

# Research on the Measurement of the Effect of E-Commerce in Promoting Economic Development based on Big Data Analysis

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## Abstract:

In order to analyze the effect of e-commerce in promoting economic development, based on big data technology, this paper constructs a measurement model of the effect of e-commerce on promoting economic development based on big data technology. Moreover, this paper proposes a method for extracting complex modal parameters of multi-degree-of-freedom structures based on similarity search. This method is based on the complex modal theory of a multi-degree-of-freedom general viscous damping system. The search in the library is the most similar match with the free response data of the structure, so as to realize the parameter identification of the multi-degree-of-freedom structure. In addition, an intelligent analysis system structure is constructed. Through experimental research, it can be seen that the measurement model of the effect of e-commerce on promoting economic development based on big data analysis proposed in this paper has certain effects.

**Keywords:** big data; e-commerce; economic development; effect measurement

## 1 INTRODUCTION

For enterprises, e-commerce can effectively improve efficiency, reduce costs, open up markets, and promote business model innovation. For individuals, e-commerce can transform consumption patterns, meet consumer needs, and enhance shopping experience. For countries and regions, e-commerce can optimize industrial structure, form new economic growth points, and enhance international competitiveness. Under the situation of rapid economic growth in China, the e-commerce industry has achieved explosive development by virtue of its significant advantages, and has given birth to a brand-new service market, namely the e-commerce service market [1]. Nowadays, many links of economic activities have been migrated to the Internet. E-commerce is not only one of the business models to choose from, and online merchants are not only part of the business community. E-commerce or no business is available. From this perspective, the significance of the e-commerce service industry, as an emerging industry cluster that has emerged from the new technological revolution, to the future economy is not only reflected in the increase in statistical significance, it will also become an important foundation for economic development in the Internet era in the form of clusters [2]. E-commerce development level measurement is an important part of e-commerce management. It builds a measurement index system, collects data, and conducts a general evaluation of the effects of all links of e-commerce based on analytical data [3].

In the process of regional economic construction, the level of e-commerce represents the level of regional economic development. Therefore, it is of great significance to measure the development level of regional e-commerce qualitatively and quantitatively. From a vertical perspective, the data measured by regional e-commerce can help measure the competitiveness of the regional economy, better understand the extent and speed of e-commerce development in a region, and provide government statistics, commerce, and information departments with information on e-commerce development. The theoretical support for evaluating the effect of e-commerce in promoting economic development provides a basis for relevant units to formulate countermeasures for the development of e-commerce to promote economic growth; from a horizontal perspective, the development level of e-commerce for different regions is measured and the results are quantified. The e-commerce index of each region is derived, so as to provide a comparable standard for the development level of e-commerce in different economic regions and the current application status.

The Organization for Economic Cooperation (OECD) is an international organization that first carried out e-commerce statistical research in the world. The OECD uses the S-shaped curve of innovation diffusion to divide the development level of e-commerce into readiness and intensity. , Three levels of impact (impact). Among them, application degree refers to the scale and application degree of e-commerce development, including e-commerce transaction scale, enterprise application situation, personal application situation, etc. Measuring the application degree of e-commerce development in a certain period in a region can directly reflect the development of local e-commerce level.

Based on big data technology, this paper constructs a measurement model of the effect of e-commerce on promoting economic development based on big data technology, and explores the effect of e-commerce in promoting economic development.

## 2 RELATED WORK

Some scholars have also done research on e-commerce measurement. Literature [4] proposes including the preparation of infrastructure for major economic participants, market-available skills and capital, the availability and cost of technical infrastructure, advances in the promotion of use and development of use value, changes in the behavior of individuals, businesses and governments, and six credits. A large-module international e-commerce measurement benchmark framework; literature [5] introduces the relevant experience of the National Bureau of Statistics of Canada in e-commerce measurement, and believes that reliable, consistent, and comparable data are necessary factors and prerequisites for e-commerce measurement standards; literature [6] ] Discussed the impact of measuring organizational constraints on the success of B2B e-commerce work; literature [7] discussed the complementarity of e-commerce capabilities and infrastructure from the perspective of resource value; literature [8] explored the advantages of small and medium-sized manufacturing The adoption of the B2B e-commerce model proposes a reasonable improvement route for the penetration of e-commerce in small and medium-sized manufacturing industries; Literature [9] uses empirical methods to measure the impact of e-commerce on improving customer satisfaction and reducing enterprise operating costs.

Literature [10] believes that different evaluation tools should use different research methods for evaluation, and each evaluation tool or model is based on different research purposes and e-commerce definitions. The objects and content of e-commerce evaluation were initially based on the macro-level evaluation of information exchange technology (ICT) based on countries, regions, or alliances. The evaluation tools of this period mainly focused on the selection of ICT infrastructure and hardware conditions in the indicator design. Fixed, the index model proposed in the literature [11]. With the deepening of research, the focus of e-commerce research has focused on the organizational level. Based on the integration of previous research results, literature [12] constructed an integrated e-commerce readiness evaluation tool that emphasizes information access. Many companies, organizations, and schools use a variety of different evaluation tools and methods to measure e-commerce readiness, generally including historical analysis, best practices, questionnaires, and statistical analysis methods [13]. The literature [14] divides each indicator into 4 stages according to the degree of development of its application, and the evaluator selects the stage it is in according to the specific situation. The data statistics only summarize the stage of each indicator, which is typical Qualitative evaluation method; while the enterprise e-commerce evaluation adopts quantitative analysis method, such as the "network ready score card" in literature [15], which calculates the total score according to the degree of conformity of the respondent's answer to each question, and then calculates the total score with the average Comparative assessment. The literature [16] puts forward 10 constituent factors at three levels of business benefits to illustrate the impact of technical compatibility and operating capabilities on all aspects of business benefits, and designs three hypotheses. Types (products and services), different technical environments (EDI and non-EDI B2B technologies) statistical analysis of the actual application of the company to support the assumptions made.

Research on the measurement of enterprise e-commerce development level in academia, the survey objects are different, and the research focus is also different. The difference in the measurement focus is roughly distributed in the study of the overall level of enterprise e-commerce application, the study of enterprise website e-commerce level measurement, and enterprise electronics Research on business application effect measurement and other aspects. Literature [17] based on the operation mechanism of enterprise e-commerce, from the perspectives of e-commerce infrastructure, e-commerce external environment, e-commerce internal management environment, e-commerce process, e-commerce security and e-commerce benefits, etc. E-commerce maturity evaluation index system based on indicators, and proposed a corresponding combination evaluation method; Literature [18] proposed an evaluation index system consisting of three indicators: enterprise needs, external environment, information technology and corporate culture. It is A quantitative and hierarchical indicator system that takes into account the relative weights between the evaluation indicators, which can be used to compare and analyze the readiness of enterprises; according to the characteristics of foreign trade enterprises, the literature [19] builds a support layer, an application layer, and a collaboration layer. The e-commerce operation framework of foreign trade enterprises composed of 25 detailed indicators in these three key elements, focusing on measuring the e-commerce maturity of foreign trade enterprises in terms of readiness and utilization: Literature [20] Based on the Enterprise Resource View (RBV) , To construct an e-commerce performance evaluation model from the causal relationship among the four dimensions of strategy construction, resource analysis, capability evaluation and performance measurement, and establish a dynamic e-commerce performance evaluation index system based on the model.

