Impact of Artificial Intelligence on Global Value Chain Networks: An Evaluation Based on Fixed Effect Regression Models

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Abstract: Economic globalization has made countries in the global value chain closely linked in economic and trade exchanges. The emergence of artificial intelligence has led to significant changes in the global value chain, and has a significant impact on the economies and economic structures of countries around the world. Fixed effect regression models can perform effect analysis under large sample data, so this article analyzed the impact of artificial intelligence combined with fixed effect regression models. Firstly, by introducing the changes in the network structure of the global value chain, the driving role of artificial intelligence technology was derived. Finally, regression models were used to conduct data statistics and predictive analysis from two aspects: the market revenue scale of artificial intelligence and the product quality level of production. The data showed that the global AI market revenue scale would exceed 3 trillion yuan by 2024, and the quality of products produced by machines was above 90%, which was high-quality products, while the quality level of products produced by humans was mostly around 80%. Therefore, it can be concluded that AI would completely change the industrial division network in the global value chain, and can bring greater economic benefits to countries in the value chain network that develop AI industries.

Keywords: Global Value Chain, Artificial Intelligence, Intelligent Robot, Industrial Structure, Fixed Effect Model

1. Introduction

The vigorous development of artificial intelligence technology has injected new impetus into the development of human society. The promotion of economic globalization and international trade has led to increasingly close ties among countries around the world. The development of the global economy is influenced by the new generation of artificial intelligence, which has deeply integrated various industries with artificial intelligence, leading the transformation of the global industrial structure. Artificial intelligence has a significant impact on global value chains, and has a significant catalytic effect on optimizing global industrial structure, increasing global trade transaction costs, optimizing global resource allocation, and many other aspects. Global value chains are closely linked to the development of various countries around the world. They

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are one of the most important organizations in international production, and have a profound impact on improving national economies and external competitiveness. Artificial intelligence provides a new research direction for global value chain networks, and provides new models and new momentum for international industrial production innovation. Emerging industries such as artificial intelligence would become an important force in promoting the development of global economic industries in the future.

Economic globalization has promoted trade ties between countries. In recent years, the foreign economy and import and export trade of countries have been continuously developing, forming a global value chain network that is closely linked to each country. The impact of global value chains is immeasurable and has become a hot topic of global trade attention. Using network analysis based on value-added trade metrics, Xiao, Hao provided a new perspective on whether global value chains (GVC) are truly global or more regional phenomena, indicating that global value chain activities can be consistently identified and divided into three types of networks, namely traditional, simple, and complex trade networks [1]. Durand, Cedric analyzed the role of intangible assets in global value chains and found that intangible assets in these chains have created new sources of market power, indicating that the expansion of trade in global value chains is related to the mobilization and circulation of intangible assets, and it is necessary to assess the monopoly dynamics generated by intangible assets in this regard[2]. Horner, Rory considered the changes in global trade dynamics and the impact of Southern actors on the conceptualization of global value chains and global production networks, and believed that in the context of the more important role played by Southern actors and southern end markets, more attention needs to be paid to the existence of multiple value chains and production networks serving different end markets, including domestic, regional, and global ones[3]. Krishnan, Aarti used selected insights from economic geography to advance our understanding of the environmental dimensions of upgrading and degrading global value chains and global production networks[4]. These studies have certain research significance, but most of them are discussed from the theoretical level.

As the most cutting-edge development achievement of human technology, artificial intelligence has also made a significant contribution to the development of international industries. Therefore, global value chain networks are also deeply affected by artificial intelligence, and are receiving more and more attention. Rehnberg, Martha discussed the possible impact of the widespread adoption of 3D printing on the restructuring, upgrading, and distribution of value-added in the global value chain of the manufacturing industry, which would have greater transformative effects in terms of “re-assembling” activities, regionalizing or localizing the global value chain, and flattening the smile curve into a “fake smile” [5]. Vidya, C. T used trade network analysis and artificial neural networks to measure trade links between countries before and after the outbreak of the epidemic, and predicted the future direction of trade[6]. Garay-Rondero has developed a reference and system model that integrates the inherent concepts and roles of supply chain management with new technological trends towards digitization, automation, and the increasing use of information and communication technologies in logistics global value chains [7]. These studies on global value chain networks have certain reference significance, but they have not been analyzed in combination with reality.

