The Economic Development Model and Strategy Selection of the Internet of Things Based on Big Data

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ABSTRACT

The internet of things (IoT) has become a key support object for Chinese strategic emerging industries. It is of great practical significance to promote the construction of the internet of things. Driven by national policies, the development of the internet of things in China has achieved certain results, but it also faces many problems. For example, there are few theoretical and empirical studies on the internet of things economy. In this context, from the perspective of big data, this paper studies the development model and influencing factors of the internet of things economy, and takes Jiangsu Province as an example to put forward development strategies. This article studies the three-stage development model of the IoT economic big data ecosystem: the primary stage, the growth and maturity stage, and the integration stage. On the basis of the research on the development model, the general evaluation method of the economic development model of the internet of things from the perspective of big data is studied, and the general model of strategy selection is established.

KEYWORDS

big data perspective, development model, Internet of Things economy, strategy choice

INTRODUCTION

Mankind has experienced three technological revolutions between the 18th century and the present. These include the steam revolution in the 1960s, the electric power revolution in the 1970s, and the information technology revolution at the beginning of the 20th century (Bi & Wang, 2021). The information technology revolution has led to changes in politics, the economy, culture, education, and many other fields. It has profoundly influenced and changed the work and lifestyle of humans, becoming a driving force for the development of modern productive forces (Bhatti et al., 2021).

The information industry has experienced three revolutions. The first revolution is represented by computer information processing. The second is information transmission, represented by Internet

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and network communications. The third revolution will be represented by the rapid development of the internet of things (IoT), which is denoted by connection, information acquisition, and perception (Li et al., 2022).

The digital economy (also known as the knowledge economy, information economy, and innovation economy) is a new economic form based on computer networks like the Internet (Xiao et al., 2017). As of late December 2014, the Internet penetration rate in China was 47.9%, an increase of 2.1% from the end of 2013. The number of Chinese netizens ranked first in the world (Throne & Lăzăroiu, 2020).

On August 7, 2009, Wen Jiabao inspected the Wuxi High-tech Yuna Engineering Technology R&D Centre of the Chinese Academy of Sciences. He pointed out that it is necessary to break through key technologies as soon as possible and cultivate new growth points. In late September of the same year, the IoT concept took shape. It went on to develop rapidly, spreading among hundreds of millions of shareholders. By 2015, the Chinese IoT industry initially formed an IoT development pattern driven by innovation, application, coordinated development, safety, and control.

In 2012, the Economic and Information Commission of Jiangsu Province issued the 12th Five-Year Development Plan for the IoT industry in Jiangsu Province. According to the plan, Jiangsu Province aims to develop the IoT economy and narrow the gap between it and developed countries.

The Chinese 12th Five-Year Plan takes scientific development as its theme and focus. The development of the IoT economy accelerates the transformation of the Chinese economic development mode, achieved through scientific development in economics, politics, society, culture, and other aspects (Sestino et al., 2020). It involves the application of advanced technologies like infrared sensor technology, radio frequency technology, laser scanning technology, and global positioning technology. It also uses a variety of technologies to connect the Internet and mobile communication networks as it realizes the intellectualization of technology (Nobre & Tavares, 2017).

The development of the IoT economy will promote the transformation of the Chinese economic structure, which is currently in a period of optimization. Industrial development is changing from extensive to intensive. The development of the IoT economy can further promote the adjustment of industrial structures and enhance the economic structure (Guo et al., 2014). These changes are conducive to environmental improvements that lead to more suitable living environments and a higher level of living standards.

China, which is in a period of urban-rural integration construction, requires rural construction through the development of smart agriculture, smart industry, and smart circulation industry. Changes will occur in production and living environments in rural areas, promoting the integrated development of urban and rural areas (Xie et al., 2020). Contributions will be made to the innovation of service models, driving the development of emerging industries.

The Internet has subverted the traditional big data model. In turn, competition between enterprises appeals to the customer. Enterprises must, therefore, adapt to this change. Results will include improved work efficiency, healthy living, and energy savings.

It has become more important to conduct research on the Internet economy due to the rapid development of China's Internet economy. From a macro perspective, the Internet economy has a vital impact on the adjustment of the economic structure, transformation of resource allocation, and provision of jobs. The development of the Internet economy plays a role in stimulating the growth of the national economy and improving the technological content of economic growth. From a mesoscopic level (the perspective of industrial development), the Internet economy drives the development of related industries. This includes the development of business formats like online trade, online shopping, online tourism, and online payments. It also encompasses network base stations, optical fiber cables, and network terminals. From a micro level, the establishment of a large-scale network virtual market can change the traditional transaction mode, reduce social transaction costs, and promote endogenous growth (Abu Ghazaleh & Zabadi, 2020).

