number of broadband subscribers grew rapidly. According to CNNIC, broadband users increased from a few million in the early 2000s to over 100 million by the end of the decade. Early ADSL services in China offered speeds starting at 128 Kbps and eventually increasing to several Mbps. This was a significant improvement over the 56 Kbps maximum speed of dial-up. Regarding applications, stable connections and higher speed provided by ADSL made it possible to provide data-intensive content and services, such as social media, video streaming, online gaming, and large file downloads.

Figure 1: "Broadband China" pilot cities



Source: Own elaboration

From 2005, broadband technologies like ADSL2, ADSL2+, Very-high-bit-rate Digital Subscriber Line (VDSL), VDSL2, Hybrid Fiber-Coaxial (HFC), and Fiber-to-the-Home (FTTH) were deployed in China with increasing speeds and reliabilities. The most advanced technology is the FTTH which involves installing optical fiber directly from a central point to individual buildings, such as residences, apartment buildings, and businesses. This contrasts with traditional broadband connections that use copper lines for the last mile. FTTH connections in China typically offer speeds ranging from 100 Mbps to 1 Gbps. Because of the high speed and low latency, FTTH makes real-time applications like online gaming and video conferencing feasible. By the early 2010s, China had made significant progress in broadband deployment, but limited in intermediate technologies like VDSL. The length of FTTH cables and overall fiber coverage were still limited compared to some OECD countries. The penetration rate of fixed broadband access in 2013 was 14%, which was much lower compared to for example Denmark (41.1%), Netherlands (40.4%), and Switzerland (45.2%[3]).Another important characteristic of the Chinese market is the digital divide between urban and rural areas in China. The Internet

[3]Historical time series, fixed and mobile broadband penetration from OECD Broadband Portal

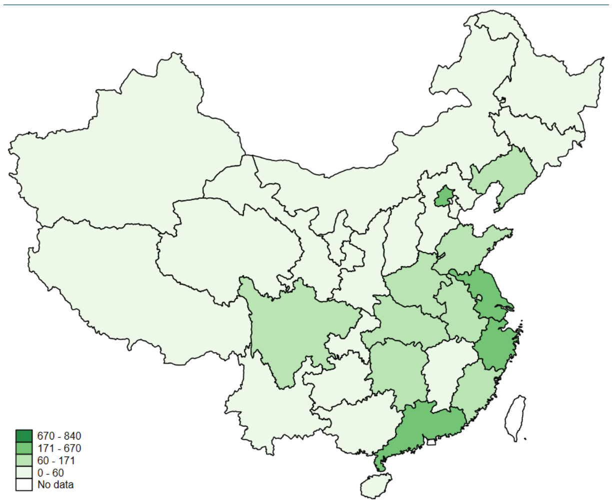
penetration rate in 2013 was 44.1%, while only 27.9%[4] of Internet users living in rural areas. Urban areas enjoyed better infrastructure and higher speeds, while rural regions often had limited access and slower connections.

In 2013[5], the Chinese government launched the “Broadband China” program, with the objective of accelerating the deployment of high-speed broadband networks across the country, to increase economic growth and social development. This program aims to ensure that urban areas have near-universal coverage and that rural and remote areas also receive substantial improvements in broadband access. Significant investments from both the government and private sector were used to build advanced fiber-optic networks, including FTTH, and upgrade existing networks. In 2023, broadband penetration in China reached 77.5%, with urban areas achieving a penetration rate of 83.3%. Significant improvements also happened in rural broadband access, with penetration rates reaching 66.5%[6]. The improved broadband infrastructure supported the rapid growth of China’s digital economy, including e-commerce, online education, telemedicine, and digital finance.

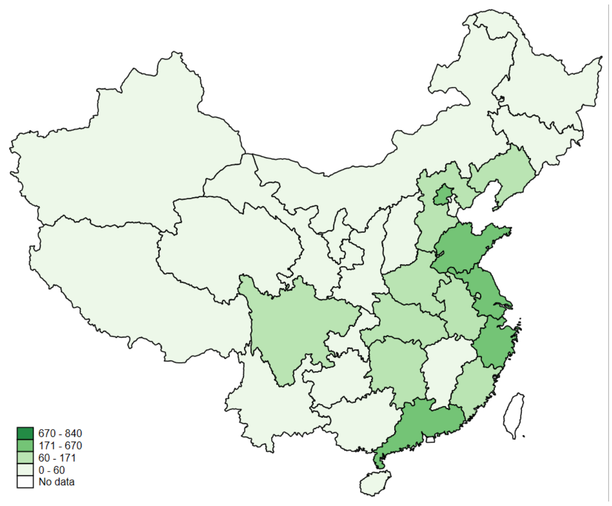
An essential aspect for the identification of the causal impact of broadband technology on the firms’ M&A decisions and their productivity is to consider that the 120 pilot cities participating in the “Broadband China” program during the period 2014-16 were selected for administrative and policy reasons, rather than for their economic potential or the needs of their firms or industries. Figure 1 shows the geographical locations of the pilot cities participating in the program. Clearly, pilot cities are distributed throughout the country, rather than being concentrated solely in coastal areas. This contrasts with the geographical distribution of most listed companies, which are predominantly located in coastal regions, as illustrated in Figure 2. Cities voluntarily applied to participate in the program. From 2014 to 2016, each year the Chinese government selected 40 pilot cities, and then the program stopped. The Ministry of Industry and Information Technology, along with the National Development and Reform Commission, prioritized the pilot cities, focusing on projects and demonstration initiatives for new information and communication technologies and services. As a result, within a few years, these pilot cities have achieved nationwide leadership in various broadband indicators, such as broadband coverage, subscriptions, and network speed.

[4]The data comes from CNNIC’s Statistical Report on Internet Development in China (January 2014)
[5]Notice from the State Council on Issuing the ”Broadband China” Strategy and Implementation Plan
[6]53rd Statistical Report on China’s Internet Development, published in March 2024.

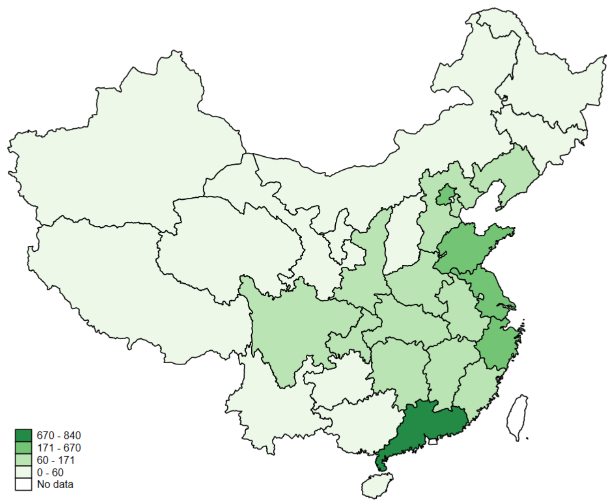
Figure 2: Number of listed firms across Chinese provinces over time.



