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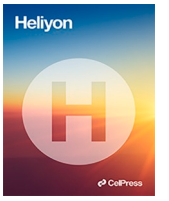

Research article

When does digital merger and acquisition create shareholder value? An empirical investigation in the Chinese context

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ABSTRACT

In China, acquiring firms are increasingly focused on the immediate financial returns that digital mergers and acquisitions (DM&A) can help them achieve in the stock market, but there is little literature that examines which acquiring firms achieve greater returns. Based on signaling theory, this study conceptualizes DM&A announcements as signals released by the acquiring firms to the stock market and explores the factors influencing the Chinese stock market's reaction to such signals. This research empirically investigates potential influencing factors using a short-term event methodology together with regression analysis based on the data collected in China's Shanghai and Shenzhen stock markets during 2012–2021. The research finds that the Chinese stock market reacts more positively to DM&A announcements for acquiring firms with high executive shareholdings, high executive openness, strong digital innovation capabilities, and in regions with higher levels of investor protection. This study is the first attempt to explore the factors influencing the stock market's response to DM&A in the Chinese context.

1. Introduction

Mergers and acquisitions (M&A) are one of the most important events in a company's life cycle, significantly influencing the shareholder value of the acquiring companies [1]. With the rapid evolution and widespread application of digital technologies, more and more companies choose to acquire digital technologies from external sources through M&A, so as to accelerate the development of digital capabilities and gain competitive advantages [2,3]. As a result, a growing subfield of M&A research has been spawned, namely digital mergers and acquisitions (DM&A). DM&A refers to the acquisition of (or mergers with) firms that intensely leverage digital technologies as vital elements of their business models [2,3]. The popularity of DM&A is due to the numerous benefits that it can bring to individual firms, including quickly gaining control of digital technologies and capturing digital markets, building digital technology barriers [4], attracting digital talent, promoting digital innovation, and empowering companies to achieve digital transformation better [2,5].

DM&A has, in fact, evolved from the concept of technological M&A that Ahuja et al. [6] initially proposed. However, DM&A is distinguished from conventional technological M&A by the distinctive attributes of digital technologies. Primarily manifested in three aspects—plasticity, homogeneity, and transferability—these attributes enable acquiring companies to accomplish synergistic innovation by speedily acquiring, integrating, applying, and redeveloping the digital technologies of target companies [2,3,5]. Considerable scholarly attention has been devoted to examining the effects of M&A on shareholder value. Research has shown that whether

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shareholders of acquiring companies can benefit from such transactions depends on a multitude of factors, which may derive from external environments [7–9], organizational capabilities [10,11], and managerial characteristics [12–14]. Additionally, a minority of scholars have also assessed the direct and indirect effects of DM&A on shareholder value. For instance, Hanelt et al. [2] find that DM&A indirectly enhances the financial performance of acquiring companies by fostering digital innovation. Tang et al.'s [3] study finds that, on average, the Chinese stock market reacts positively to DM&A announcements in the short term. However, existing DM&A research neglects to examine contextual factors, and it is still unclear under which conditions DM&A is more likely to enhance shareholder value.

Drawing on signaling theory [15], this study conceptualizes a DM&A announcement as a signal that an acquiring company releases to the stock market [3] and focuses on the conditions under which it has a greater impact on shareholder value. Signaling theory emphasizes that the effectiveness of signals depends not only on the characteristics of the signal sender (individual or organization) but is also influenced by the external environment. Regarding the external environment, prior research has demonstrated that a robust investor protection system inhibits opportunistic company behavior and increases the transparency of the M&A deal process [16–18]. Consequently, this may impact investors' confidence and expectations concerning the success of DM&A. In relation to organizational capabilities, the acquiring company's digital innovation capabilities contribute to post-merger innovation synergies [6,19], which are critical for enhancing M&A performance [20]. In terms of managerial characteristics, executives with a high shareholding often focus on long-term goals [21], while open-minded executives are more receptive to change [22]. Executives who prioritize long-term goals and have a change-oriented style play a positive role in the successful digital transformation of a company [23–25]. Given the potential impact of these factors on the link between DM&A and shareholder value, there is an urgent need for empirical research to validate them. Conducting such research is essential for gaining a deeper understanding of the conditions under which DM&A can enhance the shareholder value of the acquiring companies.

China is an ideal empirical context to investigate under which conditions DM&A can increase shareholder value for acquiring companies for two main reasons. First, China is one of the countries with the most rapid and active development of DM&A in the world. Data shows that between 2009 and 2017, the total number of DM&A by Chinese companies within the S&P Global 1200 Index basket ranked first globally [26]. Second, Chinese companies are highly focused on the immediate financial returns brought by DM&A. A study of Accenture's 2022 survey of more than 570 Chinese companies, for example, shows that more than 80 % of Chinese companies are concerned about whether DM&A can deliver immediate financial returns.[1] Furthermore, due to the difficulty of measuring long-term effects, the short-term event study approach, which examines the stock market's reaction to M&A announcements, is the preferred method for studying the impact of M&A on shareholder value [27]. Accordingly, this study also employs this methodology. We systematically reviewed the relevant literature and developed a conceptual model based on signaling theory. Then, using a short-term event study methodology and the ordinary least squares method, 200 DM&A events of listed companies in Shanghai and Shenzhen in China during the period 2012–2021 were analyzed, and the model was finally validated. We find that the Chinese stock market reacts more positively to DM&A announcements for acquiring firms with high executive shareholdings, high executive openness, strong digital innovation capabilities, and in regions with higher levels of investor protection.

This research enriches and advances at least two streams of literature. First, this study is the first to examine the conditions under which DM&A is more likely to enhance shareholder value. Although previous M&A research has emphasized that the ability of M&A to create shareholder value for the acquiring company depends on a variety of contextual factors [1,27], this study fills this research gap as existing DM&A research has neglected to examine such factors. Second, this paper conceptualizes the DM&A announcement as a signal and reveals that the effectiveness of such a signal depends on the characteristics of the signal sender and the external communication environment. In fact, it has always been an important topic in signaling theory that signals emitted by different signal emitters and different environmental factors will make signals differently effective [28]. Therefore, this study not only expands the application scenarios of signaling theory but also enriches signal validity research.

