A Study on the Economic Drivers of the Data Element

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Abstract. As the development of information technology has entered a new stage, data has become a novel factor of production in the digital economy. With its unique and fundamental economic characteristics, data participate in the production process and brings an innovative driving force to the economy. Thus, how data factors act on production and contribute to economic growth need further study. This article analyses the economic characteristics unique to the data element from the perspective of its causes. In the following parts, we propose three ways in which the data element can be combined with traditional factors of production to drive productive development: value multiplication, input substitution, and resource optimization. Furthermore, the article extends the Cobb Douglas function to investigate the possible paths of the data element economic growth model, and initially constructs a production function model including the data factor to deepen the understanding of the function of the data factor.

Keywords: data elements, economic growth, economic characteristics, production function model

1. Introduction

As emerging technologies such as big data and artificial intelligence continue to make breakthroughs and developments, big data has opened up a major period of change, and the digital economy and smart economy have become a new wave leading the world's economic development. In comparison with the traditional agricultural economy, industrial economy, and information economy, the digital economy has undergone tremendous changes in terms of economic form and development mode. Data as a factor of production is a gradual process, and the history of the development of factors of production reveals that the content of factors of production is constantly enriched in practice, not overnight. In the course of the millennia-long agricultural economy, the determinants of economic development were land and labor [1]. As we entered the industrial economy, technology gradually replaced manpower and capital breaking the constraints of the finite nature of natural resources such as labor and land, becoming the key factor of production for economic development.

In the 21st century, new economies, new businesses, and new models generated by digital technologies are overgrowing and integrating with the real economy. The digital economy has been regarded as a "new engine" for economic growth in various countries. Regions and countries like the EU, the US, Germany and Japan are all strengthening their strategic approaches to the digital economy. In 2010, the EU officially released Digital Agenda for Europe, followed by the release of UK's Digital Strategy 2015-2018 and The Definition and Measurement of the Digital

Economy respectively to provide strong policy support for achieving a digital powerhouse [2]. According to OECD Digital Economy Outlook 2020, 34 of the OECD countries have developed National Digital Economy Strategies (NDS) to accelerate digital transformation through policy coordination at the highest levels of government [3]. Finding new drivers for China's economic growth in the new era has become a focus of attention.

The definition of the digital economy includes 3 layers of meaning: the digital economy is the latest economic form; digital technology is the main driver of the digital economy, and data will become a new factor of production [4]. It can be seen that the digital economy as a whole includes new digital technologies, new processes for processing economic activities and new ways of organizing activities, which will also bring new increments to economic growth [5].

Emerging digital technology has significantly reduced the cost of data circulation and utilization, and has also facilitated the exploitation of the value of data resources. The generation and proliferation of data resources into all areas of the economy and society contributes to productivity gains; its role as a new key factor of production also helps to lessen the traditional factor inputs. The rising importance of data as a factor and the rapid development of the digital economy has stimulated a growing number of studies in business and data policy. Although a joint effort is being spent on studying the innegligible role of data elements in economic growth, research on the new drivers of China's economic growth in the digital economy has yet in its infancy and needs to be studied in depth. Based on the role of data factors in driving production and the goal of economic growth, this article argues that putting data factors into production will certainly facilitate the upgrading of initial production factors and promote economic growth in the digital economy. By briefly describing the four economic characteristics of data factors, the study will discuss how data, as a new factor of production, is different from traditional factors of production such as land, labor and capital, and how they can be combined with traditional factors of production to update, iterate and optimize traditional factors of production, and act and drive production. Finally, the paper will explore the possible paths of the data factor economic growth model and construct a preliminary growth model based on the thinking and knowledge of the Cobb Douglas function.

2. Basic Economic Characteristics of Data Elements

2.1. Non-competitive

The concept of " non-competitiveness " originates from Samuelson's first definition of a public good [6]. According to Samuelson, non-competitiveness is expressed in terms of a zero marginal cost to the consumer. Through research and collation, it is feasible to determine that non-competitiveness has two main meanings: the first is shareability, which means that it can be used by different agents at the same time; the second is an abstraction, which means that it is difficult to price through market transactions [7].

