Data Scale, Data Scope and Platform Enterprise Performance: Insights from Digital Platform M&As

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Abstract: *Data is a key asset for digital platforms, and mergers and acquisitions (M&As) are an important way for platform enterprises to acquire it. The types of data obtained from intra-industry and cross-sector M&As differ, as does the extent to which they interact within or between platforms. The impact of such data on corporate market performance is an important question to consider when selecting strategies for digital platform M&As. Based on our research on advertising-driven platforms, we developed a two-stage Hotelling game model for comparing the market performance effects of intra-industry M&As and cross-sector M&As for digital platforms. We carried out an empirical test using relevant data from advertising-driven digital platforms between 2009 and 2021, as well as a case study on Baidu's M&A activities. Our research discovered that intra-industry M&As driven by "data economies of scale" and cross-sector M&As driven by "data economies of scope" are both beneficial to the market performance of platform enterprises. Intra-industry M&As have a more significant positive effect on the market performance of platform enterprises because the same types of data are easier to integrate and develop the "network effect of data scale". From a data factor perspective, this paper reveals the inherent economic logic by which different types of M&As influence the market performance of digital platforms, as well as policymaking recommendations for all digital platforms to select M&A strategies based on data scale, data scope, and the network effect of data.*

Keywords: *Digital platforms, intra-industry M&A, cross-sector M&A, data economies of scale, data economies of scope*

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1. Introduction

Digital platforms provide critical digital infrastructure for modern socioeconomic operations. Massive data generated by user activities via data platforms has become a valuable asset for platform enterprises. In recent years, the Central Committee of the Communist Party of China (CPC) and the State Council have emphasized the importance of data in promoting social and economic development. President Xi Jinping has emphasized the importance of developing the digital economy with data as a key element. Platform businesses have been influenced in their decision-making process by the increasing significance of data factor. In order to increase their market presence and strategically plan for

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the future, platform enterprises are more frequently engaging in mergers and acquisitions to acquire data assets from other platforms. These “data-driven mergers and acquisitions”[1] share common characteristics in that both sides of M&A possess massive user data, data products, and data processing capabilities, and that data has played an important role in merger deals (Chen et al., 2022). The data aspects of platform mergers and acquisitions have increasingly attracted attention and raised related concerns. For instance, typical data-driven M&As, such as Facebook’s acquisition of WhatsApp in 2014, Microsoft’s acquisition of LinkedIn in 2017, and Google’s acquisition of Fitbit in 2021, have aroused significant attention from the regulators in relevant countries or regions, as market competition heats up and demand saturates, platform competition shifts from competing for new users to competing for existing ones. The dominant M&A mode has shifted away from intra-industry M&A within the same business field and toward cross-sector M&A involving multiple business fields. “Data acquisition” is an important strategic initiative for platform enterprises seeking rapid growth and technological advancement. When deciding on different modes of M&A, platform enterprises will consider the available data types and economic effects that may help them improve competitive advantage and market performance.

Theoretically, digital platforms can acquire data of varying volume and scale through intra-industry and cross-sector M&A. The former primarily broadens data scale horizontally to achieve economies of scale, whereas the latter primarily deepens data scope vertically to achieve economies of scope. On this basis, consumer behaviors and preferences can be tracked and analyzed using the interactions of intra-platform or inter-platform user data to improve the algorithm recommendation system, provide personalized services, and attract more users to join the platform with more data, resulting in a “data network effect” with data network economies (Tang et al, 2022). In fact, there are differences in the data network effect between various platforms under different M&A modes. There is a weak substitution relationship between goods and services in the context of intra-industry mergers and acquisitions. As a result, data integration is less difficult, and the data network effect is relatively robust. In contrast, there is a strong complementarity between goods and services involved in cross-sector M&As (Gautie and Lamesch, 2021), resulting in greater data integration challenges and a smaller data network effect. When we compare intra-industry M&As dominated by data scale implemented by platform enterprises to cross-sector M&As dominated by data scope, we seek to find out whether both modes are conducive to improving market performance and what the differences are. Answering these questions will assist platform enterprises in optimizing their strategic M&A decisions, allowing them to make better use of data scale and scope to improve their market performance. Furthermore, it provides data-driven insights into the economic motivations and intrinsic rationale for platform M&As, allowing for the development of more reasonable public policies to regulate platform M&A transactions.

Mergers and acquisitions are a classic economic issue. M&A research is fairly advanced in traditional economics. Most studies believe that mergers and acquisitions can improve corporate market performance by enhancing market power (Jiang, 2021), achieving economies of scale and synergy, increasing productivity and profit margins(Jiang, 2022), and driving corporate innovation (Chen and Zhang, 2019). In the digital economy, new economic characteristics and business models raise numerous research questions. Platform M&A research focuses on mergers and acquisitions among platforms in the same category. Based on two-sided market theory, they investigated the impact of user interactions on both sides of the platform ((i.e., cross-side network externalities or intra-platform network externalities) on platform pricing, profit, and other factors (Xie and Chen, 2018; Farronato et al., 2020; Hua et al., 2020). There is a scarcity of research on cross-sector platform M&As, which focuses on the economic

[1] When conducting M&As, digital platform enterprises typically have multiple objectives. In this paper, we use the “data-driven M&A” concept without negating other M&A motives such as “market expansion and technology acquisition”. Instead, it focuses on analyzing the role and influence of data factors in digital platform M&A transactions. Our core objective of research focuses on “M&As implemented by platform enterprises with advertising revenues as their primary source of income”. Data plays an important role in the M&A process as a critical factor for improving the quality of advertising services, delivering targeted services, and increasing profit levels.

effects of user interactions between different platforms in terms of the number of users or categories (i.e., inter-platform network externalities) (Kim, 2012; Wu and Liu, 2017; Lu and Qu, 2019; Li and He, 2022). Furthermore, some research has begun to investigate the impact of startup platform M&As on innovation from a dynamic view (Cunningham et al., 2021; Rizzo, 2021; Prado and Bauer, 2022; Li et al., 2022).

In addition to expanding the platform user base, platform M&As have gradually become more focused on acquiring data resources. However, research into the effects of acquired data is far from complete. On one hand, there has yet to be consistent research conclusions on the economic effects of data-driven platform mergers and acquisitions. According to some studies, privacy protection and network security will increase the cost of data-driven mergers and acquisitions (Goldfarb and Tucker, 2011; Kox et al., 2017). Because of the limitations of cross-border dataflow and the restrictions on M&A transactions imposed by public policies such as antitrust review (Stucke and Grunes, 2016), the multidimensional, cross-border, and severely punitive legal supervision and M&A risks of data assets and their operations will have a negative impact on platform enterprise market performance. Indeed, some research suggests that using data as a production factor can improve the effectiveness of platform-targeted advertising, resulting in increased platform revenue (Gautier and Lamesch, 2021; Chen et al., 2022). However, due to the availability of data from platform enterprises, methodologies for research on data-driven platform M&As are limited to case analysis and theoretical research. For instance, case studies have been conducted to examine the M&A volumes and strategies of large digital platforms such as GAFAM (Google, Alphabet, Amazon, Apple and Microsoft) (Parker et al., 2021; Gautier and Lamesch, 2021), while theoretical analysis has been performed by developing econometric models to assess the competition and welfare effects of data-driven platform M&As (Motta and Peitz, 2021; Katz, 2021; Chen et al., 2022). However, an adequate empirical test is missing from the picture.

As a result, from the perspective of data factor, this paper analyzes the stylized facts and economic logic of data-driven mergers and acquisitions of platform enterprise. By constructing a two-stage Hotelling model, this paper compares and studies the impact of intra-industry mergers and acquisitions and cross-sector mergers and acquisitions on platform profits from the two levels of data scale and data scope. This paper may provide the following marginal contributions: First, it conducts a data-driven analysis of the market performance of platform M&As using a two-sided market theoretical framework, thereby enriching the platform M&A economics research. The majority of existing research on platform M&As has focused on user interactions without considering the critical role of data in platform M&A analysis. Second, this paper provides a more complete understanding of the fundamental motivations and economic nature of intra-industry M&As and particularly cross-sector M&As based on data economies of scale, data economies of scope, and data network effects. Existing research focuses on intra-industry M&As while failing to adequately address cross-sector M&As in the digital economy. Third, this paper collects digital platform M&A events, advertising revenues, and other financial data, and then conducts an empirical analysis and case study to validate the market performance results of data-driven M&As and the differences between various M&A modes. Existing research methodologies are centered on theoretical models and case studies, whereas empirical research is limited due to a lack of data. This paper provides more robust empirical evidence for the market performance effects of digital platform mergers and acquisitions.

2. Stylized Facts and Economic Analysis

2.1 Stylized Facts of Data-Driven Platform M&As

Corporate mergers and acquisitions are highly active in the field of digital platform economy. According to CVSource database, the number of global digital platform M&As has increased significantly since 2008, and the total volume of M&A transactions has been steadily rising. Specifically, M&A transactions among large digital platform enterprises have been highly frequent. According to a research report of the United States Congressional Research Service, between 2000 and 2020, Facebook, Alphabet, Amazon, Apple and Microsoft acquired at least 63, 260, 100, 120, and 167 companies, respectively[2]. According to a research report of the United Kingdom's Competition and Market Authority, the big five technology companies Google, Amazon, Facebook, Apple, and Microsoft (GAFAM) engaged in a total of over 400 M&A transactions between 2009 and 2019[3]. According to data from Qichacha, a Chinese corporate data provider, Chinese digital platform enterprises conducted 542 M&A transactions between 2010 and 2020[4]. Nearly every platform M&A involved data-related concerns. Acquiring data, data processing capabilities, and data products from target platforms has become a primary goal for platform enterprises as the data factor becomes more and more important in their business operations. As Table 6 illustrates, cross-sector M&As are more frequent than intra-industry M&As, and they have emerged as a crucial competitive tactic for digital platforms. M&As might not, however, always result in a long-term competitive advantage. At least 114 companies were acquired by Yahoo[5], which had previously held a dominant market position. However, neither Yahoo's loss of a superior market position over Google nor its eventual market exit were prevented by these M&As. Given the frequency with which platform enterprises execute M&As, particularly cross-sector M&As, it is necessary to look into the underlying logic of how platform M&As that have data acquisition as their primary goal will affect the performance of their companies in the market.