2. Related literature

M&A is a collective term for mergers and acquisitions. Among them, merger refers to the behavior of two or more enterprises merging to form one enterprise, and acquisition refers to the behavior of one enterprise purchasing a certain amount of equity or assets of another enterprise [1,27,29]. M&A is the most rapid and effective growth strategy for companies and is also an important initiative for companies to respond to changes in business models, rapidly acquire innovative resources, optimize resource allocation, and generate synergies, which have a significant influence on the future development and shareholder value of companies [1,6,27,30].

Numerous studies have examined the impact of M&A on acquirers' shareholder value (e.g., Refs. [9,27,29,31]. Due to the difficulties in measuring the long-term value creation effect of M&A, most studies have focused on the assessment of the short-term value creation of M&A events. Specifically, scholars typically use short-term event studies to assess stock market reactions to M&A announcements [29,31]. However, the existing studies on the short-term value creation of M&A have yet to result in consistent conclusions. Most scholars reveal the negative impact of M&A on acquirers' shareholder value [9,31,32]. These studies argue that most of the gains generated by M&A go to the shareholders of the target company, who have most of the premium power in M&A negotiations. In contrast, the acquiring company is harmed [9,31,33].

Other scholars take a different view. They emphasize that whether an M&A creates shareholder value for the acquiring company

[1] The data comes from the "2022 Accenture China Enterprise Digital Transformation Index", published by Accenture in 2022. The report is available for download at https://www.accenture.cn/cn-zh/insights/strategy/china-digital-transformation-index-2022.

depends on a multitude of factors. These factors come from three different levels: initially, managerial factors (e.g., Refs. [13,34,35]). For example, Doukas and Zhang [13] find that the stock market reacts more positively to M&A announcements made by firms with stronger managerial abilities. Second, organizational factors (e.g., Refs. [10,11,36]). Wu and Chung [10] find that more innovative firms will receive a more positive stock market response when they engage in mergers and acquisitions. Third, external environmental factors (e.g., Refs. [7,9]). For instance, Xu [9] found that stock market reactions to M&A announcements are influenced by culture, financial development, and the legal system. Table 1 provides a summary of these investigations on influencing factors.

DM&A is a special type of M&A that integrates digital concepts into the entire process of target selection, M&A transaction decisions, and post-merger management integration, with the aim of accelerating the digital transformation and upgrading of enterprises [2,3]. Indeed, DM&A has emerged based on early-stage technological M&A within the context of the digital economy. Since Ahuja et al. [6] introduced the concept of technological M&A, the academic community has extensively explored the link between technological M&A and shareholder value [38]. However, according to Hanelt et al. [2] and Yoo [5], the specificity of digital technology makes DM&A different from other technological M&A. They argue that this specificity is reflected in three main aspects: plasticity, homogeneity, and transferability. These characteristics of digital technology allow the acquiring company to not only gain full control of the technology in a short period [4] but also to quickly integrate the target company's digital technology and further promote the building of the acquiring company's digital knowledge base and digital innovation [2,5].

A few scholars have assessed the impact of DM&A on shareholder value. For instance, Tang et al. [3] use short-term event studies to analyze the events of DM&A in Chinese listed firms and find that the stock market reacts to DM&A announcements with a positive reaction. That is, on average, DM&A increases the market value of the acquirer in the short term. Hanelt et al. [2], using data on European firms, find that DM&A promotes the level of digital innovation in the merging firms, which in turn improves the firm's financial performance. However, these studies have neglected the examination of contextual factors to the extent that there remains a lack of clarity about the conditions under which DM&As are more likely to enhance shareholder value.

The characteristics of executives are key factors influencing a company's digitalization [24]. Many scholars believe that executives who focus on long-term goals and possess a transformative style play a crucial role in successfully implementing digitalization [23–25]. However, some scholars hold the opposite view, suggesting that transformative styles and a focus on long-term goals have a "dark side" that can negatively affect a company [39]. Existing literature emphasizes that executives with a high shareholding pay more attention to long-term objectives [21], and open-minded executives encourage and support change [22]. There is a lack of empirical research on how investors interpret signals from executive shareholding and executive openness in the context of DM&A and how they respond to these signals. At the organizational level, existing literature indicates that the acquiring firm's innovation capability contributes to achieving synergistic innovation post-merger, thus enhancing M&A performance [6,20]. However, as mentioned earlier, the plasticity, homogeneity, and transferability characteristics of digital technologies make digital innovation inherently integrative [40]. How this integrative nature influences synergistic innovation post-merger and subsequently impacts external investors' reactions has yet to attract scholarly attention. Finally, when examining capital market reactions, the impact of the investor protection system cannot be ignored, as it has a positive effect on curbing companies' opportunistic behavior, lowering the cost of financing, and reducing information asymmetry [16,41]. Consequently, investor protection mechanisms may impact investors' reactions to DM&A. Given the potential impact of these factors on the relationship between DM&A and shareholder value, there is an urgent need for empirical research to identify specific influencing factors and address the existing gap in the literature regarding the neglect of contextual factors in DM&A studies.

3. Conceptual model

The objective of this research is to examine the factors that impact the response of the Chinese stock market to DM&A announcements. Signaling theory suggests that organizations should consciously use signals to reduce uncertainty and thus enhance the science of decision-making in the context of information asymmetry [15]. According to signaling theory, M&A announcements by

Table 1
Factors influencing stock market reactions to M&A events.

