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The Effect of Artificial Intelligence on Economic Growth: Evidence from Cross-Province Panel Data

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Abstract

With the Chinese government's attention to the artificial intelligence industry, the Chinese government has invested a lot in it recently. Of course, the importance of artificial intelligence industry for China's economic development is increasingly significant. The advent of artificial intelligence boom has also triggered a large number of scientists to analyze the impact of artificial intelligence on economic growth. Therefore, this paper use 31 China's cross-province panel data to study the effect of artificial intelligence on economic growth. Via empirical analyses under a series of econometric methods such as the province and year fixed effect model, the empirical result shows that artificial intelligence has a positive and significant effect on economic growth. Namely, the artificial intelligence is a new engine for economic growth. Meanwhile, the empirical results also indicate that the investment and consumption has a significant and positive effect on economic growth. Oppositely, the inflation and government purchase have a significant negative effect on economic growth. These findings in this paper also provide some important evidences for policy-makers to perform precise behaviors so as to promote the economic growth. Moreover, these finding enriches existing literature on artificial intelligence and economic growth.

Keywords: Artificial Intelligence, Economic Growth, Cross-Province Panel Data, Econometric Methods

1. Introduction

The impact of technological progress on economy has always been one of the most important concerns of economists. In fact, each major industrial and technological progress has been accompanied by a substantial increase in productivity. Recently, with the development of artificial intelligence, the impact of artificial intelligence on economy has attracted new attention from academia. Artificial intelligence is a major innovation in science and technology. A common view in the existing literature is that artificial intelligence can promote the economic growth. A report on artificial intelligence released by Accenture Consulting in 2016 regards artificial intelligence as a new production factor. it points out that artificial intelligence can promote the economic growth via three ways. Firstly, artificial intelligence can automate complex physical tasks. Secondly, artificial intelligence can supplement existing labor and assets, improve workers' ability and capital efficiency. Finally, artificial intelligence can promote innovations.

At present, some existing literature attempt to explain the influence of artificial intelligence or automation on economic growth path through economic growth model. Hanson (2001) attempts to estimate the economic impact of machine intelligence using neoclassical economic growth model. The model assumes that machines can replace or complement human labor. In different jobs, the possibilities of such complementation or replace are different. Meanwhile, the model assumes that the computer technology improves faster than the general technology, and the labor input of machine intelligence can grow rapidly according to the need. Therefore, using machine intelligence in batches will greatly increase the economic growth. He also points out that this analysis may underestimate the impact of machine intelligence on economic growth because it does not take the possibility of creating new jobs into consideration. Acemoğlu and Restrepo (2016) overcome this shortcoming. They introduce automation technology based on the task-based model of Zeira (1998) and assume that the number of tasks are endogenous. One innovation of this model is to propose a unified framework in which tasks previously completed by the labor force can be

automated and new tasks with comparative advantages can be created. They find that automation has an substitution effect. This increases the demand for labour in tasks that have not yet been automated. Aghion, Jones and Jones (2017) introduce the idea of Baumol's cost disease and assume that task share is exogenously given. 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, $Y=A_t[\beta_t(\frac{K_t}{\beta_t})^{\rho}+(1-\beta_t)(\frac{L}{1-\beta_t})^{\rho}]^{\frac{1}{\rho}} \Rightarrow Y=A_t[(B_tK_t)^{\rho}+C_tL)^{\rho}]^{\frac{1}{\rho}}$. 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.

The theory of evaluating the impact of artificial intelligence on economic growth has made great progress in recent years. Using neoclassical economic model and task-based approach are common methods to discuss the impact of artificial intelligence on economic growth. These models generally believe that the development of artificial intelligence can lead to rapid economic growth by using cheaper capital to supplement or replace labor. The rest of this paper organized as follows: Chapter two presents theoretical framework. Chapter three provides results and discussion. Chapter four draws conclusion and provides limitations.

2. Theoretical Framework

2.1. Variable Description and Hypotheses

Seven variables including one dependent variable, two proxy variables and four independent variables are involved in this paper. Economic growth is treated as dependent variable. It is measured by growth rate of GDP per capita. The rest is independent variable. Be Artificial intelligence is measured by the ratio of fixed assets investment in information transmission computer services and software industry to GDP. Investment is measured by the ratio of total provincial investment to GDP. Government is measured by the ratio of government purchase to GDP. Consumption is measured by the ratio of gross domestic provincial consumption to GDP. Inflation is measured by provincial consumer price index. Based on some previous literature, we propose the following hypotheses. H_1: Brynjolfsson and McAfee (2014) find that the second machine revolution which is based on artificial intelligence and digital revolution will realize unprecedented technological progress which can promote the economic growth. Therefore, we hypothesize that artificial intelligence is positively related to economic growth. H_2: Based on the research of Mankiw, Romer and Weil (1992), we hypothesize that investment is positively related to economic growth. H_3: Based on the research of Barro (2001), we hypothesize that government is negatively related to economic growth. H_4: Based on the research of Foster and Rosenzweig (2003), we hypothesize that consumption is positively related to economic growth. H_5: Based on the research of Valdovinos (2003), we hypothesize that inflation is negatively related to economic growth.

