The Importance of Artificial Intelligence to Economic Growth

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Abstract

The rapid development of artificial intelligence technology has exerted a great influence on all fields of the world, which of course also affects the world economy. This has also aroused a large number of economists' interest in this proposition. Since the definition of artificial intelligence is not unified yet, the results from previous researches are not reliable enough. At present, most scholars use the neoclassical growth model or task-based model to explore the path of artificial intelligence on economic variables. There into, most of them use the degree of automation to represent the artificial intelligence. They find that the degree of automation can change the proportion of industries. This only verifies that artificial intelligence can affect the economic variables. But the magnitude of artificial intelligence on economic variables can not be correctly estimated. Therefore, in order to have a better understanding on the impact of artificial intelligence on economic growth, this paper systematically reviews and collates previous literature on this topic. The results of this paper indicate that both in theoretical and empirical studies, artificial intelligence has a positive effect on economic growth. Then, some suggestions and limitations have also been put forward accordingly.

1. Introduction

Congratulations! As a new technology, the impact of artificial intelligence on economy has aroused great concerns in academia. In 1940s and 1950s, the artificial intelligence is firstly proposed by John Mcarthy and some other economists at Dartmouth Conference. Unfortunately, up to now, there is no consensus on the definition of artificial intelligence. According to McCarthy's definition, artificial intelligence is a scientific engineering for manufacturing intelligent machines, especially intelligent computer programs. With the rapid development of large data, hardware and algorithm, artificial intelligence has ushered in a new upsurge of development. In September 2018, McKinsey Global Institute releases a report, "MODELING THE IMPACT OF AI ON THE WORLD ECONOMY." It believes that Artificial Intelligence can significantly improve the overall economic productivity. Even considering the cost of transformation and the competitive effect, it can increase total output by about $13 trillion by 2030 and increase global gross domestic products by about 1.2% annually. This kind of impact is comparable to the steam power of the 19th century, the industrial manufacturing of the 20th century and the information technology of the 21st century. Based on McKinsey Global Institute's research, it provides seven channels on the impact of artificial intelligence on economic growth. The details are shown in <Figure 1>.
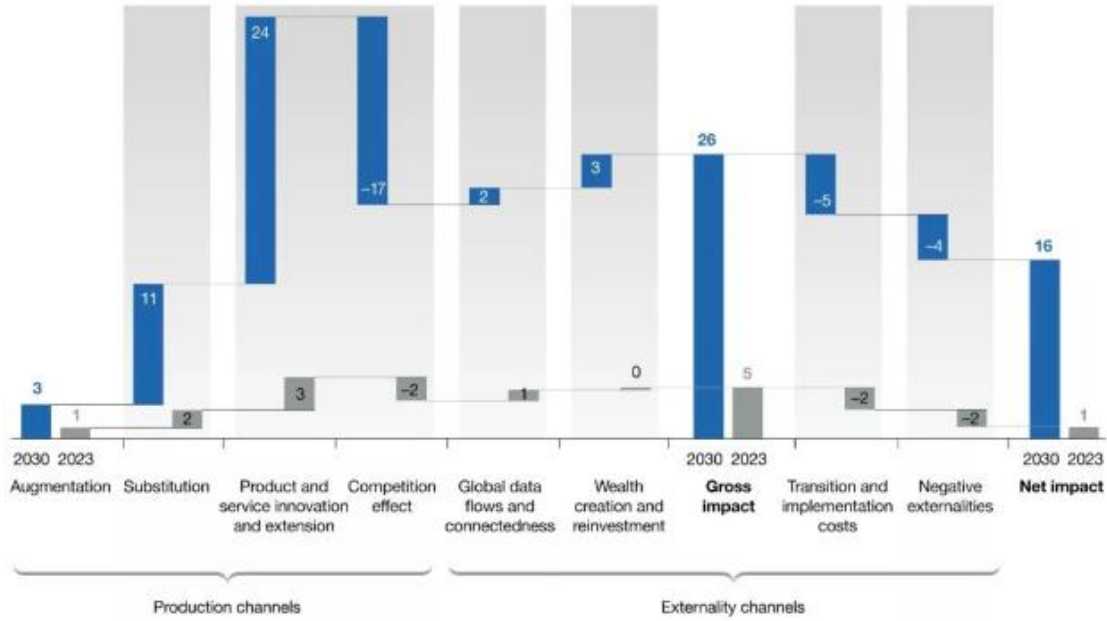
Note: Breakdown of economic impact, cumulative boost vs today, %.
Figure 1. Seven Channels of Net Economic Impact of Artificial Intelligence