Categories	References	Theories	Influencing factors
Managerial factors	Tran et al. [34] Parola et al. [35]	Human capital theory/N/A	Gender diversity
	Dong and Doukas [12] Doukas and Zhang [13]	N/A/Signaling theory	Managerial ability
	Phan [14]	N/A	CEO inside debt holdings
Organizational factors	King et al. [11]	Signaling theory and contingency theory	Firm size, prior performance, acquisition experience, and debt ratio
	Zhang et al. [36]	Signaling theory and stakeholder theory	Corporate social responsibility
	Wu and Chung [10]	N/A	Innovation output and R&D spending
	Andriosopoulos et al. [37]	Over-extrapolation theory	Institutional shareholding
External environment factors	Song et al. [7]	Market efficiency theory	Financial market
	Xu [9]	Neoclassical theory, agency theory, and valuation theory	Culture, financial development, and the legal system
	Tao et al. [8]	Signaling theory and institution-based views	Political risk level

companies can be used as signals to convey information to the market, and the market performance of M&A (e.g., abnormal returns) is essentially a measure of the market's response to a firm's M&A signals [8]. In prior research, scholars have widely applied signaling theory to investigate the deal- and firm-level influences associated with M&A announcement returns (e.g., Refs. [8,42,43]). Thus, this study uses signaling theory to explore the factors influencing how the Chinese stock market reacts to DM&A announcements.

Signaling theory suggests that the effectiveness of a signal depends not only on the characteristics of the signal sender but is also influenced by the external environment in which the signal is placed [28]. Signal senders usually represent managers and firms in management research, and the institutional environment is an important external environmental factor that influences the signaling process [28,44]. This research seeks to explore how the reaction of the Chinese stock market to DM&A depends on the following institutional, organizational, and managerial specific factors: (1) the level of investor protection in the region where the acquiring company is located [45]; (2) the acquiring company's digital innovation capabilities [19]; and (3) the level of executive shareholding and executive openness of the acquiring company [46,47]. Fig. 1 depicts the research framework for this investigation.

Investor protection refers to the extent to which laws and their enforcement protect the interests of outside investors from deprivation by corporate insiders [48]. As an institutional environment, investor protection exhibits significant differences across regions in China [45] and may have an important impact on the signaling process of DM&A. This is because (1) investor protection, as an external governance mechanism, can enhance corporate governance, effectively curb the opportunistic behavior of corporate insiders, and invest corporate resources in shareholder-friendly projects [16,17]. Alexandridis et al. 's [29] study also found that the improved level of governance of acquiring firms led to positive abnormal returns from M&A transactions; (2) good investor protection helped to reduce the cost of external financing for firms, improved the channels of external financing for firms, and better provided financial support for value-adding projects; (3) good investor protection prompts company management to enhance information disclosure and reduce information asymmetry between external investors and information senders such as managers and organizations [18,41]. In the context of the digital economy, when the government develops specific laws and regulations to make firms and transactions more transparent, firms are forced to adopt practices to increase the visibility of their business processes [49]. In other words, good investor protection not only serves as an external governance mechanism to enhance the governance of DM&A firms as a way to improve the quality of signal senders but also increases investor trust in the market, optimizes the external environment for signaling, and thus enhances the signaling effectiveness of DM&A announcements. Thus, we propose the following hypothesis.

H1. The stock market reacts more positively to DM&A announcements by companies in regions with higher levels of investor protection.

The realization of innovation synergy is the internal reason for higher M&A performance [20], and the innovation capability of the acquiring company plays a key role in the creation of post-merger innovation synergy [6]. Achieving innovation synergies requires the acquiring company to complete a number of processes, such as awareness, absorption, and application of the target company's know-how [50]. If the acquiring company is less innovative, it is difficult to complete these processes, leading to a decrease in the future output of innovation [6,51]. Digital innovation exhibits convergence [40], necessitating the integration of heterogeneous knowledge [19,52]. Additionally, digital innovation is also generative in nature [52]. The limitless possible combinations of disconnected layers along a hierarchical modular architecture generate continuous dynamics and the growing inseparability of innovation procedures and results [53]. Thus, an organization's existing digital innovation knowledge base not only enables it to directly implement and combine this knowledge but also makes it more receptive to new external knowledge [2]. It follows that companies can use DM&A to build on their own technology reserves to develop new digital technologies and businesses and gradually become even better digital players. This status, in turn, tends to attract more quality investors. Thus, we propose the following hypothesis.

H2. The stock market reacts more positively to DM&A announcements by companies with greater digital innovation capabilities.

Managerial characteristics are additional signals that investors can observe and rely on [46,54], which may influence investors' interpretation of DM&A announcements and thus lead to different market reactions. Our study focuses on the effects of managerial

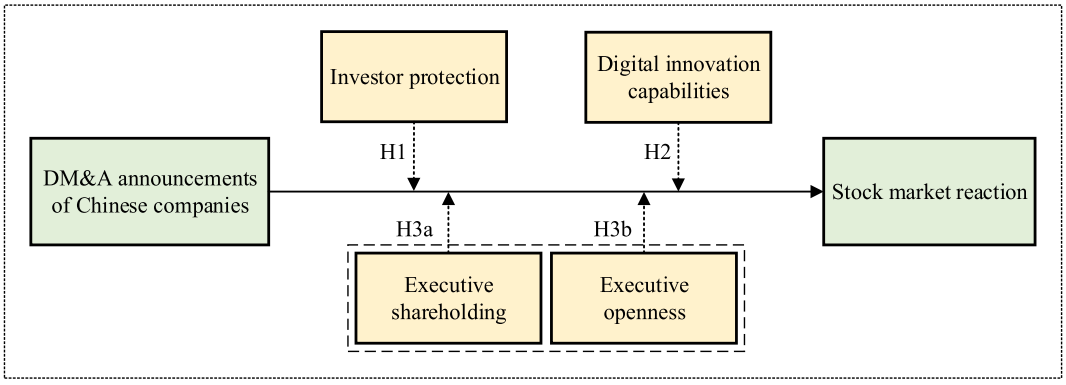

Fig. 1. Research framework.

characteristics in terms of executive shareholding and executive openness. On the one hand, according to signaling theory, when executive shareholding is high, it sends a credible signal to outsiders that they will not grab the firm's resources and encroach on shareholders' interests [46,55]. Management shareholding can also provide effective regulation [56]. When shareholdings are sufficiently large, managers have sufficient self-regulatory incentives to invest corporate resources in projects that will yield long-term benefits, thus effectively mitigating agency problems [21]. Particularly in countries with weak legal protections for investors, such as China, management shareholding is more likely to combine management incentives with shareholder incentives, sending a positive signal of improved corporate quality [46]. In contrast, improved corporate governance quality will lead to significantly higher returns for the acquiring company [27,29].