## 3 THE PRINCIPLE OF MODE SUPERPOSITION OF E-COMMERCE MODAL PARAMETERS

The vibration differential equation of a general viscous damping system is:

$$\mathbf{M}\ddot{\mathbf{x}} + \mathbf{C}\dot{\mathbf{x}} + \mathbf{K}\mathbf{x} = \mathbf{f}(t) \quad (1)$$

Among them,  $\mathbf{C}$  is a general viscous damping matrix, which cannot be diagonalized by the modal matrix of an undamped system. Formula (1) is rewritten as:

$$\begin{bmatrix} \mathbf{C} & \mathbf{M} \\ \mathbf{M} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \dot{\mathbf{x}} \\ \mathbf{x} \end{bmatrix} + \begin{bmatrix} \mathbf{K} & \mathbf{0} \\ \mathbf{0} & -\mathbf{M} \end{bmatrix} \begin{bmatrix} \mathbf{x} \\ \dot{\mathbf{x}} \end{bmatrix} = \begin{bmatrix} \mathbf{f}(t) \\ \mathbf{0} \end{bmatrix} \quad (2)$$

When  $\mathbf{f}(t) = \mathbf{0}$ , the generalized eigenvalue problem of formula (2) is obtained:

$$\left( \lambda \begin{bmatrix} \mathbf{C} & \mathbf{M} \\ \mathbf{M} & \mathbf{0} \end{bmatrix} + \begin{bmatrix} \mathbf{K} & \mathbf{0} \\ \mathbf{0} & -\mathbf{M} \end{bmatrix} \right) \Phi' = \mathbf{0} \quad (3)$$

The generalized eigenvalues of the 2N conjugate form of formula (3) are obtained by solving:

$$\begin{cases} \lambda_i = -\sigma_{mi} + j\omega_{mji} = -\zeta_{mi}\omega_{mi} + j\omega_{mi}\sqrt{1-\zeta_{mi}^2} \\ \lambda_i^* = -\sigma_{mi} - j\omega_{mji} = -\zeta_{mi}\omega_{mi} - j\omega_{mi}\sqrt{1-\zeta_{mi}^2} \end{cases} \quad (i = 1, 2, \dots, N) \quad (4)$$

Among them,  $\sigma_{mi}$  is the  $i$ -th order complex modal damping attenuation coefficient of the general viscous damping system, and  $\omega_{mi} = |\lambda_i|$  is the  $i$ -th order complex modal natural frequency,  $\zeta_{mi} = \sigma_{mi}/\omega_{mi}$  is the  $i$ -th order complex modal damping ratio, and  $\omega_{mat} = \sqrt{\omega_{mi}^2 - \sigma_{mi}^2} = \omega_{mi}\sqrt{1-\zeta_{mi}^2}$  is the  $i$ -th order complex modal damping natural frequency of a general viscous damping system. The corresponding 2N conjugate complex eigenvectors are:

$$\Phi'_i = \begin{bmatrix} \Phi_i \\ \lambda_i \Phi_i \end{bmatrix}, \quad \Phi_i^* = \begin{bmatrix} \Phi_i^* \\ \lambda_i^* \Phi_i^* \end{bmatrix} \quad (i = 1, 2, \dots, N) \quad (5)$$

Then the orthogonality of the complex eigenvectors of the general viscous damping system is expressed as follows:

$$\begin{cases} \Phi^T \mathbf{P} \Phi' = \text{diag}[a_i, a_i^*] \\ \Phi^T \mathbf{Q} \Phi' = \text{diag}[b_i, b_i^*] \end{cases} \quad (6)$$

Among them,  $\Phi' = \begin{bmatrix} \Phi & \Phi^* \\ \Lambda \Phi & \Lambda^* \Phi^* \end{bmatrix}$ ,  $\Lambda = \text{diag}[\lambda_i]$ ,  $\Lambda^* = \text{diag}[\lambda_i^*]$ , and  $\lambda_i = -\frac{b_i}{a_i}$ ,  $\lambda_i^* = -\frac{b_i^*}{a_i^*}$  ( $i = 1, 2, \dots, N$ ).

Due to the orthogonality of the complex eigenvector  $\Phi'_i$ ,  $\Phi_i^*$ , these 2N linearly independent complex vectors constitute a complete orthogonal basis in a 2N-dimensional complex vector space. Therefore, there are:

$$\begin{bmatrix} \mathbf{x} \\ \dot{\mathbf{x}} \end{bmatrix} = \begin{bmatrix} \Phi & \Phi^* \\ \Lambda \Phi & \Lambda^* \Phi^* \end{bmatrix} \begin{bmatrix} \mathbf{y} \\ \mathbf{y}^* \end{bmatrix} \quad (7)$$

Among them,  $[\mathbf{y} \quad \mathbf{y}^*]^T$  is the coordinate vector of  $[\mathbf{x} \quad \dot{\mathbf{x}}]^T$  in this complex vector space.

When  $\mathbf{f}(t) = \mathbf{0}$ , formula (7) is substituted into formula (2), and the orthogonality of complex eigenvectors is solved to obtain the following results:

$$\begin{bmatrix} \mathbf{y} \\ \mathbf{y}^* \end{bmatrix} = \text{diag}[e^{\lambda t}, e^{\lambda_i^* t}] \begin{bmatrix} \mathbf{y}(0) \\ \mathbf{y}^*(0) \end{bmatrix}$$

Among them,  $\begin{bmatrix} \mathbf{y}(0) \\ \mathbf{y}^*(0) \end{bmatrix} = \begin{bmatrix} \Phi & \Phi^* \\ \Lambda \Phi & \Lambda^* \Phi^* \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{x}(0) \\ \dot{\mathbf{x}}(0) \end{bmatrix}$  is related to the initial conditions.

