

# Evolutionary Trajectories of China's Internet User Population and Identification of Internet Usage Patterns from 2015 to 2025

Mingjun Zhan<sup>1,2</sup>, Meifang Zhang<sup>1</sup> and Jiancong Liang<sup>1,\*</sup>

<sup>1</sup>Business School, Foshan University, Foshan 528000, China

<sup>2</sup>Research Centre for Innovation & Economic Transformation, Research Institute of Social Sciences in Guangdong Province, Guangzhou 510000, China

Email: [joliang@fosu.edu.cn](mailto:joliang@fosu.edu.cn)

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## Abstract

The changes in the demographic structure and application ecosystem of the Chinese Internet have shown distinct phased characteristics with the development of digital technology. Based on the statistical reports of CNNIC from 2015 to 2025, this paper utilizes visual technology and DTW-Ward hierarchical clustering algorithm to systematically examine the evolution of the Internet user demographic structure and the time series patterns of the usage rates of major Internet applications. The study reveals that China's mobile Internet has entered a high penetration stage, with the growth of the user base slowing significantly, meanwhile, the user structure also shows new dual changes, namely, the base of both younger and older user groups is growing. The clustering results show that the evolution paths of different Internet applications are not consistent, and can be classified into four types of evolution patterns: fluctuation convergence driven by context dependence, decline and transformation driven by exogenous shocks, rapid saturation driven by network effects, and stable growth driven by ecological synergy. The development of China's Internet is shifting from scale expansion to a new stage of structural adjustment and ecological differentiation, which can provide a basis for enterprises to identify market segmentation directions and optimize business strategies, and also offer references for the government to improve digital economy policies, implement classified supervision, and conduct network governance.

## Keywords

Digital Social Governance; Internet user demographics; Internet application patterns; Dynamic Time Warping (DTW); Time series clustering

## 1. Introduction

Digital technology is profoundly reshaping the global landscape, and China has developed into one of the world's largest, most complex, and most diverse Internet

ecosystems. Over the past decade, China's Internet has undergone a significant transition from incremental expansion to structural optimization and transformation. Its developmental focus has shifted from the singular dimension of user-base growth to the new stage of adapting to demographic structural shifts and the activation of user behavior across different cohorts. On the one hand, overall growth of the user base has decelerated and the traditional demographic dividend is fading; on the other hand, the internal demographic structure is witnessing new developments that the base of younger and older user groups is expanding concurrently, reshaping the demographic profile of the digital society [1]. This structural transformation is not only altering the pathways of information dissemination but also generating new models of digital production, living, and social interaction. The success of China's Internet industry can be understood as a process of adaptive innovation with distinctive local characteristics, its vitality stems from an acute responsiveness to China's social structure, cultural context, and the public's diverse and layered needs, upon which a uniquely Chinese model of Internet application practice has been formed [2]. As the core vehicle for user behavior and digital interaction, Internet applications exhibit distinctly dynamic and heterogeneous evolutionary trajectories. Existing studies have predominantly focused on case analyses of individual applications or specific perspectives [3][4], leaving a gap in the systematic analysis of the macro-level, cross-temporal evolutionary pathways and shared regularities of Internet applications. This gap warrants further scholarly attention, and the present study aims to provide a new pathway for macro-level Internet ecosystem research.

Rogers [5] proposed in the Diffusion of Innovations theory that the adoption process of new technologies can be divided into five stages: knowledge, persuasion, decision, implementation, and confirmation. Building on this, the present study constructs an integrated analytical framework of Internet evolution pathways (see Figure 1). This framework takes "demographic structure and technology awareness" as its starting point, progresses through the stages of "behavioral adoption and diffusion" and ultimately enters the stage of "ecological synergy and feedback" thereby forming a dynamic cyclical system. Under this framework, demographic structures and social environments jointly shape the starting point of awareness and influence user behavior transformation; social networks, policy factors, and external drivers promote application diffusion; and platform synergy and embeddedness drive long-term stable development and dynamic equilibrium. Thus, the evolution of Internet applications is not merely the result of technological diffusion; rather, it is a process of mutual interaction and co-evolution among population, behavior, and institutions.