On the other hand, executive openness, as defined by Hambrick et al. [57], refers to the personality traits of executives who are willing to change the status quo of the organization and seek new institutional and strategic directions. Rather than simply inserting a digital business unit into the acquiring company through a single technology-based acquisition, DM&A is a programmatic approach to multiple small and medium-sized acquisitions within the framework of a company's digital development strategy [58]. That is, the success of DM&A needs to be supported by a company's digital transformation strategy. Open-minded executives create an environment and climate that encourages organizational change, pushes the boundaries of convention, and can provide the necessary resources and information base for organizations to implement strategic change and alter conventional paradigms [47]. In other words, executives with openness characteristics can signal to external investors that open executives are better able to drive digital transformation strategies through DM&A, boosting investor confidence and thus increasing returns for the acquiring company. Therefore, we propose the following hypothesis.

H3a. The stock market reacts more positively to DM&A announcements by companies with higher levels of executive shareholding.

H3b. The stock markets react more positively to DM&A announcements by companies with higher executive openness.

4. Empirical design

4.1. Sample and data

We obtained M&A announcements from the CSMAR database for all A-share listed companies in China over the period spanning from 2012 to 2021, resulting in 84882 M&A announcements. CSMAR is a research-based and accurate database developed specifically for the Chinese economic and financial sector in accordance with the professional standards of authoritative databases, including CRSP, COMPUSTAT, and TAQ. CSMAR provides detailed information on all M&A of listed companies, such as the date of the initial announcement, the type of M&A, the scope of operations of the primary merging company and the subject company, as well as details of the transaction. This information provides us with a reliable source for identifying the dates of M&A events and for screening DM&A events. Before identifying DM&A events, we conducted an initial screening of our sample. We first excluded M&A events in the financial sector and listed companies marked as Specially Treated (ST), *ST, or Specially Transferred (PT) due to their unusual financial conditions, trading rules, and share price changes [59], with 78205 M&A events remaining. We then excluded M&A events where the business type was asset stripping, asset replacement, debt restructuring, share buyback, and land and asset acquisition, leaving 56496 M&A events. We further excluded the sample of M&A events with an M&A value of less than RMB1 million, leaving 39610 M&A events.

And then, we used content analysis to assess whether the disclosed transaction purposes and backgrounds, as well as potential post-transaction impacts, involve terms such as "big data", "cloud computing", "artificial intelligence", "blockchain", and "digital transformation". Simultaneously, we determine whether the acquiree belongs to the digital economy industry based on its business scope. If the listed company is aiming for digital transformation and the acquiree belongs to the digital economy industry, we identify this M&A transaction as a DM&A. We obtained the industry classification of the digital economy based on the "Statistical Classification of the Digital Economy and Its Core Industries (2021)" published by the National Bureau of Statistics of China. Through this step, we obtained 226 DM&A events. In addition, for numerous M&As that the same firm did in the same year, just the first M&A that the company completed in that year was maintained, and 200 DM&A events were finally obtained. Some examples include.

- In order to improve the layout of the IDC and cloud computing businesses and enhance profitability, SZZT Electronics Co., Ltd. intends to use its funds of RMB 75.3 million to acquire a 30 % equity interest in CLOUDDCS Co., Ltd.
- In order to accelerate the layout and development of its intelligent medical business in the field of medical artificial intelligence and big data applications, Hangzhou Century Co., Ltd. intends to use its funds to acquire an 8.33 % equity interest in Hangzhou Cognitive Network Technology Co., Ltd.

After applying these screening criteria, we retained 200 DM&A events from 167 listed firms in our sample. Except that the digital innovation patent data comes from the patent database of the State Intellectual Property Office of China (SIPO), and the investor protection data comes from the "Marketization Index of China's Provinces: NERI Report 2021″ compiled by Wang et al. [60], the other data covered in this study are all obtained from the CSMAR database.

Table 2 reports statistics on the size and financial performance of the companies included in the sample. In line with Lo et al. [61], for market value, outstanding stocks, and stock price, we use statistics from the 10 days prior to the date of the first announcement of the DM&A, and for the other measures, we use statistics from the most recent fiscal year prior to the announcement date. The findings of the descriptive analysis in Table 2 indicate that the sample firms vary considerably in terms of size and profitability, with total assets

ranging from RMB 491.5 million to RMB 205600 million, revenue ranging from RMB 19.05 million to RMB 408700 million, and ROA ranging from −0.24 to 0.47. In addition, 60.8 % of the sample companies were from the manufacturing industries and 39.2 % from the non-manufacturing industries.

4.2. Measurements

Dependent Variable: ***Stock market reaction to DM&A (CAR)***. In line with recent event studies (e.g., Refs. [62,63]), we measure the stock market's reaction to a DM&A event by calculating the cumulative abnormal returns (CAR) as follows: In the first step, we determine the event date and event period of the DM&A. We searched for the specific time of the announcement through the company's official website and the official websites of the Shanghai and Shenzhen stock exchanges. If the announcement was issued before 3:00 p.m., no adjustment to the announcement date was required; if the announcement was issued after 3:00 p.m., the announcement date was positioned for the next trading day. We use the adjusted announcement day as the event day (i.e., day 0). In line with the studies of Lo et al. [61] and Jacobs and Singhal [64], which consider the possibility of event information leaking on the day before the announcement, we employ a two-day event period, including the announcement day (day 0) and the trading day before the announcement (day −1).

In the second step, the estimation period was determined. An estimation window of 200 days (from day −210 to day −11) was selected for this study. Following Lo et al. [61], to avoid non-stationarity in the estimation, this study requires companies to have no less than 40 days of stock return data in the 200-day estimation period.

In the third step, we use the market modeling method proposed by Brown and Warner [65] to calculate CAR, which is calculated as follows: $CAR_{i(t_1,t_2)} = \sum_{t_2}^{t_1}[R_{it} - (\widehat{\alpha}_i + \widehat{\beta}_i R_{mt})]$, where R_{it} is the actual return of stock i at day t, R_{mt} is the market return at day t, $\widehat{\alpha}_i$ and $\widehat{\beta}_i$ are obtained by estimating the equation $R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$, using data from the estimation period and employing ordinary least squares (OLS).