Unlike traditional production methods, artificial intelligence is an important technology in modern production and an important force in promoting global economic development, bringing a series of benefits to global trade. This article uses a fixed effect regression model to logically

analyze the impact of artificial intelligence in global value chain networks, and uses mathematical models and data to analyze the impact of artificial intelligence on global economic trade.

2. Artificial Intelligence and Global Value Chain Networks

2.1 Global Value Chain Network

Global value chains are based on international trade, which means that global value chains are global. It represents the entire process of product production, processing, and sales. Unlike the product supply chain, the core of the product value chain is value. The global value chain refers to the international trade transactions and sales of goods. The literature on global value chains has become the main international political and economic framework for understanding the challenges of economic upgrading under globalization in the 21st century[8]. The global value chain network is organized through transnational production networks, in which multinational companies are the main body. These networks closely connect the production chains of enterprises in various regions of the world. The continuous development of international trade and specialization of industrial division have formed a large-scale and complex value chain network, which has brought enormous economic benefits to countries and regions. There is a close relationship between the participation of global value chains and a country's network status[9].

The multiple dimensions of services and service functions in global value chains have not been fully explored[10]. With the development of science and technology, a new generation of technological revolution has arrived. The leading force of this revolution is artificial intelligence, which uses robots to replace humans to complete production tasks. Moreover, the efficiency of artificial intelligence in this regard is not what humans can achieve. Therefore, artificial intelligence has provided enormous convenience for humans, resulting in immeasurable economic and social benefits, and also affecting the division of labor and industrial structure in the global production chain, thereby fundamentally changing the structure and shape of global value chains. Therefore, under the influence of the new era, new technology, and new revolution, global value chain networks have gradually taken on new development directions and characteristics, which can be manifested in the following aspects:

1) Shortening of global production chains: due to the advancement of information technology in the Internet of Things, production processes have become more automated, and robots have largely replaced manual labor. Automated production technologies have led to shortened production processes, affecting global production chains, and making countries with lower technological levels less likely to participate in global production chains. Therefore, production chains in the future global value chain division network would become shorter and shorter.

2) Regionalization of global industrial division of labor: the background of regionalization is complex, including the development contradictions of regional economic integration, and the tense global international situation. Influenced by some protectionist countries, political relations between countries are tense, which has an increasingly profound impact on the regionalization of global value chains. In addition to the impact of COVID-19 in recent years, the development of foreign trade of various countries has been seriously hindered or even stalled.

Therefore, many countries have implemented the policy of "internal circular economy", which further strengthens the regionalization of the global value chain.

3) Influenced by values: the impact of the digital economy on various countries includes values, worldviews, and ideology, leading to increasing competition in trade transactions in the global value chain. For some technologically underdeveloped countries, standing at a disadvantage in the value chain would face enormous challenges.

4) Reduction of intermediate trade: due to the impact of the shortening and regionalization of the production chain, steps such as parts processing in the production process would be greatly reduced, and intermediate trade would decline, which would lead to a reduction in the production and trade of intermediate goods in many industries. For example, the automotive industry is gradually transitioning from fuel based vehicles to electric vehicles, as there are fewer intermediate production links for electric vehicles than for traditional fuel based vehicles.

