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Mutualism, Competition and Predation: An Analysis of Advertising Ecosystem from the Perspective of Ecology Theory

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Abstract*—The advertising industry has dramatically changed in recent years. The extensive automation in advertising highlights the importance of data and algorithms, most of which are controlled by platforms, which encourages companies within the advertising supply chain to rely on large platforms, thereby forming an advertising ecosystem. Participants in the advertising ecosystem may complement each other in terms of data, technology, compete for their own interests, or even merge with each other. However, there is little research on the advertising ecosystem from the perspective of ecology theory. This paper analyzes the formation, strength, and monopolization of the advertising ecosystem. Overall, our work provide an overview of the advertising ecosystem, and proposes suggestion to address the negative problems*.

***Keywords*—** *Advertising ecosystem, digital advertising, platform monopoly, ecology theory.*

I. INTRODUCTION

The advertising industry has undergone significant changes in recent years. Real-time bidding (RTB) technology allows advertisers to deliver ads precisely based on user attributes and behavioral data. The emergence of technologies such as data management platforms (DMPs) and supply-side platforms (SSPs) further enhances the sophistication and effectiveness of the advertising market. Research has found that programmatic advertising now occupying the majority of the advertising market. [1] Unlike traditional advertising models, the advertising platform is central to programmatic advertising, facilitating the purchase of advertising audiences and enhancing the efficiency and effectiveness of ad campaigns. In addition, the advertising market is characterized by a diverse range of participants, and the trend towards platformization is becoming increasingly evident. [2] Benlian et al. discussed platformization as a mechanism in platform architecture design and formation, and it is considered a process leading to an ecosystem where the platform creates opportunities for itself and its ecosystem partners. [3] From this point of view, the advertising ecosystem has gradually formed, transforming advertising from direct ad purchases to a more complex and efficient advertising platform where algorithm technology and data analysis enable ad inventory to accurately match buyers and sellers, automatically completing advertising transactions.

By gathering traffic, data, and user scale, advertising platform can build a complex system driven by capital and technology, spanning multiple markets and integrating various fields. The advertising ecosystem involves multiple types of participants, including publishers, sales houses, ad servers, trading desks, supply-side platforms, brand advertisers, demand-side platforms, data management platforms, ad exchanges, and ad networks. [4] All participants cooperate and share resources, leading to a significant improvement in the efficiency of advertising resources by connecting complementary customer groups and utilizing external network effects. [5] The advertising ecosystem promotes the refinement of advertising services, leverages the output of the advertising industry (Thomas et al., 2014) [6], and effectively stimulates market growth. While the advertising platform ecosystem creates significant value, it also faces several challenges such as opaque fees, self-preferential treatment, and unfair protocols present obstacles. Moreover, competition among advertising platforms is intense, with various ecosystems blocking data from each other, thereby hindering data liquidity and transparency within the industry and increasing advertising costs. Although many researchers focus on the cooperation and competition of advertising companies, studies from the perspective of ecology theory to explore the generation and evolution of advertising ecosystem are scarce. This article aims to address this research gap.

II. LITERATURE REVIEW AND THEORETICAL BACKGROUNDS

2.1 Ecology Theory

The concept of ecology was first introduced by the German biologist Ernst Haeckel, who defined ecology as the scientific study of the relationships between living organisms and their surrounding environment, as well as the mechanisms and principles governing these interactions. In ecological theory, mutualism, competition, predation, and the interactions between biotic and abiotic components are key factors that contribute to the dynamic balance of ecosystems. Mutualism refers to a relationship between two different species in which both benefit from the interaction, with each organism thriving due to the presence of the other. [7] Competition, on the other hand, is the struggle between organisms for limited resources, such as food, space, and water. [8] Competition can be classified into interspecific (between different species) and intraspecific (within the same species) competition. [9] Competition is most commonly observed between species