2.2 Economic Analysis of Data-Driven Platform M&As

Platform businesses can quickly and easily increase their market share and user data through mergers and acquisitions. Diverse M&A modes, such as cross-sector or intra-industry M&As, can enhance platform enterprises' digital resources in different ways. Intra-industry M&As will increase data scale by enabling platform enterprise M&As with comparable or identical business types to be combined into similar data types with a certain level of substitutability. For example, Tencent, a Chinese tech giant that specializes in social media, purchased the social community platforms "Academia" and "Kakao" in order to increase the amount of user data that is available for social communications and other categories. M&As across sectors will broaden the scope of data. M&As between platform enterprises with different business models may combine complementary data categories to expand the scope of the data and enhance user profiles. Tencent has acquired various platforms, such as "58.com" for local life services, "Tongcheng-Elong" for online tourism, "Vipshop" for e-commerce, "Huya Live" for live streaming, and "Sougou" for the search engine. These platforms offer increased access to data about job seekers, location trails, shopping transactions, browsing history, search history, and other user data that is not related to social networking. The accumulation of data scale and data scope and their interactive influence between users of a two-sided platform can further form data economies of scale, data economies of scope and data network effect. This process is the fundamental reasoning behind data-driven mergers and acquisitions carried out by digital platform companies.

2.2.1 Data economies of scale

Data economies of scale refer to the economic benefits arising from the expansion of the data scale on the supply side, specifically referring to the cost reduction or revenue increase that results from the horizontal broadening of the data scale. Through intra-industry mergers and acquisitions, the expansion of data scale can achieve non-competitive scale returns based on data (Jones and Tonetti, 2020; Tang

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[4] Qichacha venture-capital investment database. Website: https://www.qcc.com/web/project/invest-org/application/classify.

[5] Wikipedia: List of mergers and acquisitions by Yahoo!, October 24, 2020. Website: https://en.wikipedia.org/wiki/List_of_mergers_and_acquisitions_by_Yahoo!

Yaojia et al., 2022), thereby enhancing the revenue of platform enterprises in various aspects, including facilitating a leap in algorithmic capabilities based on data (Wang et al., 2022), tracking and analyzing user behavior preferences (Han, 2018), improving the accuracy of targeted advertising and achieving precise personalized marketing (Jiang, 2017), enhancing platform service quality and product innovation capabilities (Hou and Qi, 2022), or optimizing enterprise decision-making (Hagiu and Wright, 2020). The shared use and expansion of data across acquired platforms will also lower the marginal cost for businesses to provide goods or services, such as advertising services, develop new products, or enter new markets, given the "zero marginal cost" attribute of data (Prüfer and Schottmüller, 2021).

2.2.2 Date economies of scope

Data economies of scope refer to the economic benefits arising from the types of data on the supply side, specifically, the cost reduction or revenue increase brought about by the vertical expansion of the data scope. Through cross-sector M&As, platform enterprises aggregate different kinds of complementary user data. Data from other fields and business segments can be used to deduce more common preferences or new similarities between users to create additional user-product relationships and address the issue of user cold start, thereby increasing the accuracy of targeted advertisements for new users (Krämer et al., 2020). In the meantime, the combination of two different types of data from the original market and the new market will further enhance the effectiveness of targeted advertising on the platform, and the integration of new businesses with the original ones can also reduce user search costs.

2.2.3 Data network effect

The data network effect primarily refers to the economies generated by the demand side (in contrast to the platform's supply side) in terms of data scale or scope. In light of the explosion in data scale and scope, it refers to the enhancement of user utility for users on both sides of a platform. The data network effect is a mechanism of super-increasing returns that results from the superimposition of increasing returns on both the transaction and production sides (Gregory et al., 2021, 2022). The "user feedback loop" and the "monetization feedback loop," as stated by Bourreau et al. (2017), self-reinforce and mutually reinforce each other to generate the data network effect. The former refers to the positive feedback loop that exists between the number of users on the platform, user data, and service quality; the latter relates to the positive feedback loop that exists between the user base, user data, targeted advertising, advertisers, and overall service quality. Put differently, the "volume" and "variety" aspects of the "4V" data attributes - that is, the quantity and categories of data - are what propel the network effect of data. Whereas the "network effect of data scale" refers to the former, the "network effect of data scope" refers to the latter. The data network effect will significantly increase the time interval between growing returns on data (Wang et al., 2022). As was indicated in the previous section, the data network effect may vary between intra-industry M&A and cross-sector M&A platforms, and it is necessary to clarify their differentiated effects on the market performance of different M&A modes.

2.3 Two-Sided Market Analysis Framework

In the digital economy, digital platforms are a typical type of corporate structure. By matching the needs of users on both sides and creating a fair price structure, they connect user markets on both sides and enable higher transaction volumes. The existence of cross-side network externalities between users on both sides of a platform - that is, the utility for users on one side is dependent on the number of users on the other side - is the fundamental economic feature of such a two-sided market mode. Platform businesses typically use cross-side network externalities to their advantage by offering relatively cheap or even free access to entice users on one side to join and utilize their products or services. This allows them to draw in users from the other side and charge a relatively high price to maximize profit (Rochet and Tirole, 2003; Evans, 2003; Armstrong, 2006). For instance, in the “advertising-driven platform” depicted in Figure 1[6], platforms, consumers, and advertisers are transaction entities in a two-sided market. In order to make more effective and targeted advertisements using user data, platform enterprises draw in customers by providing search engines, social networks, email services, and news information for free (Bourreau et al., 2017). This helps them draw in advertisers and charge advertising fees. Advertising fees are the main source of revenue for platforms that rely on advertising under their unilateral pricing model. During the period of 2009–2021, online advertising revenues for Google, Facebook, Tencent, and Baidu increased at an annual rate of more than 50%, and in certain cases, by 100%. As stated by Qu and Liu (2019), the number of consumers on a platform will increase its utility for advertisers, but the number of advertisers on a platform may decrease its utility for consumers. This is because advertising generally results in negative cross-side network externalities.

From the perspective of data generation, flow and use, consumer data can be converted into targeted advertising (Kox et al., 2017). Platform consumers are also “data producers”. Platforms collect and use such data to customize advertising information and push individualized products or services to consumers. In other words, users trade their personal data for “free” services. Advertisers send advertisements to facilitate matched transactions with consumers based on platform-processed data. Platforms provide advertisers with ad placements and charge advertising fees from them to generate revenues. The increasing “scale” and “scope” of consumer data will increase the accuracy of targeted platform advertising and the revenues of platforms and advertisers. In fact, the exchange of transactional data has become the new currency in the digital market. Platforms increase their value to advertisers by collecting new data about user behaviors. Within the two-sided market framework, this paper will uncover the enterprise market performance effects of platform M&As.

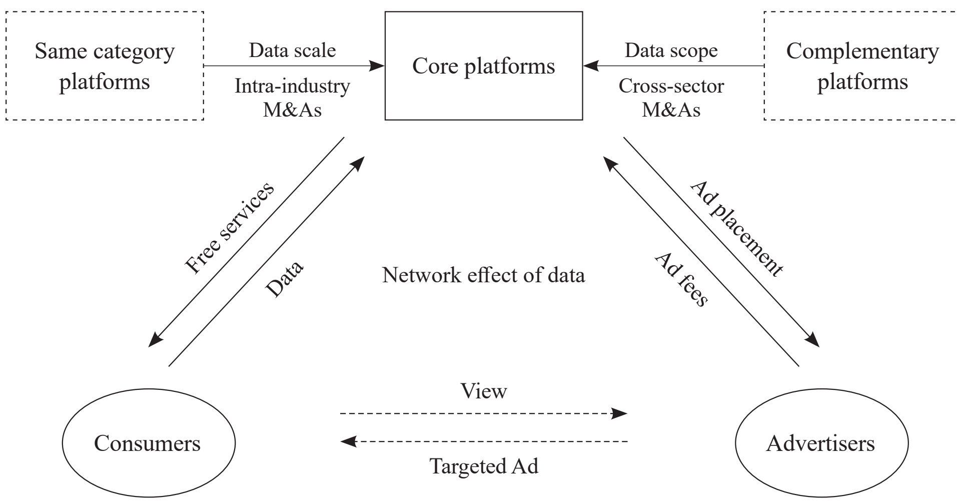

Figure 1: Two-Sided Market Structure and Analytical Framework of Advertising-Driven Platforms

[6] The concept of the “advertising-driven platform” in this paper is derived from Yu (2020, 2022). Filistrucchi et al. (2010, 2014) called it “non-transactional platforms”. These platforms have the following essential features: The pricing strategy is unilateral pricing, meaning that consumers pay nothing. The main source of income is advertising revenue. Such platforms include, for example, the search engine Google, the social network WeChat, the portal news website Sohu, and the email service Netease mailbox. These are all commonly found in the real market. Platforms, customers, and advertisers are transaction entities in a two-sided market. We collected and compiled data from platform enterprises in the four business types for the empirical research section of this paper.

3. Theoretical Analysis and Research Hypothesis

This section develops a two-stage Hotelling game model to evaluate the market performance implications of intra-industry platform M&As driven by data economies of scale and cross-sector platform M&As driven by data economies of scope, using advertising-driven platforms as an illustration. This section will provide subsequent empirical analysis and a case study with theoretical basis and research hypothesis, based on the previously mentioned theoretical framework on economic analysis and taking into account data availability for empirical analysis. We consider a duopoly platform market, where the two-stage game proceeds as follows: Stage I: Without implementing any data-driven M&As, the platform determines advertising prices based on current data conditions so that users on both sides of the platform can choose whether or not to join. Stage 2: The platform executes data-driven M&As, including intra-industry M&As that are driven by data economies of scale or cross-sector M&As that are driven by data economies of scope, to establish the new advertising price for the two-sided users to determine whether or not to join the platform.