Thus, the free response of the displacement of the formula (1) in physical coordinates can be obtained:

$$\mathbf{x} = \Phi \text{diag}[e^{\lambda t}] \mathbf{y}(0) + \Phi^* \text{diag}[e^{\lambda_i^* t}] \mathbf{y}^*(0) = \sum_{i=1}^N (\Phi_i e^{\lambda_i t} y_i(0) + \Phi_i^* e^{\lambda_i^* t} y_i^*(0)) \quad (8)$$

We set  $y_i(0) = T_i e^{j\varphi}$ ,  $y_i^*(0) = T_i e^{-j\varphi}$ , then,

$$\mathbf{x} = \sum_{i=1}^N T_i e^{-\sigma_{mi} t} \left( \Phi_i e^{j(\omega_{mi} t + \varphi)} + \Phi_i^* e^{-j(\omega_{mi} t + \varphi)} \right) \quad (9)$$

When the system uses a certain order of complex modal frequency  $\omega_{mdil}$  as the main vibration, the vibration law is:

$$x_i = T_i e^{-\sigma_{mi} t} \left( \Phi_i e^{j(\omega_{mi} t + \beta)} + \Phi_i^* e^{-j(\omega_{mi} t + \beta)} \right) \quad (10)$$

Among them,

$$x_{ji} = T_i e^{-\sigma_{mi} t} \left( \phi_{ji} e^{j(\omega_{mit} t + \varphi_i)} + \phi_{ji}^* e^{-j(\omega_{mit} t + \varphi_i)} \right) \quad (i, j = 1, 2, N) \quad (11)$$

$$\text{assume } \phi_{ji} = \eta_{ji} e^{j\gamma_{ji}}, \quad \phi_{ji}^* = \eta_{ji} e^{-j\gamma_{ji}} \quad (i, j = 1, 2, N) \quad (12)$$

$$\text{norm } x_{ji} = 2T_i \eta_{ji} e^{-\sigma_{mi} t} \cos(\omega_{mdi} t + \varphi_i + \gamma_{ji}) \quad (i, j = 1, 2, \dots, N) \quad (13)$$

It can be seen that when a general viscous damping system vibrates freely at the  $i$ -th order frequency  $\omega_{mdi}$ , its initial phase of the  $j$ -th physical coordinate is  $\varphi_i + \gamma_{ji}$ . It is not only related to  $i$ , but also related to the physical coordinate  $j$ , that is, the initial phase of each component of the mode shape is different.

After actual monitoring, the time series of the response measurement values of the structure's respective degrees of reliability can be obtained:

$$\bar{x} = [\bar{x}_1(t) \quad \bar{x}_2(t) \quad \dots \quad \bar{x}_N(t)]^T \quad (14)$$

The initial value  $a$  of  $\bar{x}_k$  ( $1 \leq k \leq N$ ) is the horizontal crossing value. In this paper, the multi-degree-of-freedom random decrement is performed on  $\bar{x}$ , and the free vibration response of  $\bar{x}$  at the initial value  $a$  of component  $\bar{x}_k$  is obtained as:

$$\begin{aligned} \delta(\tau) &= [\delta_{\bar{x}_1 \bar{y}_1}(\tau) \quad \delta_{\bar{x}_2 \bar{x}_2}(\tau) \quad \dots \quad \delta_{\bar{x}_i \bar{x}_N}(\tau)]^T \\ &= \left[ \frac{1}{N} \sum_{i=1}^N \bar{x}_1(t_i + \tau) \quad \frac{1}{N} \sum_{i=1}^N \bar{x}_2(t_i + \tau) \quad \dots \quad \frac{1}{N} \sum_{t=1}^N \bar{x}_N(t_i + \tau) \right]^T \end{aligned} \quad (15)$$

Among them, the choice of  $t_i$  satisfies the condition:  $\bar{x}_k(t_i) = a$ .

By comparing the structure free response formula (15) obtained by actual measurement with random decrement and the free vibration formulas (9) to (13) obtained by theoretical analysis, the equations are established:

$$\begin{bmatrix} \delta_{\bar{x}_k \bar{x}_1}(t) \\ \delta_{\bar{x}_k \bar{x}_2}(t) \\ \dots \\ \delta_{\bar{x}_k \bar{x}_N}(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^N x_{1i} \\ \sum_{i=1}^N x_{2i} \\ \dots \\ \sum_{i=1}^N x_{Ni} \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^N 2T_i \eta_{1i} e^{-\sigma_{mi} t} \cos(\omega_{mdi} t + \varphi_i + \gamma_{1i}) \\ \sum_{i=1}^N 2T_i \eta_{2i} e^{-\sigma_{mi} t} \cos(\omega_{mdi} t + \varphi_i + \gamma_{2i}) \\ \dots \\ \sum_{i=1}^N 2T_i \eta_{Ni} e^{-\sigma_{mi} t} \cos(\omega_{mdi} t + \varphi_i + \gamma_{Ni}) \end{bmatrix} \quad (16)$$

Formula (16) shows that the random decrement signal of the measured data can be expressed as a series of superimposed forms of free vibration attenuation functions. Therefore, the search method can be used to search and extract each free vibration attenuation sequence in the random decrement signal to achieve signal separation and modal identification. Based on the above facts, constructing data with free vibration form is the best choice. The function is:

$$g_n(t; \omega_n, \zeta_n, \theta_n) = a_n e^{-\xi \omega_n t} \cos(\omega_{mn} t + \theta_n) \quad (17)$$

is the data form in the database, where  $\omega_{\omega n} = \omega_n \sqrt{1 - \xi_n^2}$ ,  $a_n$  is the normalization coefficient, making  $\|g_n(t)\| = 1$ .

Formula (16) has a clear physical meaning, and  $\zeta_n$  describes the attenuation characteristics of the vibrating system, that is, the damping ratio of the system.  $\omega_n$  corresponds to the natural frequency of the system, and  $\theta_n$  corresponds to the initial phase of the system. Different free decay response functions can be obtained by taking different values of  $\zeta_n$ ,  $\omega_n$  and  $\theta_n$ .

The search-based e-commerce modal parameter identification is to find  $\zeta_n$ ,  $\omega_n$  and  $\theta_n$  in the database so that  $g_n(t; \omega_n, \zeta_n, \theta_n)$  is the maximum similarity match of the free response obtained by random decrement. The  $g_n(t; \omega_n, \zeta_n, \theta_n)$  with the greatest similarity is a separated free vibration attenuation function.  $g_n(t; \omega_n, \zeta_n, \theta_n)$  is separated from the random decrement data, and this process is repeated to complete the extraction of all e-commerce modal parameters.

The matching pursuit algorithm first takes the peach reduction sequence  $\delta_{\bar{y}_t \bar{t}_t}(t)$  to search and extract parameters. The best similarity comparison is based on the largest inner product of the data in the database and  $\delta_{\bar{x}_k \bar{x}_i}(t)$ .