In fact. it takes time to enjoy the benefits of artificial intelligence, especially in terms of productivity. Just as <Figure 1> indicates, by 2030, artificial intelligence may contribute three or more times more to growth than in the next five years.

As for this proposition, Accenture and Frontier Economics also release a report entitled "How AI Boosts Industry Profits and Innovation". This report compares the economic growth rates of 16 industries and forecasts the impact of artificial intelligence on global economic growth in 2035. Taking gross added value as the approximate value of gross domestic products, this report finds that the higher the degree of integration of artificial intelligence in the process of economic development is, the greater the potential of economic growth will be. One noteworthy finding in the report is that by 2035, artificial intelligence is likely to increase the economic growth rate of all industries by an average of 1.7%. Among them, in 2035, under the promotion of artificial intelligence, information & communication industry, manufacturing industry and financial services industry will be the three industries with the highest annual growth rate of added value, 4.8%, 4.4% and 4.3% respectively. According to this report, by 2035, the failure of artificial intelligence will also increase profit margins by an average of 38%, and the economic growth of 16 industries in 12 economies will reach $14 trillion. The details are shown in <Figure 2>.
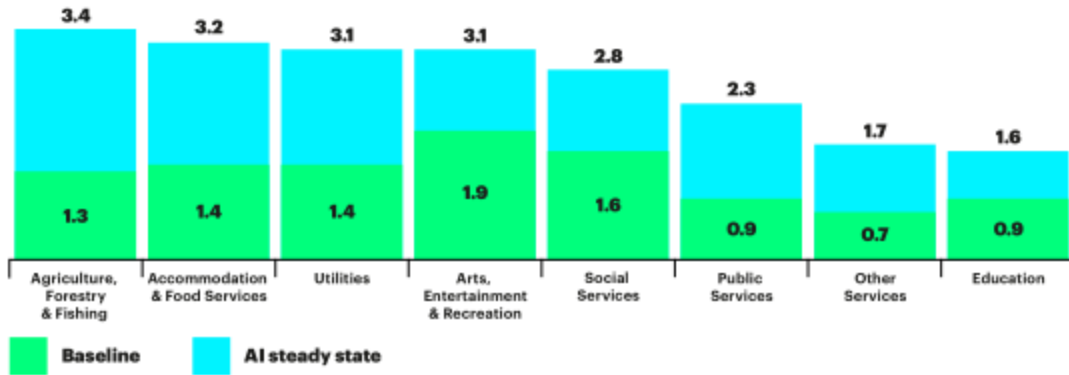
Source: Accenture and Frontier Economics. Unit: real annual gross added value growth by 2035 (%).
Figure 2. Impact of Artificial Intelligence on Industry Growth

With the gradual change of artificial intelligence in all aspects of modern and future economy and society, Studying the impact of artificial intelligence on economic growth can help us better understand the positive and negative effects of artificial intelligence development so that we can design reasonable public policies to deal with the risks and challenges it may bring. Based on previous studies, this paper attempts to explore the impact of artificial intelligence on economic growth.