From the element of land, and labor to capital and technology, the evolution of production factors is characterized by diminished competition, increased versatility and sharing. Once acquired or generated, data can be used simultaneously and repeatedly by different subjects without any qualitative loss, with zero marginal cost added by the consumer of the data element.

Data elements are mainly expressed in virtual forms such as numbers, images and language, and cannot be converted into physical objects as traditional factors of production. Labour manipulates digital technology to combine data elements with other physical elements, and the result of production is only the physical elements coalescing in the product, not the form in which the data elements exist. Furthermore, the abstract nature of data elements makes it difficult to measure and price their value in the production output.

2.2. Excludability

In contrast to the obvious exclusivity of traditional factors of production, the exclusivity of data elements is limited. The data element has distinct technical and transactional characteristics that form the basis of business models and competitive strategies for digital enterprises, so companies or users who own it rarely share it in the form of transactions rather than for free. From this perspective, data elements are exclusive in nature. In practice, nevertheless, it is extremely difficult to define the property rights of data elements, and there are legal gaps in terms of whether data can flow freely and how it can be legally traded. In addition, the ease of replication and dissemination of data makes it difficult for one subject to prevent others from collecting and using identical data, and once the data is accessed by others, the data producer will lose control over the exclusivity of the data. Hence, the data element is also non-exclusive.

2.3. Economies of Scale

The concept of economies of scale is a phenomenon in which the average cost per unit of products and services provided by an enterprise reduces continuously as the scale of production increases, within certain technological conditions and market demand. Data elements have a unique production cost structure, with high fixed costs for the first production, but extremely low variable costs for subsequent re-creation and re-production. The value of partial, isolated data is low, the cost of acquisition is high, and it exerts a small part in production operation. However, when the scale of data accumulates to a critical mass, quantitative changes lead to qualitative change, data of high quality emerges, the larger the scale of supply of data elements, the lower the unit cost, and the value extracted from the data will show exponential growth.

2.4. Integration of Reconfigurability

In general, the reconfigurability between different data elements is attributable to the complementary nature of the different data elements, which are highly mobile and infinitely available compared to traditional elements. Partial, single datasets are highly valuable and useful, but some single datasets are dormant and the value is expressed by combining it with other datasets. The Danish Cancer Society has studied whether mobile phones could increase cancer incidence, and by collecting and comparing a database of all mobile phone users and cancer patients over 17 years, concluded that there was no direct link between mobile phone use and cancer induction [8]. The study was successful and thus demonstrated that single-dimensional data can be restructured and integrated in a way that results in different dimensional datasets. These datasets often create a greater value than a single dataset, increasing the economic value of not only the sum of data elements but also the single element.

3. Data Elements for Economic Growth

3.1. Multiplying the Value

Neoclassical growth theory, which began with the Solow model, viewed economic growth as a production function relationship between factor input and output, with the output growth dependent on technological progress, labor, and capital inputs. The key theoretical prediction was that due to the regulation of diminishing returns to scale of factor inputs, the growth of labor and capital factor inputs was limited by the total supply of society and the lack of technological progress, and the outcome of economic growth was stagnation [9,10]. Although up-to-date endogenous growth theory emphasizes

technological innovation as the key determinant of long-term economic growth, endogenous growth theory is still not free from the law of diminishing returns to scale for factors of production.

As the most critical resource of the digital economy, data elements are shareable, replicable, and infinitely available, which breaks the constraints of the limited supply of traditional factors such as land and capital to drive economic growth. Compared to traditional factors such as land and capital, data factors have more multiple effects on driving economic growth. In the digital economy, due to the non-competitiveness, exclusivity, and economies of scale of data elements, the production function of digital economic growth will reflect the growth effect of incremental returns to scale, with the ratio of total output to the growth of factor inputs increasing significantly. Data can be used repeatedly without any qualitative loss and has incremental benefits since it is non-competitive, which directly contributes to high-quality economic growth. Furthermore, the process of input production of data elements does not lead to the consumption of material resources but is a continual process of information and knowledge generation. Data elements share knowledge and technology while producing high-quality knowledge, thus endogenously contributing to high-quality economic growth.

