International Journal for Housing Science and Its Applications
Publish August 6, 2025. Volume 46, Issue 3 Pages 6529-6543

https://doi.org/10.70517/ijhsa463561

Research on the Integration of Regional Economic Resource Optimization and Intelligent Technology in the Context of “Belt and Road” Based on Economic System Analysis

Kai Shang[1] **and Fang Wang**[2,*]
[1] School of Economics and Management, Voronezh National University of Engineering and Technology, Voronezh, Voronezh State, 394036, Russia
[2] School of Management, Suzhou College, Suzhou, Anhui, 234000, China
Corresponding authors: (e-mail: wf47@163.com).

Abstract With the in-depth promotion of the “Belt and Road” strategy, intelligent technology has become an important support for the optimal allocation of regional economic resources. Digital technology has become a factor of production, and the construction of “digital bridge” in regional cooperation improves the efficiency of resource allocation. This study explores the mechanism and implementation effect of the integration of regional economic resource optimization and smart technology under the background of “Belt and Road”. By constructing a stochastic DEA model with non-expected output, we analyze the regional economic resource allocation efficiency from the input-output perspective by taking the logistics industry of 17 provinces along the “Belt and Road” as the research object from 2013 to 2019. The results show that Liaoning, Shanghai and Zhejiang provinces have maintained a comprehensive technical efficiency value of 1.000 for seven consecutive years, which is located in the production frontier; the average value of the comprehensive efficiency of Heilongjiang, Qinghai and Xinjiang provinces and regions is lower than 0.5, which is far lower than the average value of the industry of 0.685; the kernel density analysis reveals that the operational efficiency of the logistics industry of the provinces along the route evolved from a single-peak distribution to a bimodal distribution from 2013 to 2019, and the phenomenon of efficiency polarization has expanded. Expansion. The study identifies input redundancy and output insufficiency problems in each province by measuring the relaxation factor, and proposes an optimal allocation scheme of regional economic resources based on intelligent technology. The study concludes that smart technology can effectively enhance the efficiency of regional economic resource allocation, weaken geospatial constraints through digital platforms, improve information transparency and flow efficiency, reduce the risk of information asymmetry, and promote the leapfrog development of regional economic cooperation.

Index Terms Regional economic resources, intelligent technology, optimal resource allocation, data envelopment analysis

I. Introduction

At present, the great change unprecedented in a hundred years accelerates the evolution, the new round of scientific and technological revolution and industrial change develops in depth, the international power balance is profoundly adjusted, unilateralism and protectionism spreads, and the world enters a new period of turbulence and change [1], [2]. 2024 In October, the International Monetary Fund issued a report warning that the world economy is facing multiple risks and structural changes. Overall, the world economic development in 2024 continues the slow recovery trend in 2023, and the related indicators such as economic growth, inflation level, labor market and trade and investment continue to undergo structural adjustments, which drive the regional economic cooperation towards adaptation and precision [3]-[6]. Meanwhile, in the wave of globalization, the development of the digital economy has had a far-reaching impact on the socio-economic structure of countries, and to cope with this change, different countries and regions have adopted diversified strategies and policies to promote their own digital transformation and enhance their competitiveness globally, especially in supporting developing countries to enhance their digital capabilities and promote digital inclusive finance, multilateral cooperation and policy innovation play a key role [7]-[10].

In addition, in the context of the “Belt and Road” strategy, the regional economy has delivered more than 1,300 large-scale cooperation projects, with a total of more than 3,000 projects on the ground, but among its resource factors, logistics costs account for a disproportionate share, and the imbalance of resource allocation in the supply chain under the dynamic demand has further increased logistics costs [11]-[13]. Energy-intensive industries account for more than 50% of the overall industrial industry, while the proportion of digital economy penetration is too low, and the efficiency of economic resource allocation in the "Belt and Road" region needs to rise [14], [15]. In this context, the "Belt and Road" regional economic resource coordination urgently needs to integrate intelligent technology into systematic and dynamic intelligent decision-making.

Against the backdrop of economic globalization and regional integration, the international economic landscape is facing profound changes, and the promotion of coordinated regional development has become a national strategic choice. Since the Belt and Road Initiative was put forward, it has optimized the allocation of regional economic resources and promoted the common development of countries along the route by deepening regional cooperation. However, compared with the infinite needs of human society, the shortage of resources is a problem that can never be avoided in the process of economic development, and the scarcity of resources will inevitably bring about selective demand, and the optimization of the allocation of regional economic resources is an important way to solve this contradiction. Based on the strategic background of "Belt and Road", this study explores the integration mechanism of intelligent technology and optimal allocation of regional economic resources, aiming to provide theoretical support and practical guidance for improving the resource allocation efficiency of countries and regions along the route. In recent years, the smart technology revolution with big data, cloud computing and artificial intelligence as the core driving force has been developing vigorously, and the proportion of digital trade in global service trade has been rising continuously, and digital resources have become an important factor of production in today's era. In the optimization of regional economic resources, smart technology, as a core engine to promote systematic openness, builds a "digital bridge" for regional cooperation, weakens the constraints of geographic space on factor flows, improves information transparency and flow efficiency, and reduces the risks and costs caused by information asymmetry. Starting from the connotation of regional economic system and optimal allocation of resources, this study analyzes the role of intelligent technology in resource optimization, and constructs a synergistic driving mode of regional economic resource optimization integrating intelligent technology. At the same time, the logistics industry in the provinces along the "Belt and Road" is selected as the research object, and the data envelopment analysis method is applied to assess the efficiency of resource allocation in the regional economy and deeply analyze its temporal differentiation characteristics. In the study, a stochastic DEA model with non-expected outputs is used to comprehensively assess the operational efficiency of the logistics industry in each province by combining input-oriented and output-oriented approaches, identify the reasons for inefficiency, and propose targeted optimization plans based on the values of relaxation factors. In order to deeply analyze the trend of efficiency change, the study also adopts the kernel density estimation method to analyze the temporal divergence of the operational efficiency of the logistics industry in the provinces along the route, so as to reveal the dynamic evolution law of the optimal allocation of regional economic resources. This study explores the integration mechanism of smart technology and regional economic resource optimization allocation from both theoretical and practical levels, which on the one hand enriches the theories of regional economics and resource allocation, and on the other hand provides references for the countries and regions along the "Belt and Road" to improve the efficiency of resource allocation and promote the coordinated development of the region. Through in-depth research on the optimal allocation of regional economic resources empowered by smart technologies, we will promote the free flow of interregional resources and factors, and push for the establishment of a more open, inclusive, balanced and inclusive framework for regional economic cooperation.

II. Optimizing the allocation of regional economic resources by integrating smart technologies

In recent years, the smart technology revolution, with big data, cloud computing and artificial intelligence as its core driving force, has flourished, and the proportion of digital trade in global trade in services has continued to rise, with digital resources becoming an important factor of production in the current era. In the optimization of regional economic resources, smart technology is the core engine for promoting systematic opening, building a "digital bridge" for regional cooperation, weakening the constraints of geographic space on factor flows, improving information transparency and flow efficiency, and reducing the risks and costs caused by information asymmetry. At the same time, the precise matching of supply and demand has promoted the in-depth integration of finance, supply chain and other fields, realized the effective allocation of resources and markets, and promoted the leapfrog development of regional economic cooperation and the optimal allocation of regional economic resources.