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with similar ecological niches, and it plays a crucial role in maintaining species diversity and ecosystem stability. Predation refers to the phenomenon in which one organism (the predator) feeds on another organism (the prey). Predators can reduce the population size of prey or decrease their population growth rate. A dynamic balance exists between predator and prey populations: as predator numbers increase, prey populations tend to decrease, and vice versa. [10] Predation helps regulate the size and distribution of prey populations, thereby maintaining the equilibrium of the ecosystem. Additionally, interactions between biotic and abiotic components are essential mechanisms in ecosystems. Biotic components include producers (e.g., green plants), consumers (e.g., animals), and decomposers (e.g., bacteria and fungi), while abiotic components encompass environmental factors such as sunlight, air, water, and soil. For example, plants absorb water and nutrients from the soil through their roots, while simultaneously contributing organic matter to the soil. These interactions make ecosystems complex and stable systems. Ecology theory is not only applicable to natural ecosystems but also provides valuable insights for analyzing and understanding the complex interactions and evolution of advertising ecosystems. In the advertising ecosystem, mutualism, competition, and predation exist in the relationships between platform owners, advertisers, advertising agencies, and technology service providers. Furthermore, the advertising ecosystem also interacts with the "abiotic components" of the system, such as technology and regulations. By analyzing the relationships among advertising ecosystem participants—such as advertising platforms, advertisers, and agencies—through the lenses of mutualism, competition, and predation, we can gain a deeper understanding of the internal operational mechanisms and principles of the advertising ecosystem, as well as the interactions between the ecosystem and its external environment.

2.2 Advertising Ecosystem

The concept of an ecosystem refers to a unified system formed by living organisms and their environment within a specific spatial context, where organisms and the environment interact and constrain each other, maintaining a relatively stable dynamic equilibrium over a certain period of time. [11] Moore (1993) first introduced the idea of a business ecosystem, which is the origin of the platform ecosystem concept. It advocates for the collaborative construction of an economic community in which core enterprises, suppliers, consumers, and market intermediaries, as different "species," are interconnected by shared economic destinies. [12] The concept of the platform ecosystem is derived from the business ecosystem, defining feature of platform ecosystems is the interdependence between a stable core or platform that interfaces with a dynamic and heterogeneous set of complementary components to generate a stream of derivative products. [13] In recent years, the advertising industry has undergone remarkable changes. Fueled by the Internet of Things (IoT) technologies and artificial intelligence, advertising platforms are pivotal in the advertising trade and distribution. They progressively utilize and integrate resources such as technology, data, and traffic on Internet platforms to establish a platform-centric advertising ecosystem. In the advertising ecosystem, participants form mutually beneficial relationships through resource sharing and complementary strengths. For instance, ad trading platforms integrate various resources to provide advertisers with more precise and efficient advertising inventories. This symbiotic relationship enhances the efficiency and value creation capabilities of the entire ecosystem.

The objective of the advertising ecosystem is to minimize ad trade costs while maximizing advertising value. Advertising ecosystem functions as a multi-sided platform, connecting advertisers, publishers, and other stakeholders, while leveraging enormous users data and advanced algorithm for optimal ad delivery. [14] This ecosystem involves various types of participants, including advertisers, advertising agencies, media platforms, demand-side platforms (DSPs), supply-side platforms (SSPs), data management platforms (DMPs), data analytics firms, content marketing companies, Key Opinion Leaders (KOLs), and short-video and live-streaming platforms. Advertisers need to identify effective ad inventories and precisely target users to achieve promotion goal, thereby improving the return on investment (ROI) of their advertising spend. Media companies, on the other hand, need to monetize their vast traffic to support their continued development. Advertising platforms meet the needs of both advertisers and media by integrating and optimizing advertising resources, thereby facilitating a healthy industrial cycle. Furthermore, the involvement of players like advertising agencies and DMPs further enriches the advertising platform ecosystem, enhancing the efficiency and effectiveness of ad transactions.