(a) 2011



(b) 2017



(c) 2022

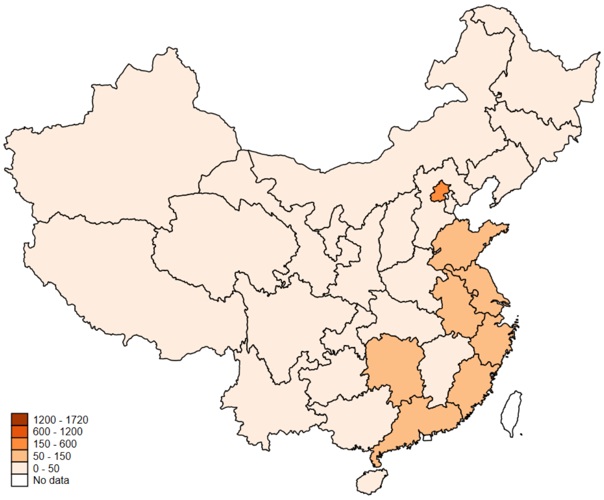
Source: Own elaboration

4. Data

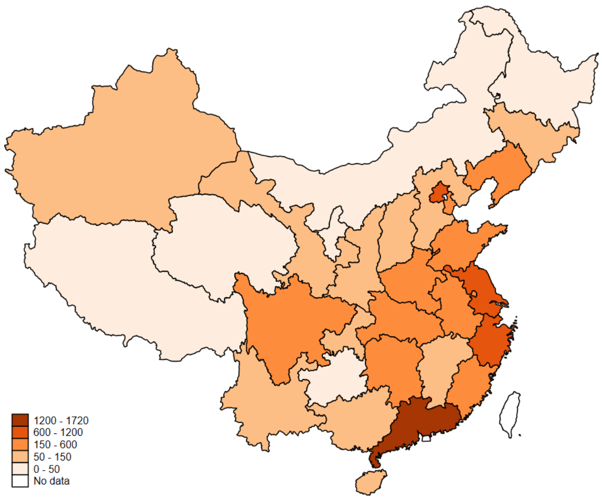
This paper uses several data sources to examine the effects of the deployment of broadband Internet lines in the M&A activity of listed firms in China and in their productivity and employment. The data for the listed firms' M&A activities comes from the Chinese Research Data Services (CNRDS). In addition, information on the characteristics of the listed firms has been obtained from the China Stock Market Accounting Research (CSMAR) database. The dataset has been built as follows: (1) we have merged firm-level information from CSMAR with M&A data from CNRDS; (2) exclude financial firms; (3) exclude firms with key missing values; (4) exclude "Special Treatment" and "Particular Treatment" firms which are flagged by market regulators for abnormal financial or other conditions; (5) the continuous variables involved in the model are winsorized at the 1st and 99th percentiles to avoid the effect of extreme values. As a result, we have obtained an unbalanced panel with the number of listed firms ranging from 2111 in 2011 to 4774 in 2022. Figure 2 shows the number of listed firms in each province across time. Clearly, coastal provinces have more listed firms compared with inland provinces. According to data availability, we focus on domestic firms located in China Mainland, and we discard merger operations in which the acquirer or the seller was a foreign firm. Moreover, cross-border M&A affected by submarine cables are not covered in this paper. As a result, we end up with 29,756 observations in total.

The main outcome variable of our analysis reflects whether the listed firm has initiated an M&A transaction, or if it has successfully completed it. M&A is a dummy variable that has a value equal to 1 if the listed firm has initiated an M&A this year, and 0 otherwise. A listed firm refers to a joint-stock firm whose shares are traded on the Shanghai and Shenzhen stock exchanges. The M&A dataset contains firms' trading positions during the M&A, including the purchaser, seller, and the underlying party that is traded between purchaser and seller. Our analysis focuses on the M&A activities of the acquirer firms. The targeted firms can be listed firms, non-listed firms, or individuals who hold shares of a company. The M&A transaction can be paid by assets (cash, land, bonds, and bearing liability), equity, or mixed payment methods. If buyers pay by equity, we can calculate the specific share change ratio in the M&A transaction. The dataset also includes the progress of M&A transactions, showing when the transactions are successful, failed, and in progress. Figure 3 illustrates the number of M&As across Chinese provinces over time. The overall number of M&As is increasing throughout China.

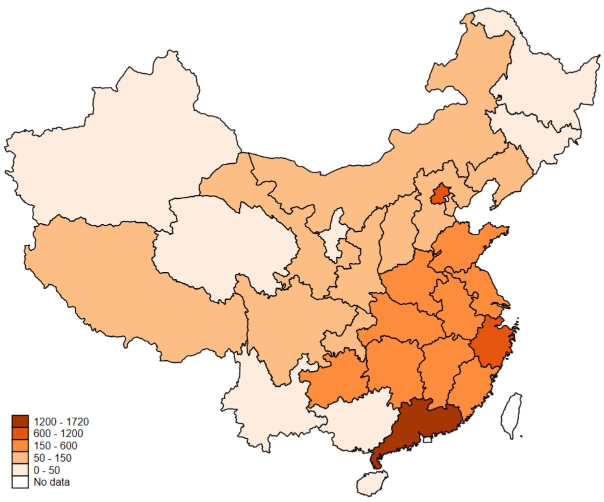
Figure 3: Number of M&As for listed firms across Chinese provinces over time.



(a) 2011



(b) 2017



(c) 2022

Source: Own elaboration

Table 1: Descriptive statistics

	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Firm Characteristics					
M&A	29,915	0.211	0.408	0.000	1.000
Broadband	29,915	0.580	0.494	0.000	1.000
Fix	29,915	0.204	0.158	0.000	0.971
Lev	29,915	0.441	0.523	-0.195	63.971
ROA	29,915	0.034	0.070	-0.321	0.209
ROE	29,731	0.060	0.140	-0.718	0.400
Shareholder	29,260	0.359	0.150	0.078	0.761
Ind	29,913	0.377	0.054	0.333	0.571
Concurrent	29,128	0.283	0.450	0.000	1.000
Board	29,915	8.500	1.698	0.000	18.000
Age	29,908	2.933	0.332	0.693	4.174
Liability	29,915	0.815	0.175	0.262	1.000
Cashflow	29,915	0.183	0.130	0.000	1.000
Revenue	29,914	1.000	0.008	0.362	1.079
Intangible	29,802	0.048	0.063	0.000	0.890
Firm Performance					
Total Factor Productivity	27,944	1.480	0.918	-8.530	6.056
Labor Productivity	29,915	13.872	0.927	0.000	18.924
Employment	29,915	7.667	1.277	4.575	11.168

The definition of variables in this table is explained in Section 4.

In the three selected years, coastal provinces consistently exhibit the highest number of M&As. When a firm has several transactions with a targeting firm, with the same starting and ending dates, we only keep the last transaction.

Another outcome variable considered in our analysis is the listed firms' performance. we measure the TFP of listed firms using the method of Ackerberg et al. (2015) (See the Appendix for a detailed description of how this measure has been calculated). We also measure labor productivity, which is the assets divided by the number of employees. Listed firms' employment is measured by the number of employees. We convert these variables to their natural logarithms.

The variable $Broadband$ is a dummy variable that takes the value of 1 if the firms are located in a city that was chosen as a pilot city in the current year or any subsequent year; otherwise, it takes the value of 0. We use this variable to measure the impact of broadband deployment on M&A activities, and also on productivity and employment.

Our analysis also includes several firm-level control variables to account for other factors that might influence the M&A decisions. Controls include the ratio of fixed assets (Fix), which is the fixed assets of a firm divided by its total assets; the ratio of liability (Lev), which is the total liability divided by total assets; return on assets (ROA), which is the net profit divided by the balance of total assets at the end of the year; return on equity (ROE), which is the net profit divided by the average balance of shareholders' equity between the end of this year and the end of the previous year controlling; shareholder (*Shareholder*), which is shares held by shareholders who possess more than 50% of the firm's total share capital, divided by the total number of shares; independent director (*Ind*), which is measured as the ratio of independent directors to the total number of board of directors; concurrent position (*Concurrent*), which is a dummy equals one if the chairman also serves as the general manager, zero otherwise; board size (*Board*), which is the number of the board members; firm age (*Age*), which is the natural logarithm of the firm age plus one; ; current liability ratio (*Liability*), which is the ratio of current liability to the total liability; cash flow (*Cashflow*), which measured as the net operating cash flow divided by total asset; operating revenue (*Revenue*), measured by the ratio of operating revenue to the total revenue; intangible assets (*Intangible*), which is the ratio of intangible assets to the total assets.

Table 1 shows the descriptive statistics of the variables used in the empirical analysis. We find that 21% of the listed firms participated in M&A activities. Moreover, 58% of the listed firms are located in the pilot cities that benefited from the "Broadband China" program.

5. Empirical Specification

The aim of our analysis is to estimate the causal impact of the deployment of broadband Internet lines on the firms' M&A decisions. For this objective, we estimate the following staggered DiD model:

$$M\&A_{i,t} = \alpha + \beta Broadband_{i,t} + \theta X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t} \tag{1}$$

where the dependent variable ($M\&A$) reflects whether the listed firm i was affected by an M&A activity in period t. Our independent variable (*Broadband*) is a dummy that takes the value of 1 when the firm is located in a city that participated in the "Broadband China" program, in the year of the implementation and the following years. Otherwise, the value of this variable is equal to zero. The coefficient of this variable represents the change in the log-odds of the dependent variable being 1 (engaging in M&A) associated with being affected by the "Broadband China" policy. $X_{i,t}$ is a set of controls that help isolate the effect of broadband by accounting for other factors that might influence M&A activity. We also include fixed effects to control time-specific and firm-specific characteristics that do not change over time but might affect the M&A activities. $\epsilon_{i,t}$ stands for the error term.