The exploitation of data elements is characterized by clear economies of scale, with large-scale and diverse data costing less. This economy of scale is reflected not only on the supply side but also on the demand side. On the supply side, enterprises can gain a comprehensive understanding of market demand and preferences based on big data, and innovate business models and products through in-depth mining and analysis to bring more tailored products and services to the demanders, thereby increasing corporate revenue. On the demand side, consumers use data to purchase more personalized products and enjoy better prices with lower transaction costs and higher efficiency. In the case of e-commerce platforms, for example, the more individual businesses that are on the platform, the better the supply of products and the lower the prices, which attracts a large number of consumers to choose e-commerce to buy products. Similarly, more consumers attract more individual merchants to e-commerce platforms, again expanding the range of products available on the platforms and attracting more consumers. Through the input of data elements, the economies of scale on the supply and demand sides achieve synergy, allowing the social production possibility curve to shift outwards and bring new incremental growth to the economy.

3.2. Input Substitution Effect

The data elements can activate other factors, increasing the innovative capacity of products and the innovative dynamism of individuals. Data elements create more material wealth and services with fewer material resources, creating a substitution effect for traditional factors of production. Currently, data elements have shown some substitution for physical factors of production. For instance, mobile payments are gradually replacing traditional ATMs and business premises, e-commerce has reduced large-scale investment in traditional business infrastructure, and the government's "most run once" has reduced the consumption of manpower and resources. The data element creates a higher value with less input. On the one hand, data elements participate in the production process in the form of virtual assets, breaking the fetters and constraints on the role of physical factors of production in driving economic growth under conditions of scarce resources. On the other hand, data factors multiply the means of production under the concept of sharing because of their properties such as reproducibility and unlimited supply, which is the most prominent feature that distinguishes data factors of production from traditional human and capital factors of production. At the same time, even though data production entails high fixed costs, the marginal cost of data replication is close to zero, which will greatly reduce the search and transportation costs for consumers and bring the supply and demand sides closer together, resulting in the widespread transmission of information across

geographical boundaries, thus breaking down the "information silos" between different industries and regions [11].

3.3. Resource Optimization

Factors of production are fundamental to economic development. Increased efficiency in resource allocation is the key to economic growth, and the flow of factors based on information exchange is the basis for increased efficiency in resource allocation. The data elements not only drive the multiple effects of single factors such as labor, capital, and technology but more importantly, they improve the efficiency of traditional elements allocation of labor, capital, and technology.

Economic growth is not a quantitative increase obtained by simply adding up different factors; high-quality economic growth should be an efficient combination of several single factors. Data cannot directly produce goods, but it can reduce production costs and improve production efficiency. The data factor has a convergent and reorganizing nature, and it reorganizes with other tangible factors to digitize the economy, which is essentially a process of innovative development of traditional factors to achieve efficient reorganization, i.e. the Creative Destruction proposed by Schumpeter [12]. The fundamental role of the data element is to provide greater convenience in a knowledge-based way, and it has an extremely strong synthetic effect with other single elements. Given the positive externalities that arise from the development and use of data elements, traditional elements create a higher value from the original elements through deeper integration with data elements. The fusion of data with capital and labor factors promotes capital deepening and labor productivity. The combination of data with other factors of production may produce total factor productivity gains.