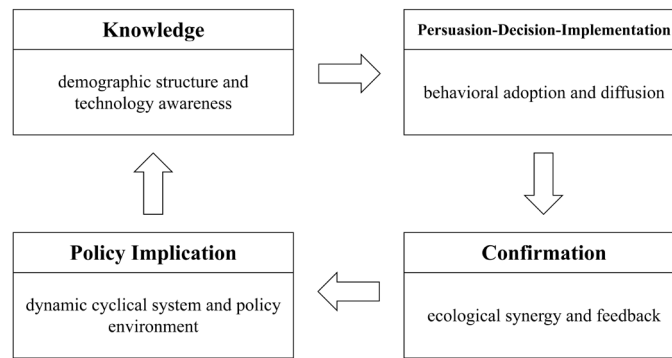


**Figure 1.** Integrated analytical framework of Internet evolution pathways based on Diffusion of Innovations theory

This study focuses on two core questions: First, what key evolutionary characteristics have emerged in China's Internet demographic structure during the critical transformation period from 2015 to 2025? Second, can representative, generalizable usage patterns be identified from the development trajectories of Internet applications? Addressing these questions, this paper draws upon ten years of macro-data from the Statistical Report on China's Internet Development to conduct a quantitative analysis, systematically examine the evolutionary trajectories of China's Internet demographic structure, and identify the developmental patterns of different Internet applications. The goal is to provide an analytical framework for understanding the macro-level evolution of China's Internet application ecosystem and to offer reference points for the modernization of the digital society governance system.

## 2. Data Source

The data for this study were extracted from the Statistical Report on China's Internet Development published by the China Internet Network Information Center (CNNIC) from 2015 to 2025<sup>①</sup>, spanning Reports No. 36 through No. 56. The extracted dimensions include time, Internet user base size, Internet penetration rate, mobile Internet user base, mobile Internet users as a proportion of total Internet users, urban and rural Internet user bases and penetration rates, gender structure, age structure (proportion of different age groups), average weekly online time per capita (hours), device access proportions, and user base and usage rates for major Internet applications<sup>②</sup>. It should be noted that this report is published twice per year, with statistical time points in June and December. Due to the impact of the COVID-19 pandemic, the report originally scheduled for December 2019 was postponed to March 2020; consequently, the statistical time points for 2020 include three nodes: March, June, and December.

## 3. Demographic Structure and Technology Awareness: Characteristics of China's Internet Population Development

As of June 2025, China's Internet user base reached 1.1223 billion, with the gender ratio maintaining a stable trend (see Figure 2). Examining the growth rate data over the past ten years, while the absolute size of the user base continues to expand, the growth rate has significantly decelerated, having now fallen to approximately 1%. The growth rate curve in Figure 2 reveals a peak in Internet growth during the 2019–2021 period, which indirectly reflects the catalytic effect of home-isolation policies during the COVID-19 pandemic on Internet penetration. During this phase, needs such as remote work, online education, and digital entertainment were rapidly released, accelerating within a short period the Internet penetration process among population segments that were originally less digitally engaged. Among them, mobile Internet users as a proportion of the total rose from 90.10% in 2015 to a peak of 99.3% during the pandemic, and has since stabilized at above 99%, indicating that mobile Internet access has approached universal coverage (see Figure 3). This further confirms that mobile terminals have become the primary means of Internet access and have, to a large degree, shaped the current digital ecosystem. It is evident that China's overall Internet user base has advanced from the initial rapid growth stage into a mature phase of steady development. As the demographic dividend fades, the developmental focus of the Internet industry is also shifting from acquiring new users to activating existing users and deeply mining the value of segmented usage scenarios in the future.