The fundamental assumption of the DiD approach is that the treated and control groups would have followed parallel trends in the outcome variable in the absence of the treatment. This assumption implies that there should be no significant differences in M&A activities between the firms located in the pilot cities (treated group) and those that are not (control group), before the implementation of the policy. Essentially, the pre-treatment trends in M&A activities should be similar for both groups, ensuring that any observed post-treatment differences can be attributed to the treatment effect rather than pre-existing differences. We run an event study to prove this assumption.

$$\begin{aligned} M\&A_{i,t} &= \beta_0 + \beta_1 Before_{i,t}^{-5} + \beta_2 Before_{i,t}^{-4} + \beta_3 Before_{i,t}^{-3} + \beta_4 Before_{i,t}^{-2} \\ &\quad + \beta_5 Current_{i,t}^{0} + \beta_6 After_{i,t}^{1+} + \beta_7 After_{i,t}^{2+} + \beta_8 After_{i,t}^{3+} + \beta_9 After_{i,t}^{4+} \\ &\quad + \beta_{10} After_{i,t}^{5+} + \theta X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t} \end{aligned} \quad (2)$$

In model (2), we replace the variable $Broadband_{i,t}$ with different time periods. All other variables in model (1) remain the same. $Before_{i,t}^{-k}$ (where $k \in \{2,3,4,5\}$), $Current_{i,t}^{0}$, and $After_{i,t}^{j}$ (where $j \in \{1,2,3,4,5\}$) are dummy variables. We construct these dummy variables by interacting the treatment status (whether a firm is located in a selected pilot city) with the time relative to policy implementation. For instance, $Before_{i,t}^{-5}$ equals one if the firm is located in a pilot city and the observation occurs five years prior to the policy implementation in that city. Otherwise, it equals zero. To ensure the result is concise, we categorize all observations that are more than 5 years away from the policy implementation as 5 years. This means that if the observation year is more than 5 years before or after the policy implementation, it is grouped into the 5-year category. We remove the year immediately before the policy implementation and use it as the benchmark. If we include dummy variables for all time periods before and after the treatment, including the year immediately before the policy implementation, it will lead to perfect multicollinearity. The sum of the dummy variables for each time period would equal a constant, making it impossible for the regression to estimate unique coefficients for all periods. By omitting one period, we avoid this issue.

We use an event study to test the parallel trend of our DiD results. Table 2 presents the results. Column (1) only uses time period dummies, column (2) adds control variables, and column (3) includes firm and year-fixed effects and control variables. The first two columns present a significant post-treatment effect, however, the pre-treatment impact is also significant. This result violates the parallel trends assumption, as it implies that pilot and non-pilot cities

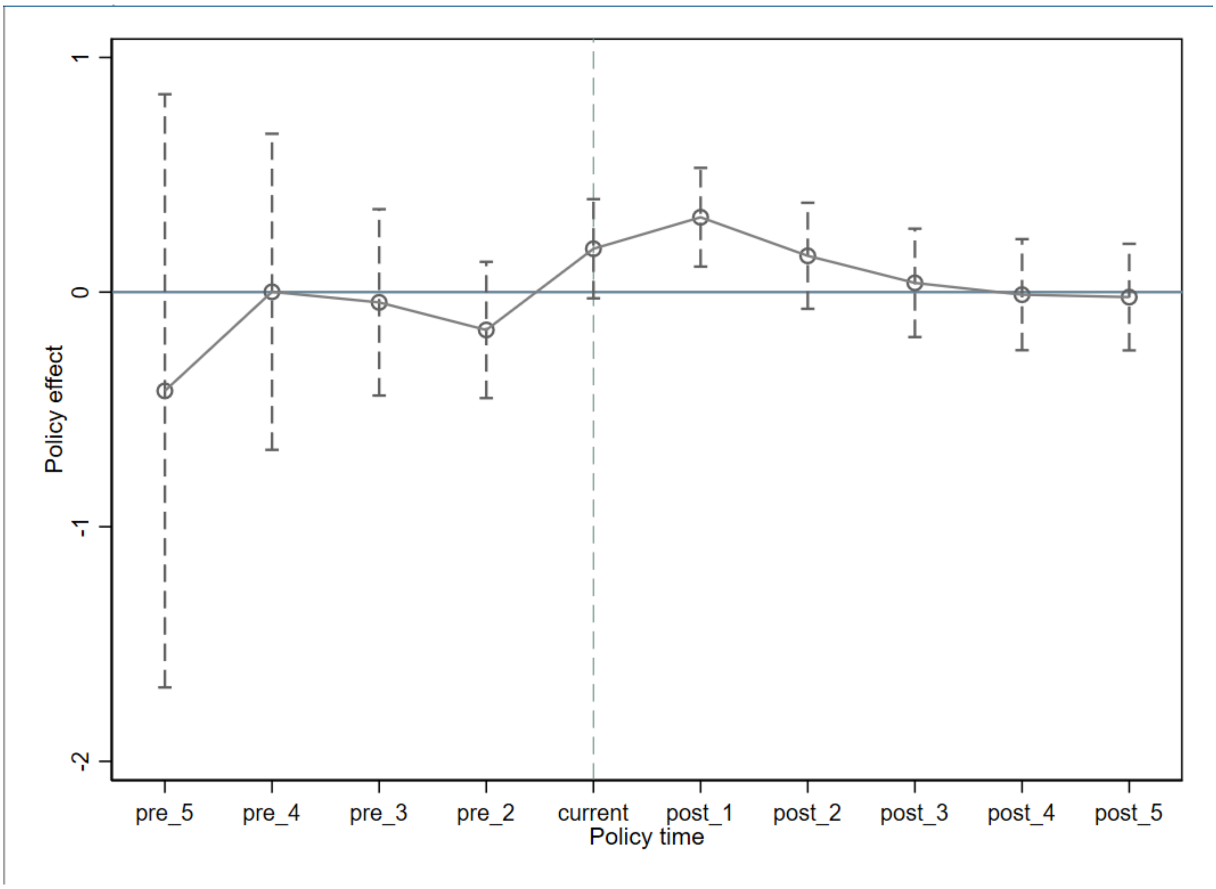
Table 2: Event study

	(1) M&A	(2) M&A	(3) M&A
pre_5	-2.971***	-2.969***	-0.421
	(0.712)	(0.713)	(0.769)
pre_4	-2.272***	-2.224***	0.001
	(0.359)	(0.360)	(0.409)
pre_3	-2.139***	-2.134***	-0.044
	(0.178)	(0.182)	(0.241)
pre_2	-1.370***	-1.359***	-0.161
	(0.120)	(0.124)	(0.177)
current	0.468***	0.475***	0.185
	(0.064)	(0.066)	(0.128)
post_1	0.945***	0.932***	0.319**
	(0.059)	(0.061)	(0.128)
post_2	0.825***	0.831***	0.155
	(0.058)	(0.060)	(0.137)
post_3	0.792***	0.778***	0.039
	(0.056)	(0.058)	(0.140)
post_4	0.585***	0.572***	-0.011
	(0.055)	(0.058)	(0.144)
post_5	-0.039	-0.065	-0.021
	(0.038)	(0.041)	(0.138)
Controls	No	Yes	Yes
Number of Observations	29756	28068	21759
TE	No	No	Yes
FE	No	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

were not following similar trends regarding their M&A activity before the "Broadband China" policy was implemented. This suggests that the estimated effect of broadband deployment might be biased, as the differences observed in the pre-treatment periods could be due to factors other than broadband. Despite this, the results of column (3) show that the coefficients for all pre-treatment periods are insignificant, supporting the parallel trends assumption. This implies that in the absence of the "Broadband China" policy, M&A activity would have followed similar trends in the firms located in both pilot and non-pilot cities. We also obtain that the

Figure 4: Parallel trends test



coefficient for the first year after the policy implementation is positive and significant, indicating a significant increase in M&A activity among firms in pilot cities compared to those in non-pilot cities. Specifically, Figure 4 shows that in the first year following the policy implementation, the odds of engaging in M&A activities are significantly higher for firms located in the pilot cities. However, the effects do not persist beyond the first year. These findings suggest that the "Broadband China" policy had an immediate but short-lived impact on promoting M&A activities in the treated cities.