II. A. Connotation of regional economic systems and optimal allocation of resources

II. A. 1) Definition of a regional economic system

Regional economic system is a system composed of various economic elements, such as labor, capital, raw materials, tools, equipment, plants, products and other economic substances, as well as economic information in terms of technology and policy. Economic material and economic information flow and interact and couple between the internal and external environment of the system, forming the overall function of the regional economic system [16]. Regional economic system in addition to the general system has the holistic, hierarchical, structural characteristics also has the following characteristics:

(1) The regional economic system is a multi-factor material system consisting of, finance, material and so on, in which people play a key role in this system.

(2) The regional economic system is a complex system with multivariate and multilevel structure. There exists a complex, non-linear mutual coupling mechanism between the constituent elements of the system. At the same time, the regional economic system is operating in multiple external environments, and the mechanism between the system and the external environment is a long-term, dynamic and non-linear mechanism.

(3) The openness of the regional economic system is manifested in the fact that the economic system is always communicating with the surrounding environment in many aspects through input and output, and thus is an open system. The exchanges between the economic system and the outside world include personnel exchanges, material exchanges and information exchanges.

The ideology and political system of human society are the social environment in which the economic system operates. The choice of direction for regional economic development must be consistent with the values of the vast majority of society, with bottom-line equity and social security mechanisms to maintain the normal functioning of society.

II. A. 2) Optimized allocation of regional economic resources

Relative to the infinite needs of human society, the problem of resource scarcity is a difficult problem that can never be avoided in the process of economic and social development, and the characteristics of resource scarcity will inevitably bring about selective demand. That is, how to rationally allocate limited resources to various social and economic activities through certain ways to better meet the needs of people's production and life and other aspects. And realize the Pareto optimization of resource utilization, to achieve the least resource consumption, production of the most applicable goods and services, to obtain the best benefits, which is actually the problem of resource allocation [17].

Regional economic resource allocation refers to a country or region to a variety of relatively scarce resources in a variety of different uses (economic areas, use of direction) between the comparison of the choice, the essence is to realize the dynamic distribution of economic resources to achieve the integration, use and achieve efficiency. China is a country with a socialist market economy system, and market allocation has become the main way of resource allocation, with the aim of creating more social wealth and obtaining greater economic benefits with limited resources. Under the “Belt and Road” strategy, the goal of optimal allocation of regional economic resources is not the same in different regions. For less developed regions, the goal of optimal allocation of resources is to promote the rapid development of social economy and narrow the gap between the level of economic development and that of developed regions. Combining the above analysis with relevant definitions, this paper considers that regional economic resource allocation refers to the reasonable gathering and integration of financial resources of a country or region, and maximizes the use of such resources to meet the various possible selective needs in socio-economic development.

II. B. Optimized allocation of regional economic resources by converging technologies

II. B. 1) The role of smart technologies in resource optimization

The emergence of intelligent technology has enabled various industries to utilize AI technology to improve efficiency, enhance quality, reduce costs, and so on. As the most important algorithm in AI technology, data-based machine learning has made significant breakthroughs, which has led to a wide range of applications of AI technology in various scenarios. Its application in the optimal allocation of regional economic resources under the “Belt and Road” strategy can effectively promote the significant improvement of regional industrial technology, which has great potential for development [18].

With the support of intelligent technology, the impact of technological innovation on employment and economic restructuring is affected by the future trend of uncertainty and complexity. Artificial intelligence should avoid Solow's paradox and the lack of economic growth promotion if it is to become a new driving force for economic growth and structural transformation as much as possible. The integration of intelligent technology with the optimal allocation of regional economic resources can effectively promote the innovation and upgrading of the industrial structure of the regional economy. Therefore, it is necessary to vigorously develop the application of artificial intelligence technology in the optimization of regional economic resources, regard the development and transformation and application of intelligent technology as a strategic development priority, and better promote the optimal allocation and stable development of current regional economic resources with the support of intelligent technology.

II. B. 2) Model for optimal allocation of regional economic resources

Taking the strategic idea of "Belt and Road" as the guidance, the optimal allocation of regional economic resources as the goal, and intelligent technology as the support, we construct the synergistic driving mode of regional economic resource optimization integrating intelligent technology, and its specific framework is shown in Figure 1. Synergistic driving mode refers to the goal of unifying the regional resource optimization allocation system and regional system, combining intelligent technology with different subjects and different resource types under the guidance of the same system configuration idea, to achieve the optimal allocation of resources in the region on different subjects. It is characterized by emphasizing the synergistic effect of subjects and resources, and theoretically outlines the future development mode of the integrated regional resource optimization and allocation system, including the transportation synergy mode, the environmental synergy mode and the industrial synergy mode.

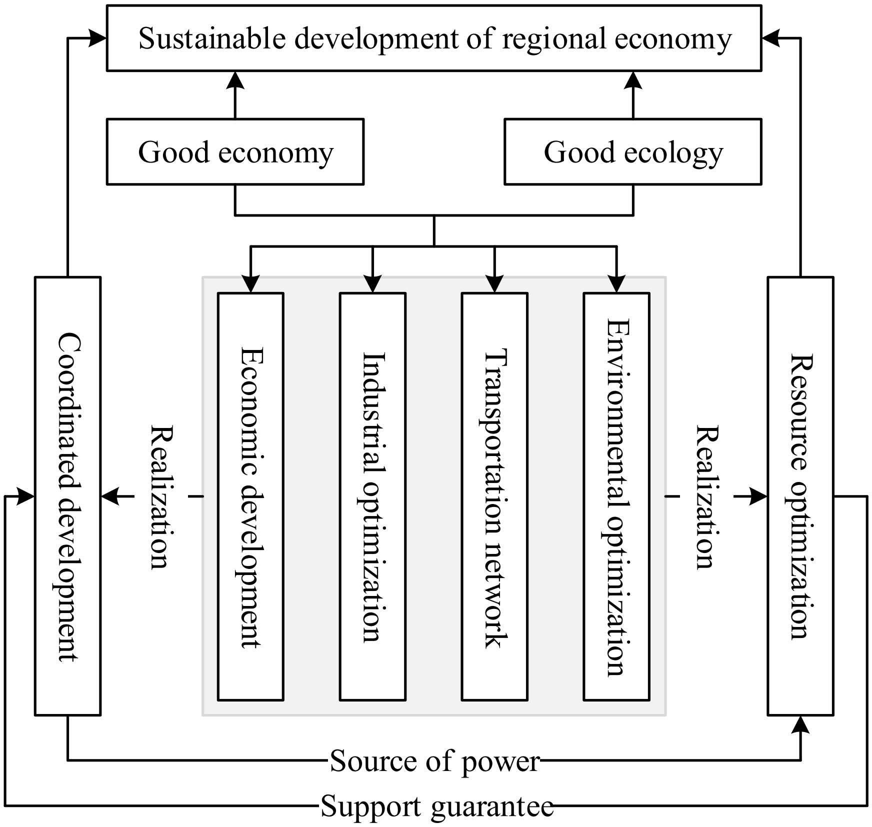

Figure 1: Optimal Allocation Model of regional economic resources

Under the model of optimal allocation of regional economic resources that incorporates intelligent technology, intelligent technology can be used to bring about the optimal allocation of resources between different regions and between different types of resources in a way that allows for mutual cooperation and complementarity of advantages, with the goal of maximizing common outcomes and benefits, and with the means of resource reconfiguration and synergy. The important value of synergy among regions and resources is clarified, and emphasis is placed on realizing the flow of resources from areas of low efficiency to areas of high efficiency through the mechanism of cooperation, prompting the expansion of the marginal benefits of optimal resource allocation.