III. MUTUALISM: THE VALUE-CREATION OF ADVERTISING ECOSYSTEM

3.1 Complementary Advantages: Motivating Complementors to Cooperate and Enable Value Creation

In the advertising platform ecosystem, platform owners and their members function similarly to different species in ecology, achieving mutual prosperity through interdependent relationships. The core platform acts as a hub that facilitates interaction and collaboration among various stakeholders, demonstrating a powerful capacity for resource integration. By leveraging its advantages in data collection, algorithm optimization, and market analysis, the platform owner provides technical support and market insights to its members. In turn, the members contribute to the platform by utilizing their specialized expertise and innovative resources, offering a diverse range of products and services. This mechanism of complementary advantages not only promotes the rational use and efficient allocation of resources but also significantly enhances the overall market competitiveness of the ecosystem. Specifically, platform owners integrate extensive data from various subsystems and members, creating aggregated data value. This data provides the platform with rich insights into consumer behavior, enabling it to deliver more personalized and precise advertising to target consumers. Meanwhile,

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members contribute additional value to the platform by leveraging their expertise in specific areas, such as providing creative content or optimizing ad placement strategies. The success of platforms relies on cooperation, coordination, and integration across a wide and diverse range of organizational units and agents. These complementary advantages ensure that all participants in the ecosystem benefit, thereby driving the collective growth and value of the ecosystem.

3.2. External Network Effects: Achieving Economies of Scale and Enhancing Efficiency

External network effects in the advertising ecosystem exhibit two key characteristics. First, the value each participant gains increases as the number of ecosystem participants grows. Second, when one participant's innovations attract additional users, other participants in the ecosystem also benefit. [15] Platform owners can leverage these external network effects by continuously expanding and diversifying the range of complementors on their platform, including advertising technology providers, data analytics firms, and creative content creators. This strategy enhances the scale effect, attracting more advertisers and consumers. The addition of advertisers not only generates direct revenue but also enriches the platform's content and services for users. As the number of advertisers grows, the variety and richness of advertising content increase, further attracting more users and creating a positive feedback loop. To motivate and incentivize participation, a platform must offer innovative incentives to attract a diverse array of complementary players. Diversifying product and service offerings not only significantly enhances user experience and satisfaction but also stimulates high user engagement. Moreover, as the functional boundaries expand and the product line becomes more comprehensive, the platform is better positioned to meet the diverse needs of the market, ultimately increasing user loyalty and dependence.

3.3. Reducing Transaction Costs

The ecosystem aims to reduce transaction costs by minimizing the friction in inter-firm interactions and optimizing transaction efficiency. [16] [17] The advertising platform, acting as a bridge between advertisers and their audiences, achieves resource optimization and precise matching by constructing an efficient and transparent transaction conduct. The transaction costs for participants within the ecosystem have been significantly reduced due to the mitigation of information asymmetry. As the leader in the ecosystem, advertising platforms leverage advanced data analytics and technological tools to deeply explore user preferences and behavior patterns, enabling more accurate and targeted advertising strategies for advertisers, markedly improve the automation and precision of the advertising industry. By automating the buying and selling of ad inventory in real-time, the advertising ecosystem minimizes the need for manual intervention, reducing labor costs and speeding up transactions. These advantages provide a solid development base for ecosystem participants, allowing them to focus more on innovation and market expansion. Furthermore, by establishing a rigorous credit evaluation system and an efficient dispute resolution mechanism, the platform effectively reduces transaction risks and enhances trust among market participants. These comprehensive measures not only improve the overall operational efficiency of the advertising market but also generate greater value returns for advertisers, thereby fostering co-creation of value and achieving a more efficient and cost-effective advertising ecosystem.