3.1 Baseline Scenario: No Platform M&As

Assuming that in a market I, two competing platforms $i(i=A,B)$ engage in Hotelling price competition at both ends of the segment [0,1], respectively. The number of user group 1 (consumers) and the number of user group 2 (advertisers) at both sides of the platform i are n_1^i and n_2^i, respectively, both of which are single-homing and uniformly distributed on the segment interval. It is assumed that V is the reservation utility for users on both sides of platform i. Let it be large enough to fully cover the market. The unit costs of transportation for user group 1 and user group 2 to reach the platforms are t_1 and t_2. t_1 and t_2 also represent the degree of platform difference and the degree of competition in the two-sided market. It is assumed that data is a byproduct generated from consumers' participation in and use of platforms, and that each consumer generates one unit of data. Using collected consumer data, platforms display targeted advertisements on behalf of advertisers (only one unit of advert for each advertiser), and collects an advertising fee p_2^i from them. Consumers have the option to exchange their personal data for free access to platform services; however, they are required to view advertisements that are displayed by the platform. It is presumed that all consumers are advertisement-averse, meaning that the advertising displayed by the platform has a negative utility for them. Let the coefficient of advertisers' cross-side network externality for consumers be α_1. Consumers' use of platforms will create positive utility for advertisers. Let the coefficient of consumers' cross-side network externalities for advertisers be α_2. Hence, the utility functions of users on both sides of the platform (consumers and advertisers) are specified as follows, respectively:

$$U_1^i = V - \alpha_1 n_2^i - t_1 n_1^i,\quad U_2^i = V + \alpha_2 n_1^i - t_2 n_2^i - p_2^i \tag{1}$$

For the convenience of analysis without loss of generality, we standardize the number of users on both sides of the platform into 1. Then, $n_1^A+n_1^B=1$ and $n_2^A+n_2^B=1$, $U_1^A=U_1^B$, $U_2^A=U_2^B$ are substituted into the equation (1) to arrive at the implicit expressions for the numbers of users on both sides of the platform i as follows, respectively:

$$n_1^i = \frac{1}{2} + \frac{1}{2}\frac{\left(p_2^i - p_2^j\right)\alpha_1}{\alpha_1\alpha_2 + t_1 t_2},\quad n_2^i = \frac{1}{2} - \frac{1}{2}\frac{\left(p_2^i - p_2^j\right)t_1}{\alpha_1\alpha_2 + t_1 t_2} \tag{2}$$

Platforms offer free services to users in exchange for advertising fees, which are derived from the placement of advertisements for advertisers. For the simplicity of analysis, it is assumed that the marginal cost and fixed cost of platform enterprises are both 0. Then, the profit function of platform i becomes: $\pi^i=p_2^i n_2^i$.

In symmetrical equilibrium, platform A and platform B charge the same price from advertisers, i.e., $P_2^A=P_2^B=P_2$. Equation (2) is substituted into the profit function of platform i, and the equilibrium price is estimated to be $P_2=t_2+\alpha_1\alpha_2/t_1$ by taking derivative of p_2^i. Then, the equilibrium price is substituted into the equation (2) to obtain an equal division of market between platform A and platform B, i.e., the equilibrium number of users in each group is 1/2. Thus, the profit for each platform is equally $\prod^i=(t_1t_2+\alpha_1\alpha_2)/2t_1$.

3.2 Intra-Industry M&As Driven by Data Economies of Scale

It is assumed that the platform A and platform B in market I are amalgamated into a single platform conglomerate for the purpose of conducting joint operations. They continue to offer differentiated services and operate autonomously; however, they are capable of exchanging data within the same platform conglomerate, which grants both of them a data advantage. It is assumed that n^i is the additional amount of consumer data obtained by platform i. Assuming that the coefficient of network externalities from additional data scale for the utility of platform users is $\alpha\in(0,1)$[7], αn^i is additional utility to consumers and advertisers from the data-driven intra-industry platform M&A, e.g., the provision of individualized services or contents and the increased accuracy of targeted advertising (Chen et al., 2022). Then, the utility functions for consumers and advertisers on platform i are specified as follows, respectively:

$$U_1^i=V-\alpha_1 n_2^i-t_1 n_1^i+\alpha n^i, U_2^i=V+\alpha_2 n_1^i-t_2 n_2^i-p_2^i+\alpha n^i \tag{3}$$

The platform conglomerate's goal following an intra-industry M&A is to maximize profit for the joint business overall as opposed to for each of its individual platforms. In other words, the platform conglomerate chooses price portfolio (p_2^A, p_2^B) with the following objective function in order to maximize joint profit.

$$\max\left(\pi^{A+B}=\pi^A+\pi^B\right)=\max\left(p_2^A n_2^A+p_2^B n_2^B\right) \tag{4}$$

Joint operations can internalize the externalities from each platform's pricing, allowing the platform conglomerate to fully extract consumer surplus by high prices without concern for user loss or profit reduction. Under the symmetrical equilibrium, we naturally have $N_1^A=N_1^B=1/2$, $N_2^A=N_2^B=1/2$. It is substituted into the equation (3) to obtain $V+\alpha_2/2-t_2/2-p_2^i+\alpha N^i\geq 0$. Intuitively, we arrive at the equilibrium price after the platform's execution of intra-industry M&A.

$$P_2^A=P_2^B=V+\frac{\alpha_2-t_2}{2}+\alpha N^i \tag{5}$$

The equilibrium price and quantity are substituted into the equation (4) to obtain the profit of the platform conglomerate:

$$\prod^{A+B}=V+(\alpha_2-t_2)/2+\alpha N^i \tag{6}$$

The subsequent equation can be derived by comparing platform profits in the two scenarios, with and without the implementation of M&As:

$$\Delta\prod^{A+B}=V+\frac{\alpha_2-t_2}{2}-\frac{t_1t_2+\alpha_1\alpha_2}{2t_1}+\alpha N^i \tag{7}$$

According to the baseline scenario $U_2^A=U_2^B\geq 0$, i.e., $V+(\alpha_2-t_2)/2\geq(t_1t_2+\alpha_1\alpha_2)/t_1\geq(t_1t_2+\alpha_1\alpha_2)/2t_1$, we have $\Delta\prod^{A+B}>0$, and the execution of intra-industry M&As by a platform may increase its profit. Considering $\partial\Delta\prod^{A+B}/\partial\alpha>0$ and $\partial\Delta\prod^{A+B}/\partial N^i>0$, $\Delta\prod^{A+B}$ is positively correlated with the network externalities of data scale α and data scale N^i. Namely, intra-industry platform M&As may increase data

[7] In our model specification, we consider the two-sided symmetry of the network externalities of data scale, which is consistent with the model conclusions of two-sided asymmetry. Due to space constraints, only the model derivation and analysis for the symmetric case are presented here. In addition, data resources with negative value are very likely to prevent the M&As of platform companies. For this reason, we assume the network externalities of data scale to be positive without considering the negative network externalities of data scale. The same treatment applies to the analysis of network externalities from data scope in the remainder of this paper.

scale and raise the level of profit. The larger the data scale, the more the profit of acquired platforms will increase. The greater the network effect generated by data scale (i.e., the "network effects" of data scale"), the more significantly profit will increase. As such, we put forth Hypothesis 1:

H_{1a}: Execution of intra-industry M&As by a digital platform is conducive to its market performance

H_{1b}: Execution of intra-industry M&As by a digital platform improves its market performance by expanding data scale

3.3 Platform Cross-Sector M&As Driven by Data Economies of Scope

Platform M&As driven by data economies of scale primarily occur within the same industry or market. In contrast, platform M&As driven by data economies of scope primarily occur between different sectors or markets. Similar to the baseline scenario, it is assumed that two competing platforms $j(j{=}C, D)$ exist in another market *II* (of a different sector from market *I*) and engage in Hotelling price competition. The numbers of their users on both sides are n_1^j and n_2^j, and the total number of users in each group is standardized to be 1. Similarly, platform j provides consumers with free services and collects advertising fees p_2^j from advertisers. Other parameter specifications are the same with the baseline scenario.

It is assumed that platform *A* in market *I* and platform *C* in market *II* conduct a cross-sector M&A, and both may share data after M&A. At this moment, platform *C* involved in M&A is able to access greater data scope n^j. Referencing the parametric specification of the "inter-platform network externalities" by Kim (2012), Wu and Liu (2017) and Lu and Qu (2019) and in light of the inter-platform data interactions, it is assumed that the coefficient of network externalities from data scope is $\beta\in(0,1)$, while no additional datatypes are acquired by platform *D* not involved in cross-sector M&A. As such, the utility functions of users on both sides of platform *D* are the same with those of users on both sides of platforms *A* and *B* in the baseline scenario, and the utility function for users on both sides of the platform *C* has changed from the baseline scenario. Undifferentiated consumers and advertisers between platform *C* and platform *D* satisfy:

$$V-\alpha_1 n_2^C - t_1 n_1^C + \beta n^j = V - \alpha_1 n_2^D - t_1 n_1^D \tag{8}$$

$$V+\alpha_2 n_1^C - t_2 n_2^C - p_2^C + \beta n^j = V + \alpha_2 n_1^D - t_2 n_2^D - p_2^D \tag{9}$$

$n_1^C{+}n_1^D{=}1$ and $n_2^C{+}n_2^D{=}1$ are substituted into the equation (8) and (9) to obtain:

$$n_1^C = \frac{1}{2} + \frac{\beta n^j + \left(1-2n_2^C\right)\alpha_1}{2t_1}, n_2^C = \frac{1}{2} + \frac{-p_2^C + p_2^D\left(1-2n_1^C\right)\alpha_2 + \beta n^j}{2t_2} \tag{10}$$