MATERIALS AND METHODS

Related Work

Zhao et al. (2016) presented a new framework for the efficient analysis of high-dimensional economic big data based on innovative distributed feature selection. The feature subset obtained by a single feature selection method may be biased; therefore, an ensemble feature selection method (SA-EFS) based on sort aggregation is proposed. This method is oriented to classification tasks (Wang et al., 2019). Jiang et al. (2019) used a Web crawler program to obtain a large amount of data on agricultural product prices from the Internet. To further enhance the performance of machine learning-based IDS(Intrusion Detection System), Zhong et al. (2020) proposed the big data-based hierarchical deep learning system (BDHDLS). Yaoteng and Xin (2022) explored the sustainable development strategy of green finance under the background of big data. Duan et al. (2021) combined the competitive characteristics of economic forestry products and the development of the Internet. The model of brand value enhancement of economic forestry products based on virtual brand communities is then constructed (Duan et al., 2021).

The use of artificial intelligence technology in e-commerce can improve the service quality and work efficiency of the e-commerce sales link. The construction of urban green space is, thus, an indispensable part of every urban ecosystem, playing an active role in promoting urban economy and development. Cao (2021) used this as a starting point, studying the structure of plant communities, pattern of plant landscapes, and correlation between plant ecological factors inside and outside the plant community. Applying big data technology to the macrodecision of regional economic information is an effective way to make a macrodecision within the current economy.

Based on this background, Lin (2022) proposed a macroeconomic decision-making method for regional industries based on big data technology. Conversely, classifier efficiency and predictive accuracy and data legality could not be optimal for practical application. In this view, Venkateswarlu et al. (2022) developed an oppositional ant lion optimizer-based feature selection with a machine learning-enabled classification (OALOFS-MLC) model for FCP in a big data environment.

Concept of Internet Economy

The Internet economy includes network infrastructure in the network economy, interconnected electronic markets, online merchants and customers, electronic money systems, legal and policy frameworks, and other factors. It proposes the four-layer structure of network economy via an electronic network, application, middleware, and online transaction (Rezabakhsh et al., 2006). According to the current article, the Internet economy is the sum of all economic activities generated by the Internet. It also includes all economic activities related to production, exchange, distribution, and consumption generated through the Internet.

More people are accessing the Internet due to its rapid development. Users, in turn, leave traces when surfing the Internet, such as browsing the Web or shopping online (Hou et al., 2020). Big data collects and transforms these traces into data (Lakshmanaprabu et al., 2019). Big data may profoundly affect our lives in the future and impact the Internet economy. One way to improve the use of big data is to improve information content and the value of big data (Ingemarsdotter et al., 2019).

The Internet economy has broken the most core transaction model in traditional economic activities. It has completed the information flow, logistics, and capital flow of transactions through the Internet, giving birth to new business models and service formats. Its development is inseparable from financial support. Corresponding financial innovation is inevitably required. Experts analyzed the main performance of financial innovation in the Internet economy, pointing out the characteristics of financial innovation in the Internet economy, including expanding financing channels, improving market efficiency, combining payment, financing, and transactions, and improving network effects (Liu et al., 2020).

The IoT economy aims to accelerate industrial integration, change corporate development strategies, and promote innovation. Feng and Liao (2020) studied the integration of the Internet economy and traditional enterprises from the perspective of industrial integration. They found that industrial integration under the Internet economy is a permeable integration.

Chinese Internet economic development is positive; however, there are regional differences. The development of the Internet has changed traditional lifestyles and some cultures, impacting routines they apply to shopping methods and payment methods. With the help of the cultural perspective, scholars have studied the influence of regional culture on the development of the Internet economy. They have put forward countermeasures and suggestions for the coordinated development of culture and Internet within a region (Campbell, 2011).

Based on the above review, the early definition and research scope of the Internet economy stems from the perspective of e-commerce. Over time, the definition of the Internet economy continues to develop. Traditional Internet economic activities (e.g., e-commerce, online games, and online searches) include economic activities involved in social media, cloud computing economy, IoT economy, and emerging network technologies and applications like big data and mobile network economic activities (Koot et al., 2021). Information technology and terminal production technology continues to evolve, as does the innovation of the big data model of the network economy (Nobre & Tavares, 2020).

IoT Economic Research

Serving as a conceptual economy, the IoT economy is an economic form based on the Internet. It is the economic format of dissemination in the non-real economy. The IoT economy transforms the traditional economic model by using IoT technology, making the economic model more intelligent. It alters the most basic operating laws of the traditional economy. The economics of the IoT is, therefore, a comprehensive discipline (Xu et al., 2022).

Currently, there is no unified definition of the IoT economy. As a new economic form, it does not have a significant impact on the traditional economy. In addition, scholars have invested little time to the subject. According to this article, the IoT economy is a high degree of knowledge and information as main resources. It dominates the IoT industry. The value is expressed as intelligent products and material products are used as auxiliary products.