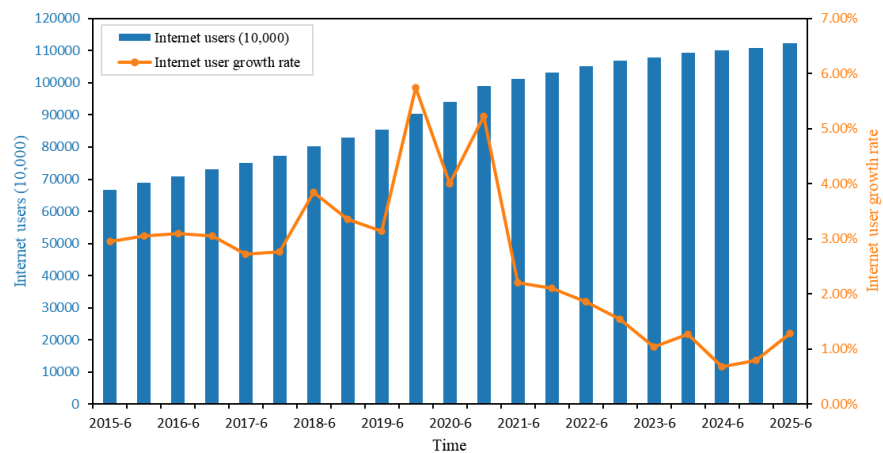


**Figure 2.** Overall Internet user base and growth trends

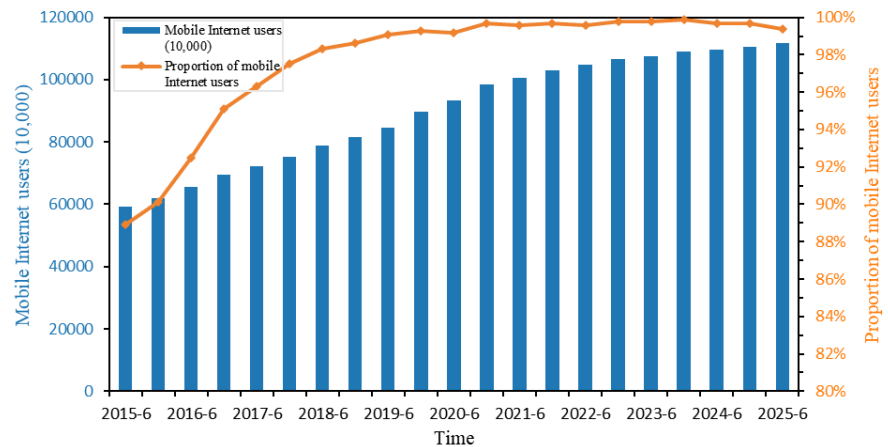


**Figure 3.** Mobile Internet users and their proportion

Through the analysis of long time-series data on the changing proportions of different age cohorts among Internet users over the past decade, it is found that the evolution of the Internet demographic structure exhibits two highly prominent trends. First, the degree of Internet penetration among middle-aged and older age cohorts has increased significantly. Before the time node of 2019, the proportion of users aged 50 and above was notably low, hovering around a relatively stable level of approximately 5%. A key turning point occurred after 2019, the proliferation of short videos, social media, telemedicine, and digital information access drove a leapfrog increase in the Internet penetration rate among middle-aged and older groups. Data as of June 2025 show that the growth rate of Internet penetration among the 50–59 age cohort ranks highest among all age groups, indicating that this cohort is becoming an increasingly indispensable component of the Internet user structure. Second, the base of underage Internet users is also steadily expanding, currently exceeding 196 million, with the proportion of the overall Internet user base showing an upward trend, reinforcing the trend of a younger user profile. The "Internet + education" model and the proliferation of digital technologies such as online learning platforms [6] and artificial intelligence are profoundly influencing the younger generation, while also imposing higher demands on their digital literacy. Although the proportion of the 6–10 age cohort has remained below 5%, under the backdrop of increasingly accessible digital touchpoints and widespread intelligent terminal devices, Internet use is becoming a necessity. Consequently, how to strengthen minors' cybersecurity awareness, digital literacy education, and online behavioral norms has become an unavoidable issue in digital governance and is critical to sustaining a healthy digital ecosystem [7]. In summary, the core drivers of China's Internet development are undergoing change, with the focus no longer resting solely on population scale but gradually shifting toward the structural optimization of the user base and the further differentiation of behavioral patterns. In this context, the subsequent sections will employ clustering methods to conduct