III. Efficiency of the optimal allocation of economic resources in the Belt and Road region

In the history of human civilization, the Silk Road was one of the most brilliant, active, harmonious and open regions, which brought unprecedented economic and cultural prosperity to the peoples of Asia, Europe and Africa. Today, the New Silk Road is strategically located between the prosperous East Asian economic circle in the east and the developed European economic circle in the west. However, due to natural and historical realities, the northwest region of China in the middle part of the Silk Road is also one of the relatively backward regions in China's development, thus, the New Silk Road presents an "economic depression zone". How to improve the regional economic development level of the regions along the “Belt and Road” and promote the optimal allocation of regional economic resources is currently a relatively cutting-edge research topic.

III. A. Theoretical Foundations of Data Envelopment Analysis

III. A. 1) Basic concepts of DEA

Data Envelopment Analysis (DEA) method is a new field of research in operations research, management science and mathematical economics, and DEA is a nonparametric statistical method based on the concept of relative efficiency for evaluating whether decision-making units (DMUs) with the same type of multiple inputs and outputs are technically efficient [19]. The basic idea is to take each evaluated unit as a DMU, and then many DMUs constitute the evaluated group, and through the comprehensive analysis of input and output ratios, the weight of each input and output index of DMUs is used as a variable for the evaluation operation to determine the effective production frontier. And based on the distance of each DMU from the effective production frontier, it is determined whether each DMU is DEA effective or not. At the same time, the projection method can be used to point out the reasons for non-DEA effective or weak DEA effective, and the direction and degree of improvement that should be made.

Let the input vector of a certain DMU in an economic (production) activity be $x=(x_1,x_2,\ldots,x_m)^T$, and the output vector be $y=(y_1,y_2,...,y_s)^T$, and thus, the entire production activity of this DMU can be simply represented by (x,y), calling the set $T=\{(x,y)|$ outputs y can be produced with $x\}$ as the set of production possibilities consisting of all possible production activities. As a matter of practicality and convenience in studying the problem, it is generally assumed that the production possible set satisfies four axioms, viz:

(1) Convexity, which shows that T is a convex set.

(2) Conicity, which shows that it is possible to obtain K times the original production if K times the original input is used as the new input.

(3) Ineffectiveness, which shows that it is always possible to produce by adding inputs or reducing outputs to the original production activity.

(4) Minimality, the set of production possibilities T is the intersection of all sets that satisfy axioms (1)-(3).

There are n decision-making units of the same type $DMU_j(j=1,2,...,n)$, for each DMU there are m kinds of inputs and s kinds of outputs, then the inputs and outputs of each DMU can be represented by vectors as:

$$\begin{aligned} &X_j=(x_{1j},x_{2j},...x_{ij},...,x_{mj})^T>0, \quad i=1,2,...,m; \quad j=1,2,...,n \\ &Y_j=(y_{1j},y_{2j},...y_{kj},...,y_{yj})^T>0 \quad k=1,2,...,s; \quad j=1,2,...,n \end{aligned} \tag{1}$$

For a certain decision unit $DMU_{j0}(1\le j_0\le n)$, two linear programming models can be constructed for input-oriented and output-oriented, i.e.:

LP_i (input-oriented). Seeking a linear combination of $DMU_j(1\le j\le n)$ with a minimum input while maintaining at least the output quantity of DMU_{j0} and checking that this input is smaller than the original input, the corresponding model is:

$$\begin{aligned} &MinZ \\ s.t.\ &\sum_{j=1}^{n}\lambda_j x_{ij}\le x_{ij0}Z, i=1,2,...,m \\ &\sum_{j=1}^{n}\lambda_j y_{kj}\ge y_{kj0}, k=1,2,...,s \\ &\lambda_j\ge 0, Z\ge 0, j=1,2,...,n \end{aligned} \tag{2}$$

Obviously, the optimal solution $Z'\le 1$, if $Z'<1$, it means that the DMU inputs resulting from the new combination are smaller and the original DMU_{j0} is not efficient.

LP_2 (output-oriented). Seek a linear combination of $DMU_j(1\le j\le n)$ for the maximum possible output without more inputs than the original inputs of DMU_{j_0}, and check that this output is not more than the original amount of output. The corresponding model is as follows:

$$\begin{aligned} &\max\omega \\ s.t.\ &\sum_{j=1}^{n}\lambda_j x_{ij}\le x_{ij0}, i=1,2,\ldots,m \\ &\sum_{j=1}^{n}\lambda_j y_{kj}\ge \omega y_{kj0}, k=1,2,...,s \\ &\lambda_j\ge 0, \omega\ge 0, j=1,2,\ldots,n \end{aligned} \tag{3}$$

Obviously, the optimal solution $\omega' \geq 1$, and if $\omega' > 1$, it means that the output of the newly combined DMUs is larger, and the original DMU_{j0} is not efficient.

Thus, the application of the DEA method to determine whether a particular DMU is valid is relative to a set of actual observations.

III. A. 2) CCR and BCC models

(1) The principle of CCR model evaluation

Suppose there are n logistics enterprises, and each enterprise can be regarded as a decision-making unit DMU. Thus, there are n decision-making units. Figure 2 shows the input-output volume and index weights of the decision-making unit. Each decision-making unit has m kinds of "inputs", representing the consumption of "resources" by the decision-making unit, and s kinds of "outputs", representing the quantity of "effectiveness" indicated after the decision-making unit has consumed "resources".

$$\begin{array}{ccc|ccccc|}
 & & & 1 & 2 & \cdots & j & \cdots & n \\
\hline
v_1 & 1 & \rightarrow & x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\
\vdots & \vdots & \vdots & \vdots & \vdots & & \vdots & & \vdots \\
v_m & m & \rightarrow & x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \\
\hline
\end{array}$$

$$\begin{array}{|ccccc|ccc}
\hline
y_{11} & y_{12} & \cdots & y_{1j} & \cdots & y_{1n} & \rightarrow & 1 & \mu_1 \\
\vdots & \vdots & & \vdots & & \vdots & \vdots & \vdots & \vdots \\
y_{s1} & y_{s2} & \cdots & y_{sj} & \cdots & y_{sn} & \rightarrow & s & \mu_s \\
\hline
\end{array}$$

Figure 2: The input-output volume and index weights of the decision-making unit

where x_{ij} is the input of the j th DMU to the i th kind of input, $x_{ij} > 0$, y_{η} is the output of the j th DMU to the r th kind of output, $y_{rj} > 0$, v_i is a measure to the i th kind of input, u_r is a measure of the output of the r th kind, $i = 1, 2, \cdots m; j = 1, 2, \cdots n; r = 1, 2, \cdots s$

(x_y, y_{η}) is known data and can be obtained from historical information. The v_i, u_r are variables corresponding to a set of weight coefficients $v = (v_1, v_2 \cdots v_m)^T, u = (u_1, u_2 \cdots u_r)^T$. Each decision unit has a corresponding efficiency evaluation index $h_j = (\sum_{r=1}^{s} U_r.Y_{\eta})(\sum_{i=1}^{m} V_r.X_{ij}), j = 1, 2, \cdots n$. We can always choose the weight coefficients v and u appropriately so that they satisfy:

$$h_j \leq 1, \quad j = 1, 2, \cdots n \tag{4}$$

Now, the efficiency evaluation $(1 \leq j_0 \leq n)$ is performed for the j_0 th decision unit, with the weighting coefficients v and u as variables, the efficiency index of the j_0 th decision unit as the objective, and the efficiency indices of all the decision units (which also include the j_0 th decision unit) as constraints. i.e:

$$h_j \leq 1, \quad j = 1, 2, \cdots n \tag{5}$$

In this way, the following optimization model is formed:

$$(I) \quad \begin{cases} \max h_{j0} = \sum_{r=1}^{s} U_r.Y_{r0} / \sum_{i=1}^{m} V_r.X_{i0} \\ s.t.(\sum_{r=1}^{s} U_r.Y_{rj}) / (\sum_{r=1}^{m} V_r.X_{ij}) \leq 1, \quad j = 1, 2, \cdots n \\ v = (v_1, v_2 \cdots v_m)^T \geq 0 \\ u = (u_1, u_2 \cdots u_r)^T \geq 0 \end{cases} \tag{6}$$

where $v \geq 0$ means that for $i = 1, \cdots m, v_i \geq 0$ and there exists at least some $i_0 (1 \leq i_0 \leq m)$ such that $v_{i_0} > 0$ has a similar meaning to $v \geq 0$ for $u \geq 0$.