Independent Variable: Investor protection. In accordance with prior literature (e.g., Refs. [44,66]), we measure the level of investor protection in the province or city where the listed company is located using the index of the development of market intermediary organizations and the legal institutional environment compiled by Wang et al. [60]. This index is derived from the "Marketization Index of China's Provinces: NERI Report 2021″ compiled by Wang et al. [60] and contains three dimensions, namely, the rule of law environment for maintaining the market, the protection of rights to intellectual property rights, and the development level of market intermediary organizations. While the index is only updated until 2020, we use the average growth of the index to predict the index for 2021. A larger index indicates a higher level of investor protection in the province or city where the listed company is situated.

Digital innovation capabilities. We use the number of digital economy invention patents to measure the digital innovation capabilities of the listed companies. Specifically, we draw on the practice of Flammer et al. [67], first adding 1 to the total quantity of patent applications for digital economy inventions in listed companies and then taking the natural logarithm of it as a measure of digital innovation capabilities. The main reasons are as follows: first, unlike measures of innovation capability such as the share of new product sales revenue, the cost paid by firms for patent applications has a screening effect on the level of innovation of firms [68], and the total quantity of patent applications is a better indicator of the true level of innovation of firms than the amount of patents granted [69]. Second, as a patent for an invention is a novel technical solution for a product, approach, or enhancement thereof, it is more technical and innovative than a utility model or design patent.

To calculate the number of digital economy invention patents of listed companies, we first retrieved information on listed companies' invention patent applications from the official website of the SIPO. Then, we used the "International Patent Classification and National Economic Industry Classification Reference Table (2018)" issued by the SIPO to match the industry classification of the patent according to its main classification number (the first one of the patent classification number). Finally, the "Statistical Classification of the Digital Economy and its Core Industries", published by the National Bureau of Statistics of China in 2021, was used to screen the digital economy invention patents of publicly traded companies.

Executive shareholding. We measure executive shareholding using the proportion of shares owned by executives relative to the total number of shares in the company. We define executive officers as the company's president, vice president, directors, general manager, secretary to the board of directors, supervisors, deputy general manager, and other senior management as defined in the

Table 2
Sample description.

Measure	Mean	Median	Std. error	Maximum	Minimum
Total assets (RMB000000)	8103	3588	18960	205600	491.50
Sales (RMB000000)	7323	1688	33500	408700	19.05
Net income (RMB000000)	410.80	136.20	1576	18610	−1565
Number of employees (000)	5.15	1.98	7.03	209.70	0.02
Return on assets	0.05	0.07	0.04	0.47	−0.24
Debt-to-equity ratio	0.92	0.69	1.18	11.63	0.01
Book-to-market value	0.31	0.30	0.13	0.76	0.05
Market value (RMB000000)	13780	6998	24900	230900	865.1
Outstanding stocks (RMB000000)	545.3	325.3	325.3	4292	12.86
Stock price (RMB)	23.34	15.93	23.04	176.67	2.88

Note. The statistics for market value, outstanding stocks, and stock price are for day −10.

company's articles of association.

Executive openness. We adapted Datta et al.'s [22] measure of CEO openness somewhat to accommodate the measurement of openness at the executive team level. The specific calculation process is as follows: (1) Three demographic characteristics are obtained, namely the mean educational attainment of executives, the mean age of executives, and the mean length of service executives within the firm. Particularly, the mean educational attainment of executives is measured by the proportion of the sum of the highest education level of executives to the total amount of executives, which is assigned as follows: 1 = secondary school, 2 = junior college, 3 = college, 4 = master, and 5 = doctorate. (2) We measure the average age of executives using the proportion of the sum of the ages of executives to the total amount of executives. And the ratio of the sum of the executives' time in their current positions to the number of executives is used to measure the mean length of service. Since executive age and tenure are negatively correlated with openness, these two indicators are multiplied by −1. (3) We standardize the executive education level and the transformed executive age and tenure and finally sum the three indicators after the above standardization to obtain executive openness.

Control variables: In accordance with previous event studies exploring the stock market's response to M&A announcements (e.g. Refs. [70–72], we control for a range of factors that may influence stock market reactions. The variables under consideration include the following: *Firm size* is represented by the natural logarithm of total assets. *Firm age* is measured by the amount of years the firm has been listed. *Leverage* is expressed as the proportion of total liabilities to total assets. *Profitability* can be defined as the proportion of net profit to the equity of shareholders. *Institutional shareholding* refers to the proportion of shares owned by institutional investors in relation to the total number of shares. We measure *Growth* as the rate at which the revenues of companies increase over time, and we control it. *Cash flow* is measured by the proportion of net cash flow from operating activities to total assets. Lastly, since accounts receivable turnover is believed to influence stock market reaction, we measure *Accounts receivable turnover* as a ratio of accounts receivable to total assets, and we control it.

4.3. Modeling

Following Lo et al. [61], we regress the cumulative abnormal returns CAR_i from day −1 to day 0 on the explanatory and control variables presented below. The independent variables and control variables mentioned above have been calculated for the most recent financial year prior to the DM&A announcement date. In addition, considering the different general economic conditions in different years and the differences in the likelihood of DM&A in different industries, following Lo et al. [61], we include year dummy variables and industry dummy variables in the model. The following model is to be utilized to test our hypothesis:

$$\begin{aligned} CAR_i = {} & \beta_0 + \beta_1 Investor\ protection_i + \beta_2 Digital\ innovation\ capabilities_i + \beta_3 Executive\ shareholding_i + \beta_4 Executive\ openness_i \\ & + \beta_5 Firm\ size_i + \beta_6 Firm\ age_i + \beta_7 Leverage_i + \beta_8 Profitability_i + \beta_9\ Institutional\ shareholding_i + \beta_{10}\mathrm{Growth}_i + \beta_{11} Cash\ flow_i \\ & + \beta_{12} Accounts\ receivable\ turnover_i + \beta_j YearDummy + \beta_k IndustryDummy + \epsilon_i \end{aligned} \quad (1)$$

Where CAR_i is he cumulative abnormal return of stock i from day −1 to day 0, ϵ_i is the error term and the expected sign of the coefficients β_1 to β_4 is positive. In the present study, the model was estimated using Ordinary Least Squares (OLS) methodology and

Table 3
Results of descriptive statistics and correlation analysis of variables.