an in-depth analysis of the usage rates of major Internet applications, identifying usage patterns and behavioral differences across application categories, thereby providing support for understanding the micro-level mechanisms and new logics underlying the structural shifts in the digital society.

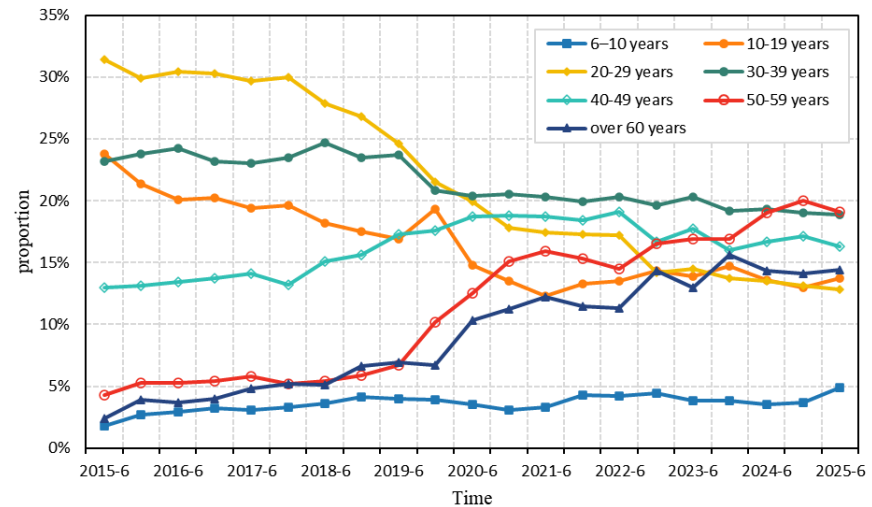


**Figure 4.** Trends in Internet penetration rates across different age cohorts over the past decade

#### 4. Behavioral Adoption and Diffusion: Pattern Recognition of Internet Application Usage

The deep integration of the Internet with big data, artificial intelligence, and the real economy has given rise to diverse application forms spanning digital tools, digital consumption, digital experiences, and digital services, with new business formats and models emerging continuously, providing new momentum for Internet development [8]. As of June 2025, China's major Internet applications have become increasingly active and their user bases have continued to grow. To provide a systematic, data-driven comparative perspective for interpreting the developmental pathways of different applications, this section explores whether there exist typical, generalizable patterns in China's Internet application landscape and what the dynamic characteristics of these patterns are. To this end, this study employs Time-Series Clustering, a quantitative clustering method, using the "usage rate" of 14 major Internet applications from 2015 to 2025 as the indicator for cluster analysis.

##### 4.1. Data Processing

User usage rate data for 14 categories of Internet applications from June 2015 to June 2025 were selected, forming 21 observation time points per time series. For applications where later observation time points preceded the initial report or

authorization time, the time of first reporting was used as the benchmark. Additionally, the dataset contained numerous missing values. For example, online education applications had no statistical data for June 2020 due to the pandemic; online healthcare and long-form video applications exhibited missing data from December 2021 to December 2022 due to changes in statistical scope. To preserve the continuity of the time series, missing values for online education and online healthcare applications were filled using linear interpolation; long-segment missing values at the boundaries of the statistical time series were uniformly filled with zero values.