4. Exploring Production Function Models for Data Elements

4.1. Independence of Data Elements

Global data is characterized by explosive growth and massive aggregation. Big data is applied in every aspect of production, exchange, distribution, and consumption, and shows typical endogenous characteristics. Data is an input-ready factor with certain productivity in itself. In the study of Su Jingchun and Xu Jing, it is mentioned that the information factor represented by data has become necessary support for production activities and can enter the production process independently without relying on other factors [7]. On the one hand, the rapid development of communication technology has allowed data to flood all aspects of production activity and everyone has become a data producer. On the other hand, data can be collected, labeled and cleansed to enable a standardized supply of products that participate in the production process by being traded for a price on the market. At the same time, companies are gradually starting to set up data departments to involve data in production activities independently. This is a way of transforming the externality of data inferior, which means that data can already generate profits independently.

4.2. Interaction of Data Elements with Other Elements

In addition to its independence, data can digitally empower other elements. The data element has the abilities of reproducibility and reusability that other elements do not have, and it can also interact with other elements to promote the efficiency of economic production activities, which gives it the potential to influence the economy in a very dynamic way.

The endogenous nature of the data elements reveals that elements such as technology are not fixed values but can be determined internally by the model and can have an impact on it. into the economy by improving production methods, creating new industries, and increasing capital output per capita.

At the same time, factors such as labor and capital can also bring about further improvements in technology and institutions through processes such as learning and education, thus achieving interactions within factors and breaking the stagnation of economic growth. It is apparent that the data element also has the same effect. Population growth, capital investment and technological progress can all lead to quantitative and qualitative improvements in data factors, which in turn can expand the boundaries of economic growth through value multiplication, input substitution and resource optimization.

4.3. A Primer on the Production Model of Data Elements

Referring to Solow's model of economic growth based on the production function:

$$Y = F(A, K, L) = AK^{\alpha}L^{1-\alpha} \tag{1}$$

Y is total output, A is the level of technology, K is capital input, L is labor input and α is an exogenous variable.

In the digital economy, the original economic growth model has changed and data itself has become a factor of production. The role of data in the production function is manifested in two ways: firstly, data itself can promote the development of the level of technology, which in turn can promote economic growth; secondly, the data element is different from traditional factors of production such as labor and capital, and it can integrate other factors of production and improve the efficiency of factor output. Data factors can also indirectly contribute to output growth by shifting the structure of production and promoting structural changes in factor endowments. Drawing on the thoughts of Yang Rudai and the specific approaches of Jones, Tonetti, Xu Xiang, Zhao Mofei and Cong et al., this paper introduces the data element into the production function, taking the Cobb Douglas function as an example [13-16]:

$$Y = F(A, K, L, D) = \alpha AK^{\beta}L^{\gamma}D^{\lambda} \tag{2}$$

D refers to the input data actor, α refers to the auxiliary augmentation effect of data on the level of technology, as well as β and γ refer to the output elasticity coefficients of capital and labor respectively after the introduction of the data factor. Because of the independence of the data elements, with reference to the original economic growth model, $\beta + \gamma = 1$, $\beta, \gamma \in (0,1)$, λ as an independent exogenous variable, is not correlated with the quantity of data itself, and its economic significance is the relative degree to which the data play a role in production relations, i.e. the contribution made by the data in production. On the one hand, in terms of economically productive activities, λ is determined by the extent to which data is useful for productive activities, and it relies on the extent to which productive activities rely on data. In the digital economy, for example, data is much more powerful for production than in the era of agrarian societies; on the other hand, also depends on an individual's ability to collect, process and use data. As mentioned above, the data element is reproducible and infinitely available and therefore has the characteristic of increasing returns to scale in the production function, $\lambda > 1$. Given that the data element can contribute to the improvement of technology and interact with other traditional factors in the production function, the values of α, β and γ are influenced by λ respectively:

$$\alpha = f_1(\lambda), \ \beta = f_2(\lambda), \ \gamma = 1 - f_2(\lambda) \tag{3}$$