2. Impact of Artificial Intelligence on Economic Growth

There are many disputes about how artificial intelligence will affect the economic growth. Solow (1957) explores the Impact of Computer on Economic Growth. Technological changes are common, and he finds that statistics do not support the impact of technology on economic growth. Since then, many studies have supported Solow's observation that the emergence of new technologies, including computers and the Internet, has not had a substantial impact on economic growth. However, artificial intelligence is a major innovation in science and technology. At present, a general view in the existing literature is that artificial intelligence can promote economic growth. In 2016, Accenture releases a report that artificial intelligence is treated as a new production factor which can affect the economic growth through three channels. The first is that artificial intelligence can automate complex physical tasks. The second is that AI can supplement the existing labor force and assets, and improve workers' ability and capital efficiency. The final is that artificial intelligence can promote innovation and spread to all industries. Based on these three channels, at present, this proposition has attracted the attention of many economists.

2.1. Theoretical Research

The definition of artificial intelligence has not been unified yet, so it is difficult to incorporate AI into the economic growth model. Some existing literature attempt to explain the mode or path of artificial intelligence input or automation affecting economic growth through economic growth model. Zeira (1998) has explored the relationship between workers, machines, and economic growth. amplification by technology adoption gives:

$Y_t = [\int_0^m \frac{l_1(j)}{Rk_1(j) + w_t l_1(j)} + \int_{m_t}^1 \frac{l_0(j)}{Rk_0(j) + w_t l_0(j)}]^{-1}$. Y stands for output and a machine made of $k_1(j)$ units of

capital. His findings show that output is increasing with technology adoption. Hanson (2001) tried to employ the neoclassical economic growth model to analyze the impact of machine intelligence on economy. The basic model he used gives: $Y = Y(A, L, K, M) = AL^\alpha K^\beta M^\gamma$ with $\alpha + \beta + \gamma = 1$. The model assumes that machines can complement or replace human labor. In different jobs, the possibilities of such complementation or substitution are different. At the same time, the model assumes that the computer technology improves faster than the general technology, and that the labor input of machine intelligence can grow rapidly according to the need, so that the economic growth rate can be increased by an order of magnitude or more by batch use of machine intelligence. In addition, he points out that this analysis may underestimate the impact of machine intelligence on economy because this model does not consider the possibility of creating new jobs. Fortunately, Acemoglu and Restrepo (2017) preform a research which makes up for this shortcoming. Their model is established based on that of Zeira (1998). The model gives:

$Y = \tilde{B}(\int_{N-1}^{N} y(i)^{\frac{\sigma}{\sigma-1}} di)^{\frac{\sigma}{\sigma-1}}$. On the basis of Task-based model, automation technology is introduced into this model and the number of tasks is assumed to be endogenous. One innovation of the model is that it proposes a unified framework in which tasks previously performed by the labor force can be automated. Meanwhile, new tasks with comparative advantages can be created. They find that automation has both substitution effect and productivity effect. The substitution effect itself reduces labor demand, while the productivity effect improves productivity by replacing labor with cheaper capital and increases the demand for labor in unauthorized tasks. Furthermore, in 2018, they point out that possible constraints to productivity include the incompatibility of skills required by new technologies with those provided by labour, and the introduction of automation at an excessive rate. New tasks tend to use new skills, but if the education system does not provide these skills in time, economic transformation will be hampered. In addition, because the current tax system tends to subsidize capital rather than labor, as well as the friction and imperfection of the labor market, the equilibrium wage will be higher than the social opportunity cost of labor, which leads to the overuse of automation technology, the improper allocation of capital and labor, and hinders the improvement of labor productivity. Based on the research of Zeira (1998), Aghion, Jones and Jones (2018) introduce the Baumol's Cost Disease which assumes that task share is exogenously given into the model. This model finds that automation leads to an increase in the proportion of some industries and a decrease in others. To see this, generalize slightly the task-based production function gives: $Y = [\int_0^1 (a_{it} X_{it})^{\rho} di]^{\frac{1}{\rho}}$. Let β_t is equal to fraction of tasks automated by date t. So, $Y = A_t [\beta_t (\frac{K_t}{\beta_t})^{\rho} + (1-\beta_t)(\frac{L}{1-\beta_t})^{\rho}]^{\frac{1}{\rho}} \Rightarrow Y = A_t [(B_t K_t)^{\rho} + C_t L)^{\rho}]^{\frac{1}{\rho}}$. Where $B_t = \beta_t^{\frac{1-\rho}{\rho}}$ and $C_t = (1-\beta_t)^{\frac{1-\rho}{\rho}}$. Therefore, it can be concluded that an increase in β_t will lead to an increase in $C_t = (1-\beta_t)^{\frac{1-\rho}{\rho}}$ and a decrease in $B_t = \beta_t^{\frac{1-\rho}{\rho}}$. If a country is capital-intensive, automation will increase output. On the contrary, if a country is labor-intensive automation will decrease output.