## 4.2. DTW-Ward Clustering Modelling

To achieve pattern recognition of application development pathways, this study adopts a hierarchical clustering method based on Dynamic Time Warping (DTW-Ward) [9]. The method comprises the following two components:

**(1) Distance metric.** Traditional Euclidean distance directly compares numerical differences at the same time points, making it highly sensitive to minor offsets or asynchronous shifts in time series. However, different Internet applications may exhibit lead-lag effects in their diffusion curves, and differences in growth rates; such temporal elasticity and length discrepancies render traditional Euclidean-distance-based clustering methods less effective. Dynamic Time Warping (DTW) overcomes the offset problem by non-linearly warping the time axis to find the optimal alignment path between time series, thereby more accurately measuring pattern similarity between curves. For 20 application time series  $S = \{S_1, S_2, \dots, S_k\}$ ,  $1 \leq k \leq 20$ . Given two application time series  $S_i = \{s_{i1}, s_{i2}, \dots, s_{ip}\}$  and  $S_j = \{s_{j1}, s_{j2}, \dots, s_{jq}\}$ , with dimensions  $1 \leq p, q \leq 21$ , their distance matrix  $D$  can be expressed as:

$$D = \begin{bmatrix} d(s_{i1}, s_{jq}) & d(s_{i2}, s_{jq}) & \dots & d(s_{ip}, s_{jq}) \\ \vdots & \vdots & \vdots & \vdots \\ d(s_{i1}, s_{j2}) & d(s_{i2}, s_{j2}) & \dots & d(s_{ip}, s_{j2}) \\ d(s_{i1}, s_{j1}) & d(s_{i2}, s_{j1}) & \dots & d(s_{ip}, s_{j1}) \end{bmatrix} \quad (1)$$

where  $d(s_{ip}, s_{jq})$  represent the Euclidean distance between corresponding time points  $i$  and  $j$  of the two series. The warping path must satisfy boundary, monotonicity, and continuity constraints, and the cumulative distance along a local path  $D_T$  is:

$$D_T(s_{ig}, s_{jh}) = d(s_{ig}, s_{jh}) + \min[D_T(s_{ig}, s_{jh+1}), D_T(s_{ig+1}, s_{jh+1}), D_T(s_{ig+1}, s_{jh})] \quad (2)$$

Thus, the optimal warping path for time series  $S_i$  and  $S_j$  would be  $W^*$ , and the resulting distance are:

$$D_L(S_i, S_j) = D_T(W^*)(S_i, S_j) \quad (3)$$

**(2) Clustering algorithm.** The second component employs a bottom-up agglomerative hierarchical clustering algorithm. This algorithm does not require

pre-specifying the number of clusters. Its core logic is to initialize each sample as an independent cluster and then iteratively merge the most similar clusters based on the distance matrix. For the cluster merging criterion, Ward's minimum variance method is selected. The principle is to minimize the increase in within-cluster sum of squares after each merge, thereby yielding a clustering structure that is compact and highly interpretable.

### 4.3. Identification of Internet Application Development Patterns

To further explore the regularized development patterns within different application usage behaviors, the time series of usage rates for 14 Internet applications were used as features for hierarchical clustering, yielding the dendrogram shown in the left panel of Figure 5. Based on the dendrogram, cutting at a threshold value of 2 divides the applications into four clusters with distinct characteristics and meaningful interpretability. The time-varying usage rates of the four clusters, labeled by application, are visualized in the development pattern plots shown in the right panel of Figure 5. As can be observed, applications within the same cluster exhibit similar trajectory patterns.