6. Effects of broadband access on M&A activities

This section presents the results of our analysis of the effects of broadband deployment on the M&A activity of Chinese firms. Table 3 shows the regression results of model 1. As the coefficients in the logistic regressions cannot be explained directly, we convert them to odds ratios using the exponential function. Column (1) shows the results of the model when we exclude all control variables and fixed effects. We find that the odds of engaging in M&A activities for the firms located in the pilot cities participating in the "Broadband China" program is approximately 1.91 times higher than for the rest of the firms (0.647 coefficient). Column (2) repeats the previous estimation, adding year and firm fixed effects. The result shows that the odds of engaging in M&A activities are approximately 1.22 times higher for firms located in the pilot cities (0.199 coefficient). Finally, columns (3) and (4) repeat the previous estimations adding the list of controls at the firm level. Results are very similar to those obtained before. Column (3) shows that firms located in pilot cities have nearly twice the odds (1.90 times) of participating in MA activities compared to the rest of the firms. Column (4) shows that when we include the year and firms fixed effect the odds of engaging in M&A activities is approximately 1.26 times (0.23 coefficient) higher for firms in the pilot cities relative to those in other cities. Overall, our baseline regressions show that firms with access to broadband technologies are more likely to engage in mergers or acquire other firms. This suggests that improved access to information and communications technologies has important effects on the configuration of markets.

We complement the previous analysis by examining the effect of broadband deployment on the probability that firms successfully complete the M&A activities that they initiate. Indeed, there is the probability that firms that gain access to broadband lines engage in more M&A operations, but that they do not complete them successfully. In order to test this possibility, we run the previous regression but using *Successful M &A* as the dependent variable, which has a value equal to 1 if a firm merges or acquires another firm successfully, and zero otherwise. Column (1) in Table 4 presents the results of this analysis, showing that firms located in pilot cities are more likely to experience a successful M&A than firms in the rest of the cities. Specifically, treated firms have 31.5% higher odds of engaging in successful M&A activities compared to the other firms in our sample. Broadband increases information flows between firms, providing acquirers with a more efficient way to negotiate with targeted firms. This improvement in

Table 3: Broadband effect on M&A

	(1) M&A	(2) M&A	(3) M&A	(4) M&A
Broadband	0.647***	0.199**	0.643***	0.230**
	(0.030)	(0.095)	(0.033)	(0.100)
Fix			-0.989***	-1.430***
			(0.107)	(0.287)
Lev			-0.003	0.368*
			(0.089)	(0.191)
ROA			-2.959***	-2.657***
			(0.635)	(0.826)
ROE			2.494***	2.771***
			(0.309)	(0.388)
Shareholder			-0.423***	1.776***
			(0.103)	(0.293)
Ind			-0.338	0.101
			(0.327)	(0.647)
Concurrent			0.063*	-0.001
			(0.034)	(0.062)
Board			-0.013	0.021
			(0.011)	(0.025)
Age			-0.114**	-0.821**
			(0.048)	(0.405)
Liability			-0.215**	-0.201
			(0.092)	(0.164)
Cashflow			-1.576***	-0.724***
			(0.142)	(0.242)
Revenue			0.485	-0.766
			(2.737)	(4.445)
Intangible			0.665***	0.893
			(0.223)	(0.551)
Number of Observations	29915	23476	28221	21834
TE	No	Yes	No	Yes
FE	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

the information and the communication between stakeholders makes it more likely that the M&A operations end up successful. Important documents such as legal permissions, financial reports, and strategic plans can be shared by the legal teams of the firms, financial experts, and consultants. This information and the communications between the managers involved in the process are essential to the success of M&A transactions. Acquiring firms might also anticipate lower costs of integrating the targeted firm when they have access to broadband connections.

Another aspect that is important for our analysis is the type of operation that is incentivized by the broadband technology. The M&A activities might involve acquiring 100% of the targeted firm (full acquisitions) or just a share of the capital of the targeted firm. This can depend on the strategic motivation of the operation and the financial constraints of the acquirer firm. Firms can fully acquire their competitor to increase their market share and obtain more market power. They can also buy other firms as a mechanism to smooth the entry in regions in which they do not have a presence. Some firms might also want to buy a share of some competitors to control their operations or to diversify risks. In all these cases, broadband technology facilitates swift and effective communication between the acquirer's shareholders, enabling them to make more informed strategic decisions.

Considering this, we want to know whether the impact of broadband depends on the type of M&A transaction developed by the firm. Columns (2) to (6) in Table 4 show the result of the model when we consider the dependent variable as the share of the targeted firm that is acquired with the transaction. Specifically, we replace the original dependent variable with a variable that reflects if the acquirer has bought 100%, 80%, 50%, 30%, and 10% of the targeted firm during the M&A operation, respectively. In this sense, the variable 100% M&A has a value equal to 1 if the acquirer takes full control of the targeted firm after the M&A, and zero otherwise. The variable 80% M&A has a value equal to 1 when the buyer acquires no less than 80% of the targeted firm, and has a value equal to zero otherwise. The rest of the partial acquisition thresholds have similar definitions. Column (2) shows that broadband boosts full acquisitions. The odds of a firm participating in a 100% M&A are approximately 2 (coefficient 0.692) times higher for listed firms in pilot cities, compared to listed firms in not pilot cities. By contrast, columns (3)-(6) show that broadband access has a negative and non-significant effect in the partial acquisition of targeted firms. Therefore, we can conclude that access to broadband telecommunications lines has a significant and positive impact on the full acquisition of targeted firms, but has a neutral effect on cross-participation.

Table 4: M&A status and proportion

	(1) successful M&A	(2) 100% M&A	(3) 80% M&A	(4) 50% M&A	(5) 30% M&A	(6) 10% M&A
Broadband	0.274**	0.692***	-0.079	-0.149	-0.227	-0.011
	(0.133)	(0.208)	(0.112)	(0.123)	(0.139)	(0.193)
Fix	-1.607***	-0.721	1.398***	1.389***	1.100***	1.287**
	(0.388)	(0.562)	(0.321)	(0.347)	(0.382)	(0.508)
Lev	0.143	0.569	-0.173	-0.218	0.068	0.384
	(0.257)	(0.383)	(0.211)	(0.226)	(0.253)	(0.341)
ROA	-6.463***	-2.604	2.269**	2.358**	2.888***	6.755***
	(1.208)	(1.651)	(0.906)	(0.972)	(1.113)	(1.529)
ROE	5.399***	1.627**	-2.631***	-2.658***	-2.885***	-4.990***
	(0.621)	(0.716)	(0.430)	(0.466)	(0.544)	(0.791)
Shareholder	1.387***	1.551***	-1.587***	-1.344***	-1.320***	-1.245**
	(0.372)	(0.544)	(0.327)	(0.353)	(0.393)	(0.519)
Ind	-0.293	-0.857	-0.429	-1.496*	-0.904	-0.775
	(0.856)	(1.307)	(0.711)	(0.769)	(0.861)	(1.163)
Concurrent	0.090	-0.014	-0.002	-0.034	0.009	-0.083
	(0.082)	(0.136)	(0.067)	(0.071)	(0.079)	(0.104)
Board	0.030	-0.035	-0.036	-0.076**	-0.047	-0.043
	(0.033)	(0.050)	(0.028)	(0.030)	(0.033)	(0.045)
Age	-0.425	-1.117	0.467	0.243	0.306	0.721
	(0.542)	(0.795)	(0.463)	(0.509)	(0.571)	(0.792)
Liability	-0.541**	-0.390	0.150	0.091	0.144	0.583**
	(0.217)	(0.330)	(0.180)	(0.194)	(0.218)	(0.286)
Cashflow	-0.806***	0.303	0.891***	0.854***	1.155***	1.259***
	(0.310)	(0.492)	(0.267)	(0.291)	(0.332)	(0.446)
Revenue	8.414	-29.422*	-2.160	-1.046	-1.577	-36.730
	(10.555)	(17.505)	(6.095)	(6.342)	(7.845)	(26.192)
Intangible	1.394**	0.240	-1.051	-1.336*	-0.739	0.070
	(0.674)	(0.989)	(0.653)	(0.703)	(0.801)	(1.141)
Number of Observations	15699	7879	19668	17730	15290	9551
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

We complete our analysis by examining the geographical dimension of the M&A operations promoted the by rollout of broadband lines. Broadband helps firms overcome geographical limitations. Without access to high-speed Internet connections, firms located in different cities have to invest significant time and resources in face-to-face meetings to discuss and negotiate M&A deals. This makes long-distance M&A activities more challenging and costly. With all the parties having access to a broadband connection, the entire negotiation process can be conducted online, significantly reducing the need for physical travel and meetings. This digital communication facilitates real-time discussions, document sharing, and collaborative decision-making, thereby making long-distance M&A more feasible and efficient.