Hence, the implicit expression for the numbers of users on both sides of platform *C* can be obtained:

$$n_1^C = \frac{1}{2} + \frac{\beta n^j\left(t_2-\alpha_1\right) + \alpha_1\left(p_2^C - p_2^D\right)}{2\left(\alpha_1\alpha_2 + t_1 t_2\right)}, n_2^C = \frac{1}{2} + \frac{\beta n^j\left(\alpha_2 + t_1\right)t_1 + \left(p_2^D - p_2^C\right)t_1}{2\left(\alpha_1\alpha_2 + t_1 t_2\right)} \tag{11}$$

After cross-sector M&A, platform *C*'s data scope has increased, and the network externalities from data scope between it and platform *A* have transformed the symmetry between platform *C* and platform *D*. Therefore, there is no symmetrical equilibrium solution to the game model in this stage. By taking derivative of the profit function $\pi^C{=}p_2^C n_2^C$ for platform *C* with respect to p_2^C and taking derivative of the profit function $\pi^D{=}p_2^D n_2^D$ for platform *D* with respect to p_2^D, we may obtain the price response functions of platform *C* and platform *D* as follows, respectively:

$$p_2^C = \frac{\alpha_1\alpha_2 + p_2^D t_1 + t_1 t_2 + \beta n^j\left(\alpha_2 + t_1\right)}{2t_1}, p_2^D = \frac{\alpha_1\alpha_2 + p_2^C t_1 + t_1 t_2 - \beta n^j\left(\alpha_2 + t_1\right)}{2t_1} \tag{12}$$

It can be obtained that the advertising fees collected by platform C and platform D from advertisers at the equilibrium state are as follows, respectively:

$$P_2^C = t_2 + \frac{\alpha_1\alpha_2}{t_1} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1}, P_2^D = t_2 + \frac{\alpha_1\alpha_2}{t_1} - \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1} \tag{13}$$

P_2^C and P_2^D are substituted into equation (11), and the numbers of consumers and advertisers on both sides of the platform can be expressed as follows based on $n_1^C+n_1^D=1$ and $n_2^C+n_2^D=1$:

$$N_1^C = \frac{1}{2} - \frac{\beta N^j\left[\alpha_1 t_1 - \left(2\alpha_1\alpha_2 + 3t_1t_2\right)\right]}{6t_1\left(t_1t_2 + \alpha_1\alpha_2\right)}, N_1^D = \frac{1}{2} + \frac{\beta N^j\left[\alpha_1 t_1 - \left(2\alpha_1\alpha_2 + 3t_1t_2\right)\right]}{6t_1\left(t_1t_2 + \alpha_1\alpha_2\right)} \tag{14}$$

$$N_2^C = \frac{1}{2} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{6\left(t_1t_2 + \alpha_1\alpha_2\right)}, N_2^D = \frac{1}{2} - \frac{\beta N^j\left(\alpha_2 + t_1\right)}{6\left(t_1t_2 + \alpha_1\alpha_2\right)} \tag{15}$$

It can be further obtained that the equilibrium profit of platform C is:

$$\prod^C = \frac{\alpha_1\alpha_2 + t_1t_2}{2t_1} + \frac{\left(\beta N^j\right)^2\left(\alpha_2 + t_1\right)^2}{18t_1\left(\alpha_1\alpha_2 + t_1t_2\right)} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1} \tag{16}$$

Prior to the execution of a cross-sector M&A, the profit of platform C was equivalent to platform A of the baseline scenario. Then, the difference of profit before and after cross-sector M&A by platform C can be obtained in comparison:

$$\Delta\prod^C = \frac{\left(\beta N^j\right)^2\left(\alpha_2 + t_1\right)^2}{18t_1\left(\alpha_1\alpha_2 + t_1t_2\right)} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1} \tag{17}$$

Since $\alpha_1\alpha_2+t_1t_2>0$, $t_1>0$, $t_1+\alpha_2>0$, $\beta>0$, $N^j>0$, it can be seen that for platform C, $\Delta\prod^C>0$, i.e., cross-sector M&As driven by data economies of scope may increase platform profit. In addition, $\partial\Delta\prod^C/\partial\beta>0$, $\partial\Delta\prod^C/\partial N^j>0$ suggests that $\Delta\prod^C$ is positively correlated with the network externalities of data scope β and data scope N^j. In other words, platforms may enhance their profitability by conducting cross-sector mergers and acquisitions. More extensive data means a more substantial increase in platform profit. For the platforms involved in an M&A, a broader profit increasing interval means greater network effect generated by data scope (also known as the "network effect of data scope"). Therefore, Hypothesis 2 is put forward in accordance with the preceding economic analysis:

H_{2a}: Execution of cross-sector M&As by a digital platform is conducive to its market performance

H_{2b}: Execution of cross-sector M&As by a digital platform improves its market performance by expanding data scope

3.4 Comparative Analysis of Intra-Industry M&A and Cross-Sector M&A

Based on the foregoing theoretical analysis, the market performance of platform enterprises can be enhanced through intra-industry and cross-sector M&A, as a result of data scale, data scope, and the network effect of data. The question at hand pertains to which mode of M&A generates the most significant impact. To delve deeper into this question, we may arrive at the following equation by comparing the platforms' equilibrium profit of intra-industry and cross-sector M&As:

$$\begin{aligned}\Delta\prod &= V + \left(\alpha_2 - t_2\right)/2 + \alpha N^i - \left[\frac{\alpha_1\alpha_2 + t_1t_2}{2t_1} + \frac{\left(\beta N^j\right)^2\left(\alpha_2 + t_1\right)^2}{18t_1\left(\alpha_1\alpha_2 + t_1t_2\right)} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1}\right] \\ &\geq \alpha N^i - \left[\frac{\left(\beta N^j\right)^2\left(\alpha_2 + t_1\right)^2}{18t_1\left(\alpha_1\alpha_2 + t_1t_2\right)} + \frac{\beta N^j\left(\alpha_2 + t_1\right)}{3t_1}\right]\end{aligned} \tag{18}$$

As can be learned from equation (18), when $\alpha N^i > (\beta N^j)^2(\alpha_2+t_1)^2/18t_1(\alpha_1\alpha_2+t_1t_2)+\beta N^j(\alpha_2+t_1)/3t_1$, we have $\Delta\prod>0$; when $\alpha N^i < (\beta N^j)^2(\alpha_2+t_1)^2/18t_1(\alpha_1\alpha_2+t_1t_2)+\beta N^j(\alpha_2+t_1)/3t_1$, we have $\Delta\prod<0$. Obviously, $(\beta N^j)^2 (\alpha_2+t_1)^2/18t_1(\alpha_1\alpha_2+t_1t_2)+\beta N^j(\alpha_2+t_1)/3t_1$ is always positive. It can thus be learned that when data economies of scale αN^i are significant, intra-industry platform M&As can yield higher profits compared with cross-sector M&As. Based on the above theoretical discussions, we put forth Hypothesis 3 considering the relatively low difficulty of data integration between platforms involved in intra-industry M&As and the relatively strong network effect of data scale:

H3: Intra-industry M&As driven by data economies of scale and executed by a digital platform are more conducive to improving its market performance as compared with cross-sector M&As driven by data economies of scope

4. Empirical Strategies and Results Analysis

4.1 Research Design

4.1.1 Data and variables

We selected the "advertising-driven platforms" as the subject of our research, taking into account the theoretical hypotheses in the aforementioned game model and the availability and integrity of data. We collected relevant information in the form of panel data between 2009 and 2021, and we winorized primary continuous enterprise data at 1% to eliminate the impact of outliers. M&A data was sourced from the BVD (Zephyr) and CVSource databases, while other financial data was obtained from Wind database. We manually collected certain missing data from company annual reports and other sources. Ultimately, we obtained 81 advertising-driven platform enterprises, resulting in a total of 703 observations.

(i) Explained variable: Platform advertising revenue (*Adv*). Our subject of research is advertising-driven platforms. Therefore, as the initial step in our sample research, we identified "Internet companies" in the Wind database. We then screened each company listed in the US, Hong Kong, Shanghai, Shenzhen, Beijing, and other stock markets to see if it was an advertising-driven platform. Ad revenue was the main source of income for these platforms. Therefore, we used advertising revenue as a primary metric to investigate how data-driven M&As affected platform enterprises' market performance. The complete data set of platform advertising revenue is not available to the general public. This paper employs the Wind database as a platform for data collection, allowing us to analyze the composition of each platform enterprise's primary revenue stream over the course of the investigation. We then manually gathered and obtained the complete panel data of advertising revenue for each of the sample platform enterprises across multiple years, applying a natural logarithmic treatment to the data, based on the product and sector classification information.

(ii) Core explanatory variable: Data-driven M&As (*MA*). In the Zephyr and CVSource M&A databases, we searched, matched, and integrated the M&A events of advertising-driven platforms identified in the Wind database. We applied the following criteria when choosing data samples to ensure data integrity and robustness: ① Samples containing the acquiring party's status of ST and ST* are eliminated; ② M&A samples with the transaction status of "Completion Confirmed" or "Completion Assumed" are chosen; ③ samples involving the acquiring party from the Internet finance industry are excluded; ④ equity repurchase and related transaction samples are excluded; ⑤ M&A samples involving the acquired party being a non-digital platform enterprise whose primary sources of revenue are traditional manufacturing, corporate services, construction, media publishing, and other physical businesses are excluded to ensure that acquiring and acquired parties in the chosen samples had massive user data, data products and data processing capabilities; ⑥ the M&A event with the highest volume of transactions is chosen for multiple M&As of the same platform enterprise. The amount of

M&A transactions determines the amount of surplus that the acquiring party may obtain from the target platform and is a reflection of each party's information holdings and bargaining power. The target platform's data resources are more valuable to the acquiring party in proportion to the amount of M&A (Liu et al., 2024). High-value M&A events have a significant influence on market performance, and M&A information is more comprehensive and easier to analyze. The acquiring and acquired parties were separately categorized based on "core platform services," referencing CVSource's "Internet" industry classification. In order to further differentiate the data-driven M&A mode, we individually queried Qianfan.tech's classification of apps from sample platform enterprises by sector or category to ascertain whether an acquiring platform had any core business of the target platform prior to the implementation of M&A. If this is the case, the transaction is classified as an intra-industry M&A; otherwise, it is classified as a cross-sector M&A.