	Mean	S.D.	VIF	1	2	3	4	5
1.*CAR*	1.516	6.314		1				
2.*Investor protection*	10.768	2.426	1.07	0.093	1			
3.*Digital innovation capabilities*	2.588	1.451	1.29	−0.058	0.130[b]	1		
4.*Executive shareholding*	0.208	0.204	1.83	0.103	0.203[b]	−0.012	1	
5.*Executive openness*	−0.197	1.469	1.44	−0.02	−0.145[b]	0.022[b]	0.027[b]	1
6. *Firm size*	22.096	1.083	2.21	−0.102	0.214[b]	0.275[b]	−0.170[b]	−0.174[b]
7. *Firm age*	1.869	0.801	1.86	−0.01	0.061[b]	0.081[b]	−0.366[b]	−0.294[b]
8. *Leverage*	0.401	0.195	2.05	0.029	−0.091[b]	0.108[b]	−0.254[b]	−0.043[b]
9. *Profitability*	0.074	0.087	1.25	−0.216[b]	0.012[a]	0.029[b]	0.086[b]	0.019[b]
10. *Institutional shareholding*	0.328	0.202	1.53	0.023	0.236[b]	0.138[b]	−0.198[b]	−0.213[b]
11. *Growth*	0.191	0.354	1.23	−0.192[a]	−0.065[b]	0.041[b]	0.031[b]	0.091[b]
12. *Cash flow*	0.029	0.063	1.42	0.016	0.013[b]	−0.023[b]	−0.002	−0.063[b]
13. *Accounts receivable turnover*	0.168	0.098	1.33	−0.170[a]	0.083[b]	0.140[b]	0.135[b]	0.079[b]
	6	7	8	9	10	11	12	13
6. *Firm size*	1							
7. *Firm age*	0.382[b]	1						
8. *Leverage*	0.449[b]	0.373[b]	1					
9. *Profitability*	0.100[b]	−0.156[b]	−0.147[b]	1				
10. *Institutional shareholding*	0.502[b]	0.377[b]	0.160[b]	0.134[b]	1			
11. *Growth*	0.027[b]	−0.057[b]	0.057[b]	0.250[b]	−0.006	1		
12. *Cash flow*	0.071[b]	0.004	−0.127[b]	0.287[b]	0.105	0.030[b]	1	
13. *Accounts receivable turnover*	−0.208[b]	−0.189[b]	0.016[b]	−0.057[b]	−0.183	0.025[b]	−0.214[b]	1

[a] $p < 0.05$.
[b] $p < 0.01$.

applying Petersen's [73] one-way cluster-robust standard errors approach to ensure the robustness of the findings.

5. Empirical analysis and results

5.1. Descriptive and correlational analysis

Table 3 reports the results of descriptive statistics and correlation analysis for the main variables in equation (1). Most of the independent variables were significantly correlated with the control variables. To mitigate the effect of multicollinearity, we did variance inflation factor (VIF) diagnostics on all explanatory and control variables that went into the model. The results showed that the VIF was within 2.21, which is well below the critical value of 10 [74]. This means that the problem of multicollinearity did not pose a serious threat.

5.2. Regression results

The results of the regression analysis are presented in Table 4. To avoid the problem of multicollinearity [75], we tested hypotheses 1–4 using stepwise regression analysis. In model 1, solely control variables were incorporated, whereas independent variables were progressively introduced in models 2–5. With the sequential inclusion of independent variables, R^2 increased from 0.314 in Model 1 to 0.582 in Model 5, indicating that the inclusion of independent variables enhanced the validity of the regression analysis. Hypothesis 1 argues that good investor protection enhances the positive stock market response to DM&A announcements. The results of Model 2 in Table 4 show that the coefficient of Investor protection is significantly positive at the 5 % level. This finding suggests that the better the investor protection of the province or city where the listed company is located, the more positive the stock market response to DM&A announcements. Therefore, Hypothesis 1 is supported.

Hypothesis 2. argues that the digital innovation capabilities of firms enhance the positive stock market response to DM&A announcements. The results of models 3–5 in Table 4 demonstrate that the coefficient of Digital innovation capabilities is significantly positive, at least at the 5 % level, indicating that the stronger the digital innovation capabilities of listed companies, the more positive the stock market response. Therefore, Hypothesis 2 is supported.

Table 4
Results of regression analysis.

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Investor protection		0.594[b]	0.721[b]	0.771[b]	0.859[b]
		(2.241)	(2.042)	(2.155)	(2.425)
Digital innovation capabilities			1.389[b]	1.607[c]	1.424[c]
			(2.528)	(3.535)	(2.861)
Executive shareholding				8.166[b]	11.997[c]
				(2.143)	(3.320)
Executive openness					1.215[b]
					(2.357)
Firm size	−0.041	0.116	−0.661	−0.393	0.052
	(-0.069)	(0.193)	(-0.981)	(-0.573)	(0.069)
Firm age	−1.524[b]	−1.283[a]	−0.186	0.574	1.211
	(-2.116)	(-1.804)	(-0.198)	(0.605)	(1.211)
Leverage	4.826	4.609	6.285	5.838[a]	4.619
	(1.342)	(1.340)	(1.578)	(1.712)	(1.388)
Profitability	−24.219[b]	−24.558[c]	−22.223[c]	−21.881[c]	−24.875[b]
	(-2.598)	(-2.836)	(-2.701)	(-2.799)	(-2.622)
Institutional shareholding	0.179	−0.847	−1.597	1.804	3.342
	(0.050)	(-0.237)	(-0.405)	(0.445)	(0.892)
Growth	−2.055[a]	−1.964[a]	−1.636	−2.035	−3.145[a]
	(-1.974)	(-1.891)	(-0.941)	(-1.134)	(-1.733)
Cash flow	13.321	14.391	13.084	7.172	8.136
	(1.435)	(1.543)	(1.446)	(0.822)	(0.805)
Accounts receivable turnover	−10.751[b]	−10.681[b]	−13.448[a]	−15.067[b]	−16.112[b]
	(-2.100)	(-2.123)	(-1.883)	(-2.405)	(-2.551)
Constant	3.701	−3.016	14.430	9.499	−5.158
	(0.322)	(-0.252)	(1.174)	(0.680)	(-0.347)
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Observations	200	200	200	200	200
R^2	0.314	0.341	0.485	0.504	0.582