Table 5: M&A in different locations

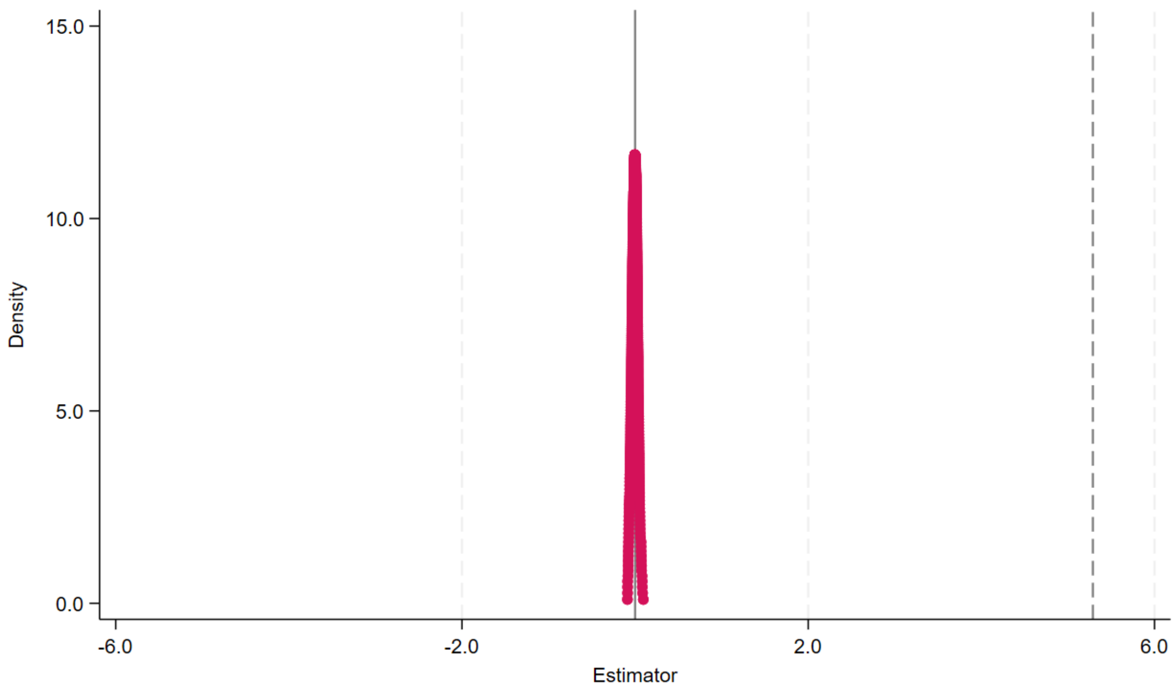
	(1) Cross-city M&A	(2) Cross-province M&A	(3) Cross-city but Within-province M&A	(4) Within-city M&A	(5) Within-province M&A
Broadband	0.137	0.006	0.727**	0.222*	0.285**
	(0.137)	(0.149)	(0.345)	(0.126)	(0.120)
fix	-0.819**	-1.062**	0.542	-1.435***	-1.231***
	(0.383)	(0.417)	(0.961)	(0.367)	(0.345)
lev	0.891***	0.659**	2.199***	-0.224	0.041
	(0.256)	(0.273)	(0.707)	(0.241)	(0.229)
ROA	-4.272***	-4.087***	-4.746	-0.618	-1.016
	(1.106)	(1.174)	(3.030)	(1.028)	(0.985)
ROE	3.108***	3.037***	2.925**	1.641***	1.810***
	(0.520)	(0.555)	(1.371)	(0.477)	(0.455)
Shareholder	1.153***	1.137***	1.210	1.776***	1.788***
	(0.387)	(0.417)	(0.942)	(0.371)	(0.352)
Ind	0.098	0.451	-1.486	0.186	-0.148
	(0.877)	(0.941)	(2.227)	(0.808)	(0.767)
Concurrent	0.031	0.029	0.031	-0.036	-0.027
	(0.084)	(0.090)	(0.208)	(0.076)	(0.073)
Board	0.017	0.036	-0.067	0.023	0.008
	(0.034)	(0.037)	(0.087)	(0.031)	(0.030)
Age	-0.871	-0.801	-1.099	-0.420	-0.543
	(0.587)	(0.637)	(1.417)	(0.502)	(0.477)
Liability	-0.161	-0.141	-0.031	-0.178	-0.189
	(0.222)	(0.235)	(0.597)	(0.205)	(0.196)
Cashflow	0.050	0.134	-0.321	-1.091***	-1.060***
	(0.333)	(0.351)	(0.977)	(0.300)	(0.289)
Revenue	1.439	5.303	-28.921	-2.558	-4.410
	(6.336)	(11.354)	(22.670)	(6.923)	(6.771)
Intangible	1.786***	1.679**	3.848*	-0.148	0.166
	(0.687)	(0.736)	(2.126)	(0.741)	(0.682)
Number of Observations	13964	12598	2790	17419	18318
TE	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

Table 5 examines how broadband affects M&A operations, considering the geographic location of the acquiring and targeted firms. Specifically, *Cross-city M&A* is a dummy variable that takes a value equal to 1 when both parties are in a different city; *Cross-Province M&A* reflects whether broadband increases the probability of cross-province M&A; *Cross-City-Within-Province M&A* considers transaction between firms of different cities in the same province; *Within-City M&A* considers M&A operations of firms located in the same city, and finally *Within-Province M&A* considers operations of firms in the same province.

Results in columns (1) and (2) show that the deployment of broadband does not increase the probability of M&A transactions between firms located in different cities or between firms located in different provinces. Even though broadband reduces communication costs, there are still barriers that make difficult this type of operation. For instance, there could be logistical and operational challenges for the integration of firms that have different locations. Physical distance still matters for the integration of certain activities that require in-person coordination, such as aligning corporate cultures or managing physical assets. In addition, these operations might be constrained by administrative costs and differences in regional regulations.

Figure 5: Placebo test: random independent variable



Column (3) restricts the analysis to M&A operations between firms located in different from the deployment of the broadband lines were 2.069 (coefficient 0.727) times more likely to participate in this type of operation than the rest of the firms. This suggests that after the arrival of broadband, firms might be hesitant to participate in cross-provincial M&A activities, but they are more inclined to participate in M&A activities within the same province, leveraging broadband to facilitate communication and operational integration. Column (4) shows that broadband also has a significant positive impact on M&A where both firms are located in the same city. The log-odds coefficient for Broadband is 0.222. This indicates that firms within the same city are more likely to engage in M&A activities. The enhanced local communication and reduced transaction costs make these transactions more attractive and feasible. Finally, column (5) shows a significant positive impact of broadband on M&As where both firms are located within the same province. The odds coefficient for Broadband is 1.336 (coefficient 0.285), which means that the likelihood of MA activities is 1.33 times higher for firms with broadband within the same province.

To sum up, comparing columns (1)-(2) with columns (3)-(5) we conclude that while broadband facilitates communication and reduces transaction costs, its effects are more pronounced over shorter distances where other barriers such as regulatory differences and physical asset management are less relevant.

Robustness Check - We have conducted two placebo tests in order to verify the validity of our results. These tests aim to show that the effect in the M&A activity that we obtain in the firms located in the pilot cities is driven by the "Broadband China" policy, and not by other factors. The first placebo test follows the methodology of Sun et al. (2023) and involves creating "false" policy implementation years. Specifically, we generate two new variables, *Broadband1* and *Broadband2*, which simulate the treatment occurring one and two years before the real policy implementation years, respectively. The rest of the model's estimates remain as in Table 3. Table 6 shows that the results of this exercise are not significant for the "false" treatment years, indicating that our findings are not spurious.

The second placebo test follows the method developed by Ferrara et al. (2012). In this test, we use the "permute" command to randomly generate an independent variable, simulating a situation where the treatment is assigned randomly rather than being based on actual policy implementation. We repeat this random assignment process 500 times and perform the regression each time. The results of these 500 regressions are shown in Figure 5. In this figure, the red curve represents the distribution of the coefficients from the randomly generated independent variables. This distribution is centered around zero and follows a normal distribution. The dashed vertical line represents the actual coefficient found in Table 3. The fact that the red curve is centered around zero and far from the actual coefficient indicates that the significant results observed in our main analysis are not likely due to random chance. This placebo test further demonstrates the robustness and plausibility of our findings.