At present, research on the IoT economy focuses on theoretical analysis. The scope of the research is also limited to the entire IoT industry chain. In recent years, the IoT economy has developed rapidly, contributing to the gross domestic product. To conduct more in-depth research on the IoT economy and better promote the development of the IoT economy, it is necessary to study the IoT economy and big data ecosystem in which it is located.

In traditional IoT economic models, the system often uses a centralized architecture in which IoT devices are connected to a central server through a centralized connection. In this model, IoT devices send the collected data to a central server for processing and analysis. However, this architecture has limitations. First, IoT devices usually have limited computational and storage capabilities. Thus, the main data processing and analysis tasks rely on the central server. Second, the data needs to be transmitted to the central server to process results in high communication latency. This seems less applicable in scenarios with high real-time requirements. In addition, setting up and maintaining the central server and related infrastructures may bring considerable cost pressures.

Data privacy and security are two prominent issues. As data is stored and processed centrally during transmission, this may increase the risk of data privacy and security. Data that is not properly protected may be compromised during transmission, triggering potential privacy and security breaches.

In summary, the traditional centralized IoT economic model suffers from challenges like limited computing power, high communication latency, high costs, and data privacy issues.

RESULTS AND DISCUSSION

To analyze the scale of the IoT economy from the perspective of big data, we can learn from the population growth model in the ecological theory. Any population grows in a certain space. With the change of time, the population shows a certain quantitative change. The growth function has two forms. One is the exponential type (J type), which represents the Gompertz curve model. This type is suitable for the infinite growth of the population. The characteristics of the phenomenon described by Gompertz curve are a slow initial growth and a gradual acceleration. When it reaches a certain degree, the growth rate gradually decreases. Finally, it approaches a horizontal line. The Gompertz curve is often used to describe the periodic process of the development of things from germination or growth to saturation. The other is the logistic type (S type), which represents the logistic curve model. The logistic model is suitable for population competition under certain spatial and resource conditions. The form is as follows:

The general model of the Gompertz curve can be transformed into:

$$Y = K + Agb^{t} \tag{1}$$

The general model of the logistic curve is:

$$y = {}^{1}\!\Big/_{1 + ab^{t}} \tag{2}$$

In the above formulas, *a* and *b* represent the external influence coefficient and internal influence coefficient, respectively.

Economic Development Model of IoT: Big Data Perspective

Primary Stage

At this stage, the IoT economy is in early development. The government plays a major role in promoting the development of the IoT economy (Tzafestas, 2018). Target industries during this period included the fields of public management and public service. The government's goal is to optimize the efficiency of these industries to obtain profits by reducing management costs, energy consumption, and environmental protection costs.

Growth and Maturity Stage

A mature IoT has been formed through technological innovation and the IoT economy has begun to take shape. Different industries have achieved a mature mode of economic development of the IoT. The profit margin has increased steadily as the company's benefits have gradually increased to the maximum and entered a stable period of development (Tang et al., 2018). The development of the IoT industry is gradually slowing.

Integration Stage

This is an advanced stage of the economic development of the IoT. All parties involved in the IoT achieve a high degree of integration. The government gathers manufacturers, integrators, operators, and developers to build a cloud computing platform. This model is also a manifestation of public goods. It integrates internal and external resources through the cloud platform, collecting the behavior and data of all participants. It opens application interfaces and permissions for the corresponding participants, forming a networked development model in which managers, merchants, users, and other market participants create value together (Buyya et al., 2010).

Evaluation of the Economic Development Model of the IoT: Big Data Perspective

Selection of Evaluation Methods

The evaluation process of the economic development model of the IoT from the perspective of big data includes indicators that are difficult to quantify or directly compare. Therefore, it needs to be judged according to the experience of the evaluator. When there are more qualitative problems and fewer quantitative problems, the AHP(Analytic Hierarchy Process) and fuzzy comprehensive evaluation methods are usually used.

In this article, AHP is used to determine the weight of indicators at all levels. After determining the index weights, the cloud model method is selected for systematic evaluation and analysis. Compared with the fuzzy comprehensive evaluation method, the cloud model method can account for randomness and fuzziness. It has a positive effect on solving complex and fuzzy systems. It can also realize the conversion between qualitative and quantitative problems, making the evaluation results more convincing. The results are closer to expectations.

At the same time, the cloud model method can effectively reduce the subjective feelings of experts in the evaluation process. Using the fuzzy processing of the evaluation language, it is convenient to quantify the randomness and ambiguity indicators. Thus, it improves the evaluation accuracy.

The specific algorithm steps are as follows:
Calculate the average value of this group of samples from the sample point x.

$$Ex = \bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{3}$$

Calculation of sample variance.