Based on this, we represented data-driven M&As (*MA*) using the interaction term (*Group*×*Post*) between the dummy variable of the data-driven M&A group and the dummy variable for the M&A execution time. We designated platform enterprises that had executed data-driven M&As as *Group* 1, which represents the treatment group, and platform enterprises that did not have data-driven M&As as *Group* 0, which represents the control group. For the divisions prior to and following the data-driven M&A, the time dummy variable *Post* is defined as 0 and 1. When it comes to data-driven M&A (*MA_Cross*), we designated the treatment group's intra-industry M&A as 1 and both the control group and cross-sector M&A as 0.

(iii) Control Variables: Given that many firm-level factors may influence platform advertising revenue, we controlled for the following variables: Platform scale (*Scale*, logarithm of the total number of platform enterprise employees); management expense ratio (*Manage*, ratio between management expenses and business revenue); sales expense ratio (*Sale*, ratio between sales expenses and business revenue); equity concentration (*Share*, shareholding ratio of the largest shareholder); platform enterprise assets (*Assets*, logarithm of total assets); platform operation duration (*Age*, age since founding).

4.1.2 Model setting

In this paper, we treated platform enterprise data-driven M&As as a "quasi-natural experiment". Given that M&A is an internal decision made by platform enterprises, endogeneity may be an issue. Therefore, to mitigate the endogeneity problem resulting from selective bias and missing variables that do not change with time, we combined the propensity score matching (PSM) and differences-in-differences (DID), accounting for the individual fixed effect and the time fixed effect. Over the course of the observation period, *MA* varies for the treatment group in different years. In order to give each platform enterprise taking part in data-driven M&A a specific year for M&A execution, we developed the following staggered DID model.

$$Adv_{i,t} = \alpha + \beta MA_{i,t} + \sum_{j=1}^{n} \gamma_j Controls_{i,t} + \lambda_i + v_t + \varepsilon_{i,t} \tag{19}$$

In equation (19), $Adv_{i,t}$ represents the advertising revenue of No.i platform enterprise in year t; $MA_{i,t}$ denotes whether No.i platform enterprise executed a data-driven M&A in year t; $Controls_{i,t}$ is the unobservable control variable for platform enterprise i that changes with time t, and γ_j is the estimated coefficient of each control variable. λ_i is the individual effect of platform enterprise i that does not change with time, v_t is the time fixed effect, and $\varepsilon_{i,t}$ is the disturbance term. The estimated coefficient β is the average difference of the platform enterprise's advertising revenue before and after intra-industry M&A and cross-sector M&A.

4.2 Empirical Result

We used the PSM-DID methodology, citing Chen and Zhang's (2019) research methodology and approach, to examine the effects of data-driven intra-industry and cross-sector M&A on platform enterprises' market performance. We also tested the differences between the effects of these M&A strategies using the difference-in-differences-in-differences (DDD) method.

As indicated by Table 1's columns (1) and (2), platform advertising revenues (market performance) have been positively impacted by both intra-industry and cross-sector M&A modes, supporting Hypotheses H1a and H2a. Column (3) also shows that, at the 1% level, data-driven M&As have a significantly positive effect on advertising revenue. We introduced the dummy variable MA_Cross for intra-industry M&As for a difference-in-difference-in-differences (DDD) analysis in order to further investigate differences in the effects of M&A modes on the market performance of platform enterprises. H3 is confirmed by the fact that, as column (4) demonstrates, intra-industry M&As have a greater impact on improving platform enterprises' market performance than do cross-sector M&As. Comparatively speaking, intra-industry M&As involve platforms operating the same businesses, which require less difficult data migration, data integration and data management. Platform enterprises can expect an easier rise in market performance as a result of the ensuing data network effect. Cross-sector M&As, on the other hand, typically involve platforms with various business models. While it is simpler to create data economies of scope through cross-sector M&As, managing data migration, integration, and management becomes more challenging. This hampers the development of the network effect of data. Therefore, the promotion of market performance for platform enterprises is less affected by cross-sector M&As.

Table 1: Estimated Results of Baseline Regression

Variable	Intra-industry platform M&A	Cross-sector platform M&A	DID	DDD
	(1)	(2)	(3)	(4)
MA	0.39** (0.19)	0.35*** (0.10)	0.35*** (0.10)	0.30*** (0.10)
MA_Cross				0.36* (0.21)
Control variable	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed-effect	Yes	Yes	Yes	Yes
Sample size	294	568	628	628
Adjusted R^2 value	0.95	0.94	0.93	0.93

Note: ***, ** and * denote significance levels at 1%, 5% and 10%, respectively, and numbers in parenthesis are standard errors.

4.3 Robustness Test

(i)The dynamic effect and parallel trend are tested. Adopting the multi-time-point DID model requires that the parallel trend hypothesis be fulfilled. Specifically, a consistent trend of change prior to the execution of the M&A must be shared by the treatment group carrying out an M&A and the control group not carrying out any M&A. The relative time dummy variable for the execution of M&A for each platform enterprise must be specified because these enterprises execute data-driven M&As at different times. The following equation is developed in this paper to perform the parallel trend test:

$$\begin{aligned} Adv_{i,t} = {} & \alpha + \beta_1 Before4_{i,t} + \beta_2 Before3_{i,t} + \beta_3 Before2_{i,t} + \beta_4 Before1_{i,t} \\ & + \beta_5 Current_{i,t} + \beta_6 After1_{i,t} + \beta_7 After2_{i,t} + \beta_8 After3_{i,t} + \beta_9 After4_{i,t} \\ & + \beta_{10} After5_{i,t} + \sum_{j=1}^{n} \gamma_j Controls_{i,t} + \lambda_i + v_t + \varepsilon_{i,t} \end{aligned} \tag{20}$$

In equation (20), the time dummy variables are observations in n years prior to, the current year and n years after a data-driven M&A, and the dummy variables for platform enterprises with non-data-driven M&As are all 0. Given the small sample size before phase -4 and after phase 5, we divided them into phases -4 and 5, and removed phase -1 to avoid multi-collinearity. The results shows that the coefficients of the relative time dummy variables are all insignificant, implying that there is no significant difference in advertising revenue between the treatment and control groups prior to platform M&A, thereby supporting the parallel trend hypothesis. Regarding the dynamic effect, there is a slight lag in the impact of data-driven M&As on the market performance of platform enterprises, and the impact coefficient is negligible in the current M&A phase. Platform enterprises require a considerable amount of time to integrate data resources and leverage additional data scale, scope, and network effect in order to increase advertising revenues. In the five phases that follow an M&A, the coefficient of impact of data-driven M&As on market performance is significantly positive and steadily increasing, implying that data-driven M&As have a significant positive effect on digital platform market performance.

(ii) Utilizea model-specified test methodology. We used the nearest neighbor matching method instead of the radius matching method in this paper to perform a robustness test, and employed year-by-year PSM samples due to the "self-matching" issue that arose during the conversion of panel data into cross-section data. The findings indicate that the MA coefficients for the two matching strategies are both significantly positive, indicating the robustness of the effects of data-driven intra-industry and cross-sector M&As on market performance.

(iii) Change of variable measurement methods. ① The replacement of explanatory variable. In order to replace the explanatory variable, we collected the frequencies of data-driven M&As executed by each digital platform enterprise in each observation year (*MA_Scale*) to reflect the differences in the frequency or intensity of M&As of digital platform enterprises. The estimated results show that the market performance of platform enterprises has been significantly influenced by the frequency of data-driven M&As, which to a certain extent demonstrates the robustness of our baseline regression results. ② Replacement of explained variable. Further, we conducted a regression analysis based on the ratio of advertising revenue to operating revenue. The results show that the *MA* coefficient is significantly positive at 1%. This is generally consistent with the baseline regression result.

(iv) Placebo test. The estimated results of data-driven M&As may still be influenced by certain unobserved firm characteristics, despite the controls of multiple firm characteristic variables in the baseline regression. Thus, the subsequent placebo test is implemented. Our model is a staggered DID model, in which the time point of data-driven M&A for each platform enterprise is distinct. The dummy variable for the pseudo-treatment group $Group^{ran}$ and the dummy variable $Post^{ran}$ for the pseudo-data-driven M&A shock must be generated randomly. In other words, a random sample period must be selected for each sample object as the time of its M&A. We conducted 500 random shocks of pseudo-data-driven M&As on 81 sample platform enterprises, randomly extracting 49 platform enterprises as the treatment group each time. The M&A time points were randomly designated, resulting in 500 groups of MA^{ran} (i.e., $Group^{ran} \times Post^{ran}$). This was done in accordance with Bai et al. (2022). The results show that the randomly generated β^{ran} is concentrated around 0, as evidenced by the distribution, and the p-values are primarily greater than 0.1. This suggests that our estimated results are not significantly influenced by other potential factors, which means they are robust.

(v) Evaluation of the heterogeneous treatment effect of staggered DID heterogeneity. The "heterogeneous treatment effect" may result in estimated bias in the staggered DID model (De Chaisemartin and D'Haultfoeuille, 2020). We employ the "twoway-feweights" command to retest the baseline regression model, referencing the aforementioned scholars and Bai et al. (2022). The estimated result is more robust when the heterogenous treatment robustness indicator is closer to 1, while the estimated result is less robust when it is closer to 0. The result suggests that 182 of the 222 weights are positive, 40 are negative, and the indicator of heterogeneity treatment robustness is 1.86. This suggests that the estimated result of this paper is robust, and the heterogeneous treatment effect has no substantive impact on it to a certain extent.