Table 6: Placebo test: change years

	(1) One Year Before	(2) Two Years Before
$Broadband_1$	-0.025	
	(0.228)	
$Broadband_2$		0.021
		(0.300)
Fix	-1.451***	-1.451***
	(0.288)	(0.288)
Lev	0.362*	0.362*
	(0.191)	(0.191)
ROA	-2.691***	-2.691***
	(0.827)	(0.827)
Shareholder	1.789***	1.789***
	(0.293)	(0.293)
Ind	0.076	0.076
	(0.647)	(0.647)
Concurrent	0.003	0.003
	(0.062)	(0.062)
Board	0.020	0.020
	(0.025)	(0.025)
Age	-0.818**	-0.819**
	(0.404)	(0.404)
ROE	2.775***	2.775***
	(0.388)	(0.388)
Liability	-0.214	-0.214
	(0.165)	(0.165)
Cashflow	-0.732***	-0.731***
	(0.242)	(0.242)
Revenue	-0.606	-0.605
	(4.493)	(4.495)
Intangible	0.914*	0.914*
	(0.551)	(0.551)
Number of Observations	21759	21759
TE	Yes	Yes
FE	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

Table 7: Broadband, M&A, and firm performance

	(1) Total Factor Productivity	(2) Labor Productivity	(3) Employment	(4) Total Factor Productivity	(5) Labor Productivity	(6) Employment
Broadband	-0.015	-0.028	0.052**	-0.016	-0.029	0.051**
	(0.019)	(0.022)	(0.025)	(0.020)	(0.022)	(0.025)
Successful M&A				0.034***	-0.041**	0.075***
				(0.013)	(0.016)	(0.017)
Broadband × Successful M&A				0.019	-0.049**	0.125***
				(0.023)	(0.024)	(0.028)
Fix	-0.729***	-0.502***	0.286**	-0.724***	-0.506***	0.296**
	(0.094)	(0.119)	(0.119)	(0.094)	(0.119)	(0.119)
Lev	-0.150**	0.535***	0.901***	-0.150**	0.536***	0.899***
	(0.073)	(0.067)	(0.085)	(0.073)	(0.067)	(0.085)
ROA	8.952***	0.622***	0.352	8.974***	0.616***	0.368*
	(0.449)	(0.194)	(0.216)	(0.448)	(0.194)	(0.215)
ROE	0.854***	0.678***	0.256**	0.837***	0.686***	0.236**
	(0.220)	(0.089)	(0.102)	(0.220)	(0.089)	(0.101)
Shareholder	-0.083	-0.157	0.227*	-0.086	-0.154	0.219*
	(0.088)	(0.102)	(0.133)	(0.088)	(0.102)	(0.132)
Ind	0.010	0.084	0.307*	0.010	0.083	0.309*
	(0.153)	(0.163)	(0.183)	(0.152)	(0.163)	(0.183)
Concurrent	0.002	-0.021	0.021	0.001	-0.021	0.020
	(0.014)	(0.015)	(0.019)	(0.014)	(0.015)	(0.019)
Board	0.006	0.000	0.051***	0.006	0.000	0.051***
	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)	(0.008)
Age	-0.052	0.268***	0.264**	-0.051	0.268***	0.265**
	(0.085)	(0.097)	(0.129)	(0.085)	(0.097)	(0.129)
Liability	-0.259***	0.129***	-0.060	-0.257***	0.128***	-0.056
	(0.046)	(0.047)	(0.054)	(0.046)	(0.047)	(0.054)
Cashflow	0.183***	0.026	-0.230***	0.187***	0.024	-0.223***
	(0.059)	(0.063)	(0.070)	(0.059)	(0.063)	(0.069)
Revenue	-2.118***	2.478**	2.912***	-2.126***	2.479**	2.911***
	(0.604)	(1.039)	(0.853)	(0.607)	(1.038)	(0.853)
Intangible	0.294*	-1.238***	0.735***	0.289	-1.234***	0.726***
	(0.178)	(0.232)	(0.274)	(0.178)	(0.233)	(0.273)
Number of Observations	25893	27613	27613	25893	27613	27613
TE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

7. Broadband effects on M&A activities and firm performance

The results of the previous section have shown that the deployment of broadband telecommunications lines boosted the M&A activities for the firms located in the pilot cities. We next want to explore whether this effect had consequences on firm productivity and employment. In order to examine this situation, we replace the dependent variable in Model 1 with *TFP*, *Labor Productivity*, and *Employment*. In addition, in order to capture the differential impact on the performance of the firms affected by the broadband deployment that also were affected by the M&A activity, we interact *Broadband* with *Successful M&A*. Indeed, one of the mechanisms why which broadband deployment can affect the performance of the firms is by promoting the development of M&A activities. Considering this, the interaction term included in the model aims to capture the subsequent results of M&A on firms' performance. The model that we estimate is as follows:

$$TFP_{i,t} = \alpha + \beta Broadband_{i,t} * SuccessfulM\&A_{i,t} + \theta X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t} \quad (3)$$

$$LaborProductivity_{i,t} = \alpha + \beta Broadband_{i,t} * SuccessfulM\&A_{i,t} + \theta X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t} \quad (4)$$

$$Employment_{i,t} = \alpha + \beta Broadband_{i,t} * SuccessfulM\&A_{i,t} + \theta X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t} \quad (5)$$

Table 7 shows the results of our estimations. The first two columns reveal that broadband does not show a significant impact on TFP and labor productivity. One possible explanation for this result is that the broadband infrastructure does not have an immediate effect on the firms' productivity. There could be a delay between the widespread adoption of broadband and observable gains in productivity. This delay may result from the time required for businesses to train employees, optimize procedures, and integrate new technology into their daily operations. The lack of complementary investments could be another reason. The capacity of broadband networks to affect productivity hinges on several critical factors, including the existence of complementary investments in human capital, changes in the organization of firms, and the integration of other technologies. Merely investing in broadband infrastructure is insufficient to realize significant productivity gains. Firms must also commit to these additional investments to fully leverage the potential benefits of broadband. Column (3) in Table 7 shows that the number of employees in firms located in pilot cities is 5.2% bigger than in firms located in non-pilot cities. Broadband increases communication between firms and between the firms and their consumers. As a result, firms might need to hire more employees to handle the extra activity and the extra demand generated by the new information flows.

Column (4) in Table 7 considers the interaction between *Broadband* and *Succesful MA* . As in column (1), we obtain that the effect of broadband on TFP is not significant. This suggests that simply having access to broadband infrastructure does not directly translate into productivity gains for firms. However, successful M&A activities are associated with higher productivity, as indicated by the positive and significant coefficient. Specifically, we find that one more successful M&A leads to a 3.4% increase in the TFP. The economic intuition for this result is that M&A can lead to the consolidation of resources, synergies, and more efficient use of combined assets. Finally, the interaction term *Broadband*Successful M&A* is not statistically significant. This implies that while successful M&A on its own contributes to higher productivity, the presence of broadband does not enhance this effect significantly.

The analysis of column (5) reveals that broadband does not have a significant effect on labor productivity. However, we do find that successful M&A activities are associated with lower labor productivity, as indicated by the negative and the 1% level significant coefficient. This result can be explained by the disruptions and adjustments that typically follow M&A activities. During the integration process after an M&A operation, firms may face challenges such as aligning different corporate cultures, restructuring their organizations, and eliminating redundancies, which can temporarily reduce labor productivity. The interaction term between broadband and successful M&A is also negative and statistically significant at the 5% level. This implies that when M&A is driven by broadband, one unit increase in the interaction term leads to a 4.9% decrease in labor productivity, which has an even more pronounced negative impact on labor productivity.

Finally, column (6) shows that broadband has a positive and significant effect on the number of employees, which is in line with column (3). In addition, one more successful M&A makes firms hire 7.5% more employees. When acquirers buy technologies, acknowledgment, and shares from targeting firms, they need to hire more people to make use of these new resources. For example, when a firm decides to use M&A to enter into a new market, it has to hire more employees in the new regional area. The interaction term between broadband and successful M&A is positive and significant. Interestingly, one unit increase in the interaction leads to 12.5% more employees. Broadband facilitates smoother and faster integration processes during M&A, which can support the hiring of additional employees to handle more efficiently the increased operational load. Also, the combination of broadband and successful M&A can increase innovation and efficiency, leading to business growth and the need for a larger workforce to manage new initiatives and projects. Notice that the results in column (6) are in line with the negative coefficients observed in column (5). The impact of broadband on productivity is often lagged. While firms do not experience a significant change in output in the short term, they might need to hire more employees in anticipation of future growth and efficiency gains. The increase in employment, driven by the initial implementation of broadband, can temporarily lead to lower labor productivity as the output per worker decreases during the adjustment period.