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{X}\right)^2 \tag{4}$$

Entropy and Hyper: Calculation method of entropy.

$$En = \sqrt{\frac{\pi}{2}} \times \frac{1}{n}\sum_{i=1}^{n}\left|x_i - Ex\right| \tag{5}$$

$$He = \sqrt{S^2 - En^2} \tag{6}$$

The comment cloud needs to calculate the digital features. The calculation formula is as follows:

$$\begin{aligned} Ex &= \left(C_{\min} + C_{\max}\right)/2 \\ En &= \left(C_{\max} - C_{\min}\right)/6 \\ He &= k \end{aligned} \tag{7}$$

$$Ex = \frac{Ex_1 \times En_1 + Ex_2 \times En_2 + Ex_3 \times En_3}{En_1 + En_2 + En_3} \tag{8}$$

$$En = En_1 + En_2 + En_3 \tag{9}$$

$$He = \frac{He_1 \times En_1 + He_2 \times En_2 + He_3 \times En_3}{En_1 + En_2 + En_3} \tag{10}$$

The cloud model uses a multi-level comprehensive evaluation. The specific equation is as follows:

$$Ex = \frac{Ex_1 \times En_1 \times W_1 + Ex_2 \times En_2 \times W_2 + \cdots + Ex_n \times En_n \times W_n}{En_1 \times W_1 + En_2 \times W_2 + \cdots + En_n \times W_n} \tag{11}$$

$$En = \left(En_1 \times W_1 + En_2 \times W_2 + \cdots + En_n \times W_n\right) \times n \tag{12}$$

$$He = \frac{He_1 \times En_1 \times W_1 + He_2 \times En_2 \times W_2 + \cdots + He_n \times En_n \times W_n}{En_1 \times W_1 + En_2 \times W_2 + \cdots + En_n \times W_n} \tag{13}$$

$$\begin{cases} Ex = \sum_{i=1}^{n} Ex_i W_i \\ En = \sqrt{\sum_{i=1}^{n} En_i^2 W_i} \\ He = \sum_{i=1}^{n} He_i W_i \end{cases} \tag{14}$$

According to the calculated digital features, use the forward cloud generator to generate cloud entropy. Draw a cloud map of the total evaluation cloud. If necessary, the membership degree of the final evaluation result cloud and each comment cloud can be calculated according to equation 8.

$$\Phi = \exp\left[\frac{-\left(x - Ex\right)^2}{2\left(En\right)^2}\right] \tag{15}$$

To analyze the elements of IoT economic strategy selection from the perspective of big data, it is necessary to consider the external environment and players (and their influence) within the system. Specifically, according to the research in this article, it includes six elements: (1) resource integration; (2) customer demand; (3) product production; (4) product promotion; (5) funding; and (6) branding. See Figure 1.

These elements need to be analyzed at different stages of the economic development of the IoT. In addition, each element plays a unique role in the different stages. The IoT economy in this article is viewed from the perspective of big data. Therefore, environmental factors must be considered. The PEST(Political, Economic, Social, Technological) method is suitable for this analysis based on environmental factors. This article, therefore, adds the PEST analysis method to the strategy selection.

The system of the IoT economy under big data includes the primary stage, growth and maturity stage, and integration stage (Grau et al., 2017). The core subject, individual roles, value chain, co-opetitive relationship, operation model, marketing model, and cost and profit of the system differ at various stages of development. Thus, the strategy choices at different stages also vary (Liu et al., 2019).

This article's model is based on the analysis of the influencing factors of the IoT economy, the analysis of the development model, and the analysis of the elements at this stage. This model can be applied in each stage. There are certain differences that are reflected in the analysis. Both the content of the research and the focus are different (Cavalieri et al., 2021). The research can formulate targeted countermeasures and suggestions based on the results of the strategy selection model at this stage, as shown in Figure 2.

In the above model, the analysis is carried out under the basic condition of the big data perspective. First, the influencing factors of the IoT economy are analyzed. The existing problems are found from the influencing factors. Then, the development of this stage is analyzed. Next, through the evaluation of the development mode, we can understand the development status of different indicators. These are evaluated by "excellent," "good," "general," "relatively poor," and "poor." Then, we find the existing problems and make adjustments. Finally, the PEST comprehensive