2.2 Artificial Intelligence and Global Value Chains

Although the deployment of the Internet of Things in global value chains is increasing, some challenges may lead to a lack of trust among value chain partners, such as technical and security challenges[11]. The use of artificial intelligence technology has profoundly changed the resource base of international competition, led to the deep adjustment of global value chains, led to the digital transformation of production links, and improved production efficiency. At the same time, the production division network has also changed, and has a certain impact on product quality. Therefore, the impact of artificial intelligence on global value chains is divided into the following aspects:

1) Impact of labor division networks in value chain networks: the impact of artificial intelligence on labor division links in global value chain networks can be manifested in increased productivity, improved labor levels, and improved product quality. First of all, in terms of productivity, artificial intelligence technology replaces artificial production with robots, applying intelligent machinery and equipment to the production process, and greatly saving production costs. Moreover, the high-tech nature of intelligent technology makes production steps more accurate and scientific, and production standards are highly unified, greatly improving production efficiency, thereby improving product quality, and achieving twice the time efficiency of the production process with half the effort. Moreover, artificial intelligence technology initially led to the development of the product production chain towards a high-quality stage, which led to a gradual shift in the requirements for labor in the production chain towards skilled and technical talents, such as technical engineers, scientists, management managers, etc., which greatly improved the level and quality of labor.

2) Spillover benefits: artificial intelligence has changed the original market structure. Intelligent robots have gradually shifted towards technological development, and the original production links have gradually been replaced by robots, which has led to changes in the upstream and downstream production links of the industrial chain, resulting in spillover effects on other industries. There is a certain connection between inputs and outputs in different countries and regions, which makes it possible for enterprises to affect other links when using robots, generating chain effects, and ultimately affecting the development of enterprise value chains in other countries. The use of robots would likely replace most production links in the future, and the division of labor in the value chain would completely change, affecting the development of

other industries. This is the spillover benefits brought by artificial intelligence.

3) The transformation of the global industrial structure: the role of artificial intelligence in promoting the transformation and upgrading of the industrial structure.The emergence of artificial intelligence has caused profound changes in the entire industry.In the process of converting old and new kinetic energy, more and more traditional industries have begun to regard artificial intelligence as a new driving force for transformation and upgrading.The use of artificial intelligence machines and equipment to replace or cooperate with people has promoted the development of network intelligent design, manufacturing and service, thereby greatly improving labor productivity and reshaping the industrial chain and value creation and distribution methods.

Particularly relevant to global value chains is the rise of digital technologies such as big data, the Internet of Things, and artificial intelligence [12]. In general, artificial intelligence has made a good contribution to the global economy. Each country in the world has developed artificial intelligence to improve national competitiveness, and artificial intelligence can play a role in maintaining national security. According to data statistics, the share of artificial intelligence in various industries is increasing. As shown in Table 1, it is about the share of artificial intelligence technology in various industries:

Table 1. Market share of artificial intelligence technology by industry

Industry type	Security	Manufacturing	Finance	Marketing	Agriculture
Industry share	54%	3%	16%	12%	1%
Industry type	Education	Medical	Traffic	Customer service	Retail
Industry share	2.5%	0.5%	4%	4%	3%

From Table 1, the security industry accounted for the largest proportion, accounting for more than half of the market. It can be seen that artificial intelligence technology has made the greatest contribution to the security real economy. Artificial intelligence can not only be used as a product to improve enterprise innovation capabilities, but also as a service to participate in enterprise production and have a transformative effect on the global economy. It is a mechanism that can be used to improve supply chain elasticity by developing business continuity functions [13]. The impact of AI on global value chains can be analyzed from the following aspects, as shown in Figure 1:

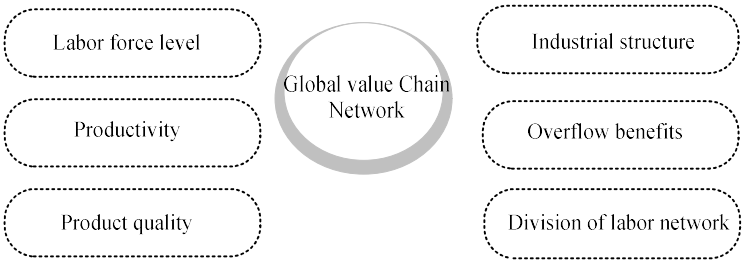

Figure 1. Impact of AI on global value chains

2.3 Fixed Effect Regression Model

The fixed effect regression model is a method of panel data analysis, while the fixed benefit model in panel data analysis is a variable method that changes with individuals but does not change with time. The face-fixed effect regression model compares the differences and interactions between each category. There are three major categories of fixed benefit models, namely, individual fixed benefit, time fixed benefit, and time individual solid benefit.