The above model is utilized to evaluate whether the decision unit j_0 is valid with respect to all n decision units. Using matrix notation, there are:

$$(P)\begin{cases} \max & h_{j0} = U^T.Y_0 / V^T X_0 \\ s.t. & U^T.Y_j / V^T X_j \le 1, j = 1,2,\cdots n \\ & v \ge 0; u \ge 0 \end{cases} \tag{7}$$

where $X_j = (X_{1j}, X_{2j} \cdots X_{mj}), j = 1,2,\cdots n Y_j = (Y_{1j}, Y_{2j} \cdots Y_{sj}), j = 1,2,\cdots n$.

Decision cell j_0 is said to be weakly DEA efficient if the optimal solution of linear programming (P) is $h_{j0} = 1$. Decision cell j_0 is said to be DEA efficient if there exists $v^{'} > 0, u^{'} > 0$, and $h_{j0} = 1$.

(2) Principles of BCC modeling

Constant returns to scale is a more ideal assumption, in the actual social economy there are often changes in returns to scale, some researchers based on the assumption of variable returns to scale in the production of possible sets, proposed the DEA-BCC model to make up for this shortcoming.BCC model and CCR model is similar to the former, but on the basis of the former increased constraints, the specific model is as follows:

$$Min\theta = \theta_0 - \varepsilon\left(\sum_{r=1}^{s} s_r^+ + \sum_{i=1}^{m} s_i^-\right) \tag{8}$$

$$s.t.\begin{cases} \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0}, \\ \sum_{j=1}^{n} \lambda_j x_j ij + s_i^- = \theta_0 x_{r0}, \\ \sum_{j=1}^{n} \lambda_j = 1, \\ \lambda_j \ge 0, j = 1,2,...,n, \\ s_r^+, s_i^- \ge 0, r = 1,2,...,s, i = 1,2,...,m. \end{cases} \tag{9}$$

Three types of efficiency are included in the model, namely technical efficiency, scale efficiency and pure technical efficiency. Technical efficiency is the ratio of the actual output value to the maximum output value with fixed input factors, reflecting the difference between the current level of technology and the maximum output technology level. Scale efficiency is the degree of difference between the current scale of output and the optimal scale of output, reflecting the degree of deviation. Pure technical efficiency is technical efficiency after the removal of scale efficiency, reflecting the ability to utilize available resources, i.e., the minimized inputs required for a given output.

The rules for judging pure technical efficiency are as follows:

When $\theta = 1, s^- = 0$ and $s^+ = 0$, this DMU pure technology is valid; when $\theta = 1, s \ne 0$, or $s^+ \ne 0$, this DMU pure technology is weakly valid; and when $0 < \theta < 1$, this DMU pure technology is invalid.

For scale efficiency judgment, the first step is to calculate the return to scale index. To wit:

$$k = \frac{1}{\theta}\sum_{i-1}^{n}\lambda_j \tag{10}$$

When $k = 1$ when the returns to scale unchanged, the DMU inputs and outputs with the same multiplier increase, has reached the maximum output size; when $k < 1$ when the returns to scale increasing, the DMU output growth rate to be greater than the rate of input growth; when $k > 1$ when the returns to scale diminishing, the DMU output growth rate to be less than the rate of input growth, at this time there is no need to increase inputs.

Technical efficiency judgment rules for technical efficiency = scale efficiency * pure technical efficiency, when the efficiency value reaches 1 to prove that the DMU is effective, and vice versa is invalid.

III. A. 3) DEA evaluation steps

(1) Determine the purpose of evaluation. The efficiency results of DEA evaluation are objective, and before selecting input and output variables, the purpose of the evaluation should be clarified, and samples, indicators, models, etc. should be selected according to the purpose. The purpose of this paper is to understand the overall efficiency difference of the integration of intelligent technology into the optimal allocation of regional economic resources under the “Belt and Road” strategy, mainly take the logistics of the provinces along the “Belt and Road” as the object of study, find the benchmark cities, and analyze the improvement direction and degree of improvement of the cities in the optimization of regional economic resources. We will find the benchmark cities, analyze the improvement direction and improvement degree of each city in the optimization of regional economic resources, and provide suggestions for the optimal allocation of regional economic resources under the “Belt and Road” strategy.

(2) Screening of decision-making units: DEA requires that the selected decision-making units are homogeneous, that is, the decision-making units are in the same external environment, have the same objectives, and are due to the same input and output indicators. Decision-making units only to achieve homogeneity, the relative efficiency indicators analyzed by DEA method have practical significance. In addition, the constraint that the indicator value is positive should also be considered in the selection of decision-making units, and the DEA method's treatment of negative values will make the overall efficiency results inaccurate, and such decision-making units should be excluded.

(3) Indicator selection. After the purpose of the study and the decision-making unit are determined, the next is the most important indicator selection problem in the DEA method. Since DEA does not assume the production frontier function, its production frontier surface is described by the input-output worth of relative efficiency points, the choice of indicators is different, the evaluation results may vary widely. Only by selecting indicators through the principles of comprehensiveness and systematicity can we clearly and accurately reflect the relative DEA efficiency value between decision-making units.

(4) Selection of DEA model. With the continuous development of the DEA method, there are currently many different applicable models for different research purposes and different practical situations. When the research unit focuses on output indicators, it should select the output-type DEA model with certain inputs and maximized outputs, and if the research unit focuses on the value of cost indicators, it should select the input-type DEA model.

(5) Summarize the results and recommendations. After sample selection, indicator selection and model selection, the data are finally analyzed by DEA to derive the efficiency ranking of each decision-making unit, and compared from multiple perspectives, and relevant suggestions are made to help regional economic resource allocation find the direction of improvement and reach the research purpose of this paper.

III. B. Data Sources and Model Indicator Selection

III. B. 1) Sample selection and data sources

The current statistical yearbook does not classify the logistics industry as an independent industry for statistics and classification, therefore, this paper is consistent with the methodology of related research, and selects the transportation, warehousing and postal industries of the provinces along the “Belt and Road” to quantify the situation of the urban logistics industry. The “Belt and Road” strategy has been proposed since 2013, so the sample data selected for this paper is from 2013 to 2019, and the required data comes from the China Statistical Yearbook and the statistical yearbooks of each province and autonomous region.

III. B. 2) Indicator selection and modeling

(1) Selection of Input-Output Indicators

In order to effectively analyze the resource optimization and allocation efficiency of the logistics industry in the provinces along the “Belt and Road” strategy, this paper combines the characteristics of the logistics enterprises and refers to the relevant literature on the basis of the index research, this paper chooses three representative financial indicators as the input variables, i.e., net fixed assets, payable employee compensation, and the current year's increase in the total operating costs, i.e., IN1~IN3, total operating costs, i.e. IN1~IN3.