IV. Competition: The Strength of Advertising Ecosystem

4.1 Intraspecific Competition: Driving Companies to Strengthen through Mergers and Acquisitions

In the natural ecosystem, based on the classification of competitive entities, competition can be divided into intraspecific competition and interspecific competition. Intraspecific competition, which refers to competition within the same species for the same resources, is the most fundamental and universally present form of competition in ecosystems. [18] In the advertising industry, intraspecific competition is particularly intense. Companies often need to continuously enhance their capabilities in order to compete for limited client resources, ad spaces, and market share. When intraspecific competition reaches a certain level, a phenomenon of "the strong devouring the weak" emerges. More efficient companies will acquire less efficient ones to further expand their market share and enhance their overall competitiveness. For example, Google, through acquisitions of companies such as DoubleClick and AdMob, not only solidified its dominant position in the online advertising market but also successfully expanded into emerging areas like mobile advertising and programmatic buying. Mergers and acquisitions within the advertising ecosystem have rapidly transformed previously fragmented and competitive companies into concentrated and powerful entities. This process continually consolidates leading companies in niche segments, enhancing the overall strength and cohesion of the advertising ecosystem. As a result, the interdependence among businesses within the entire advertising platform ecosystem increases, leading to an expansion of market share.

4.2 Interspecific Competition: Encouraging Companies to Innovate and Market Expansion

Unlike intraspecific competition which occurs within the same species, interspecific competition happens between different species competing for the same resources within an ecosystem. In the advertising ecosystem, interspecific competition will drive companies to continuously innovate and develop, reducing costs and improving efficiency through the expansion of their business offerings. In such competition, some ecosystem companies continually innovated and expanded their profitable and advantageous area, which leads to the emergence of new business models, and expands their business into a different sector. For instance, Miaozhen Systems, a Chinese ad tech company using big data computing technology to provide internet advertising monitoring services to advertisers, has a core product called Admonitor, by which the company accumulated a vast amount of data and rich practical experience. This unique advantage encouraged

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Miaozhen established Miaozhen Academy of Marketing Science, an enterprise can help clients unlock the value of their data, providing highly valuable and commercially significant marketing services, and provides marketing training services to cultivate industry talent. This transformation from ad monitoring to marketing services exemplifies how interspecific competition drives innovation and business expansion. Addition, an advertising ecosystem competed with other rivals also can be regard as interspecific competition within a larger competitive environment. The more intense this competition, the more important an ecosystem's evolution becomes for surviving and thriving. A vibrant and dynamic ecosystem is therefore key to the survival of any companies, and increasingly of products and services as they morph into advertising ecosystem.

V. Predation: The Monopoly of Advertising Ecosystem

5.1 Platforms exploit other participants in advertising ecosystem

According to ecology theory, predation includes any interaction in which energy flow from one organism to another. [19] From this explanation, predator interaction with prey species primarily involves energy distribution, which in the advertising ecosystem resembles profit distribution. Predators will leverage all advantages within the ecosystem to seize the interests of prey. But the interaction between predator and prey is dynamic and complex, that Curio consider the predation is a process by which an animal spends some effort to locate a live prey and, in addition, spends another effort to mutilate or kill it. [20] It is common in the advertising ecosystem for advertising platforms to provide foundational and technical services to other participants. These platforms act as infrastructure upon which an array of firms can develop complementary products, technologies, or services. They share critical assets with partners, enabling personalized ad targeting and enhancing the advertising efficiency of the ecosystem. This process is akin to how animals spend effort to locate live prey. Through the continuous accumulation of user data and technological advantages, platforms gradually assume the role of predators within the ecosystem, gaining the ability to exploit other participants. In the natural world, predators capture prey through stealth and rapid action, maintaining ecological balance. Similarly, in the advertising ecosystem, platforms use their data and technology to "prey" on advertisers, publishers, and other participants. By controlling data interfaces, setting market entry barriers, and establishing operational rules, platforms can easily restrict competitors' entry and development. They seize market share that originally belonged to small and medium-sized enterprises, leading to a shift in the distribution of interests similar to the transformation of energy from prey to predator. Additionally, platforms exploit big data and algorithms for price discrimination, such as "big data loyalty penalties," further harming consumer interests. As the advertising ecosystem continues to expand, the monopolistic position of platforms becomes increasingly entrenched. This predatory behavior not only weakens market competition but also reduces the overall innovation capacity and service quality of the advertising industry.