$\delta_{\bar{x}_1 \bar{x}_t}^{(1)}(t) = \delta_{\bar{x}_{\lambda_1}}(t)$ , and the algorithm searches in the database  $g = \{g_n(t; \omega_n, \zeta_n, \theta_n) \mid 0 \leq \omega_n, \theta_n \leq 2\pi, 0 \leq \zeta_n \leq 1\}$  to get:

$$b_{k1} = \left\langle \delta_{\bar{x}_1 \bar{x}_k}^{(1)}(t), g_{k1}(t; \omega_1, \zeta_1, \theta_{k1}) \right\rangle = \max_g \left| \left\langle \delta_{\bar{x}_k \bar{x}_k}^{(1)}(t), g_n(t; \omega_n, \zeta_n, \theta_n) \right\rangle \right| \quad (18)$$

Therefore, there are:

$$\delta_{\bar{x}_{\bar{\mu}_k}}(t) = b_{k1} g_{k1}(t) + \delta_{\bar{x}_k \bar{x}_t}^{(2)}(t) \quad (19)$$

It can be seen from formula (16) that the random decrement signals of other degrees of freedom also contain the same frequency and damping characteristics as  $g_{k1}(t)$ . Therefore, we set  $\delta_{\bar{x}_k \bar{x}_j}^{(1)}(t) = \delta_{\bar{x}_i \bar{x}_j}(t), (j = 1, 2, \dots, N \quad j \neq k)$  and search in the database subset  $g_1 = \{g_n(t; \theta_n) \mid 0 \leq \theta_n \leq 2\pi, \omega_n = \omega_1, \zeta_n = \zeta_1\}$  to get:

$$b_{j1} = \left\langle \delta_{\bar{x}_k \bar{x}_j}^{(1)}(t), g_{j1}(t; \theta_{j1}) \right\rangle = \max_{g_1} \left| \left\langle \delta_{\bar{x}_k \bar{x}_j}^{(1)}(t), g_n(t; \theta_n) \right\rangle \right|, (j = 1, 2, \dots, N; j \neq k) \quad (20)$$

Combining formula (19), there are:

$$\delta_{\bar{x}_k \bar{x}_j}(t) \doteq b_{j1} g_{j1}(t) + \delta_{\bar{x}_k \bar{x}_j}^{(2)}(t), \quad (j = 1, \dots, N) \quad (21)$$

Similarly, the algorithm repeats the above process for the first residual signal  $\delta_{\bar{x}_1 \bar{x}_j}^{(2)}(t), (j = 1, \dots, M)$  to obtain  $b_{j2}, g_{j2}(t)$  and  $\delta_{\bar{x}_i \bar{x}_j}^{(3)}(t)$ . By analogy, the algorithm gets:

$$\delta_{\bar{y}_1 \bar{R}_j}(t) = b_j g_{j1}(t) + b_{j2} g_{j2}(t) + \dots + b_{jM} g_{jM}(t) + \delta_{\bar{x}_k \bar{x}_j}^{(M)}(t), (j = 1, \dots, M < N)$$

Since in actual systems, low-order modes often play a dominant role, when  $M$  takes a certain value less than  $N$ , the energy of the residual signal  $\delta_{\bar{x}_i \bar{x}_j}^{(M+1)}(t)$  is sufficiently small relative to the original signal, and the expansion term can describe all the characteristics of the signal.

It is written in matrix form:

$$\begin{bmatrix} \delta_{\bar{x}_1}(t) \\ \delta_{\bar{x}_2}(t) \\ \dots \\ \delta_{\bar{x}_N}(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^M b_{1i} g_{1i}(t) \\ \sum_{i=1}^M b_{2i} g_{2i}(t) \\ \dots \\ \sum_{i=1}^M b_{Ni} g_{Ni}(t) \end{bmatrix} + \begin{bmatrix} \delta_{\bar{x}_1}^{(M+1)}(t) \\ \delta_{\bar{x}_2}^{(M+1)}(t) \\ \dots \\ \delta_{\bar{x}_N}^{(M+1)}(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^M b_{1i} a_{1i} e^{-\xi_i \omega_i t} \cos(\omega_{di} t + \theta_{1i}) \\ \sum_{i=1}^M b_{2i} a_{2i} e^{-\xi_i \omega_i t} \cos(\omega_{di} t + \theta_{2i}) \\ \dots \\ \sum_{i=1}^M b_{Ni} a_{Ni} e^{-\xi_i \omega_i t} \cos(\omega_{di} t + \theta_{Ni}) \end{bmatrix} + \begin{bmatrix} \delta_{\bar{x}_1}^{(M+1)}(t) \\ \delta_{\bar{x}_2}^{(M+1)}(t) \\ \dots \\ \delta_{\bar{x}_N}^{(M+1)}(t) \end{bmatrix} \quad (22)$$

By comparing formula (6) and (12), we get:

$$\begin{cases} 2T_i \eta_{jj} = b_{ji} a_{ji} \\ \sigma_{mi} = \zeta_i \omega_i \\ \omega_{m\omega\phi} = \omega_{d\phi} = \omega_i \sqrt{1 - \zeta_i^2} \\ \varphi_i + \gamma_{ji} = \theta_{ji} \end{cases} \quad (i = 1, 2, \dots, M \quad j = 1, 2, \dots, N \quad M < N) \quad (23)$$

From formula (23), the natural frequency  $\omega_{mi}$  and damping  $\sigma_{mi}$  of the  $i$ -th order complex mode in formula (1) can be determined. In addition, according to formula (12),

$$\begin{cases} \phi_{ji} = \eta_{ji} e^{j\gamma_j} = \frac{1}{2T_i} b_{ji} a_{ji} e^{j(\theta_{\mu} - \phi_j)} = \frac{e^{-j\phi}}{2T_i} b_{ji} a_{ji} e^{j\theta_j} \quad (i, j = 1, 2, \dots, N) \\ \phi_{ji}^* = \eta_{ji} e^{-j\gamma_j} = \frac{1}{2T_i} b_{ji} a_{ji} e^{-j(\theta_{\mu} - \phi)} = \frac{e^{j\phi}}{2T_i} b_{ji} a_{ji} e^{-j\theta_j} \end{cases} \quad (24)$$

Therefore, the  $i$ -th complex mode of formula (1) is:

$$\Phi_i = [\phi_i, \phi_{2i}, \dots, \phi_{Ni}]^T, \Phi_i^* = [\phi_{ii}^*, \phi_{2i}^*, \dots, \phi_{Ni}^*]^T \quad (i, j = 1, 2, \dots, N) \quad (25)$$

In formula (24), after taking  $\varphi_i = 0$  and normalizing it,  $T_i$  can be eliminated, that is, the  $i$ th-order complex mode shape after identification can be obtained.

Since similarity search is a process of multi-parameter optimization, genetic algorithm is used here to speed up the optimization. The genetic algorithm is an algorithm to search for the optimal solution with reference to the evolutionary thoughts of natural creatures. The main steps include parameter encoding, defining fitness function, initializing population, genetic operation, and judging the end condition of iteration. Combining matching pursuit algorithm and genetic algorithm, the process of e-commerce modal parameter extraction is as follows:

(1) Parameter coding. Genetic algorithm optimization must first encode parameters. Since most of the parameters for modal recognition are floating-point numbers, the most direct real number encoding is used to encode the parameter variable

$\{\omega_n, \zeta_n, \theta_n\}$  in the database. The encoded group of individuals  $\{\omega_k, \zeta_k, \theta_k\}$  ( $1 \leq k \leq n$ ) constitutes a dictionary data  $g_k(t; \omega_k, \zeta_k, \theta_k)$  in the database.