The first is individual based fixed benefit models, which are models with only different intercept terms for different individuals:

$$f_t = \beta_i + \sum_{i=2}^{i} x_{it}\alpha_i + \sigma_t \ (1)$$

Formula (1) is about an individual based fixed benefit model. f_t is a function of its model, and x_{it} represents different time series, that is, individuals. Then there is the second model, which is a fixed benefit model based on time points. It represents different intercept models for different time points. Unlike individual fixed benefits, the time point fixed effect model corresponds to different cross sections, and the intercept belonging to the model is obviously different. Therefore, for such models, the following formula should be used to express:

$$f_t = \gamma_t + \sum_{i=2}^{i} x_{it}\alpha_i + \sigma_t \ (2)$$

Formula (2) is about the effect model based on time points, and finally about the fixed effect model based on time points and individuals. Unlike the previous two models, this model is based on different cross sections, and the model intercept is different for different individuals. Therefore, this is the state where the first two models are combined. Therefore, such models can be represented by Formula (3):

$$f_t = \beta_i + \gamma_t + \sum_{i=2}^{i} x_{it}\alpha_i + \sigma_t \ (3)$$

The above is about three different fixed benefit models. For fixed benefit models, the variables are all true effect quantities. Therefore, the fixed effect model is applied to the analysis of the impact of artificial intelligence on global value chains, where the background, influencing factors, and analysis variables of the global value chain are consistent. The difference in the observed effects of each study on the impact of artificial intelligence is only caused by errors in selecting samples. Therefore, in this model, the allocation of weights depends on accuracy. For the impact factor samples extracted by artificial intelligence, the larger the amount, the larger the variance of the effect amount, and the more weight allocation. The following is an analysis of the impact of artificial intelligence in global value chains.

3. Simulation Experiment on the Impact of Fixed Effect Models on Artificial Intelligence

Three technologies are expected to change supply chain business processes, including robotic process automation, artificial intelligence, machine learning, and blockchain [14]. The global value chain network has undergone profound changes under the influence of artificial intelligence. The main research topics of the Internet of Things have shifted from general supply chain and business information management to more specific environments, including supply chain design, models, and performance [15]. This impact is visible. In order to analyze the factors affecting it, a fixed effect regression model is used for analysis, and it is converted into data. The impact of analyzing its data on artificial intelligence is examined. This paper analyzes the three impact mechanisms of the changes in the market revenue scale and product quality level of artificial intelligence, as well as the changes in the global industrial structure. The use of artificial intelligence has brought about changes in global market revenue, product quality, and industrial structure, using a fixed effect regression model.As shown in Figure 2：