Heterogeneity effects - An additional objective of this research is to examine whether the effect of broadband access on the performance of firms can vary across different sectors. According to the industry classification criteria established by the China Securities Regulatory Commission, we can classify the firms in our sample into 19 industries. Notice, however, that around 65% of the firms in our sample belong to the category of manufacturing firms (19,160 out of 29,756 observations).

Tables 8 and 9 repeat the analysis of Table 7 above for manufacturing and non-manufacturing industries, respectively. Similar to before, we do not find statistically significant relationships between broadband and TFP or labor productivity in manufacturing firms. Additionally, M&A driven by broadband does not have a significant effect on TFP. Column (6) in Tables 8 and 9 illustrates that M&A driven by broadband increases employment across all industries. However, columns (3) and (5) differ from Table 7, showing that broadband has a positive but not significant effect on employment and that the M&A driven by broadband deployment does not have a significant impact on labor productivity.

Finally, it is noteworthy that within the manufacturing industry classification, there are 30 sub-categories. After excluding manufacturing sub-industries with a small number of observations, we focus our analysis on the chemical raw materials and chemical products manufacturing industry (1,992 observations) and the electrical machinery and equipment manufacturing industry (1,893 observations). Columns (1) and (2) in Table 10 show that in these two sectors, broadband deployment significantly increases the number of employees, consistent with the findings presented in Table 7. However, we did not find a significant effect of broadband on labor productivity.

Interestingly, column(3) implies that firms in regulated activities (electricity, heat, gas, and water production industries), with 902 observations, are the only ones that show a significant decrease in labor productivity due to broadband deployment. This suggests that while broadband facilitates employment growth, it may also introduce integration challenges or inefficiencies in resource management in this particular type of firm, which could temporarily reduce labor productivity.

8. Conclusion

This paper has analyzed the effect of broadband deployment on M&) activities using data from Chinese-listed firms between 2011 and 2022. By leveraging the "Broadband China" policy that promoted the rollout of broadband connections in 120 pilot cities in the period 2014-2016, we employ a staggered DiD model that aims at identifying the causal effect of broadband access on the firms' M&A activities.

The main finding of our analysis is that broadband deployment significantly increased the

Table 8: Broadband, M&A, and firm performance in manufacturing industries

	(1) Total Factor Productivity	(2) Labor Productivity	(3) Employment	(4) Total Factor Productivity	(5) Labor Productivity	(6) Employment
Broadband	-0.017	-0.016	0.034	-0.017	-0.019	0.033
	(0.022)	(0.022)	(0.027)	(0.022)	(0.022)	(0.027)
Successful M&A				0.036**	-0.033*	0.069***
				(0.015)	(0.017)	(0.018)
Broadband × Successful M&A				0.016	-0.025	0.096***
				(0.026)	(0.025)	(0.030)
Fix	-0.651***	-0.333**	0.186*	-0.644***	-0.337**	0.200*
	(0.097)	(0.137)	(0.107)	(0.097)	(0.137)	(0.107)
Lev	-0.053	0.378***	0.911***	-0.054	0.379***	0.908***
	(0.079)	(0.070)	(0.082)	(0.078)	(0.070)	(0.082)
ROA	9.737***	1.268***	0.073	9.759***	1.265***	0.088
	(0.523)	(0.228)	(0.232)	(0.522)	(0.228)	(0.232)
ROE	0.342	0.432***	0.301***	0.326	0.437***	0.283**
	(0.262)	(0.105)	(0.115)	(0.262)	(0.105)	(0.114)
Shareholder	-0.051	-0.125	0.187	-0.055	-0.124	0.181
	(0.102)	(0.105)	(0.139)	(0.102)	(0.105)	(0.139)
Ind	0.148	0.101	-0.054	0.151	0.099	-0.048
	(0.185)	(0.146)	(0.173)	(0.185)	(0.146)	(0.173)
Concurrent	0.006	-0.005	0.035*	0.006	-0.005	0.035*
	(0.015)	(0.015)	(0.018)	(0.015)	(0.015)	(0.018)
Board	0.013*	0.005	0.037***	0.013*	0.005	0.037***
	(0.007)	(0.006)	(0.008)	(0.007)	(0.006)	(0.008)
Age	0.041	0.026	0.798***	0.042	0.025	0.799***
	(0.087)	(0.100)	(0.139)	(0.087)	(0.100)	(0.139)
Liability	-0.202***	0.070	-0.129**	-0.200***	0.068	-0.126**
	(0.053)	(0.045)	(0.052)	(0.053)	(0.045)	(0.052)
Cashflow	0.268***	0.085	-0.231***	0.271***	0.084	-0.223***
	(0.067)	(0.069)	(0.075)	(0.067)	(0.069)	(0.074)
Revenue	-1.971	2.203***	2.160*	-1.960	2.204***	2.173*
	(1.215)	(0.530)	(1.174)	(1.216)	(0.529)	(1.170)
Intangible	0.333	-0.903***	0.107	0.322	-0.896***	0.090
	(0.203)	(0.328)	(0.361)	(0.204)	(0.329)	(0.361)
Number of Observations	16810	17874	17874	16810	17874	17874
TE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

Table 9: Broadband, M&A, and firm performance in non-manufacturing industries

	(1) Total Factor Productivity	(2) Labor Productivity	(3) Employment	(4) Total Factor Productivity	(5) Labor Productivity	(6) Employment
Broadband	-0.010	-0.017	0.035	-0.010	-0.014	0.035
	(0.037)	(0.044)	(0.045)	(0.037)	(0.044)	(0.045)
Successful M&A				0.033	-0.021	0.102***
				(0.027)	(0.037)	(0.037)
Broadband × Successful M&A				0.018	-0.049	0.111**
				(0.041)	(0.048)	(0.051)
Fix	-0.675***	-0.260	0.059	-0.672***	-0.263	0.068
	(0.167)	(0.209)	(0.196)	(0.167)	(0.209)	(0.196)
Lev	-0.331***	0.707***	0.729***	-0.331***	0.708***	0.726***
	(0.115)	(0.125)	(0.158)	(0.115)	(0.125)	(0.158)
ROA	7.398***	-0.238	0.675*	7.416***	-0.242	0.686**
	(0.763)	(0.317)	(0.348)	(0.762)	(0.317)	(0.346)
ROE	1.726***	0.915***	0.109	1.712***	0.922***	0.089
	(0.327)	(0.152)	(0.152)	(0.328)	(0.152)	(0.152)
Shareholder	0.022	-0.065	-0.015	0.017	-0.061	-0.027
	(0.160)	(0.184)	(0.217)	(0.160)	(0.184)	(0.216)
Ind	0.031	0.177	0.689**	0.029	0.178	0.683**
	(0.261)	(0.320)	(0.294)	(0.261)	(0.320)	(0.295)
Concurrent	0.001	-0.024	-0.063**	0.001	-0.024	-0.063**
	(0.027)	(0.028)	(0.030)	(0.027)	(0.028)	(0.030)
Board	-0.001	-0.005	0.043***	-0.001	-0.005	0.043***
	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)	(0.011)
Age	-0.246*	0.580***	-0.380*	-0.245*	0.580***	-0.379*
	(0.132)	(0.175)	(0.196)	(0.132)	(0.175)	(0.196)
Liability	-0.298***	0.287***	0.081	-0.297***	0.286***	0.084
	(0.072)	(0.085)	(0.092)	(0.072)	(0.085)	(0.092)
Cashflow	0.068	0.038	-0.406***	0.071	0.036	-0.401***
	(0.099)	(0.112)	(0.117)	(0.099)	(0.112)	(0.117)
Revenue	-1.903***	2.840	4.257**	-1.913***	2.851	4.235**
	(0.570)	(2.224)	(2.125)	(0.571)	(2.213)	(2.123)
Intangible	0.125	-1.132***	1.263***	0.126	-1.132***	1.267***
	(0.250)	(0.350)	(0.404)	(0.251)	(0.351)	(0.402)
Number of Observations	8974	9639	9639	8974	9639	9639
TE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