Cohesive Clustering Analysis of Internet Application Development Patterns

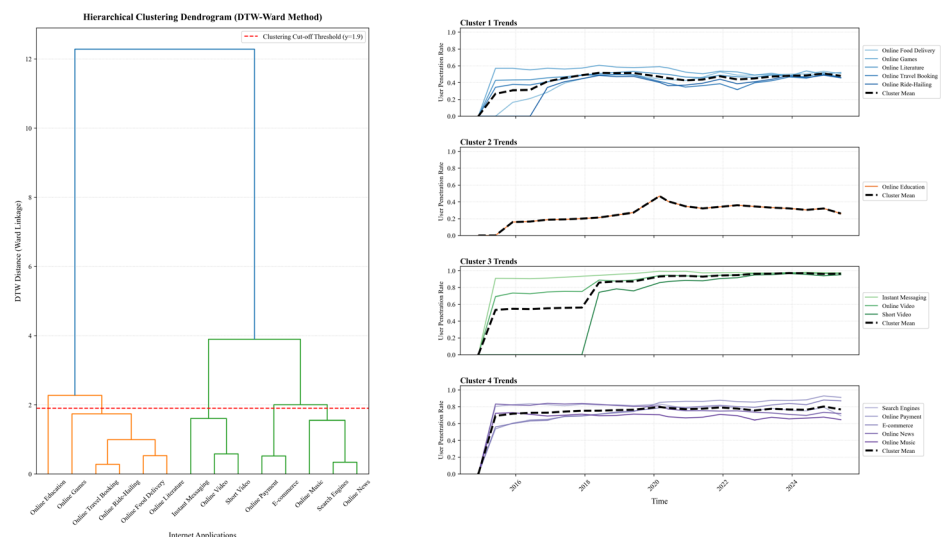


**Figure 5.** Hierarchical clustering dendrogram and clustering results of Internet application development patterns

**(1) Context-Dependent Fluctuation Convergence Pattern (Cluster 1).** Cluster 1 includes online gaming, live streaming, online education, online ride-hailing, and online ride-booking applications. Applications in this cluster exhibit relatively high initial usage rates, but their subsequent development is characterized by a pattern of fluctuation and convergence toward a plateau. Specifically, these applications began with usage rates in the 20%–60% range, experienced oscillation, and ultimately converged around the 50% level, which reflects a clear developmental ceiling. These applications are products of the deep integration of digital technology

and the real economy; their oscillatory pattern primarily stems from strong contextual dependence on real-world scenarios and real-world complexity. Their user base is often concentrated within specific demographic segments, with relatively fixed target user groups. Therefore, such applications should focus on intensive user operations (value mining from existing users) rather than extensive expansion (new user acquisition). At the same time, attention should be paid to the potential demand of future user cohorts, for instance, the health and wellness needs of the aging population in online education applications.

**(2) Exogenous-Shock-Driven Rise-and-Dcline (Inverted U-Shaped) Pattern (Cluster 2).** Cluster 2 is composed of a single application: online office/schooling. Its development trajectory displays a pronounced "exogenous shock" driven peak, an inverted U-shaped surge followed by decline. Specifically, this application's usage rate experienced explosive growth in the early period, displaying a clear rapid-climbing trend, reaching a peak of 46.8% around 2020, after which it gradually declined and returned to a lower level. This pathway is closely tied to mega-events during a specific period: under the pandemic-driven home-isolation policy, demand for online learning and remote work was passively and dramatically activated, and user behavior shifted rapidly online. As society returned to normalcy, the rigid demand for remote work and online education gradually receded to offline settings, and the online office/schooling usage rate correspondingly declined. However, while short-term shocks and rapid growth have subsided, the usage rate remains elevated compared with the pre-peak period, indicating that online office applications have solidified their role as an effective complement to knowledge acquisition and productivity.

**(3) Network-Effect-Driven Rapid Saturation Pattern (Cluster 3).** Cluster 3 comprises instant messaging, short video, and long-form video applications. The development trajectories in the figure show that usage rates for these applications rose rapidly early on and subsequently maintained levels close to the ceiling. Among them, instant messaging was the earliest to show a large user base; short video, marked by the rise of Douyin (TikTok) in 2016, benefited from recommendation algorithms, intelligent distribution technologies, and the wave of we-media development, achieving widespread dissemination. Within the observation window, short video's initial usage rate was as high as 74.1% and has since climbed to over 95%; together with instant messaging, it forms an indispensable digital infrastructure. It is evident that applications in this cluster have entered a fully saturated stage approaching universal penetration, inter-platform competition will intensify around the retention and redistribution of existing users' attention, making the negative externalities potentially generated by high application penetration a governance issue that warrants serious attention.