(vi) Treatment of the endogeneity problem. The following three methods are employed in this paper to conduct an endogeneity test: ① Heckman two-stage model. In the first stage, we created the probit model to determine whether a platform enterprise has participated in a data-driven M&A. The calculated IMR is then incorporated into equation (19) as a control variable for regression estimation. The results show that the market performance of platform enterprises has been enhanced by data-driven M&As, as evidenced by the significant positive coefficient of explanatory variable *MA* at 1%. After controlling for the endogeneity issue that may result from sample selection bias, the baseline regression results remain valid. ② The generalized method of moments for dynamic panels. In order to mitigate the potential endogeneity issue, we employed different GMM to apply a lag term of the explained variable (L. *Adv*) as an instrumental variable in this paper. The results show that the one-order lag of the explained variable is significantly positive at 1%. Namely, the market performance of platform enterprises is significantly influenced by data-driven M&As, and the baseline regression results are both robust and reliable. Moreover, we computed the Arellano-Bond estimator, and the results indicate that the difference of the disturbance term contains a first-order autocorrelation, while no second-order autocorrelation is present. ③ Instrumental variable methodology. The scale of sector M&As in the previous year may influence platform M&A decisions; however, it cannot directly affect the advertising revenue of a specific digital platform enterprise. The instrumental variable (*IV*) is the mean value of the M&A scale in the sector of the acquiring platform (listed) based on the aforementioned platform classification (i.e., search engine, social network, portal news information, and email platforms), referencing Wan and Yang (2022), and the regression estimation is conducted using 2SLS. The first-stage and second-stage results are both significantly positive. The p-value of the Anderson LM statistic is 0.007, which rejects the hypothesis of instrumental variable under-identification. We employed the limited information maximum likelihood (LIML) for an additional round of regression to address the issue of weak instrumental variable (IV) referencing Combes et al. (2019), and found no significant difference in the estimated values of LIML and 2SLS. This demonstrates that the conclusion that data-driven M&As enhance the market performance of platform enterprises remains valid even after the endogeneity problem is considered.

4.4 Mechanism Test: Effects of Data Economies of Scale and Data Economies of Scope

We developed an intermediate effect model to investigate the mechanisms of data economies of scale and data economies of scope between platform M&A and corporate market performance in order to further elucidate the role and impact of data on the M&As and market performance of platform enterprises.

$$Med_{i,t} = \alpha + \delta MA_{i,t} + \sum_{j=1}^{n} \gamma_j Controls_{i,t} + \lambda_i + v_t + \varepsilon_{i,t} \tag{21}$$

$$Adv_{i,t} = \alpha + \vartheta MA_{i,t} + \rho Med_{i,t} + \sum_{j=1}^{n} \gamma_j Controls_{i,t} + \lambda_i + v_t + \varepsilon_{i,t} \tag{22}$$

In the above equations, $Med_{i,t}$ is the mechanism variable, which is substituted by data scale (*Ias*) and data scope (*Divhhi*), respectively, and the definitions of other variables are the same as previously mentioned. ϑ is direct effect, and $\delta \times \rho$ is intermediate effect. If δ and ρ are both significant, an intermediate effect exists; if at least either δ or ρ is insignificant, the bootstrap method is adopted to test whether $\delta \times \rho$ includes 0 in the 90% confidence interval. If it does not include 0, the intermediate effect exists; otherwise, the intermediate effect does not exist.

4.4.1 Data economies of scale

Previous theoretical analysis indicates that platform M&As are conducive to enhancing the market performance of digital platform enterprises by expanding the scale of data. The classification of data resources as intangible assets has been widely accepted in both academia and industry (Gupta and Lehmann, 2003). The acquirer will recognize the intangible assets of target platform enterprises, including users and data. For example, Alibaba classified the customers and customer relationships of merged parties as “intangible assets” in its 2021 annual report. The user base, in some respects, reflects the data scale that platform enterprises possess. Throughout the stages of data collection, data storage, data processing, and data application, platform enterprises’ other intangible assets, such as software copyrights, websites, apps, WeChat public accounts, and patents, are all digital infrastructures. They also reflect the scale of data that is available to them to a certain extent. In this regard, the data scale of target platform enterprises increases as the number of intangible assets increases. The logarithm of intangible assets is employed to represent the data scale in order to evaluate the mechanistic effect of intra-industry M&A samples, as per the research conducted by Liu et al. (2023). The regression results are presented in columns (1) and (2) of Table 2. The impact coefficient of variable *MA* with respect to *Ias* in column (1) is significantly positive at 5%, and the coefficient of data-driven M&A *MA* and the coefficient of intangible assets *Ias* are both significantly positive. This suggests that intra-industry mergers and acquisitions can enhance the market performance of digital platform enterprises by expanding the scale of their data, which supports H_{1b}. In order to achieve economies of scale in data and increase platform revenues, digital platform enterprises expand their data scale through intra-industry mergers and acquisitions.

4.4.2 Data economies of scope

This section evaluates the potential for cross-sector mergers and acquisitions to enhance the market performance of platform enterprises by increasing the scope of their data. In order to quantify data scope, we implemented the Herfindahl index (*Divhhi*) in accordance with the data availability of digital platform enterprises and Yang et al. (2018). The data scope that digital platform enterprises can acquire through multiple products or businesses is measured by this index, which reflects the product diversity or business type diversity of digital platform enterprises. Equation for computing the Herfindahl index: $Divhhi=1-\sum P_i^2$, P_i=Revenue from primary business category i of a digital platform enterprises / Aggregate primary business revenue. A higher *Divhhi* indicates a greater degree of business diversification. This information is derived from the Wind database’s primary business composition. Columns (3) and (4) of Table 2 are tests of the mechanism effect of data economies of scope, using cross-sector M&As as samples. The regression results in column (3) indicate that cross-sector M&As have an insignificant effect on the increase of data scope for digital platform enterprises, and the 90% confidence interval of a bootstrap test of $\delta\times\rho$ contains zero. The implication is that the mechanism effect of data economies of scope is insignificant for advertising-driven platforms, and hypothesis H_{2b} is not verified. A primary explanation for the occurrence of such a result could be as follows: On the one hand, as previously mentioned, cross-sector M&As may have a weaker data network effect as a result of difficulties for data migration, data integration, and data management between platforms, which may restrict data economies of scope. On the other hand, regulatory oversight has been increasingly rigorous regarding data consolidation for cross-sector mergers and acquisitions in the platform economy. For instance, the 2020 Digital Markets Act (DMA) of the European Union explicitly prohibits the consolidation of data from various business segments and the utilization of the “leverage” effect, as well as the enforcement of data concentration by “gatekeeper” platforms. The United States 2020 Investigation of Competition in Digital Markets mandates the limitation of the scope of a dominant platform business, with the objective of enabling Amazon to expand its user database by acquiring companies from other market segments that are related to its primary business. The 2021 Guidelines for the Implementation of Entity Responsibilities by Internet Platforms (Consultation Draft) of China explicitly stated that “no Internet platform operators may consolidate personal data acquired from platform services with personal data from other services of its own or any third party" without user consent. In 2022, Alibaba and Ant Group terminated the Data Sharing Agreement in order to satisfy regulatory rectification obligations, which were motivated by financial and data security concerns. The consolidation of various types of data and the efficient operation of the data economies of scope have been somewhat restricted by the enforcement of these regulatory policies. In other words, this outcome partially indicates that the mechanism effect of data economies of scope is less robust than the mechanism effect of data economies of scale. In other words, intra-industry mergers and acquisitions are more likely to enhance the market performance of platform enterprises than cross-sector mergers and acquisitions.

Table 2: Mechanism Test: Data Economies of Scale and Data Economies of Scope

Variable	Data economies of scope		Data economies of scope	
	Ias	*Adv*	*Divhhi*	*Adv*
	(1)	(2)	(3)	(4)
MA	3.50^{**} (1.56)	0.34^{*} (0.19)	-0.02 (0.02)	0.36^{***} (0.10)
Ias		0.02^{*} (0.01)		
Divhhi				0.43^{**} (0.20)
Control variable	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Sample size	294	294	568	568
Adjusted R^2 value	0.80	0.95	0.64	0.94

Notes: Same as Table 1.

4.5 Extended Research: Data Network Effect Analysis

The first step of our mechanism test demonstrated that platform mergers and acquisitions had a significantly greater impact on data scale than on data scope. The market performance of platform enterprises is significantly positively correlated with data scale and data scope, as demonstrated by the second step. The question is whether there is a network effect in the market performance effect of data scale and data scope on platform enterprises. In other words, the question at hand is whether there is a critical mass in data scale and data scope (the minimum network scale required to maintain equilibrium) that enables the accumulation of user base and data and the formation of a positive feedback effect, thereby preventing a forced market exit. In order to determine whether the data scale and data scope between data consolidation platforms will generate a network effect, we implemented a threshold regression model, which utilized the intermediate variables of data scale (*Ias*) and data scope (*Divhhi*) as threshold variables, as per Lin et al.'s (2023) analytical approach for the network effect. At first, we employed the bootstrap method to sample 300 times in order to conduct a test of threshold existence. The results in Table 3 indicate that the single-threshold p-value of data scale is significant at 10%, while the p-values of double thresholds and triple thresholds are insignificant. Additionally, the p-value of data scope is insignificant. This suggests that a single threshold exists for data scale, and the threshold effect for data scope is insignificant. This conclusion has partially addressed the theoretical analysis that the network effect of data scope between different types of platforms is weaker than the network effect of data scale for the same type of platforms. It has also substantiated the regression result that the market performance of enterprises conducting intra-industry M&As is stronger than that of enterprises conducting cross-sector M&As in the baseline regression. The rationale is as follows. The expansion of data scope will also result in the expansion of data scale, as cross-sector M&A will increase the number of business types. The network effect of data scale will be reinforced by the network effect of data scope (Schäfer and Sapi, 2020). However, the existence of data sparsity makes it difficult for data scope to reach the basic critical point of the network effect. This has resulted in a restricted network effect of data scope (Schepp and Wambach, 2016), whereas the network effect of data scale is more easily achievable. Then, the statistics are evaluated using the likelihood ratios for each model in Table 3 to generate a likelihood ratio function chart of the data scale within the 95% confidence interval, as shown in Figure 2.