Output indicators are also known as output indicators. In this paper, we do not choose ratio financial indicators, such as asset turnover ratio, profitability indicator, price-earnings ratio, and so on. Because the DEA performance evaluation results itself is the ratio of the ratio, if you add the more complex ratio class indicators in the financial indicators will make the whole system too cumbersome, with many other indicators have a linear relationship. And finally, it is difficult to analyze specific problems by combining the results of efficiency evaluation, so this paper chooses two representative output indicators, namely, total operating income and operating profit, i.e., OUT1~OUT2.

(2) Stochastic DEA model containing non-expected outputs

Let $x_i (i = 1, 2, \ldots, n)$ be a known constant and g^0 be the objective, and find the n-dimensional decision variable $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n)$ such that:

$$\sum_{1}^{\infty} \lambda_i x_i \geq g^0, \lambda \in S \tag{11}$$

holds, and this type of target is called positive response class (PRT).

Similarly there are negative reaction classes (NRT), i.e:

$$\sum_{1}^{\infty} \lambda_i x_i \leq g^0, \lambda \in S \tag{12}$$

This leads to the following form of PRT multi-objective planning:

$$\left(\sum_{1}^{\infty}\lambda_i x_i^1 \ge g_1^0, \sum_{1}^{\infty}\lambda_i x_i^2 \ge g_2^0, \ldots, \sum_{1}^{\infty}\lambda_i x_i^m \ge g_m^0\right)\lambda \in S \tag{13}$$

The NRT multi-objective planning form is as follows:

$$\left(\sum_{1}^{\infty}\lambda_i x_i^1 \le g_1^0, \sum_{1}^{\infty}\lambda_i x_i^2 \le g_2^0, \ldots, \sum_{1}^{\infty}\lambda_i x_i^m \le g_m^0\right)\lambda \in S \quad (NRT) \tag{14}$$

There are n decision-making units, each of which gets s different outputs from m different inputs. $X_j = (x_{1j}, x_{2j}, \ldots, x_{mj})^T$ is the inputs to DMU_j, while $Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})^T$ is the output of DMU_j, $X| = (X_1, X_2, \ldots X_n)$ is the input matrix, and $Y = (Y_1, Y_2, \ldots Y_n)$ is the output matrix.

When the objective type of the input-output system is PRT, i.e., when minimum inputs and maximum outputs are desired it is a positive response class, which is in line with the valid definition of the traditional DEA model. When the objective type is NRT, i.e., when minimum inputs and minimum outputs are desired, it is a negative response class, which is both the non-desired outputs that are the focus of this paper. Let $X(\lambda) = \sum_{1}^{n}\lambda_i X_i$, where $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n) \in S$, while set 5 contains at least $(e_1, e_2, \ldots, e_n)$.

Consider the evaluation of the validity of DMU_{j_0}. In the DEA model, the underlying assumption of its effectiveness is that DMU_{j_0} is effective when the initial target level (X_0, Y_0) cannot be further improved.

Therefore, for PRT, the initial target is $X(\lambda) \le X_0, Y(\lambda) \ge Y_0$, while for NRT, the initial target is $X(\lambda) \le X_0, Y(\lambda) \le Y_0$. After determining the target level, different DEA models can be composed according to the selection of different objective functions.

For PRT, there are DEA models:

$$\min \theta$$
$$s.t.\begin{cases} \lambda X + S_{IP} = \theta X_0 \\ \lambda Y - S_{PR} = Y_0 \\ S_{IP}, S_{PR} \ge 0 \\ 0 \le \theta \le 1 \\ \lambda \in S \end{cases} \tag{15}$$

The model is the C^2GS^2 model when the proper set of S is taken such that λ satisfies $\sum_{i=1}^{2}\lambda_i = 1$, which is proved to be the case when $\theta = 1, S_{IP} = S_{PR} = 0$, DMU_{j_0} is valid.

For NRT, there is the DEA model:

$$\min \theta$$
$$s.t.\begin{cases} \lambda X + S_{IP} = \partial X_0 \\ \lambda Y + S_{NR} = Y_0 \\ S_{IP}, S_{NR} \ge 0 \\ 0 \le \theta \le 1 \\ \lambda \in S \end{cases} \tag{16}$$

Similarly it can be shown that DMU_j is valid when $\theta = 1, S_{IP} = S_{NR} = 0$.

Now consider a real problem, such as a paper mill, where investment is taken as the input and profit and pollution level as the output, then investment and profit constitute a PRT problem and investment and pollution level constitute a NRT problem. Now consider the most informative decision in the mixed case of investment, profit and pollution level. Divide the output of DMU_j into two parts, i.e., Y_j into Y_j^{PR} and Y_j^{NR}, such that $X_j \to Y_j^P R$ is the PRT and $X_j \to Y_j^{NR}$ is the NRT.

Assuming that the first p outputs and inputs in the inputs s indicators form the PRT, and the second $s-p$ outputs and inputs form the NRT, there is a hybrid DEA model:

$$\min \theta$$
$$s.t.\begin{cases} \lambda X + S_{IP} = \partial X_0 \\ \lambda_{PR} Y^{PR} - S_{PR} = Y_0^{PR} \\ \lambda_{NR} Y^{NR} + S_{NR} = Y_0^{NR} \\ e^T \lambda = 1 \\ S_{IP}, S_{PR}, S_{NR} \geq 0 \\ 0 \leq \theta \leq 1 \end{cases} \tag{17}$$

where $\lambda = \begin{bmatrix} \lambda_{PR} \\ \lambda_{NR} \end{bmatrix}, e = (1,1,\ldots 1) \in R^n$.

From the optimal solution of model (15)(16), DMU_{j_0} is valid when $\theta = 1, S_{IP} = S_{PR} = S_{NR} = 0$.

The economic implication of model (17) is that within the set of production possibilities consisting of constraints, inputs X_0 are reduced as much as possible $(0 \leq \theta \leq 1)$ in the same proportion θ when output Y_0 is kept constant, and if inputs X_0 cannot be reduced in the same proportion θ then the decision cell DMU_{j_0} is DEA efficient.

On this basis, assuming constant returns to scale, the input-based stochastic DEA model is constructed as:

$$\min \theta_k$$
$$s.t.\begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_k x_{ik}, i = 1,2,\ldots,m \\ P\left\{ \sum_{j=1}^{n} \lambda_j \bar{y}_{rj}^1 \geq \bar{y}_{rk}^1 \right\} \geq 1-\alpha, r = 1,2,\ldots,p \\ P\left\{ \sum_{j=1}^{n} \lambda_j \bar{y}_{rj}^2 \leq \theta_k \bar{y}_{rk}^2 \right\} \geq 1-\alpha, r = P+1, P+2,\ldots,s \\ \lambda_j \geq 0, j = 1,2,\ldots,n \end{cases} \tag{18}$$

where θ_k represents the efficiency value of the decision unit DMU_k, λ_j represents the weight coefficients of each decision unit, P represents the probability, α represents the level of risk, and $1-\alpha$ represents the level of confidence. When $\theta_k = 1$, said the decision unit DMU_k in the confidence level $1-\alpha$ for the random DEA effective, when $\theta_k < 1$, It indicates that the decision unit DMU_k is randomly DEA invalid at the confidence level $1-\alpha$.

IV. Empirical analysis of the efficiency of the optimal allocation of regional economic resources

The strategic vision of building the "Belt and Road Initiative" hopes to create a mutually beneficial "community of shared interests" and a "community of shared destiny" for common development and prosperity through trade and cooperation among countries, thereby achieving the optimal allocation of regional economic resources. Under the background of promoting the "Belt and Road" strategy, combining intelligent technology with the optimization of regional economic resources can promote economic exchanges and cooperation among different countries to varying degrees. This article starts from the operational efficiency of the logistics industry in the provinces along the "Belt and Road" and explores its specific role in the optimization of regional economic resource allocation, providing reliable support for further optimizing regional economic resources.