Table 10: Broadband, M&A, and firm performance in chemical and electric equipment manufacturing industry

	(1) Chemical Employment	(2) Electrical Employment	(3) Electricity Labor Productivity
Broadband	0.218***	0.174**	-0.308***
	(0.073)	(0.082)	(0.093)
Successful M&A			-0.117
			(0.075)
Broadband × Successful M&A			-0.381***
			(0.110)
Fix	0.138	-0.010	0.127
	(0.265)	(0.341)	(0.251)
Lev	1.166***	0.592***	0.405
	(0.210)	(0.190)	(0.328)
ROA	0.882	-0.362	-0.091
	(0.590)	(0.573)	(1.071)
ROE	-0.242	0.519*	0.936**
	(0.228)	(0.277)	(0.399)
Shareholder	1.015**	-0.389	-0.025
	(0.403)	(0.268)	(0.330)
Ind	0.320	0.244	0.130
	(0.489)	(0.515)	(0.663)
Concurrent	0.042	0.060	0.008
	(0.046)	(0.045)	(0.078)
Board	0.070**	0.032	0.079***
	(0.027)	(0.022)	(0.019)
Age	1.477***	0.361	-0.301
	(0.372)	(0.393)	(0.511)
Liability	-0.050	-0.146	0.227
	(0.162)	(0.188)	(0.219)
Cashflow	-0.583**	-0.474**	0.020
	(0.230)	(0.239)	(0.389)
Revenue	-40.531	2.287***	-44.824
	(31.362)	(0.424)	(32.477)
Intangible	-0.230	2.210**	-0.795
	(0.759)	(1.056)	(0.694)
Number of Observations	1868	1791	828
TE	Yes	Yes	Yes
FE	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1.
Standard errors are in parentheses.
All standard errors in the regression are clustered at the firm level.

probability of firms engaging in M&A activities. Firms located in pilot cities with broadband access are approximately 1.26 times more likely to initiate M&As compared to those in other cities. This result reflects that the enhancement of the communication and information flow reduces the transaction costs and information asymmetries and facilitates the negotiations between firms. Broadband access not only increases the likelihood that firms initiate M&A negotiations, but also enhances the probability that firms reach an agreement and successfully complete the M&As. Firms in pilot cities are 1.32 times more likely to achieve successful M&As and twice as likely to complete the full acquisition of the targeted firms, compared to firms in non-pilot cities. Our interpretation of this result is that broadband infrastructure provides an essential tool for effective communication between firms and facilitates the decision-making process during the M&A process.

Another relevant finding of this research is that broadband deployment has a more pronounced effect on short-distance M&As. While it has a significant effect on M&A operations between firms located in the same city, the same province, or different cities in the same province, it does not favor these operations between firms in different provinces. This finding highlights that broadband access does not completely remove distance barriers between firms, as logistical and regulatory barriers might still pose challenges in the integration of firms. Physical distance still plays a significant role in integrating certain activities that require in-person coordination, such as aligning corporate cultures or managing physical assets. In other words, it seems that broadband connections facilitate the consolidation process within certain markets, as listed firms tend to acquire other firms in the same region. However, in the period examined, we do not observe a significant increase in the acquisitions of firms in other regions.

The second part of the paper has examined the implications that broadband deployment has on the firms' TFP and labor productivity. We have shown that this technology does not affect firms' productivity, but it significantly increases firm employment. We also examine the combined effect of broadband access and participation in an M&A operation and find that they do imply a significant impact on TFP. However, we do find a positive and significant impact on employment in firms that engaged in M&A activities after broadband deployment. Moreover, we find that this leads to a reduction in labor productivity. This is likely due to the integration challenges and the need to hire an additional workforce to manage new resources and operations after an acquisition. While the positive impact on employment is observed across all industries, the reduction in labor productivity is particularly significant in regulated firms (electricity, heat, gas, and water production sectors). Broadband enables these sectors to modernize their operations by integrating advanced technologies such as smart grids, remote monitoring systems, and automated control systems. This integration often requires additional personnel with specialized skills to install, operate, and maintain these technologies. If companies acquire these advanced technologies through M&As, employees need time to learn and install new equipment or upgrade existing systems. This process can initially lead to paused or even reduced production until the new systems and processes are fully operational.

The findings of this study have important policy and managerial implications. For policymakers, the results reveal the importance of investing in broadband infrastructure to facilitate market economic consolidation and growth. However, to maximize productivity gains, policies should also focus on complementary investments in skills training and organizational development. Since broadband can facilitate M&A and the combined effect of broadband and M&A can increase employment, the government could further expand broadband deployment to boost employment rates. For managers, understanding the role of broadband in enhancing communication and reducing transaction costs can inform strategic decisions related to M&A activities.

Future research could delve into the post-M&A performance of the targeted firms, especially in cases where the M&A is not a full takeover. The target firm remains in the market, and it would be valuable to investigate how these firms perform after the M&A. Key areas to explore include changes in productivity, profitability, market share, and operational efficiency. This would help in understanding the broader implications of M&A on market dynamics and competition. Another significant area of future work is to explore whether M&A activities are aimed at acquiring firms within the same sector or from different sectors. This analysis can provide insights into the strategic motivations behind M&As. For instance, acquiring firms within the same sector might be driven by a desire to consolidate the market position, achieve economies of scale, or eliminate competition. On the other hand, cross-sector acquisitions might be aimed at diversification, entering new markets, or acquiring new technologies and capabilities.

Appendix: Productivity Measurement

The calculation of the TFP implies an important challenge, due to simultaneity and selection bias. Simultaneity occurs when productivity and input demands (like labor and capital) are correlated over time. A more productive firm invests more in labor and capital, which can lead to an upward bias in ordinary least squares (OLS) estimations. If productivity correlates more with labor, the labor coefficient will be overestimated. Selection bias arises when firms with larger capital are less likely to exit the market, leading to a downward bias in the capital coefficient. Mundlak (1961) propose a fixed-effect method to address this problem, assuming productivity is firm-specific but constant over time. However, this approach does not account for changes over time. Olley & Pakes (1992) develop a semi-parametric method to tackle both selection bias and simultaneity by using investment decisions as a proxy for unobservable productivity shocks. However, their method assumes a constant relationship between investment and total output, which isn't always realistic. Levinsohn & Petrin (2003) improve this method by using intermediate inputs (like raw materials) as a proxy, which is easier to obtain than investment data. Both Olley Pakes (1992) and Levinsohn Petrin (2003) use two-stage methods, estimating labor input first. However, if labor choices also depend on unobserved productivity, collinearity issues arise. Ackerberg et al. (2015) further refine these methods by estimating inputs in the second stage, mitigating collinearity. We measure the productivity of listed firms using the method of Ackerberg et al. (2015).

We build a Cobb-Douglas production function to measure the total factor productivity as follows:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} M_{it}^{\beta_m} \tag{6}$$

Where Y_{it} represents the value-added output for firm i in year t; A_{it} is the total factor productivity (TFP); K_{it}, L_{it}, and M_{it} are capital, labor, and intermediate inputs, respectively. We define these variables refer to Li & Lv (2021). We define Y_{it} as the sum of compensation of employees, depreciation of fixed assets, net taxes on production, and operating profit. L_{it} is measured by the number of employees; K_{it} is firm i's assets in year t; we define M_{it} = production cost - compensation of employees - depreciation of fixed assets. We can take the natural logarithm of (6) to get:

$$y_{it} = \beta_0 + \beta_k k_{it} + \gamma l_{it} + \beta_m m_{it} + \omega_{it} + \mu_{it} \tag{7}$$

Where y_{it}, k_{it}, l_{it}, and m_{it} are variables per capita; $\gamma = (\beta_l + \beta_k + \beta_m - 1)$; ω_{it} is the observable shock on productivity that can be predicted by firms; μ_{it} is the unobservable shock; and TFP is measured by $\beta_0 + \omega_{it}$. The ACF method assumes that the intermediate input is a function of TFP, labor, and capital inputs as follows:

$$m_{it} = f_t\left(k_{it}, l_{it}, TFP_{it}\right) \tag{8}$$

We can invert (8) to get TFP:

$$TFP_{it} = f_t^{-1}\left(k_{it}, l_{it}, m_{it}\right) \tag{9}$$

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