(2) Define the fitness function  $f(X)$ . The fitness value is the only deterministic indicator for the survival of individuals in the group. Formula (18) is selected as the fitness function for extracting the modal frequency, damping and phase, and formula (20) is selected as the fitness function for extracting the phase and mode parameters of the remaining degrees of freedom in the same modal. The individual with the largest fitness function value has the strongest survivability.

(3) Initialize the population. The algorithm uses the prior knowledge of the signal (power spectrum, time domain characteristics) to determine the size of the database to generate the initial population, so that each step of the search does not have to be carried out in the entire range of  $\omega_k, \zeta_k, \theta_k$ . This not only speeds up the optimization speed, but also improves the search accuracy.

(4) Genetic manipulation. The algorithm selects, crosses, and mutates the population formed by the database  $g_n(t; \omega_n, \zeta_n, \theta_n)$ , so that the population continuously evolves to obtain the optimal solution, which is the data that has the most similar match with the original signal. The maximum fitness function determined by formulas (18) and (20) is the expansion coefficient of matching pursuit, which is a search process.

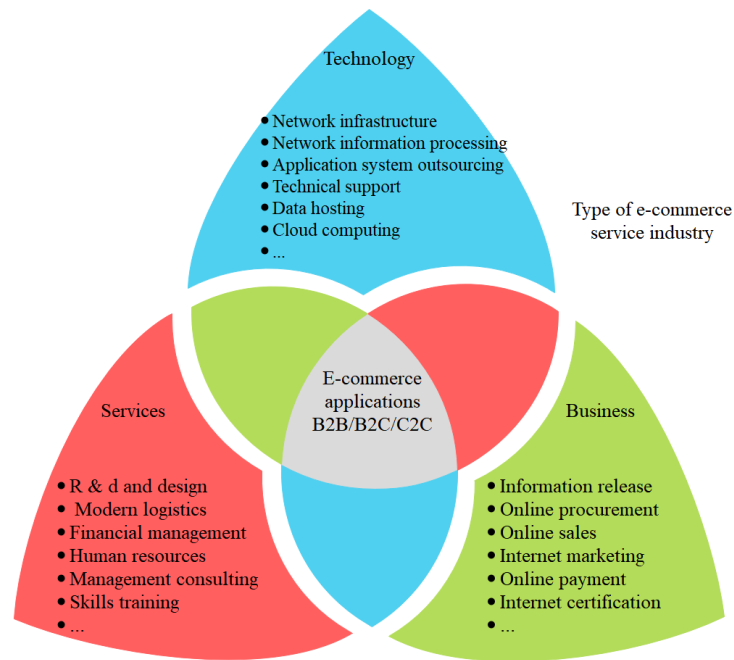
(5) According to formula (21), it can be seen that the first residual signal is calculated as  $\delta_{\bar{x}_k \bar{x}_j}^{(2)}(t)$ .

$$\delta_{\bar{x}_k \bar{x}_j}^{(2)}(t) = \delta_{\bar{x}_k \bar{x}_j}(t) - b_{j1} g_{j1}(t) \quad (26)$$

(6) The end condition of the iteration is judged. The algorithm repeats (2)-(4) until all the e-commerce modal parameters of the system are extracted.

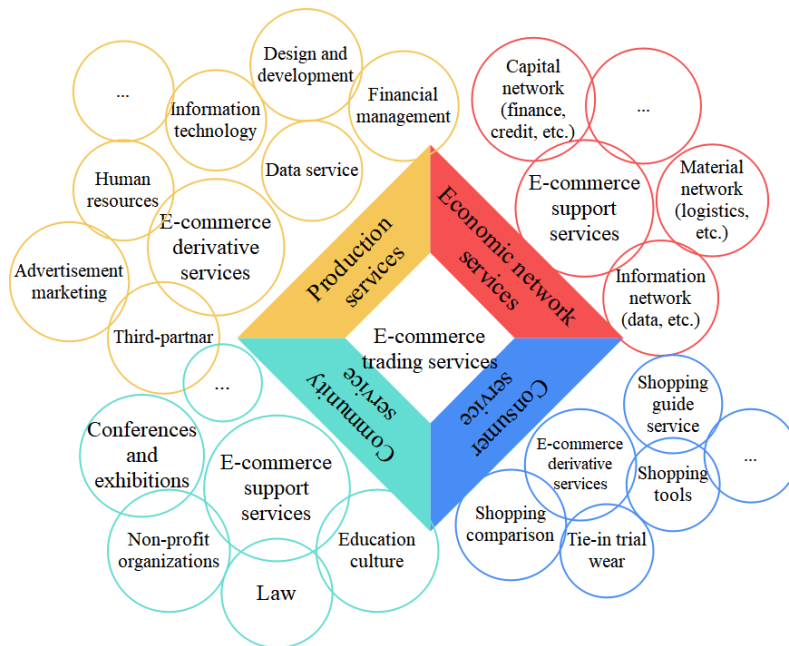
#### 4 RESEARCH ON THE MEASUREMENT OF THE EFFECT OF E-COMMERCE IN PROMOTING ECONOMIC DEVELOPMENT BASED ON BIG DATA ANALYSIS

This article analyzes Chinese e-commerce service providers and divides e-commerce service providers into two major categories: system service providers and intermediary service providers. The details are as follows: (1) System service providers include network access service providers, network operation service providers, network content service providers, application service providers, and commercial service providers. Among them, network operation service providers include network media operators, database operators, information consultants and information publishing agents. Application service providers include system solutions and application leasing services. (2) Intermediary service providers include intermediary service providers that provide trading platforms and intermediary service providers that provide service platforms. Among them, the intermediary service providers that provide trading platforms are divided into B2B, B2C and C2C types. Intermediary service providers that provide service platforms are divided into credit certification type, electronic finance type and logistics distribution type. The types of e-commerce service industry are shown in Figure 1 below.



**Figure 1** Types of e-commerce service industry

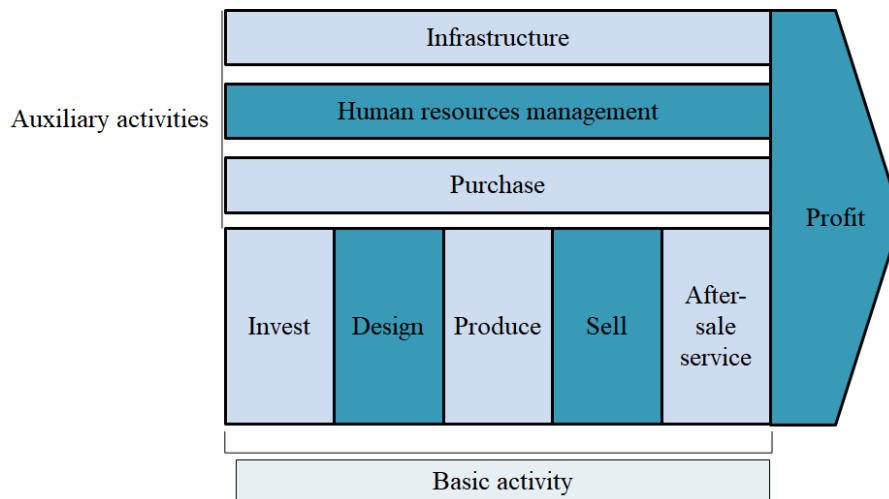
This article further refines the e-commerce service industry and forms an e-commerce service system with e-commerce transaction services as the core, economic network services and social services as the support, and consumer services and producer services as derivative services. The details are as follows:



**Figure 2** Types of e-commerce derivative services

Porter's value chain is a typical of the traditional value chain, and this model is mainly aimed at manufacturing companies. Drawing lessons from Porter's value chain model, this article combines the characteristics of e-commerce service companies providing services to users. We divide the value activities of e-commerce service companies into basic service activities and auxiliary service activities, as shown in Figure 3.