IV. A. Results of Allocation Efficiency Measurement in the Provinces Along the Route

IV. A. 1) Stochastic DEA model parameter selection

In this section, we will use the deterministic DEA model and stochastic DEA model with non-expected output to evaluate and analyze the operational efficiency of the logistics industry in 17 provinces along the “Belt and Road”. In order to clearly understand the impact of risk appetite α on the efficiency value, we set the risk appetite as 0.02, 0.04, 0.08, 0.12 and 0.16. The efficiency evaluation results are shown in Table 1.

The following information can be derived from the table:

(1) The efficiency values of the logistics industry in each province measured using the stochastic DEA model are different at different risk levels α. With the increase of α, the efficiency value of the logistics industry in each province largely decreases, i.e., the lower the confidence level 1-α, the smaller the efficiency value.

(2) Under different risk levels α, the average value of the efficiency of the logistics industry in the provinces along the Maritime Silk Road is higher than that of the Silk Road Economic Belt, in which the value of the efficiency of the logistics industry in Shanghai is always located on the optimal production frontier, whereas the efficiency of the logistics industry in the two provinces, Yunnan and Xinjiang, is lower and is always located in the bottom position of all the provinces.

(3) The efficiency value of logistics industry in each province measured by deterministic DEA is basically higher than that measured by stochastic DEA model.

(4) The rankings of the efficiency of the logistics industry in each province measured by the deterministic DEA model and the stochastic DEA model are also different. Under the deterministic DEA model, the comprehensive efficiency values of Inner Mongolia, Shanghai and Fujian are all 1, which are all located on the efficient frontier and cannot be further differentiated, while under the stochastic DEA model, only Shanghai is located on the efficient frontier.

Therefore, compared with the deterministic DEA, the stochastic DEA model has more differentiation and can better reflect the development of the logistics industry in each province. In summary, we will choose the stochastic DEA model to measure the efficiency of the logistics industry in the provinces along the “Belt and Road”. Due to the small differences in efficiency values among provinces at different risk levels α, we set the risk level α to 0.04 and the confidence level to 95%. Under these conditions, we applied a stochastic DEA model with undesirable outputs to evaluate and analyze the comprehensive efficiency, pure technical efficiency, and scale efficiency of the logistics industry in 17 provinces along the “Belt and Road” from 2013 to 2019.

Table 1: Average efficiency of the logistics industry in the provinces along the route

Province	Definite DEA	Random DEA				
	Efficiency	α=0.02	α=0.04	α=0.08	α=0.12	α=0.16
Xinjiang	0.616	0.553	0.563	0.567	0.563	0.562
Shaanxi	0.735	0.721	0.714	0.702	0.706	0.704
Gansu	0.793	0.774	0.762	0.745	0.751	0.749
Ningxia	0.972	0.973	0.971	0.969	0.969	0.969
Qinghai	0.614	0.576	0.565	0.558	0.559	0.557
Neimenggu	1.000	0.996	1.000	0.995	0.995	0.995
Heilongjiang	0.693	0.683	0.676	0.663	0.667	0.663
Jilin	0.721	0.705	0.702	0.694	0.695	0.691
Liaoning	0.946	0.952	0.955	0.952	0.948	0.951
Guangxi	0.753	0.706	0.703	0.702	0.702	0.702
Yunnan	0.348	0.311	0.301	0.313	0.301	0.301
Chongqing	0.716	0.674	0.672	0.672	0.672	0.673
Shanghai	1.000	1.000	1.000	1.000	1.000	1.000
Fujian	1.000	0.993	0.993	0.990	0.985	0.987
Guangdong	0.933	0.912	0.901	0.878	0.879	0.878
Zhejiang	0.989	0.974	0.946	0.975	0.975	0.976
Hainan	0.672	0.675	0.663	0.664	0.662	0.659

IV. A. 2) Vertical Logistics Industry Operational Efficiency Values

Using the DEA model with non-expected output, based on the sample data selected in the previous section, the operational efficiency of the logistics industry in the provinces along the “Belt and Road” has been measured using MATLAB software, and the specific results are shown in Table 2.

Based on the data in the table, the following conclusions can be drawn:

(1) From the data of 2013-2019 comprehensive technical efficiency value, in the time frame of 2013-2019, Liaoning Province, Shanghai Municipality and Zhejiang Province have maintained a comprehensive technical efficiency value of 1.000 for seven consecutive years, which has been on the production frontier, and it is DEA effective. This indicates that the operational performance of the logistics industry in these three provinces along the “Belt and Road” has been at the forefront of the team for six consecutive years, and has reached the leading level in the industry in terms of management level, technology level and regional economic resource allocation. Inner Mongolia Tibetan Autonomous Region, Fujian Province, Guangdong Province, Gansu Province and other provinces of the logistics industry operating efficiency followed, seven years of the average value of the comprehensive efficiency to remain above 0.8, in the comprehensive management and resource allocation, although there are still

deficiencies, but still in the industry ahead of the position. However, Heilongjiang Province, Qinghai Province and Xinjiang Uygur Autonomous Region are in the bottom three in terms of comprehensive efficiency, with an average value of less than 0.5, which is far lower than the industry average of 0.6.85 These three provinces along the Belt and Road may have problems of wastage of economic resources, difficulties in management and low level of technology in relation to other provinces along the Belt and Road. These three provinces along the “Belt and Road” may have problems of wasted economic resources, management difficulties and low technology level compared with other provinces. On the whole, the average value of the operational efficiency of the logistics industry in some provinces along the “Belt and Road” can be maintained above 0.7 in each year, which indicates that the comprehensive efficiency of the regional economic resource allocation in these provinces along the “Belt and Road” is still maintained at a high level, and that the efficiency of the logistics industry in these provinces along the “Belt and Road” is still at a high level. This indicates that the overall performance of logistics industry in this part of the provinces along the Belt and Road is at a more developed level in terms of management, scheduling, technology and resource allocation.

(2) From the ranking point of view, the top several provinces along the route are mainly concentrated in the freight logistics and supply chain logistics enterprises, which can be seen in the field of logistics in the field of segmentation, freight and supply chain of these two logistics areas have been more mature, the system is more complete, the operation process is mature, and the overall operation has been maintained at the first-class level. Relatively speaking, segments in the express logistics still has a larger space for development, including the last three provinces along the route, the express industry-oriented logistics enterprises accounted for a quarter. Visible, in the express logistics industry, still in the management or technical level, compared with other logistics industry there is a small gap.