Figure 1. Elements of strategy selection

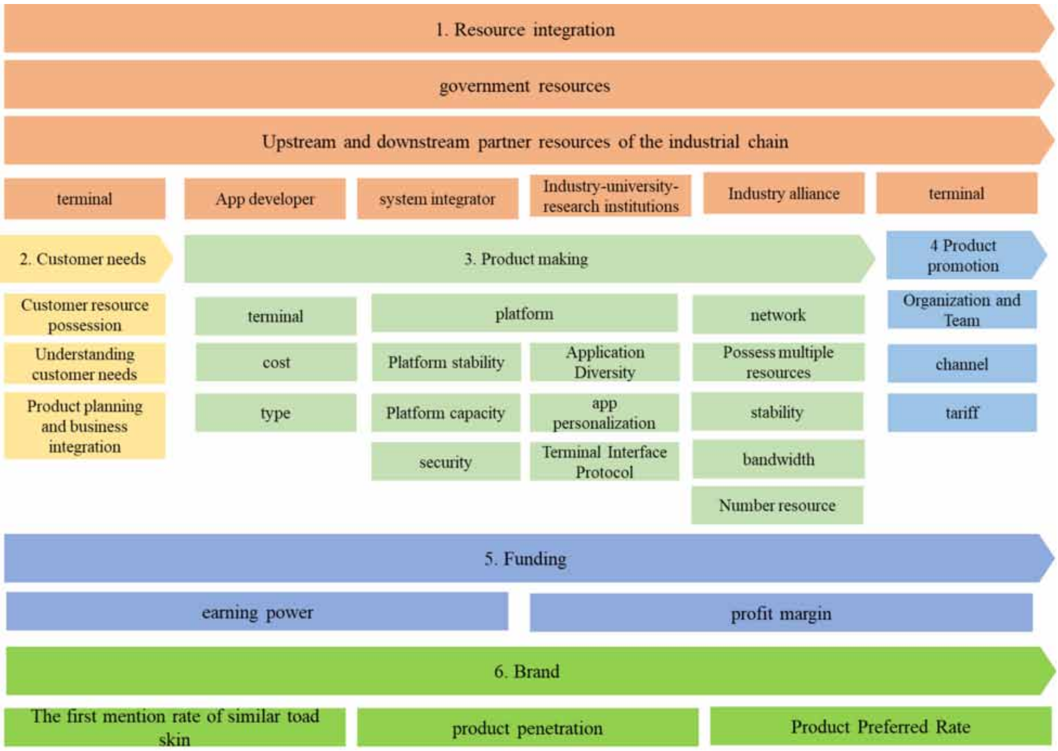
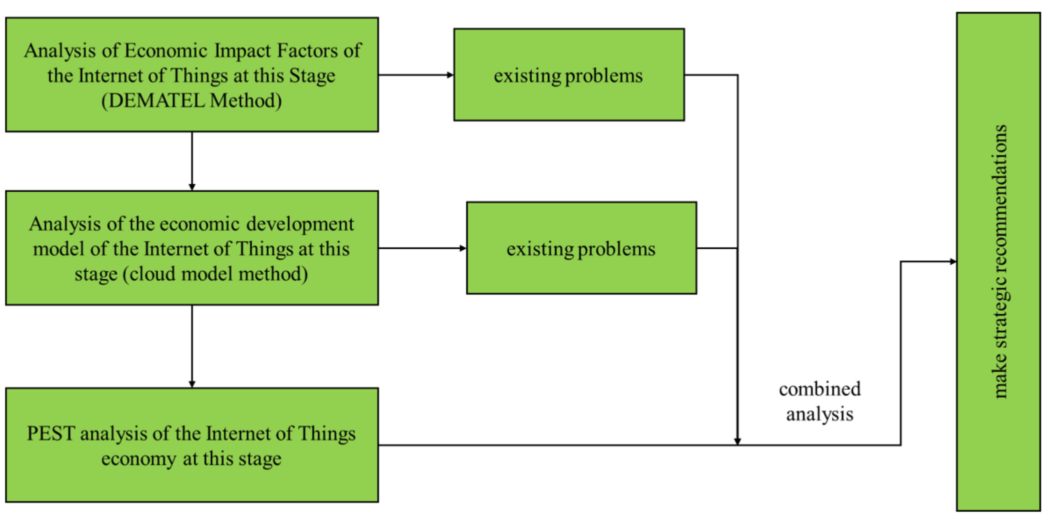


Figure 2. Theoretical model of IOT economic strategy selection from the perspective of big data



analysis method is used to further understand the environmental factors of the IoT economy. It is combined with the analysis results of the influencing factors and development models before effective strategic suggestions are put forward.

This article first outlines the development model of the IoT economy from the perspective of big data. Then, it analyzes the development model of the initial stage, the growth and maturity stage, and the integration stage. Based on the above analysis, a general method for evaluating the economic development model of the IoT is proposed (the cloud model method). A general model of the strategy selection of the IoT economy is established. After analyzing the influencing factors and the PEST analysis of the development model, the model finds the existing problems and puts forward countermeasures and suggestions.

RESULTS AND DISCUSSION

This article establishes a general evaluation model and general strategy selection model for the economic development of the IoT from the perspective of big data. Whether the application of the model is general requires an empirical test. This article uses data for verification. It is expected that this model can be applied to other regions through verification.

This section takes the economic development model of the IoT in Jiangsu Province as an example. It aims to understand the development status of the IoT economy in Jiangsu Province through the evaluation of problems. At the same time, it provides suggestions for better development in the next stage.