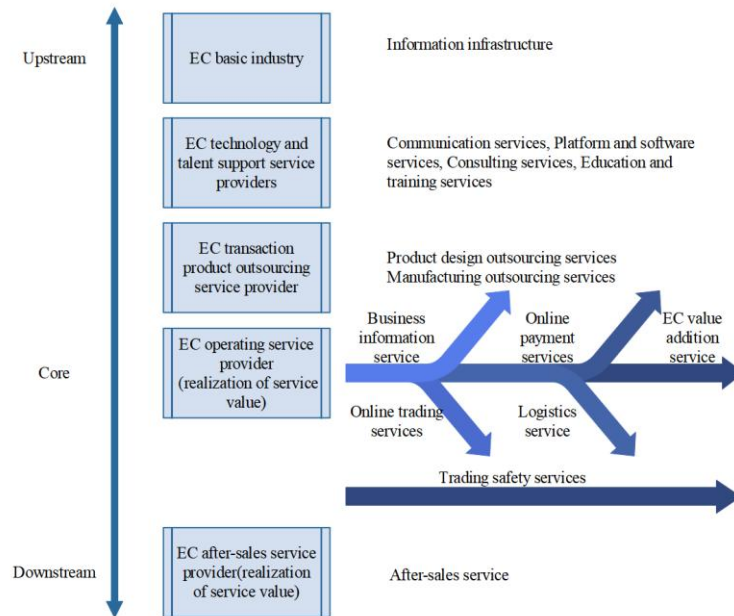


**Figure 3** Value chain model of e-commerce service enterprise

Basic service activities refer to activities directly related to the services provided by the enterprise. They are the actual creation of services, which mainly include investment, design, production, sales and after-sales service. The investment of e-commerce service companies is mainly to store customer demand information and allocate it to different departments to provide guarantee for the production of e-commerce service companies. Based on the needs of customers, companies began to provide customers with "tailor-made" services, including the development of new services, service technology transformation, software development and other activities. Design activities run through every process of the enterprise value chain and support the entire value. After the completion of the design activity, the service company proceeds to the production stage to transform customer needs and design into the final service product. Sales are a way to realize the value of service products. Enterprises promote and guide buyers to make purchases through advertising and sales channels to obtain profits. In the after-sales service stage, e-commerce service companies increase or maintain the value of the services provided by providing comprehensive after-sales service. Auxiliary service activities refer to activities that provide resources or infrastructure for the development of basic service activities, mainly including procurement, human resource management, and infrastructure construction. Purchasing refers to the activities of purchasing various inputs needed to meet customer service needs. The main emphasis is on the process of purchasing, which is an important link to ensure the smooth progress of basic activities in the enterprise value chain. The various activities of e-commerce service companies require the participation of people, so the role of human resource management is particularly important. It supports the entire value chain process and is mainly responsible for all types of personnel recruitment, performance measurement and compensation activities.

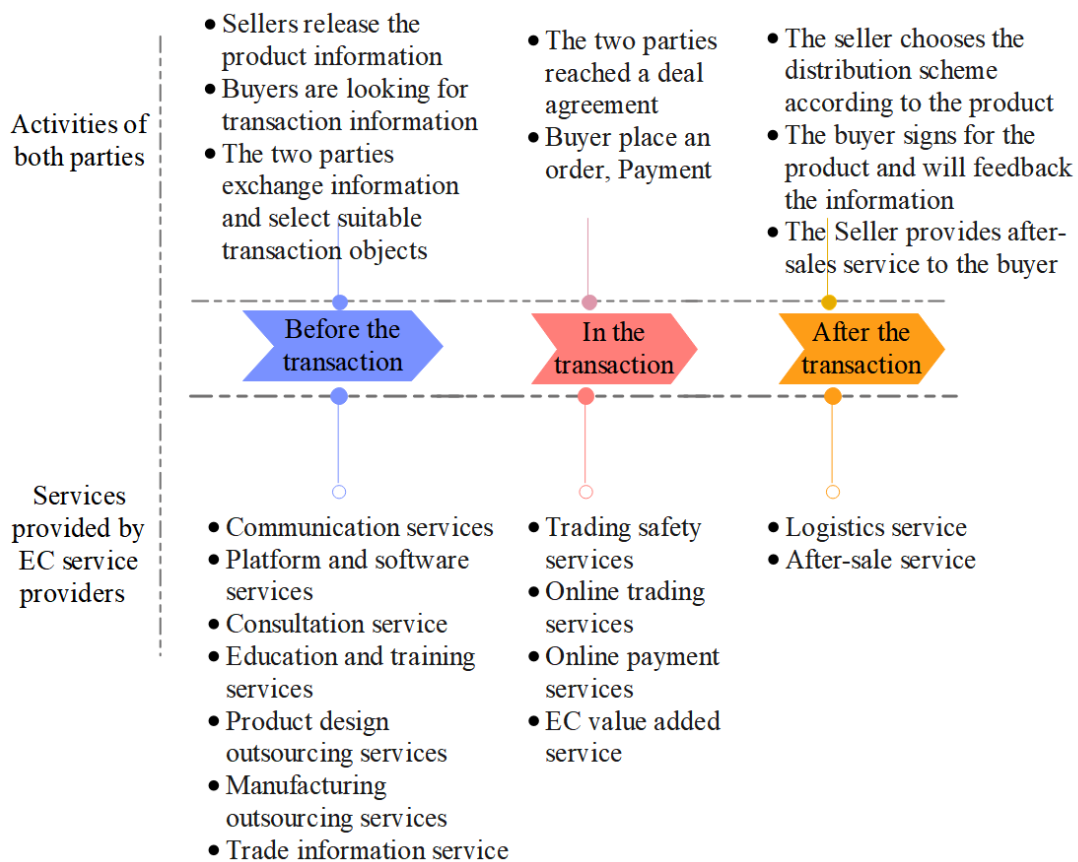
In addition, infrastructure construction includes not only the construction of hardware infrastructure such as plant facilities, machinery and equipment, but also the construction of soft infrastructure such as systems, plans, and finance. For the value chain of service enterprises, basic service activities mainly produce value. Ancillary service activities are inputs to value generation, which are ultimately contained in service products, and their value is realized through sales. The value chain of a company does not exist in isolation, and other companies in the same industry will have a greater impact on the costs and benefits of the company. Therefore, studying the value chain of the e-commerce service industry has theoretical and practical significance. The author believes that the e-commerce service industry value chain generally consists of e-commerce basic industries, e-commerce technology and support service providers, e-commerce transaction product outsourcing service providers, e-commerce operation service providers and e-commerce after-sales service providers. The transfer process of the e-commerce service value chain is the process by which the value of e-commerce service products is realized and the e-commerce service industry obtains profits. Different levels of e-commerce service companies inject value into e-commerce application products through professional division of labor and collaboration. Users realize customer value by using the services provided by service companies, as shown in Figure 4.