Table 2: Operational efficiency value of the logistics industry

Province	2013	2014	2015	2016	2017	2018	2019	Means
Neimenggu	0.615	0.693	0.691	1.000	1.000	1.000	1.000	0.857
Liaoning	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Jilin	0.538	0.552	0.452	0.513	0.523	0.523	0.518	0.517
Heilongjiang	0.426	0.418	0.347	0.357	0.281	0.273	0.276	0.340
Shanghai	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Zhejiang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Fujian	0.656	0.776	1.000	1.000	0.835	0.834	1.000	0.872
Guangdong	0.614	0.781	0.716	1.000	0.867	0.862	0.834	0.811
Guangxi	0.608	0.600	0.598	0.634	0.616	0.616	0.618	0.613
Hainan	0.543	0.603	0.463	0.436	0.402	0.403	1.000	0.550
Chongqing	0.462	0.559	0.492	0.492	0.551	0.542	0.578	0.525
Yunnan	0.218	0.223	0.222	0.223	1.000	1.000	1.000	0.555
Shaanxi	0.553	0.635	0.583	0.551	0.593	0.573	0.606	0.585
Gansu	0.779	0.789	0.834	0.774	0.726	1.000	1.000	0.843
Qinghai	0.369	0.412	0.416	0.332	0.328	0.262	0.292	0.344
Ningxia	1.000	1.000	1.000	0.718	0.567	0.619	0.643	0.792
Xinjiang	0.437	0.518	0.435	0.446	0.453	0.493	0.316	0.443
Means	0.636	0.68	0.662	0.675	0.691	0.706	0.746	0.685

IV. B. Optimization of the allocation of resources to the regional economy

IV. B. 1) Analysis of time variations in operational efficiency

The logistics industry in the provinces along the “Belt and Road” has been developing rapidly by relying on national strategies, resources and factor inputs. However, due to the optimal allocation of regional economic resources since the effective distribution of intelligent technology, and distribution of the logistics industry in the provinces along the route of the intelligent technology utilization rate is not high, resulting in a certain amount of regional economic resources to increase the amount of consumption. In order to better understand the trend of the operational efficiency of the logistics industry in the provinces along the Belt and Road in time, this subsection adopts the kernel density estimation method to analyze the operational efficiency of the logistics industry in time as measured in the previous section.

In this subsection, the distribution of the kernel density of the operational efficiency of the logistics industry in the provinces along the “Belt and Road” during 2013, 2016 and 2019 is drawn using STATA software as shown in Figure

3. The horizontal axis represents the operational efficiency of the logistics industry in the provinces along the "Belt and Road", and the vertical axis represents the kernel density.

In terms of shape, the kernel density curve in 2013 shows a single peak, and the peak value is slightly larger than 1.6, indicating that most regions have lower efficiency values. However, there is a trailing phenomenon to the right of the kernel density curve, indicating that a small number of regions have higher efficiency values.In 2016, the kernel density curve shows a double-peak form, and the left peak is larger than the right peak, indicating that there are more regions with low efficiency than high efficiency in the operation of the logistics industry in the provinces along the "One Belt and One Road". By 2019, the kernel density curve shows a double-peak form, but the left peak is smaller than the right peak, indicating that there are fewer inefficient areas and more efficient areas in the logistics industry in the provinces along the "Belt and Road". From the position of the curve, from 2013 to 2019, the distribution of kernel density shifted from left to right in three years, indicating that the operational efficiency of the logistics industry in the provinces along the "Belt and Road" is generally on the rise, and the rise is larger, and the operational efficiency of the logistics industry has improved more obviously. With the passage of time, the number of provinces in the low-value zone is decreasing, the number of provinces in the high-value zone is increasing, and many provinces have a comprehensive efficiency value of more than 1.000 in 2019.

In terms of the peak value, the main peak value of the curve moved to the left and then to the right during the period of 2013-2019, indicating that the overall level of efficiency was first reduced and then increased, and it changed from a single peak to a double peak during this seven-year period, reflecting that the overall efficiency polarization phenomenon in provinces and cities is expanding.

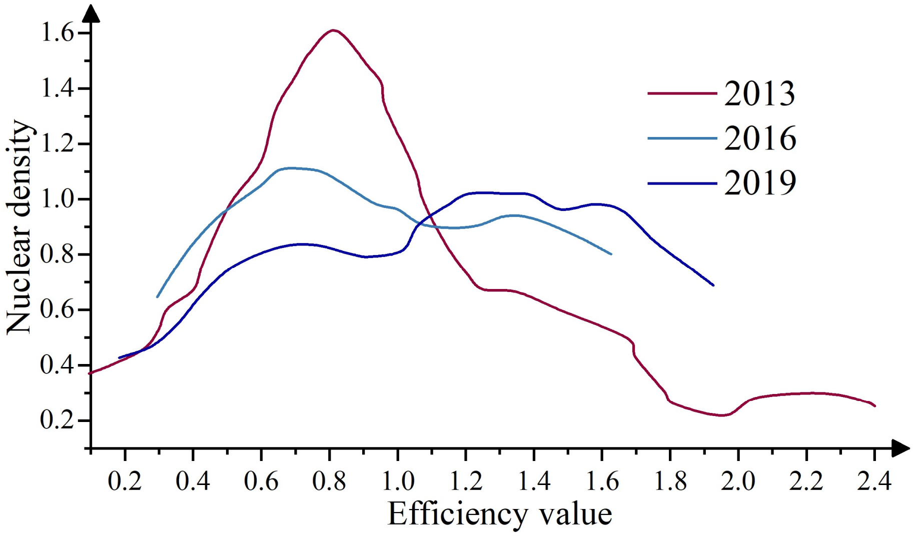

Figure 3: Kernel density analysis diagram

The results of the kernel density analysis show that the input and output of the logistics industry in the provinces along the "Belt and Road" are not balanced, and there is a polarization of efficiency within the regional economic resources, with much room for improvement. The reason for the polarization phenomenon may be due to the fact that among the provinces along the "Belt and Road", the integration level of the "soft and hard" infrastructure configuration for the development of the modern logistics industry is not high, and the industry has not been able to form a good interaction with each other. In addition, there are large differences in the endowment of natural and economic factors within the provinces, resulting in the loss of efficiency of the logistics industry in the region, increasing the additional costs, but also providing some guidance for the optimal allocation of regional economic resources.

IV. B. 2) Optimization programme for regional economic resources

According to the above analysis of the operational efficiency of logistics industry in the provinces along the "Belt and Road", in order to explore the reasons for the inefficiency of DEA ineffective unit allocation, through the DEAP software, the redundancy of each input index and the lack of each output index in each province along the Belt and Road that is not in the optimal state are calculated, and the values of the residual variables that make them become DEA effective can be obtained. The values of the residual variables that make them turn into effective DEA can be obtained. Table 3 shows the values of the relaxation factors of the provinces along the Belt and Road.

The results show that the operational efficiency of the logistics industry in the provinces along the “Belt and Road” with ineffective DEA suffers from different degrees of input redundancy and output insufficiency. According to the values of the relaxation factors of the non-DEA effective provinces along the Belt and Road, by applying the “projection” theorem, we can calculate the “ideal value” that can be transformed into the DEA effective one, i.e., the optimal plan for the allocation of regional economic resources.

Table 3: The quantity value of relaxation factors

Province	Output relaxation factor		Input relaxation factor		
	OUT1+	OUT2+	IN1-	IN2-	IN3-
Neimenggu	1.754	0.963	0.216	0.341	0.000
Liaoning	0.000	0.000	0.000	0.000	0.000
Jilin	3.279	0.875	0.174	0.226	0.000
Heilongjiang	2.665	1.107	0.000	0.349	0.173
Shanghai	0.000	0.000	0.000	0.000	0.000
Zhejiang	0.000	0.000	0.000	0.000	0.000
Fujian	4.228	0.000	0.263	0.152	0.138
Guangdong	0.159	0.000	0.148	0.000	0.036
Guangxi	0.000	0.137	0.352	0.000	0.174
Hainan	0.000	0.428	0.000	0.000	0.109
Chongqing	0.473	2.759	0.049	0.135	0.000
Yunnan	0.251	1.634	0.137	0.000	0.000
Shaanxi	0.796	0.000	0.158	0.119	0.000
Gansu	0.138	0.122	0.000	0.127	0.226
Qinghai	0.154	0.084	0.143	0.138	0.000
Ningxia	0.339	0.000	0.085	0.000	0.151
Xinjiang	0.417	0.268	0.072	0.000	0.136