The process of data selection involves the first-level indicators of evaluation, four subsystems of informatization development level, equipment level, research and development level, and development effect derived from relevant yearbooks and survey reports. There are a total of 10 experts from the Provincial IoT Research and Development Center, department of IoT in colleges and universities, and IoT practitioners.

This section hopes to provide quantitative data to provide reference for experts to score and ensure the reliability of the survey. The article selects the years 2010 through 2013 as relevant data of Jiangsu Province. It comes from the Jiangsu Province Statistical Yearbook, Jiangsu Province High-Tech Industry Statistical Yearbook, and Jiangsu Province Internet Development Report. A small amount of missing data is supplemented by regression fitting. The quantitative data is shown in Figures 3 through 5.

Judging from the above-mentioned indicators, the development stage of the IoT economy in Jiangsu Province is at the end of the primary stage of the IoT economy.

This article uses the cloud model in the previous section to evaluate the evaluation factors and generate the results.

This article adopts a five-segment scoring method. The standard is: “good = [0.8,1], good = [0.6,0.8), general [0.4,0.6), relatively poor = [0.2,0.4), poor = [0 0.2),” totaling five levels. According to equation 7, the numerical features of the comment cloud are calculated as cbud1(1,0.10,0.01), ckoud2(0.7,0.07,0.01), cloud3(0.5,0.07,0.01), ckoud4(0.3,0.10,0.01), and cbud5(0, 0.10, 0.01). According to the MATLAB program (combined with the specific steps of cloud model evaluation), the cloud image obtained for evaluation is shown in Figure 6.

The score of the economic development model of the IoT in Jiangsu Province comes from 10 experts. The expert scores are according to the classification level. According to the scoring table by experts, the total cloud (U) and cloud characteristic values of seven first-level indicators were calculated using the reverse generator in the cloud model, MATLABR2009a software, and a combination of the calculation steps of the cloud model.

After obtaining the eigenvalues through the cloud model forward generator and matlab program, the overall cloud map of the economic development model of the IoT in Jiangsu Province can be obtained. See Figure 7.

Referring to the comment set cloud, it can be intuitively seen from Figures 6 and 7 that the evaluation of the development model of the IoT in Jiangsu Province is between the comment cloud cloud2 (0.7, 0.07, 0.01) and cloud3 (0.5, 0.07, 0.01), between “good” and “fair.” It is closer to “good.”

Figure 3. Quantitative index data of the level of informatization development

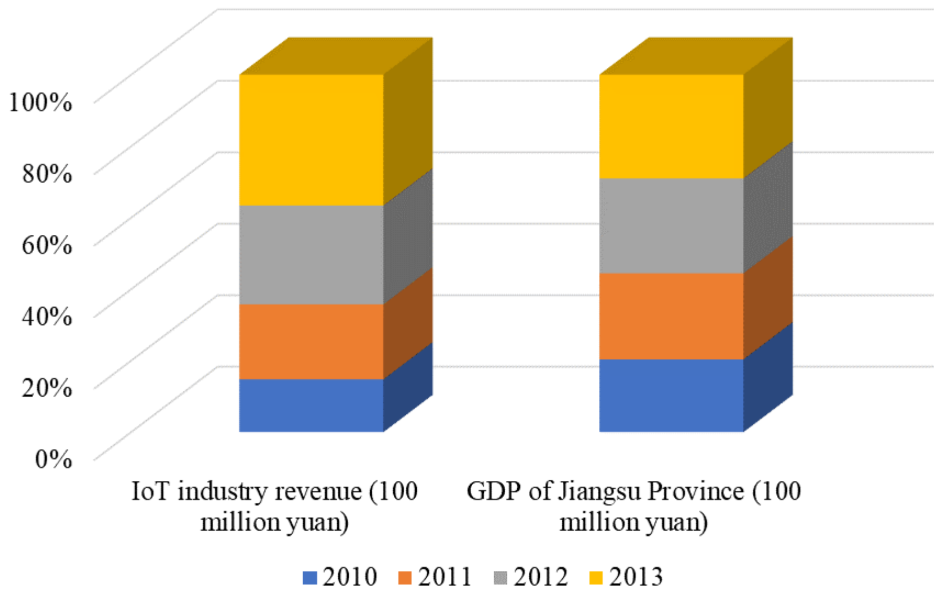
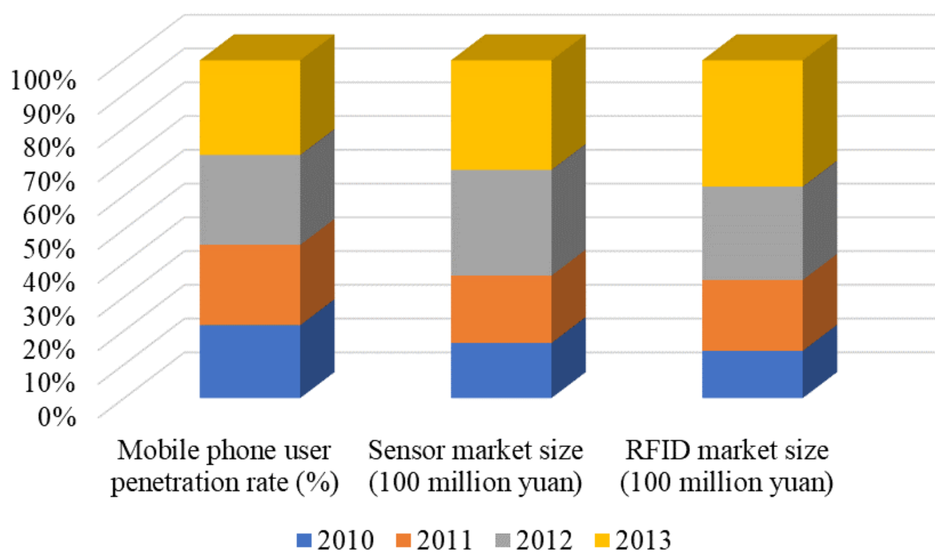