Expressing α, β and γ as λ respectively, presents a certain functional relationship and further discussion of the function:

$$\alpha' = f_1'(\lambda) > 0, \ \alpha'' = f_1''(\lambda) > 0 \tag{4}$$

$$\beta' = f_2'(\lambda) < 0, \ \beta'' = f_2''(\lambda) > 0 \tag{5}$$

$$\gamma' = -f_2'(\lambda) > 0, \ \gamma'' = -f_2''(\lambda) < 0 \tag{6}$$

In the formula, α represents the enhanced utility of the data element on the level of technology, and the functional relationship is increasing. As the input of data element increases, the technological level progress more significantly. Considering that the input of data elements into production makes novel technology generated continuously, it accelerates the innovation of the technology level. Therefore the enhanced utility of each unit of data element input on the technology level is incremental, and the second order derivative function is also greater than zero. The functional relationship of γ takes into account the effect of the data element on the elasticity coefficient of the labor force. As can be seen from equation (6), the first-order derivative function is greater than zero while the second-order derivative function is less than zero. The data factor can optimize the structure of the labor force to a certain extent by increasing the number of machines controlled per unit of labor, thus increasing the output utility of the labor force and therefore presenting an increasing relationship with the output coefficient of the workforce infinitely close to one. Furthermore, data can be used repeatedly without any qualitative losses, so that the continuous input of data elements does not result in repeated consumption of labor, thus achieving increasing returns to scale in the production function and increasing the ratio of output to the growth of factor inputs. Subject to the condition, the functional relationship in equation (5) is the opposite of equation (6).

In reality, the precise values of α, β and γ depend on the actual scenario in which the information in the data elements comes into play and may vary at different stages of development.

From the model above, it appears that the role of the data element in economic growth is mainly attained through its enabling role in all aspects of economic activity. The digital economy, which corresponds to the data element, is a component of the original GDP in the new perspective rather than an additional new increment, which broadly corresponds to how the data element plays a role in the actual economic activities of countries today, for example [17]. Theoretical studies have found that the contribution of data to China's economic growth will gradually increase and eventually become an important driving force of economic growth.

5. Conclusion

In the digital economy, data, as a new factor, plays a major role in contributing to economic growth both directly and indirectly by driving structural change. Domestic and international scholars have also constructed models to examine the role played by data elements in the production. Jones and Tonett emphasized that data elements would affect total output after being input into production [14]. Due to the non-competitive nature of data, data sharing generated additional scale effects and promoted economic growth. Xu Xiang and Zhao MoFei introduced the concept of data capital and used an endogenous growth model to study the impact of data capital on economic growth, and finally concluded through numerical simulations that data capital could drive economic growth [15]. Cong et al. introduced data as an intermediate product into the endogenous growth model and argued that data could contribute to the final product, thus achieving economic growth [16].

This paper has discussed some of the economic characteristics of the data element and subsequently has confirmed the ways that how data drive production and economic development. In the end, the research has presented a preliminary possibility model of the data element regarding economic growth based on the Cobb Douglas production function. From the above discussion, compared to traditional factors such as labor and capital, data factors embody the economic nature of non-competition, excludability, economies of scale, and convergence and reorganization. Data elements create value through three modes of value multiplication, input substitution and resource optimization, which act on production, and their value is embodied in the dynamic evolution of continuous iteration, renewal and innovation to maximize the value of data. This paper introduces the data element on the basis of the Cobb Douglas production function, and analyses the direct and indirect effects of the data factor in driving economic growth through theoretical mechanisms. The independence of the data element makes it possible to directly promote economic growth by increasing the input of the data factor, while the data factor plays an "enabling" role in economic activities, promoting the optimization of resource allocation and indirectly promoting economic growth through the combination and substitution of data with traditional factors of production.

The findings of this study have to be seen in the light of some limitations. First, there are still imperfections in the research on the role of data elements in the production. Second, there is no consensus on how to construct an appropriate model for the production of data elements. Third, the existing models do not objectively and comprehensively reflect the nature and mechanisms of the role of data factors. This study only focused on the ways in which data elements create value, but the pathways through which data elements drive production and contribute to economic development are not limited. Future research on data elements might extend the explanations of how to act on production.

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