T-value in parentheses below the coefficient estimates.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

hypothesis 3a. argues that executive shareholding enhances the stock market's positive response to DM&A announcements. The results of Models 4–5 in Table 4 show that the coefficient of Executive shareholding is significantly positive at least at the 5 % level. This indicates that the greater the shareholding of executives of listed companies, the more positive the stock market response to DM&A announcements. Therefore, hypothesis 3a is supported.

hypothesis 3b. argues that executive openness enhances the positive stock market response to DM&A announcements. The findings from Model 5 in Table 4 indicate that the coefficient of Executive openness is significantly positive at the 5 % level. This finding suggests that the higher the degree of executive openness of listed companies, the more positive the stock market reaction to DM&A announcements. Therefore, hypothesis 3b is supported.

5.3. Robustness checks

We conducted various robustness checks to guarantee the reliability of the study's findings. First, whether a firm undertakes a DM&A is not the result of a random selection but is influenced by many firm characteristics. As a result, a regression using only a sample of firms that undertake DM&A is a self-selected sample rather than a random sample. This non-random data selection itself leads to biased estimates. Referring to the practices of existing event studies (e.g., Refs. [63,76]), we adopt the two-stage model proposed by Heckman [77] to eliminate the endogeneity problem caused by sample bias. In the first stage, we construct the dummy variable DM&A_Dummy (assigned a value of 1 if the firm undertakes a DM&A and 0 otherwise), use it as an explanatory variable, and construct a probit model with all the control variables in Equation (1) as explanatory variables. We then estimate the probability of firms undertaking digital M&A using sample data from all A-share non-financial listed firms and calculate the Inverse Mill's Ratio (IMR) for each observation. In the second stage, we included the IMR as a control variable in Equation (1) for regression. Model 1 in Table 5 reports the results of the second-stage regression, and our conclusions are robust.

Second, adjust the event window used to calculate CAR. Considering the potential for capital markets to be unresponsive, we follow Chen et al. [62] and use a 3-day event window, including the announcement day (Day 0) and two days before and after the announcement (Day −1 and Day 1). We then recalculate CAR and use it as the dependent variable. The findings of Model 2 in Table 5 demonstrate the robustness of our main conclusions when the event window period is replaced.

Third, adjust the estimation period used to calculate CAR. Following Tang et al. [3], we use 30 to 150 trading days before the

Table 5
Results of robustness checks.

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6a)	Model (6b)
Investor protection	0.916[b]	1.448[c]	0.917[b]	0.834[b]	0.795[b]	0.833[a]	0.706[b]
	(2.546)	(2.836)	(2.480)	(2.401)	(2.214)	(1.875)	(2.113)
Digital innovation capabilities	1.321[c]	1.497[a]	1.520[c]	1.385[c]	1.403[b]	1.821[b]	0.941[a]
	(2.768)	(1.857)	(3.090)	(2.845)	(2.524)	(2.617)	(1.955)
Executive shareholding	12.109[c]	18.092[c]	11.573[c]	10.430[c]	11.788[c]	10.846[c]	15.534[c]
	(3.322)	(3.121)	(3.210)	(2.958)	(3.319)	(2.859)	(3.750)
Executive openness	1.251[b]	1.505[a]	1.246[b]	1.106[b]	1.181[b]	1.371[b]	2.386[c]
	(2.453)	(1.727)	(2.381)	(2.118)	(2.260)	(2.040)	(3.654)
Firm size	0.292	−0.309	−0.045	−0.018	−0.152	−0.442	−0.417
	(0.381)	(-0.268)	(-0.058)	(-0.023)	(-0.208)	(-0.303)	(-0.520)
Firm age	1.216	3.104[a]	1.032	0.571	1.421	1.331	0.380
	(1.253)	(1.973)	(1.018)	(0.566)	(1.466)	(0.836)	(0.402)
Leverage	3.701	2.789	4.155	5.980[a]	5.179	9.050	3.890
	(1.053)	(0.541)	(1.210)	(1.783)	(1.536)	(1.626)	(0.626)
Profitability	−23.547	−33.487[b]	−24.470[b]	−24.016[b]	−24.421[b]	−37.751[c]	−9.918
	(-2.721)	(-2.479)	(-2.543)	(-2.475)	(-2.551)	(-3.639)	(-1.132)
Institutional shareholding	3.726	9.255	3.604	2.812	3.279	2.497	4.332
	(1.033)	(1.658)	(0.977)	(0.758)	(0.888)	(0.618)	(1.130)
Growth	−2.658	−4.225	−2.936	−3.405[a]	−2.842	−3.446	−2.603[b]
	(-1.364)	(-1.535)	(-1.650)	(-1.822)	(-1.515)	(-1.609)	(-2.678)
Cash flow	2.366	−1.393	9.938	11.354	10.253	12.945	37.981[b]
	(0.218)	(-0.093)	(0.989)	(1.146)	(1.006)	(1.070)	(2.328)
Accounts receivable turnover	−14.656[b]	−19.680[a]	−15.511[b]	−18.358[c]	−14.885[b]	−18.772[b]	−11.947
	(-2.198)	(-1.730)	(-2.395)	(-2.813)	(-2.442)	(-2.316)	(-1.313)
IMR	−111.097 (−0.862)						
Constant	−8.316	−7.275	−3.602	−2.165	−0.341	6.344	5.358
	(-0.533)	(-0.312)	(-0.236)	(-0.145)	(-0.022)	(0.212)	(0.362)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	200	200	200	200	200	41	159
R^2	0.582	0.551	0.588	0.596	0.581	0.616	0.864

T-value in parentheses below the coefficient estimates.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

DM&A event as the estimation period. We then recalculate the CAR and use it as the dependent variable. The regression results presented in Model 3 of Table 5 indicate that our findings remain consistent even after making adjustments to the estimation period.