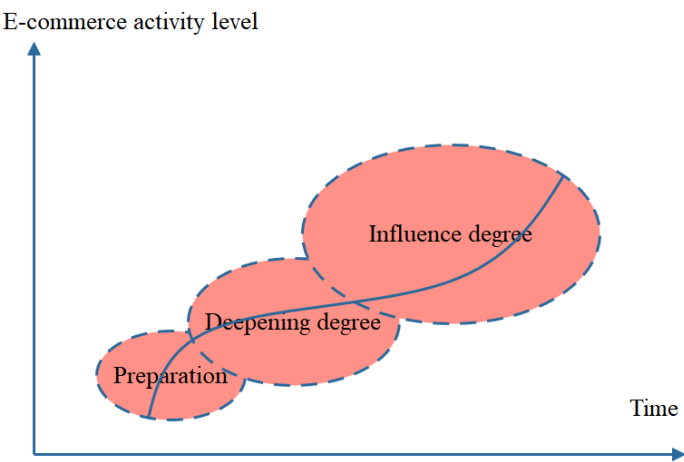
**Figure 4** Value chain model of e-commerce service industry

Completing transactions is the most direct purpose of profit for companies that provide e-commerce services. We take the transaction as the center to explore the transaction process structure of the e-commerce service industry based on the information flow, capital flow and logistics around the first three stages of the transaction. The main research here is the transaction activities carried out by the B2B, B2C, and C2C three types of trading platforms provided by the platform operators, as shown in Figure 5.



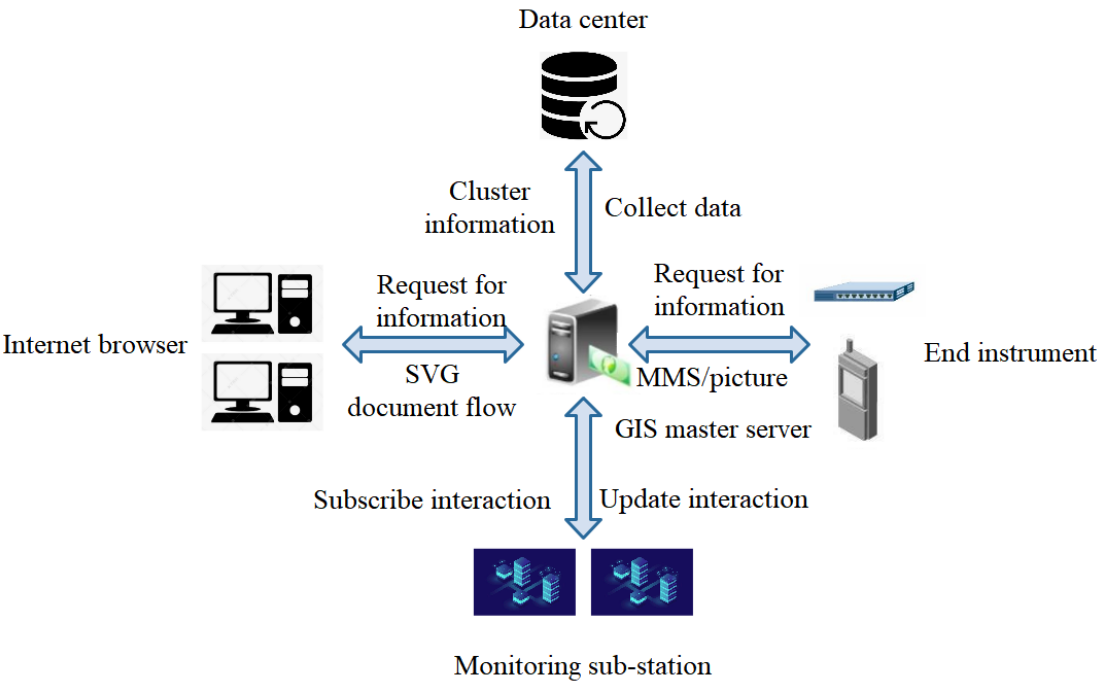
**Figure 5** E-commerce service enterprise transaction process

The e-commerce development process is divided into three stages: E-readiness, E-intensity, and E-impact according to the priority sequence of its measurement (Figure 6). E-readiness refers to the preparation of business environment, technology and social infrastructure in order to support the development of e-commerce, corresponding to the initial stage of e-commerce development. E-intensity refers to e-commerce applications, corresponding to the intermediate stage of e-commerce development. E-impact mainly refers to the impact of e-commerce on the economy and society, corresponding to the advanced stage of electronic development.



**Figure 6** S-curve diagram of the priority sequence of e-commerce measurement

This article combines data mining algorithms to study the information release system of the e-commerce measurement analysis model. The platform not only provides stand-alone real-time geographic environment data monitoring and collection information on top of its host's station integration system, but also has the function of providing multiple forms of geographic information publishing to multiple platforms in a distributed environment. That is, a GIS publishing server platform oriented to the marine distributed field on an embedded platform is realized. Figure 7 describes the interactive process of the e-commerce measurement information release system based on the C/S architecture.



**Figure 7** The interactive process of the e-commerce measurement information release system based on the C/S architecture

The embedded GIS server platform designed and implemented in the article is located on the station system responsible for data integration. The platform uses Intel's Sitsang embedded development board as its hardware platform. Figure 8 shows the functional hierarchical architecture of the GIS server platform we designed and implemented in the entire system.