5.2 Platforms Distort Nutrient Cycling of Advertising Ecosystem

Nutrient cycling is a factor of central importance in regulating the structure and function of ecosystems. The content of nutrients varies with different ecosystems. For example, In plant ecosystems, nutrients mainly include nitrogen, phosphorus, and potassium, whereas in biological ecosystems, they refer to proteins, sugars, and fats. Just like in a natural ecosystem, where organisms rely on nutrient cycles to sustain themselves, the advertising ecosystem relies on data, money, and user attention to function effectively. Drawing an analogy to the advertising ecosystem, users' data and algorithm acts as the flowing "nutrient" that nourishes the development of the entire system, which is essential for implementing target advertising and providing measurement and attribution services to advertisers. The collection, storage, and transmission of data are primarily under the control of platform, and the processing of vast amounts of data requires advanced algorithmic technologies, which can transform data from general nutrients into specialized nutrients. Platforms such as Google and Facebook can collect and process large datasets directly from their extensive user bases, a resource generally not accessible for free to other participants in the ecosystem. If platforms block the flow and migration of data or adopt unequal practices in the use of data and algorithms—such as sharing more data and technology with affiliated companies while providing less to competitors—it will disrupt the balance of the advertising ecosystem. The UK's Competition and Markets Authority (CMA) raised concerns in a report that Google might exploit the data it collects from its wider ecosystem to gain a competitive advantage in digital advertising. [21] In the distribution of 'nutrients,' platforms have an incentive to self-preference, which means give its own services or products favorable treatment compared to those of competitors, often at the expense of fairness and competition. This can lead to a monopolistic dominance where the platform strengthens its market position by limiting opportunities for others. The reality is consistent with research that predators can have cascading effects that extend beyond their prey base to impact on ecosystem nutrient dynamics that may then feed back upward to influence the biological productivity. [22]

VI. Conclusion

The advertising industry is shift towards a platform ecosystem due to its efficiency and automation. These factors attract a diverse array of participants and facilitate collaboration between different players in the advertising ecosystem, fostering innovation and growth. Drawing on concepts such as mutual symbiosis, competition, and predation, all rooted in ecology theory, this study delves into the operational mechanisms of the advertising platform ecosystem and analyzes the formation, strength, and monopolization of the advertising ecosystem. The research finds that advertising ecosystem platforms, by continuously accumulating user data and technological advantages, have

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built large-scale ecosystems, resembling the "super-species" in nature. The study found that within the advertising ecosystem, members' cooperation becomes more intimate, allowing for complementary strengths. This leads to value co-creation and reduced transaction costs. At the same time, intense competition exists among ecosystem members, which can be categorized into intraspecific competition and interspecific competition. Intraspecific competition enhances the quality and efficiency of company services. Small and fragmented companies are gradually merged by larger and stronger ones, becoming leading enterprises in niche markets. Interspecific competition drives technological innovation and the development of new business models, promoting the continuous expansion of advantaged companies' business scopes. Given their dominant position in the advertising ecosystem, platforms leverage their vast amounts of data and advanced algorithms not only to support other participants but also to encroach on the interests of these participants. When platforms pursue their own maximum benefit and come into conflict with other ecosystem members, they act like predators, using their monopolistic advantage to exploit and restrict the development of other businesses. This shifts the distribution of benefits within the advertising ecosystem, which is detrimental to the ecosystem's overall development.

The study's contribution to the current literature lies in its analysis and assessment of the relationships among various enterprises within the advertising ecosystem. This is crucial for a comprehensive understanding of the current development of the advertising industry. However, the advertising ecosystem continues to evolve with emerging technologies like artificial intelligence, blockchain, and the Internet of Things (IoT), promising even more innovations in the future. This will inevitably lead to the continued evolution of the advertising ecosystem. Additionally, due to the competition among large internet platforms, the advertising industry may form several distinct advertising ecosystems around these platforms, such as Google, Meta, ByteDance, and others. The competition among these advertising ecosystems will also bring new issues worth studying, which deserve further research attention.

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