**(4) Ecological-Synergy-Driven Steady Growth Pattern (Cluster 4).** Cluster 4 includes search engines, online payment, online shopping, online news, and digital

music applications. The trajectories of online payment and online shopping display a classic S-shaped curve form, consistent with Rogers' innovation diffusion theory predictions. The average usage rate for applications in this cluster rose steadily from approximately 50% in 2015 to a high level of 90% by 2025, with a smooth and continuous upward trend, reflecting robust and sustained market demand. The overall development of this cluster is steady, with usage rates concentrated in the 60%–90% range. Broadly, the growth momentum of these applications has reached a mature and stable state, with no significant short-term drivers for a second growth spurt. These applications fulfill users' stable and repetitive functional needs, exhibiting the characteristics of infrastructure-type applications.

## 5. Implications for Digital Ecosystem Governance

Drawing on the preceding analysis of demographic structural evolution and the pattern mining of Internet applications, it is evident that the maturation of the Internet ecosystem is manifested not only in the progression of innovation diffusion but also in the synergistic relationships among multiple agents. Based on this, the following policy recommendations are proposed for three dimensions of ecological synergy of government, industry, and society.

**(1) Government dimension.** The government should take the synergistic evolution of the digital application ecosystem as its guiding objective and promote the optimization of the digital demographic structure through tiered, differentiated policy intervention mechanisms. At the demographic structure level, attention should be directed to the quality of digital engagement among youth, as well as to cybersecurity awareness and digital literacy education among middle-aged and older groups, progressively constructing a multi-layered digital literacy cultivation system. At the Internet application level, differentiated governance policies should be formulated in accordance with the distinct development patterns of different Internet applications, promoting cross-modal integration and innovation while strengthening information security and privacy protection.

**(2) Industry dimension.** Enterprises should recognize the positioning of digital products within the ecosystem, viewing Internet applications as identifiable, analyzable dynamic systems. They should match heterogeneous strategic approaches based on different patterns for precision decision-making. For "fluctuation-convergence" type applications, efforts should be directed at activating existing users and intensively cultivating segmented markets. For "rapid-saturation" type applications, enterprises should leverage data-driven innovation and actively explore new avenues for monetization and commercial diversification to seek new growth curves. For "steady-growth" type applications, platform synergy should be strengthened to build a diverse and integrated ecosystem to further consolidate competitive advantages, such as forming synergistic, mutual-reinforcement dynamics.

**(3) Society dimension.** In the course of digitalization, achieving digital equity and inclusiveness remains a core issue of concern. With the deepening penetration of the Internet among youth and older cohorts and the widespread application of artificial intelligence in the new phase, the role played by Internet use is gradually shifting from optional to essential in daily life and learning. However, the digital divide and issues such as algorithm-induced information cocoons, addiction to recommendations, fraud, and other harms are exhibiting an amplifying trend that far exceeds the pace of enhancement in digital literacy. Whether the existing family-school-society collaborative education model can effectively address these multi-dimensional challenges remains questionable. Therefore, it is necessary to establish an integrated education system centered on family-school-society collaboration, elevating the risk prevention capabilities and digital literacy levels of key demographic groups through policy guidance, preventive intervention, and digital-support-based approaches. At the same time, promoting corporate platform social responsibility, like building diverse, co-governing, and shared digital ecosystems, is also crucial to achieving digital equity and sustainable development.