Figure 4. Quantitative index data of equipment level



According to the calculated eigenvalues, combined with the forward cloud generator, the evaluation and comparison cloud map of each first-level index of the economic development model of the IoT in Jiangsu Province can be drawn.

Figure 5. Quantitative index data of development effect

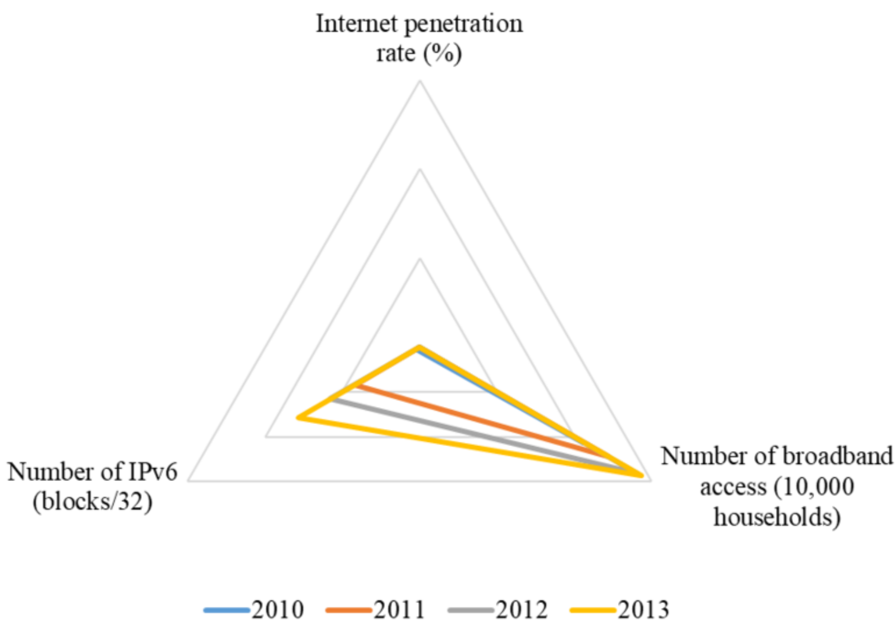


Figure 6. Cloud map of the evaluation model

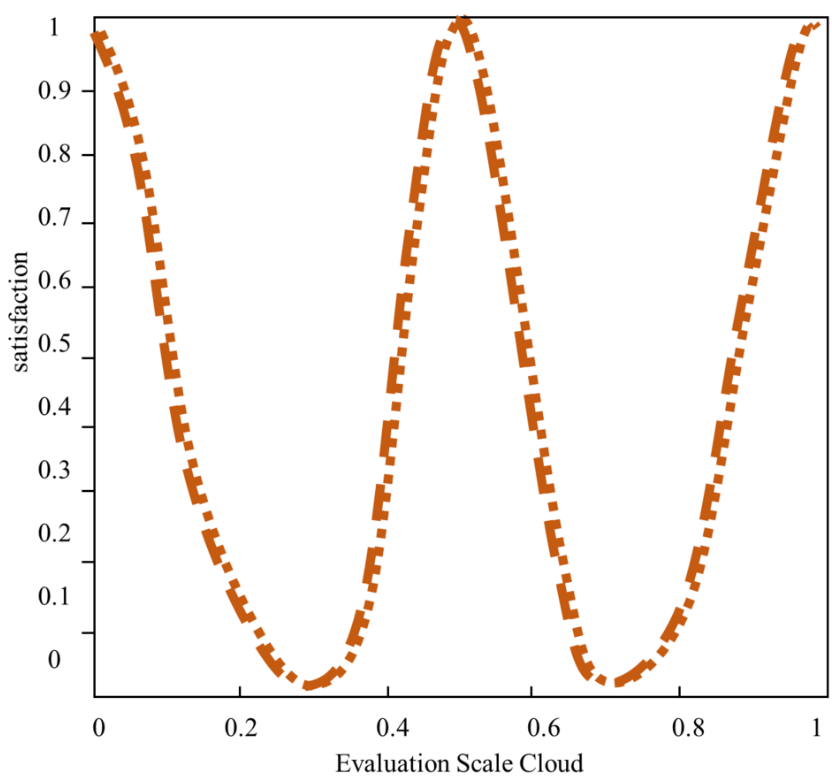
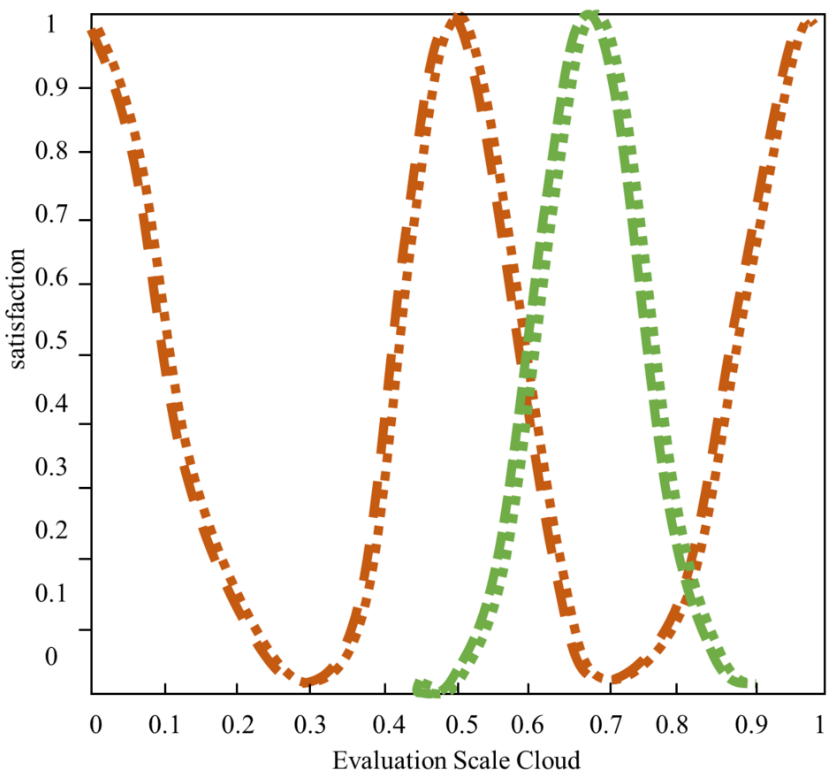


Figure 7. Overall cloud map of the evaluation of the economic development model of the IoT in Jiangsu province



CONCLUSION

In the context of today's connected economy, the IoT economy under the cloud model presents a compelling novelty. The introduction of the cloud model injects innovative vitality and opportunities into the traditional IoT economic model. The unique feature it implies lies in its ability to realize elastic resource management, enabling IoT systems to flexibly allocate computing and storage resources according to actual demand. Thus, it provides support for the diversity of application scenarios. By combining edge computing with cloud computing, real-time data analysis becomes possible. It enables the IoT devices to carry out data preprocessing locally, thereby reducing communication latency and meeting application scenarios with high real-time requirements. Overall, it brings new prospects for industrial automation, intelligent transportation, and other fields.

In addition, the wide application of the cloud mode has triggered the emergence of innovative application scenarios. From smart homes to smart healthcare to smart agriculture, the combination of cloud computing and big data analytics has brought new possibilities, driving a deeper development of the IoT economy.

The design of the cloud model emphasizes the importance of data privacy and security, which significantly reduces the risk of data leakage through local pre-processing and targeted data transmission. This provides a more solid guarantee for the robust operation of IoT systems.

Finally, the cloud model is cost effective. Through elastic resource allocation and pay-as-you-go models, enterprises can circumvent high initial investments and flexibly adjust resource usage in response to changes in demand. This, in turn, reduces deployment and maintenance costs while promoting the sustainable development of the IoT economy.

In summary, the IoT economy under the cloud model has an attractive novelty. It will bring opportunities and challenges to the development of various fields and stimulate a broader development space.

This study provides strategic recommendations to support the development of the IoT economy in Jiangsu. Strong government support has enabled enterprises to formulate early development strategies. However, as the development progresses, continued government support is crucial. Enterprises must focus on customer engagement, technology and service innovation, and organization and management innovation. It is also essential to expedite the construction of a talent system. An evaluation of the current development mode in Jiangsu shows positive prospects but still room for improvement. By implementing these suggestions, the IoT sector in Jiangsu can continue to thrive.

DATA AVAILABILITY

The figures used to support the findings of this study are included in the article.

CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest.

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