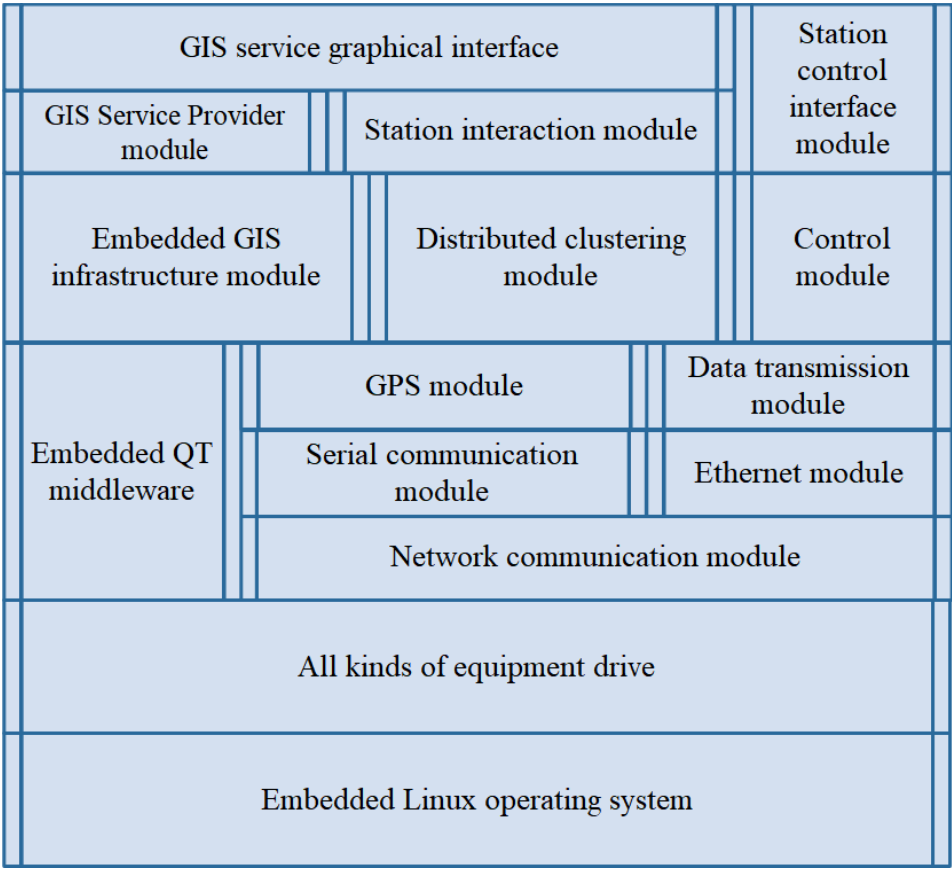


Figure 8 Functional hierarchical structure diagram of server platform

On the basis of the above research, this paper conducts a measurement analysis of the effect of e-commerce on promoting economic development based on big data analysis.

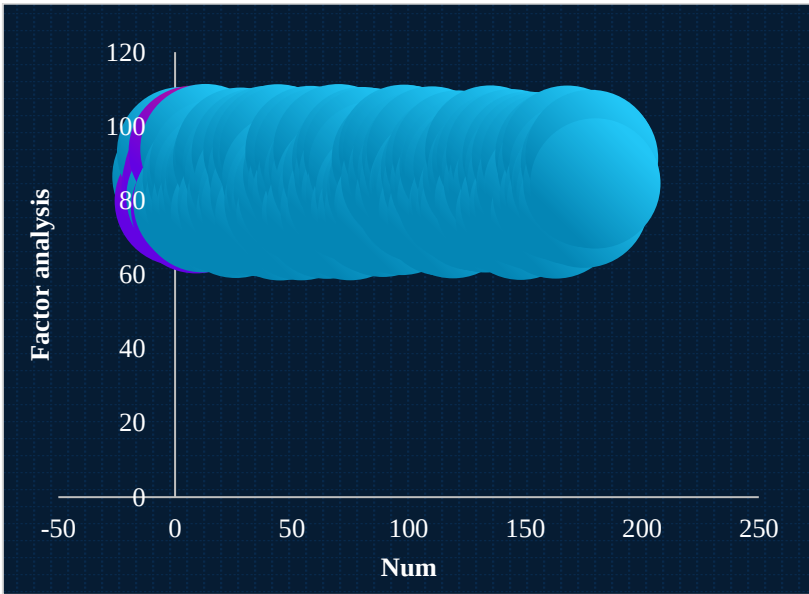
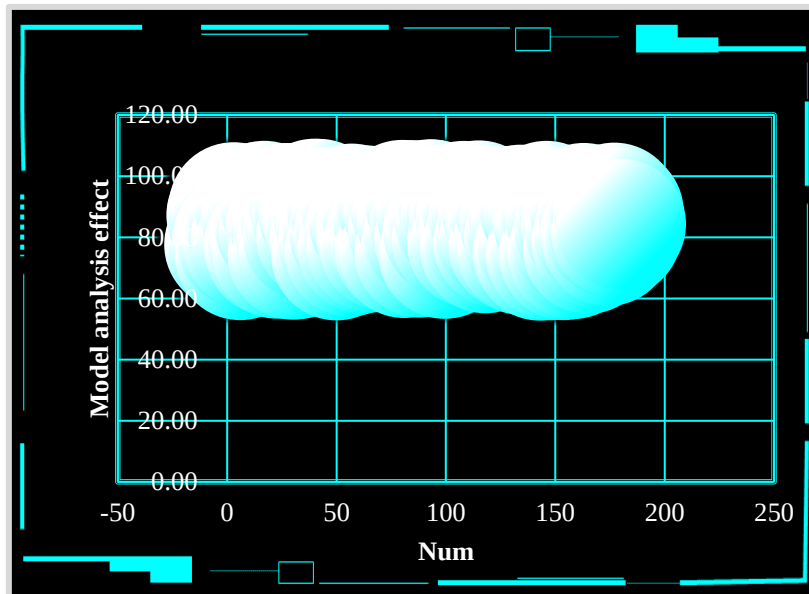


Figure 9 Measurement analysis of the effect of e-commerce on promoting economic development based on big data analysis

From the above research, it can be seen that the analysis model of the effect of e-commerce promoting economic development based on big data analysis proposed in this paper has a certain effect. On this basis, the effect of this model is evaluated, and the results are shown in Figure 10 below.



**Figure 10** Performance evaluation of the measurement analysis model of the effect of e-commerce on promoting economic development based on big data analysis

From the above research, it can be seen that the measurement model of the effect of e-commerce on promoting economic development based on big data analysis proposed in this paper has certain effects.

## 5 CONCLUSION

The development level of e-commerce is a comprehensive concept, and the designed index system should be able to deeply reflect the development level and status of e-commerce in a certain area, and highlight the application and contribution of e-commerce in the economic field. In the design process of the e-commerce development level measurement index system, the different actors participating in e-commerce activities are fully considered, and the evaluation of the regional e-commerce development level mainly involves measuring the enterprise application degree and the personal application degree. E-commerce transactions should also be considered when measuring e-commerce applications. In view of this, the indicator system constructed in this study fully takes into account the factors that directly play a role in e-commerce transactions, that is, designing statistical indicators of e-commerce development level from the aspect of e-commerce transaction scale. Moreover, based on big data technology, this article constructs a measurement model of the effect of e-commerce on promoting economic development based on big data technology, and explores the effect of e-commerce in promoting economic development.

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