## 6. Conclusion

This study collected statistical data from the Statistical Report on China's Internet Development spanning 2015–2025 and conducted analysis within the framework of innovation diffusion theory. First, through visualization of the demographic structure, the study effectively identified several key trends: universal mobile Internet penetration, the fading of the traditional demographic dividend and the concurrent shift toward both younger and older user profiles, and the leapfrog growth of middle-aged and older user cohorts. Second, using the DTW-Ward hierarchical clustering method, the time-series usage data of 14 Internet applications were analyzed, successfully identifying four heterogeneous development patterns: context-dependent fluctuation convergence, exogenous-shock-driven rise-and-decline, network-effect-driven rapid saturation, and ecological-synergy-driven steady growth. The findings provide a transferable analytical framework for interpreting the evolutionary pathways of Internet applications, aiding enterprises in identifying the macro-evolutionary patterns within which specific applications are situated, thereby enabling forward-looking business strategy formulation. At the same time, these findings offer a reference basis for governments to design differentiated digital governance and digital literacy enhancement measures.

The limitations of this study lie in the fact that the data used are macro-level Internet data, making it difficult to capture individual-level differences in usage behavior and motivations. The conclusions of the study represent an exploratory application of macro data, and the potential impact of artificial intelligence technologies on Internet usage behavior patterns merits further investigation. In addition, more granular

individual user-level data are needed for deeper analysis, as AI is becoming a significant factor that reshapes information ecosystems and may further alter the landscape of the digital society [10]. Future research could focus on behavioral data to more precisely delineate the internal structural dynamics and evolutionary mechanisms of the digital society, which is an important direction worthy of deeper and more enriched exploration.

## Acknowledgements

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## Notes

- ① The statistical reports are sourced from: <https://cnnic.cn/6/86/88/index1.html>. The reports are semi-annual; the data cutoff for the most recent report cited is July 21, 2025.
- ② The Internet applications covered include: Instant Messaging, Search Engines, Online Payment, E-commerce, Online Food Delivery, Online Video, Online Games, Online Literature, Online Travel Booking, Online Ride-Hailing, Online Education, Short Video, Online News, Online Music.

## References

- [1] Liu, S. (2022). A Study on Chinese Internet Population and Digital Humanistic Development. *Population Journal*, 44(6), 33–37. (In Chinese)
- [2] Xie, X. and Zhang, J. (2025). Thirty Years of the Internet in China: Formation and Development of Internet with Chinese Characteristics. *Journal of Information Resources Management*, 15(1), 21–29. (In Chinese)
- [3] Wu, S. and Zhang, Y. (2019). Internet user profiles in China and their evolution: A historical perspective based on diffusion of innovation theory. *Shanghai Journalism Review*, (10), 20–30. (In Chinese)
- [4] Fang, X. and Wang, B. (2023). 30 Years of Chinese Internet: A Perspective of Internet Users' Group Portrait. *Media Observer*, (1), 60–72. (In Chinese)
- [5] Rogers E., Singhal A., and Quinlan M. *Diffusion of innovations[M]//An integrated approach to communication theory and research*. Routledge, 2014: 432-448.
- [6] Qin, Y., Liu, G., Liu, Y., et al. (2024). Research on the Construction of an Evaluation Index System for Adolescent Cognitive Development in Internet Educational Applications. *China Educational Technology*, (8), 62–70. (In Chinese)
- [7] Han, B. and Wang, H. (2025). Research on the Main Theme of the Comprehensive Governance of Cyberspace in the New Era. *Journal of Journalism & Communication Studies*, 32(2), 5–19+126. (In Chinese)
- [8] Guo, Q. and Zhang, J. (2024). China's 30 years of Internet development: A "five-new" analytical framework of accelerated innovation diffusion. *Journalism Lover*, (8), 10–16. (In Chinese)
- [9] Liu, Y. (2016). Research and Application of Panel Data Clustering Method Based on Dynamic Time Warping. *Statistical Research*, 33(11), 93–101. (In Chinese)

- [10] Zhang, H., Bu, J. M., Zhang, S., et al. (2025). AI large models and the new global Internet ecosystem: Spatial structure, user landscape, and content production based on information flows. *News and Writing*, (12), 5–17. (In Chinese)