In short, artificial intelligence is treated as automation in this section, and it is introduced into the classical models. The findings indicates that the development of artificial intelligence can boost the economic growth by using cheaper capital to supplement or replace labor.

2.2. Empirical Research

Type In section 2.1, a general view that artificial intelligence has a positive effect on economic growth. But there is a limitation of the previous researches. The reason is that they only put a part of artificial intelligence into classical theoretical models. These results are only at the theoretical level and lack of data validation. Therefore, this section will focus on the empirical analysis on the impact of artificial intelligence on economic growth. Brynjolfsson and Hitt (1995) sets American 527 companies with eight-year stock data as an example to make an empirical analysis so as to explore the impact of computerization on productivity. They find that computerization has a positive effect on productivity. Hasa, Malkamäki and Schmiedel (2003) employs 49 stock exchanges over the period from 1989 to 1998 with unbalanced panel data to track the productivity of different types and types of stock exchanges. They find that Automation has a significant positive impact on productivity, but this influence varies in different regions. Kromann, Skaksen and Sørensen (2011) make a hypothesis that automation increases productivity both in the short and in the long run. The empirical study is performed by using cross country, cross industry data on the use of industrial robots as a measure of automation. They find that automation has a significant positive impact on productivity in the short run and long run. Said in details, the countries in this sample may increase aggregate productivity in the manufacturing sector between 8% in Germany and Japan, 22% in United Kingdom. Dinlersoz and Wolf (2018) use the constant elasticity of substitution production function with endogenous technology choice to establish the relationship model between automation and relative factor use. They find that the higher the degree of automation is, the lower the share of production labor will, and the higher the share of capital is, and the smaller the proportion of production workers who get higher wages will be. Therefore, it can be concluded that automation has a positive effect on productivity. He (2018) regards artificial intelligence as a new production factor to explore

the impact of artificial intelligence on United states of America's macro-economy. Via conducting an empirical analysis under the vector error correction model, he finds that an increase in artificial intelligence input can promote the economic growth.

This section employ data to explore the impact of artificial intelligence on productivity and economy growth. The results of this section is consistent with that of section 2.1. These results also support the general idea that artificial intelligence has a positive effect on economic growth.

3. Conclusion

With the increasing convenience brought by artificial intelligence, a large number of literature have been published to explore the impact of artificial intelligence on economic growth. By using neoclassical growth model or task-based model, this paper explores the path of artificial intelligence on economic growth. Via a lot of theoretical and empirical literature analysis, the results of this paper indicate that artificial intelligence has a positive effect on economic growth. Based on the results of this paper, governments should distribute more expenditure in the development of artificial intelligence so that it can fully promote the economic growth. Of course, there are some limitations of this study. Due to that the impact mechanism of artificial intelligence is complex, it is difficult to be fully introduced into the theoretical model. The reason is that the definition of artificial intelligence is not unified up to today. The existing literature only adds part of artificial intelligence (automation, computerization an so on) to the model for analysis, which will lead to the deviation between empirical results and actual values. Furthermore, It is difficult to obtain the complete data of artificial intelligence, which will also lead to deviations in the empirical results. All these shortcomings are somewhat to be solved by future scientists.

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