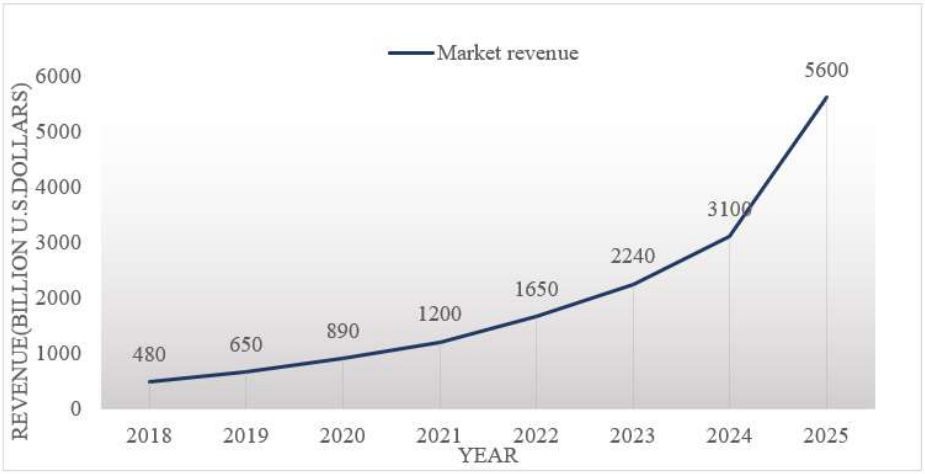

Figure 2. Scale of global market revenue generated by artificial intelligence

Figure 2 shows the revenue statistics brought by the global artificial intelligence market in recent years, and predicts the revenue of the artificial intelligence market size in the coming years using a fixed benefit regression model. From the line chart, the artificial intelligence market has always shown an upward trend in scale, and the rising base is becoming larger and larger. According to the data, the revenue scale of the global artificial intelligence market would exceed 3 trillion yuan in 2024, and the revenue scale of the global artificial intelligence market has already exceeded 1 trillion yuan in 2021. This shows that the artificial intelligence market would become larger and larger, and its impact on the global value chain network would also become larger and larger. It would change the global industrial structure and affect the industrial division in the value chain. The role of artificial intelligence is tested from a quality level, as shown in Figure 3:

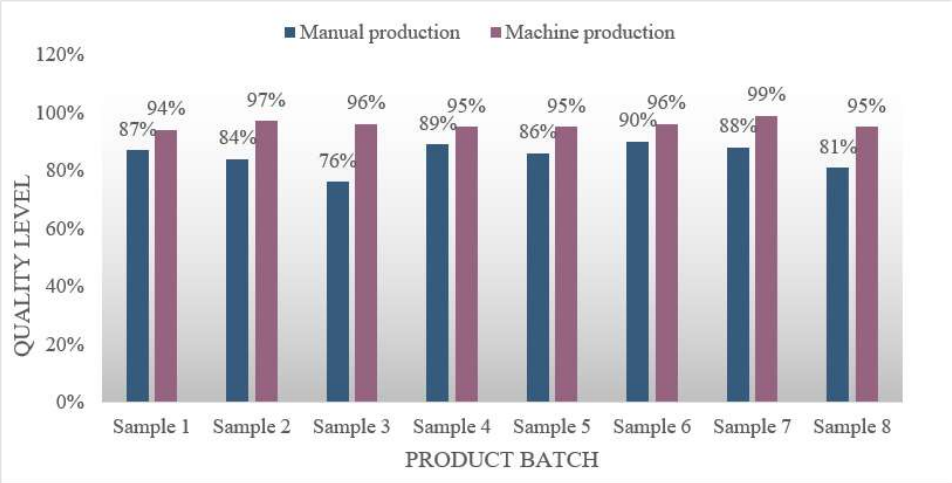

Figure 3. Comparison of product quality levels between manual production and machine production

Figure 3 shows a comparison between the quality level of products simulated by regression models and artificially produced products. For products with a quality of less than 50%, they are low quality products; those with a quality of between 50% and 90% are medium quality products; more than 90% are high quality products. From the distribution of the histogram in the figure, the quality level of the eight product sample batches produced manually and mechanically is above that of medium quality products. However, it can be concluded from the data that the quality of products produced by machines is above 90%, which is a high-quality product, and the quality level of the highest product batch reaches 99%. Looking at the quality level of manually produced products, most of them are around 80%; the highest is only 90%; the lowest batch quality level is only 76%. Through calculation, the average quality level of products produced by machines is 96%, while the average quality level of products produced manually is 85%. Therefore, it can be seen that artificial intelligence produces higher quality products than manual production, thereby bringing more economic value to the global production value chain. The global value chain would also be affected by artificial intelligence, changing its production chain and supply chain structure.The following describes the changes brought about by the emergence of artificial intelligence technology to the structure of the global industrial chain, and uses a fixed effect model to conduct data statistics, as shown in Figure 4.：