2.2. Methodology

One of the main tasks of endogenous growth theory is to explain the possibility of sustained economic growth. Romer (1990), Aghion & Howitt (1991) and Grossman & Helpman (1991) perform researches on endogenous growth theory. They find that endogenous growth theory can well explain the positive impact of endogenous technological progress on balanced growth. Therefore, in this paper, we hypothesize that artificial intelligence plays an important role in promoting technological progress in an economy. Namely, artificial intelligence has a positive effect on economic growth. Then, a model about artificial intelligence gives:

$$growth_{i,t} = c + \gamma_1 ai_{i,t} + \gamma_2 investment + \gamma_3 government_{i,t} + \gamma_4 consumption_{i,t} + \gamma_5 \inf lation_{i,t} + \nu_i + \varsigma_t + \varepsilon_{i,t} \quad (1)$$

Where c represents the constant. i represents the province. t represents the year. $\gamma_1 ... \gamma_5$ represent coefficients of independent variables respectively. ν_i represents an individual (province) effect. ς_t represents a time effect. $\varepsilon_{i,t}$ represents the white noise.

3. Results and Discussion

Cross-province panel data for 31 provinces over the period from 2003 to 2017 are sourced from the National Bureau of Statistics of China. Then, a series of econometric methodologies (Pooled ordinary least squares, individual (province) fixed effect, time (year) fixed effect, individual (province) & time (year) fixed effect and panel-generalized method of moments) are employed to conduct empirical analyses. These empirical results are shown in <Table 1>.

Table 1: Effect of Artificial Intelligence on Economic Growth

Method ***Variable***	***Pool OLS***	***Individual Fixed Effect***	***Time Fixed Effect***	***Individual & Time Fixed Effect***	***P-GMM***
ai_t	0.754*** (0.311)	1.244* (0.059)	1.900*** (0.420)	1.932*** (0.454)	1.652*** (0.314)
$investment_t$	0.099*** (0.022)	0.180*** (0.020)	0.143*** (0.027)	0.118*** (0.047)	0.120*** (0.020)
$government_t$	-0.023 (0.112)	-0.179* (0.110)	-0.016 (0.045)	-0.065*** (0.027)	-0.017 (0.125)
$consumption_t$	0.161*** (0.061)	0.104* (0.056)	0.130*** (0.051)	0.155** (0.066)	0.107*** (0.041)
$\inf lation_t$	-0.673*** (0.141)	-0.576*** (0.132)	-0.227*** (0.066)	-0.234*** (0.068)	-0.291*** (0.038)
$cons\tan t$	0.141*** (0.031)	0.239*** (0.024)	0.140*** (0.016)	0.162*** (0.026)	-0.106** (0.046)
R^2	0.236	0.385	0.368	0.730	0.728
$J-statistic$					11.762 (0.109)
$observation$	465	465	465	465	403
IV		$growth_{t-1}$, ai_{t-1}, $investment_{t-1}$, $government_{t-1}$, $consumption_{t-1}$, $\inf lation_{t-1}$ $growth_{t-2}$, ai_{t-2}, $investment_{t-2}$, $government_{t-2}$, $consumption_{t-2}$, $\inf lation_{t-2}$			

Note: * means 10% significant level. ** means 5% significant level. *** means 1% significant level. ( ) means standard error. IV means instrumental variables.

<Table 1> shows the results of various estimations. In this paper, the pooled ordinary least squares regression is treated as a benchmark regression. The estimated coefficient of artificial intelligence is 0.754 and significant at 1% level. This indicates that when artificial intelligence increases by 1%, the economic growth will increase by 0.754%. This result is consistent with hypothesis one (H_1). The estimated coefficient of investment is 0.099 and significant at 1% level. Namely, if investment increases by 1%, the economic growth will increase by 0.099%. This result is consistent with hypothesis two (H_2). The estimated coefficient of government is -0.023 but not significant. This result can not support hypothesis three (H_3). The estimated coefficient of consumption is 0.161 and significant at 1% level. This indicates that when consumption increases by 1%, the economic growth will increase by 0.161%. This result is consistent with hypothesis four (H_4). The estimated coefficient of inflation is -0.673 and significant at 1% level. This indicates that when inflation increases by 1%, the economic growth will decrease by 0.673%. This result is consistent with hypothesis one (H_5). Due to that cross-province panel data is employed to conduct empirical

analyses. We use the individual fixed effect, time fixed effect and individual & time fixed effect to re-estimate equation (1). The estimated coefficients of artificial intelligence are 1.224, 1.900 and 1.932. All these coefficients are significant at 10% level. This indicates that when artificial intelligence increases by 1%, the economic growth will increase by 1.224%, 1.900% and 1.932%. The estimated coefficients of investment are 0.180, 0.143 and 0.118. All these coefficients are significant at 1% level. This indicates that when investment increases by 1%, the economic growth will increase by 0.180%, 0.143% and 0.118%. the estimated coefficients of government, consumption and inflation are similar to that of benchmark regression. Moreover, since these independent variables can affected by economic growth, endogeneity problems will arise. Therefore, the panel generalized method of moments is used conduct empirical analyses to overcome endogeneity problems. The estimated coefficients of artificial intelligence, investment, government, consumption and inflation support that of previous estimations. Meanwhile, the value of J-statistic is 11.762 (0.109). this verifies effectiveness of instrumental variables. Namely, the estimated results of panel generalized method of moments are robust, reliable and efficient.

4. Conclusion

This paper uses cross-province panel data for 31 provinces over the period from 2003 to 2017 to perform empirical analyses under series of econometric methods. When investment, government, consumption and inflation are treated as control variables, the empirical result shows that artificial intelligence has a positive and significant effect on economic growth. That is to say, artificial intelligence is a new engine for economic growth. Meanwhile, this result also supports the hypothesis. Of course, some limitations still exist. The most representative one is that the influence mechanism of artificial intelligence on economic growth is complex and difficult to be fully introduced into the theoretical model. Another important one is that the data on artificial intelligence is difficult to obtain comprehensively. It is because of these limitations that later researchers have motivations to study this proposition.

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