Table 4 shows the results of threshold regression, which is conducted in accordance with the number of thresholds that were established in the first step. The market performance effect of data scale on platform enterprises is significantly positive, exhibiting an increasing marginal effect. The regression coefficient of market performance for platform enterprises is 0.07 and significantly positive at 10% when the data scale is below 23.75. The regression coefficient of market performance for platform enterprises is 0.08 and significantly positive at 5% when the data scale exceeds 23.75. The regression coefficient and significance both experienced substantial increases. This demonstrates that the value of data scale is further released when it reaches a specific critical value, resulting in a more substantial stimulative effect. The rationale is as follows. Data-driven learning and decision-making experience an increasing return on data scale when the scale of the data is modest. The network effect of data scale accelerates the increasing return on scale and expands the interval of such increase as the data scale generated by

Table 3: Test Results of Threshold Effect

Number of thresholds	Data scale		Data scope	
	F-value	p-value	F-value	p-value
	(1)	(2)	(3)	(4)
Single threshold	12.63	0.09	10.77	0.21
Double thresholds	7.38	0.35	13.58	0.13
Triple thresholds	4.56	0.73	5.64	0.83

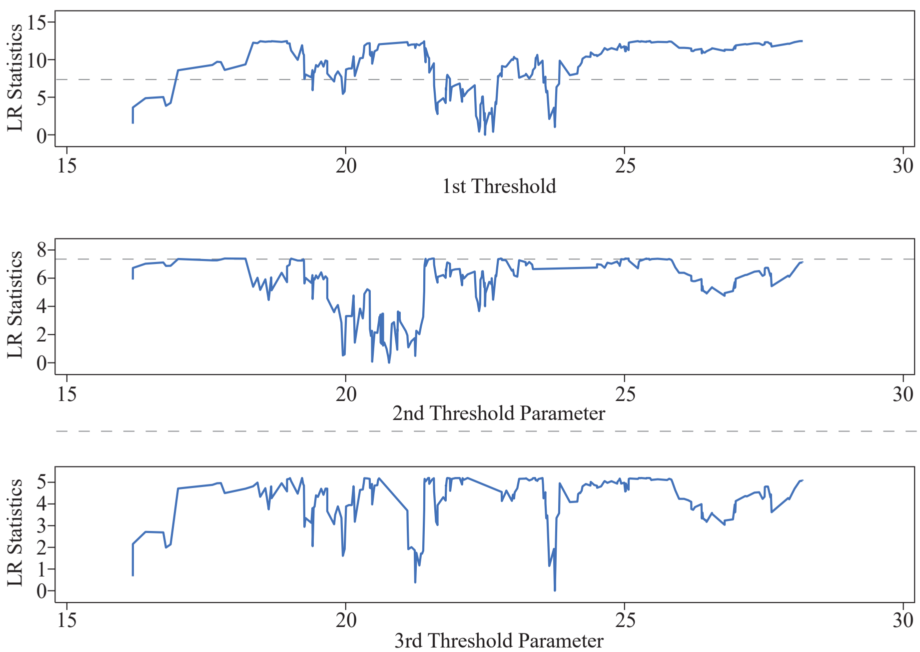

Figure 2: Estimated Value and Confidence Interval of Data Scale Thresholds

platform enterprise M&A reaches the critical value. This results in a more significant positive impact, as the market performance stimulation effect of data scale is magnified. Hence, it can be concluded that when platform enterprises' data scale reaches a critical value, further expansion has a significantly stronger stimulative effect on their market performance, i.e., the "network effect" of data scale exists. In comparison to cross-sector M&As, intra-industry platform M&As generate higher market performance due to the network effect of data scale.

Table 4: Threshold Value of Data Scale and Results of Parametric Estimation

Panel A: Estimation of threshold value	Threshold value corresponding to *Ias*	95% confidence interval
Single threshold	23.75	(23.66 23.78)
Panel B: Parametric estimation of threshold model		
Variable	*Adv*	T value
	(1)	(2)
Control variable	Yes	Yes
0≤*Ias*≤23.751	0.07*	1.79
Ias≥23.751	0.08**	2.12

Notes: Same as Table 1.

5. Case Study

5.1 Market Structure of Search Engine Platforms

In a case study of platform M&As from a data factor perspective, we employed a search engine as a typical advertising-driven platform, as relevant case data is available. Market structure is a critical factor that influences corporate behavior and market performance, as per the "structure-conduct-performers" (S-C-P) classical research paradigm in the industrial organization theory. This section begins with an analysis of the market structure of China's search engine platforms. The performance effect of Baidu's M&A behaviors is further investigated in the subsequent section.

Table 5 illustrates that China's search engine market concentration had been relatively high from 2009 to 2022[8], with a market structure of "oligopolistic competition". Between 2009 and 2012, there were four search engine platforms in the market, with Baidu and Google jointly holding a market share of more than 90%. The market share of Baidu experienced a consistent increase following the latter's departure from the Chinese market in 2000, while the other two companies (Bing and Yahoo) had a negligible market share. The market structure was distinguished by duopolistic competition. Despite the fact that Google's market share experienced a significant decline in 2013 and 2014, Haosou (previously known as "360 Search") maintained a consistent increase in its market share. In addition to Baidu, which maintained a relatively high market share, other search engines held extremely low market shares. At this point, the market structure maintained a "duopolistic competition" landscape. Seven search engine platforms persisted in the marketplace subsequent to 2015. Nevertheless, Baidu maintained a market leadership position with a market share of approximately 70%. The combined market share of the other six search engines was less than 20%. This resulted in a market structure that was characterized by "single oligopolistic competition[9]". In general, China's search engine market had consistently adhered to a duopolistic competition model. Baidu search engine's dominant position appeared to be precarious. Baidu has been significantly affected by the entry and development of new platform enterprises,

[8] In this paper, we used HHI to measure market concentration.

[9] Monopolistic competition is characterized by a single platform's market share exceeding 50% and a significant margin over the market share of the second-ranked platform (Fu et al., 2014).

including Haosou, Sougou, and Shenma. Google tried to reenter the Chinese market. It is highly probable that the future search engine market will develop into a duopoly or multi-oligopoly structure.

Table 5: Evolving Market Share of China's Search Engine Platforms

Unit: %, each

Year	Baidu	Haosou	Google	Sougou	Shenma	Bing	Yahoo	Number of platforms	Market concentration
2009	55.84	—	41.21	—	—	0.08	2.43	4	4822
2010	60.63	—	37.44	—	—	0.11	1.44	4	5080
2011	64.89	—	31.38	—	—	1.56	1.70	4	5201
2012	65.40	3.50	26.80	—	—	1.8	2.09	5 (+1)	5015
2013	65.90	20.84	9.61	1.40	—	1.15	0.93	6 (+1)	4874
2014	61.95	20.42	6.32	7.97	—	1.99	1.06	6	4363
2015	78.75	9.41	1.97	6.17	0.58	1.9	1.01	7 (+1)	6337
2016	77.07	8.81	2.39	3.93	5.63	1.41	0.63	7	6073
2017	77.31	8.06	1.71	3.56	7.72	1.12	0.42	7	6118
2018	69.04	5.24	1.83	4.86	17.42	1.26	0.22	7	5126
2019	69.51	2.83	2.77	13.78	8.58	2.34	0.02	7	5116
2020	69.95	3.47	2.83	18.15	3.09	2.38	0.02	7	5258
2021	78.32	1.81	2.19	12.99	1.35	3.08	0.02	7	6322
2022	73.71	3.17	2.99	7.15	1.91	9.63	0.04	7	5600

Notes: Data is from Statcaouter website (https://gs.statcounter.com). In this paper, we only selected top seven digital search engine platforms on the Chinese market, and the market share of other digital platforms such as YANDEX, YANDEX RU, Naver, AOL, Ask Jeeves, and MSN had been smaller than 0.1, which is negligible.

5.2 Market Performance Analysis of Baidu's Data-Driven M&A Behaviors

We collected and analyzed Baidu's M&A activities from 2009 to 2021, as outlined in Table 6. In total, Baidu engaged in 28 cross-sector M&As and one intra-industry M&A[10]. It is evident that cross-sector mergers and acquisitions were more prevalent in platform competition. The question at hand is whether this suggests that "cross-sector M&As" are more effective in improving the market performance of platform enterprises than "intra-industry M&As". The answer is negative. Baidu's frequent cross-sector M&As during this period are due to the fact that the competition among platform enterprises had shifted from competition for new users to competition for existing users as the digital platform market in China became increasingly competitive and demand became saturated. Based on the data and users they had accumulated in their core business lines, major platform enterprises tended to expand into other business segments. Baidu, for example, concentrated on its search engine platform business and expanded it through cross-sector M&As to create an ecosystem and access a broader range of users and complementary data resources. This was done to enhance user portraits and the accuracy of targeted advertising.

Between 2009 and 2021, Figure 3 illustrates the annual fluctuations in Baidu's data scale[11], data

[10] According to CVSource's "M&A event" database, Baidu's acquisition of Taboola is classified as a "non-controlling acquisition" and is classified as a "equity transfer". Yu et al. (2021) referred to these types of events as "acquisition of partial ownership". Taboola's privacy policy stipulates that it will disclose user information to unrelated third parties, and Baidu is identified as one of its "third-party demand and supply partners". Consequently, Baidu was both justified and motivated to acquire Taboola's user data in order to offer its users more precise content recommendations. As a result, the acquisition of Taboola will lead to an expansion of Baidu's data scale.