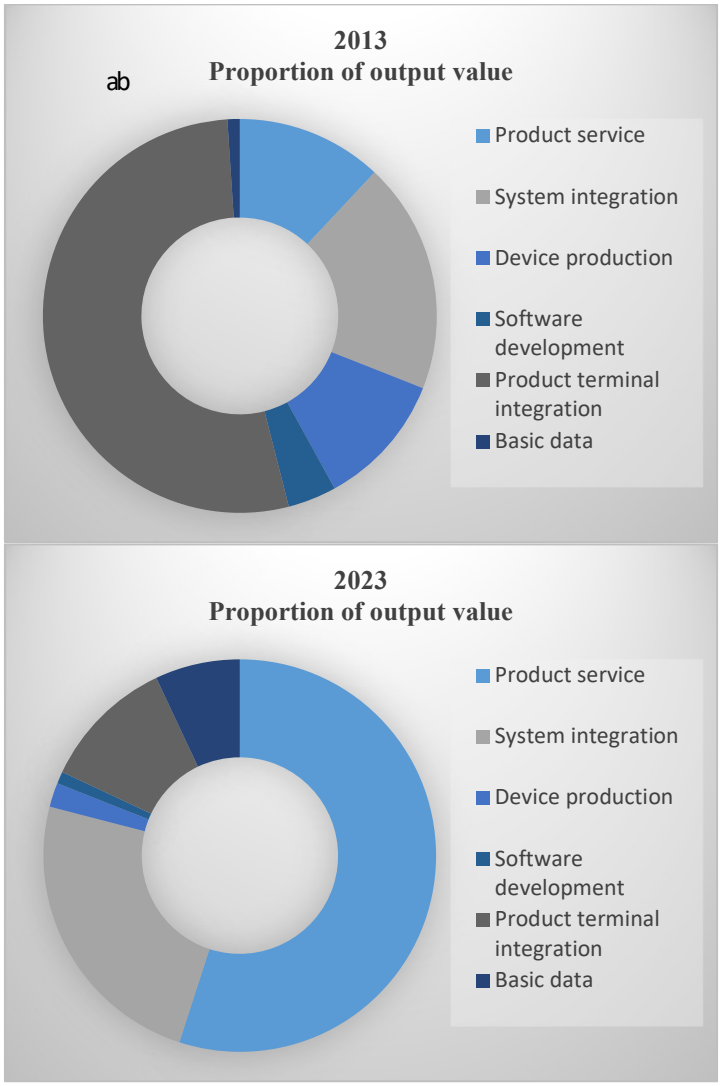

Figure 4. Data on the impact of artificial intelligence on the global industrial structure

Figure 4a.Global industrial structure data for 2013

Figure 4b.Global industrial structure data for 2023

Figure 4 is the analysis of the global industrial chain structure data for 2013 and 2023 using the fixed benefit regression model. Judging from the data in the figure, in 2013, the main part of the global industrial structure was product terminal integration, which accounted for 53%, but by 2023, under the influence of artificial intelligence technology, the global industrial chain structure has mainly become dominated by products and services, which is 55%, while product terminal integration has fallen to 11%. It can be seen that artificial intelligence technology has a relatively large impact on the global industrial chain structure, and the industrial structure is

gradually shifting to the tertiary industry. Services are also operating. Industry and other transformation.

4. Conclusions

Artificial intelligence is a new opportunity for global economic development, and countries in the global value chain network would undergo profound changes in various industries due to its impact. This article has conducted a profound analysis of the impact of artificial intelligence on global value chains, introduced the changes in global value chains, and indicated that artificial intelligence would occupy an important position in the production chain of global value chains, and the division of labor network of value chains would also be thoroughly reformed. Then, a fixed effect analysis model was introduced to analyze the impact of artificial intelligence through data analysis. Finally, statistics were conducted from two aspects: the market revenue scale of artificial intelligence and the quality level of products produced. The conclusion is that the impact of artificial intelligence on global value chains is enormous, and artificial intelligence would occupy an important position in the global economic value chain in the future.

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