Fourth, following Brennan et al. [78], we replace the dependent variable with CAR calculated using a market-adjusted model, and the regression results are shown in Model 4 of Table 5. The results show that our main conclusions remain robust after replacing the measure of CAR.

Fifth, alternative measures of digital innovation capabilities. We incorporate digital economy utility model patents into the measures of digital innovation capabilities, i.e., we use the natural pair of the sum of digital economy invention patents and utility model patents plus one as a proxy variable for digital innovation capabilities. The regression results presented in Model 5 of Table 5 demonstrate the robustness of our main conclusions even when the measures of digital innovation capabilities are replaced.

Finally, the outbreak and spread of COVID-19 have led to a deeper and wider diffusion of online offices, online education, smart manufacturing, and big data research, accelerating to some extent the digital transformation of Chinese companies. For this reason, we divided our sample into two groups, before and after the COVID-19 outbreak, to examine whether the factors influencing the stock market's response to DM&A are affected by the COVID-19 outbreak. Model 6a (before the COVID-19 outbreak) and Model 6b (after the COVID-19 outbreak) in Table 5 report the findings of the grouped regressions and find that all the independent variables have a significant positive impact on CAR before and after the COVID-19 outbreak once again suggesting that our conclusions are robust.

6. Discussion and implications

6.1. Summary of results

DM&A is becoming increasingly important for firms to develop their digital capabilities in today's competitive market. In China, many companies are still wary of DM&A, and the ability to achieve immediate financial returns in the stock market has become an important basis for these companies to pursue DM&A. Based on this unique background and insights from signaling theory, we examine for the first time how the Chinese stock market's reaction to DM&A announcements depends on the external environment, organizational and managerial specific factors: investor protection, digital innovation capabilities, executive shareholding, and executive openness. The empirical results show that, under specific conditions, stock market reactions show some variation. Specifically, the Chinese stock market reacts more positively to DM&A announcements for acquiring firms with high executive shareholdings, high executive openness, strong digital innovation capabilities, and in regions with higher levels of investor protection.

6.2. Theoretical contributions

First, this study is the first to examine the conditions under which DM&A is more likely to enhance shareholder value. Prior M&A research has emphasized the importance of not neglecting the examination of contextual factors when assessing the impact of M&As on shareholder value [1,27]. The distinctive attributes of digital technologies—plasticity, homogeneity, and transferability—make DM&A distinctly different from other M&A [2,3], and there is an urgent need to explore whether and when DM&A can enhance shareholder value. While studies have focused on the direct and indirect effects of DM&A on shareholder value, they have neglected to examine contextual factors. To fill this gap, this study identifies potential influencing factors at the external environment, organizational, and managerial levels to better understand how acquiring firms benefit from DM&A. At the same time, the findings of this study can serve as a foundation for further research on stock market reactions to DM&A in different contexts.

Second, although signaling theory has developed a theoretical framework that includes elements such as signal emitters, signal receivers, signals, feedback, and environmental factors [79], it has always been an important topic that signals emitted by different signal emitters and different environmental factors will make signals differently effective [28]. This study conceptualizes DM&A announcements as a kind of signal, and examines how signal effectiveness is affected by signal emitter characteristics and the external environment, and specifies it into four specific factors: investor protection, digital innovation capabilities, executive shareholding, and executive openness, which not only broadens the scope of application of signaling theory but also enriches the related research on signal effectiveness.

6.3. Practical implications

Firstly, this study shows that in China, the higher the level of investor protection in the region where the acquiring company is located, the greater the financial returns it will receive from the stock market through DM&A. For this reason, the government should recognize the importance of strengthening the investor protection environment in promoting DM&A and developing the digital economy. On the one hand, information disclosure is an effective means to protect the interests of investors, so the government should further improve the information disclosure system so that listed companies and intermediary structures can fully disclose DM&A information to investors at the lowest possible cost and provide guarantees; on the other hand, the government should strengthen the implementation of laws and regulations to provide investors with the protection and confidence to achieve returns.

Secondly, companies should take a conscious approach to communicating with external investors during the DM&A process to send positive messages about their organizational attributes to the capital markets, thereby better supporting DM&A activity. Our research shows that not only do DM&A announcements themselves have a positive signaling effect, but so do corporate characteristics such as digital innovation capabilities, executive shareholding, and executive openness. For this reason, in addition to DM&A announcements, companies should also send positive messages to the capital market at the management and company level through various channels

such as their websites, forums, and conferences.

6.4. Limitation and future research

This study has several limitations, which subsequently open the way for new contributions to future research. First, in line with the large body of research on M&A transactions, we only provide evidence for a short-term perspective on the ability of acquiring firms to benefit from DM&A due to the difficulties in measuring long-term performance. However, accurately measuring long-term returns and identifying the factors that influence them remains critical, as short-term announced returns often do not fully reflect the value-creating effects of a transaction, as information on synergies and the success of the integration process is only gradually available to the market [1]. Therefore, future research could further examine the long-term impact effects of DM&A using long-term stock returns or corresponding accounting metrics and what factors influence the long-term effects.

Second, we identify only four factors that influence the effectiveness of DM&A announcement signals, which include investor protection, digital innovation capabilities, executive shareholding, and executive openness. However, prior research suggests that there are many other factors that can influence the stock market interpretation of M&A announcements, such as executive over-confidence [80], corporate culture [81], and political affiliation [82]. Therefore, future research could further identify key factors that may influence the stock market's interpretation of DM&A announcements.

Data availability statement

The data associated with this study has not been uploaded into a publicly available repository. However, data will be made available on reasonable request.

CRediT authorship contribution statement

Guangyu Huang: Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Liqiong Shen:** Writing – review & editing, Software, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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