It can be seen through the above analysis that the provinces along the “Belt and Road” should improve the regional economic resource allocation capacity of each subject in the process of regional economic resources. This is also very important in the “Belt and Road” regional economic resources allocation process, a region must ensure that a variety of enterprises to create a reasonable and efficient allocation of resources to ensure the smooth progress of the region's creative activities, which is also a region want to achieve the essence of long-term development requirements. So, how to better optimize the distribution of regional economic resources has become a key issue, and according to the distribution of regional economic resources, we can know that this process is not static, on the contrary, it is actually a dynamic process of development and change. It not only changes according to the change of regional economic development, but also changes according to the change of regional innovation mode, so this process is also somewhat complex. In addition, the optimal allocation of regional economic resources is not carried out by itself, on the contrary, it will change accordingly with the degree of optimization of each organization. Precisely because of this, the region to carry out the process of optimizing the allocation of regional economic resources, in order to achieve the purpose of optimizing the allocation and the goal of continuous optimization, can not be developed alone without regard to other. On the contrary, it is necessary to take into account the degree of optimization of each organization in each region, coordinate with them, and at the same time take the regional economic resources themselves into account, so as to realize the way of optimizing the allocation of the regional economic resources effectively and to give full play to its maximum effect.

V. Conclusion

This study analyzes the operational efficiency of logistics industry in the provinces along the Belt and Road by constructing a model of optimal allocation of regional economic resources integrating intelligent technology, and draws the following conclusions:

Intelligent technology plays a key role in the optimal allocation of regional economic resources, and effectively promotes regional economic cooperation by improving information transparency, reducing transaction costs, and accurately matching supply and demand. Empirical analysis shows that the operational efficiency of the logistics industry in the provinces along the “Belt and Road” during the period of 2013-2019 showed an overall upward trend, with the average value rising from 0.636 to 0.746, an increase of 17.3%.

There are obvious regional differences in the operational efficiency of the logistics industry in the provinces along the Belt and Road, with Liaoning, Shanghai and Zhejiang maintaining the leading position in terms of efficiency, while the efficiency of Heilongjiang province is only 0.340, and that of Xinjiang is 0.443, reflecting the imbalance in the allocation of regional economic resources.

Kernel density analysis reveals that the distribution of operational efficiency of the logistics industry in the provinces along the route evolves from a single peak to a double peak in 2013-2019, and the phenomenon of efficiency polarization expands, indicating that there are still structural problems in the allocation of regional economic resources.

The relaxation factor analysis reveals that non-DEA effective provinces have different degrees of input redundancy and output insufficiency, and need to optimize the input structure and improve the output efficiency through intelligent technology.

In the future, we should strengthen the in-depth integration of intelligent technology and the optimal allocation of regional economic resources, construct a cross-regional collaborative development mechanism, promote the free flow of resource factors, and realize the overall improvement of the efficiency of regional economic resource allocation.

References

[1] Weber, M. S., & Monge, P. R. (2017). Industries in turmoil: Driving transformation during periods of disruption. Communication Research, 44(2), 147-176.

[2] Lawrence, M., Homer-Dixon, T., Janzwood, S., Rockstöm, J., Renn, O., & Donges, J. F. (2024). Global polycrisis: the causal mechanisms of crisis entanglement. Global Sustainability, 7, e6.

[3] Habibjonov, U. (2024). PARTICIPATION OF FREE ECONOMIC ZONES IN THE WORLD ECONOMY AND THEIR ROLE IN THE ECONOMY OF DEVELOPING COUNTRIES. Nordic_Press, 5(0005).

[4] Pollin, R., & Bouazza, H. (2024). Considerations on inflation, economic growth, and the 2 per cent inflation target. Review of Keynesian Economics, 1(aop), 1-22.

[5] Fadinger, H., Herkenhoff, P., & Schymik, J. (2024). Reprint of: Quantifying the Germany shock: Structural labor-market reforms and spillovers in a currency union. Journal of International Economics, 149, 103931.

[6] Jaloliddin, R. (2024). The Role of Regional Trade Agreements in Promoting International Trade and Investment: A Case Study of the Regional Comprehensive Economic Partnership (RCEP). Central Asian Journal of Social Sciences and History, 5(8), 417-424.

[7] Kryshtanovych, S., Prosovych, O., Panas, Y., Trushkina, N., & Omelchenko, V. (2022). Features of the Socio-Economic Development of the Countries of the World under the influence of the Digital Economy and COVID-19. International Journal of Computer Science & Network Security, 22(2), 9-14.

[8] Ignatov, A. (2020). The digital economy of BRICS: Prospects for multilateral cooperation. International Organisations Research Journal, 15(1), 31-62.

[9] Garnov, A. P., Garnova, V. Y., Shabaltina, L. V., Begishev, I. R., & Panferova, L. V. (2020). New opportunities for the digital economy: The implementation of an effective state innovation policy. Journal of Environmental Treatment Techniques, 8(4), 1321-1325.

[10] Lin, H., & Peng, P. (2025). Impacts of Digital Inclusive Finance, Human Capital and Digital Economy on Rural Development in Developing Countries. Finance Research Letters, 73, 106654.

[11] Li, X., Sohail, S., Majeed, M. T., & Ahmad, W. (2021). Green logistics, economic growth, and environmental quality: evidence from one belt and road initiative economies. Environmental Science and Pollution Research, 28, 30664-30674.

[12] Qian, X. Y., Liang, Q. M., Liu, L. J., Zhang, K., & Liu, Y. (2022). Key points for green management of water-energy-food in the Belt and Road Initiative: Resource utilization efficiency, final demand behaviors and trade inequalities. Journal of Cleaner Production, 362, 132386.

[13] Thürer, M., Tomašević, I., Stevenson, M., Blome, C., Melnyk, S., Chan, H. K., & Huang, G. Q. (2020). A systematic review of China’s belt and road initiative: Implications for global supply chain management. International Journal of Production Research, 58(8), 2436-2453.

[14] HAN, M. Y., XIONG, J., & LIU, W. D. (2020). China's cross-border energy relations between direct trade and embodied transfers: Based on" the Belt and Road" energy cooperation. Journal of Natural Resources, 35(11), 2674-2686.

[15] Sun, J., & Li, Y. (2022). A reseach on the Measurement and Trend Forecasting of Digital Economy Development in Cities along the “Belt and Road”. J. Comput. Financ. Econom, 2, 5-13.

[16] Lei Qi,Hina Najam,Yessengali Oskenbayev,Sansyzbaev Alisher & Kamla Hairis. (2025). Impact of rapid urban construction land expansion on spatial inequalities of ecosystem health in China: Evidence from national, economic regional, and urban agglomeration perspectives. Ecological Indicators,172,113196-113196.

[17] Guangtao Fu,Renfu Tu,Rui Qiu,Xinwei Wan,Yiwei Su,Fangliang Zhang... & Yongtu Liang. (2025). Energy, economic and environmental impact analysis of adjusting oil refinery capacity: An interregional optimization approach for resource allocation. Energy,320,135275-135275.

[18] Longhai Tang ,Lei Wang& Yuan He. (2023). Influence and optimization of regional enterprise spatial structure change on regional economic pattern under artificial intelligence. Soft Computing,28(23),1-10.

[19] Mojtaba Ghiyasi,Luyao Zhao & Weiwei Zhu. (2025). Non-cooperative two-stage inverse DEA: a Stackelberg games approach for the efficiency analysis of China’s regional economic development and people’s living standards. Annals of Operations Research,346(3),1-29.