[11] Most data of platform enterprises came from platform users. In this sense, user scale to some extent may represent the data scale available to a platform, i.e., the platform's possession of data scale. Hence, data scale is expressed by Baidu's number of monthly active users.

scope[12], advertising revenue[13], and market share. It is evident that Baidu's continual M&A activities have resulted in a nearly 20-fold increase in its advertising revenue, a deepening of its data scope, and an increase in its platform user base and data scale. Baidu's advertising revenue is also influenced by a variety of factors, including the market environment, policy conditions, and various types of M&A events. Consequently, the long-term impact of mergers and acquisitions may not be accurately revealed in individual case studies. The economic implications of an M&A event in the current year are the primary focus of this paper, which endeavors to isolate the impact of various types of M&As on platform revenues by excluding factors other than the M&A event. In general, Baidu's advertising revenue experienced a substantial increase prior to 2015 and subsequently maintained a relatively consistent level. One significant factor is the relatively favorable market and policy environments that existed prior to 2015, during which time nearly all platform enterprises were in the process of rapid development. Additionally, Baidu's advantageous market position in the search engine market was further bolstered by Google's exit from the Chinese market in 2010. Baidu's revenues have been substantially diminished by a series of crisis incidents and regulatory policy changes that have occurred since that time. For instance, Baidu faced a significant setback in 2016 when Wei Zexi, a cancer patient, passed away after he received an experimental cancer treatment advertised by the search engine. This incident sparked a public outcry against the reliability of advertising information on the Baidu platform, which in turn impeded its advertising revenue growth in the same year. The advertising revenue of Baidu experienced a rebound as a result of the incident's abated shock. Nevertheless, Baidu's "Du Xiaoman" Internet finance business was spun off in 2018 as a result of the central bank's special campaign on the risks of Internet finance. The platform economy was subject to more stringent regulatory oversight following 2020. Consequently, Baidu's advertising revenue experienced a consistent decline following 2018.

Table 6: Statistics of Baidu's M&A Cases

Year	Target platform	Mode of acquisition	Year	Target platform	Mode of acquisition
2009	Online video: pp Video	Cross-sector M&A	2015	Search engine - Taboola	Intra-industry M&A
2010	E-commerce: LEEODU Trading / Jia.com	Cross-sector M&A	2016	Short video: Kuaishou Online finance: Zestfinance / JoinQuant Online tourism: C-trip travel Auto trading: Yiche	Cross-sector M&A
2011	Online tourism: Qunar.com Job search and recruitment: dupeng01.com Online video: iqiyi.com	Cross-sector M&A	2018	Short video: Pear Video Online finance: duxiaoman.com Online video: Baidu Video Online translation: jeemaa.com	Cross-sector M&A
2012	Auto trading: 58che.com	Cross-sector M&A	2019	Social networking community: Zhihu	Cross-sector M&A
2013	Local services: Peixe Urbano / Nuomi.com Mobile Internet: 91 Wireless Online reading: Zhongheng Literature Online lottery: Baidu lottery Online video: PPS Video	Cross-sector M&A	2020	Online education: Wisdom Tree	Cross-sector M&A
2014	Online education: Chuanke.com / Yunxue Times /Innovation partner	Cross-sector M&A	2021	Live streaming: YY Live	Cross-sector M&A

Source: Compiled based on Zephyr (https://login.bvdinfo.com/R0/ZephyrNeo) and CVSource (https://www.cvsource.com.cn/).

[12] Data scale is denoted by the product diversity of platform enterprises (income entropy index Diventro). See Yang et al. (2018), $Diventro = \Sigma X_i \times ln(1/X_i)$, X_i = Platform enterprise's revenue from category i primary business / Total revenue from primary business. Its value is positively correlated with product diversity.

[13] Based on the game model and empirical analysis, market performance is denoted by platform advertising revenue.

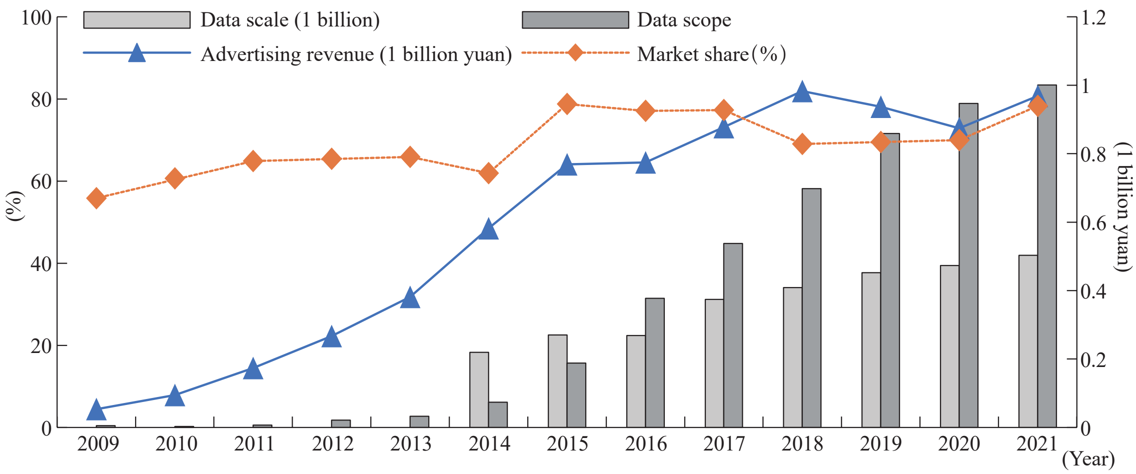

Figure 3: Baidu's Changing Status Scale, Data Scope, Market Performance and Market Share

Notes: "Data scale" is from Qianfan.tech. The interval of such data spans from 2014 to 2021 due to of the data's limited availability. Data scope and advertising revenue data are obtained from Baidu's financial statements, while market share data is obtained from the Statcaouter website.

We further focused on the changes in Baidu's advertising revenue after implementing intra-industry M&A in 2015, following the acquisition of Israel's reverse search engine Taboola. Our analysis was conducted after excluding relevant impact factors of market and policy. Figure 3 illustrates that Baidu's advertising revenue "increased sharply" and its market share "surged" in 2015. But in comparison, Baidu's advertising revenue experienced the most significant growth between 2013 and 2014, but less so over the period between 2014 and 2015. This appears to be in direct opposition to the findings of both empirical and theoretical research. According to Table 12, 2013 was the year with the highest frequency of M&As, with a total of six cross-sector M&As. This included the acquisition of mobile Internet company "91 Wireless" for a total of 1.91 billion US dollars, which was the largest M&A event in China's platform economy. In 2015, Baidu executed only one intra-industry M&A transaction, the acquisition of Taboola for a mere few million US dollars. The advertising revenue of Baidu increased at a faster pace between 2013 and 2014 than between 2014 and 2015 as a result of the impact of M&A frequency and value. If the frequency is excluded, it is evident that intra-industry M&As led to a more significant increase in advertising revenue growth in 2015 than did cross-sector M&As in other years. In general, intra-industry M&A is more likely to enhance Baidu's competitive advantage and market performance than cross-sector M&A. The results of the case analysis have partially corroborated our theoretical and empirical analysis conclusions.

6. Concluding Remarks and Policy Implications

Platform M&As with the primary objective of data acquisition are becoming more prevalent, as data is a critical production factor for digital platform enterprises. We conducted an analysis of stylized facts regarding the transition of digital platform M&As from intra-industry to cross-sector M&As from the data factor perspective. Our findings indicate that the various modes of M&As have the potential to result in the acquisition of data economies of scale, data economies of scope, and network effects of data. Secondly, we developed a two-stage Hotelling game model to conduct a comparative analysis of the market performance of advertising-driven platform enterprises in response to intra-industry and cross-sector M&As. The results suggest that the two M&A modes have the potential to increase platform profits by generating a data network effect within or between platforms, as well as to expand data scale and scope. Third, we empirically tested the analytical results of our theoretical model by utilizing relevant data from advertising-driven platform enterprises between 2009 and 2021 and applying a combination of DID, DDD, and propensity score matching (PSM) methods. It is found that the intra-industry M&As are more effective at improving the market performance of platform enterprises than cross-sector M&As since it does more to integrate and foster the "network effect of data scale" for the same types of data, and the intermediate effect of data scale is stronger than the intermediate effect of data scope. Finally, we conducted a comparative analysis of the market performance effects of various M&A modes in relation to Baidu's search engine business, which has also confirmed our previous conclusions. In light of the above research findings, we propose following policy recommendations:

First, platform enterprises should exercise caution when selecting their M&A strategy and should refrain from following the crowd and replicating low-value practices. The economic effects of various M&A modes on the market performance of enterprises are distinct, and they result in the acquisition of varying types of data. In order to prevent post-M&A disarray, platform enterprises should formulate and implement M&A strategies that are tailored to their specific circumstances, including the degree of data network effect and the scale or scope of data obtained from M&As in sufficient detail. In terms of privacy protection, network security, and antitrust review, data assets are subject to exorbitant operating costs and increasingly rigorous legal supervision. Platform enterprises should endeavor to improve their digital innovation capabilities by achieving a balance between the security, efficiency, and compliance of inter-platform data sharing.

Secondly, regulatory policies regarding inter-platform data sharing should account for the potential negative impacts on the performance of platform enterprises. The consolidation of cross-sector platform data is typically restricted by global competition policy. Furthermore, data security regulations related to "data divulgence" and "privacy protection" will impede the network effect of data between complementary platforms and data economies of scope. Of course, it is imperative that industrial policies that are designed to enhance platform inter-connectivity and data integration are founded on the full protection of data property rights and adhere to the inherent logic and laws of the market economy in order to account for the influence of data factors on platform enterprise performance. The main objective is to evaluate the advantages and disadvantages, reconcile corporate interests with individual and social interests, and underscore the beneficial effects of data-driven mergers and acquisitions and data sharing in the efficient development of the digital platform economy and corporate performance.

Third, it is crucial to remain vigilant regarding the potential peril of monopoly, despite the fact that data-driven platform M&As have the potential to enhance the performance of platform enterprises. Platform enterprises can leverage the data economies of scale and the network effect of data scale through data-driven mergers and acquisitions, which also enhance their market share and power. Regulators should be mindful of the potential for "data monopoly" and "ecosystem monopoly" to undermine competition in the context of data-driven platform M&As. In order to mitigate mergers and acquisitions that consolidate and expand cross-sector monopolistic positions and exploit monopolistic interests, antitrust law enforcement should enhance competition analysis and competition damage evaluation in digital platform M&As by leveraging data economies of scale, data economies of scope, and the network effect of data. Large platforms should be prohibited from utilizing their data advantage to enforce "skiller acquisitions" in order to preserve a competitive market. CE

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