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A Comparison of Growth Pattern between Intelligent Services Industry and Communication Industry in China

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Abstract: Since the 1980s, the global economy has shown a general trend of transition from an industrial economy to a service economy. The service industry has gradually become an important engine for world economic growth. The intelligent service industry has developed rapidly and has become an important industry to promote regional economic growth. This paper first adopts panel VAR (Vector Autoregression) and the Feder two-sector model to study the diffusion and lag effects of smart technology on the smart service industry sector itself, the industrial sector, and the entire economic system. The research results confirm that China’s intelligentization and industrialization have formed a preliminary coupling interaction mechanism. Under the new normal, the intelligent service industry has become one of the emerging drivers of economic growth, and the diffusion effect of the intelligent service industry on economic growth will take 2-5 years. Since there is a two-way causal relationship between the intelligent service industry and the economic environment, the dynamic panel sys-GMM (System Generalized Moment Estimation) regression is used to investigate the lag effect of the factors affecting the development of China's smart service industry. It is proposed to adopt intellectual property protection and a common technical support system and enhance the hysteresis effect.

Keywords: Information and Communication Technology, Intelligent Services Industry, Diffusion Effect, Hysteresis Effect

1. Introduction

Since the 1980s, the global economy is showing a general trend of transition from an industrial economy to a service-based economy. The service sector has become an important engine of world economic growth. At present, intelligence has become the general trend of economic development. Intelligent manufacturing is the core technology of the new round of industrial revolution, and the industrial Internet platform has become an operating system linking upstream and downstream enterprises and various users. At the same time, with the servitization of the manufacturing industry, the intelligent service industry has developed rapidly and has become an important industry that promotes regional economic growth. The intelligent service industry in this article includes not only service formats that are innovated and transformed with technological development and social progress, but also traditional service industries that use modern information and communication technology to transform, integrate, and upgrade across borders, which provide information, digital resources, and other smart service business. The nature of the intelligent service industry belongs to the information-intensive industry branch of the producer service industry, which originated from the Information Communication Technology (ICT) industry. Traditional economic growth length theory is not difficult to explain this kind of material resource constraints intrinsically linked emerging industries and economic growth, while the contribution to economic growth provides a theoretical foundation based on a new theory of economic growth endogenous economic growth for. This paper attempts to explore the operating mode of information, knowledge, and intellectual resources relying on the intelligent service industry carrier, which is different from the traditional service industry system, the economic effect produced, and the transmission and influence mechanism of soft elements to the industrial sector and the entire economic system. Using smart services as a soft element of modern production input provides value-added services through the diffusion effect of related industries and the improvement of the efficiency of production factors.

The remainder of this paper proceeds as follows. Section 2 provides a literature review on intelligent service industry development. Section 3 proposes the hypotheses. Section 4 describes the data. Section 5 presents the empirical analysis. Concluding remarks are made in Section 6.

2. Literature Review

The predecessor of the intelligent service industry is the information and communication technology industry ICT, which means that information technology is the technical foundation for the establishment of intelligent services. Therefore, studying the diffusion effect of information technology is useful for exploring the mechanism of the intelligent service industry and clarifying the relationship between the intelligent service industry and various economic entities. The relationship between them is very important. At the end of the last century, the U. S. economy appeared in a situation where the "two highs" of high economic growth rate and high production efficiency coexisted with the "two lows" of low unemployment and low inflation rates, which was largely due to the rise of the Internet economy, information technology is regarded as an exogenous variable in the traditional neoclassical growth theory and cannot explain its spillover effect on economic growth. At the city level, Das (2019) study the development of the information technology industry in a South African city [1]. At the industry level, Moyo (2003) demonstrates the use of information and communication technology in education in Africa [2]. The Solow model in the theory of exogenous technological growth believes that in the absence of continuous technological progress, per capita economic growth will eventually stop, that is, conditional convergence, which is mainly due to the law of diminishing marginal returns of capital. Frankel (1962), Romer (1986), and Lucas (1988) proposed diminishing marginal returns to break the law of capital would have to rely on knowledge and technology, which is the starting point for endogenous economic growth theory [3-5]. Physical capital, labor, and land due to the physical nature does not like technological progress and knowledge presented marginal returns increasing phenomenon. To R&D endogenous growth model can be divided into vertical product R&D model and the horizontal level of the product R&D model. The horizontal level of product R&D model of technological progress performance of product categories continues to increase, while the vertical product R&D model China believes that technological progress and improvement will improve product quality. Also coupled with the spillover model of technology diffusion from three to explain the development dimension of the economic growth effects. Different from the traditional exogenous economic growth model, the new economic growth model is endogenous. There are two reasons why the theory of growth from exogenous to endogenous is important: (1) The new growth theory puts emerging technologies in an important position to promote economic growth rather than uncontrollable events or environments. (2) The theory of endogenous growth emphasizes human capital and knowledge. The so-called endogenous is the belief that growth is largely determined by humans. Welfens (2002), Biswas (2004), Kazuyuki, and Takahito (2008) believed that IT production is an input factor [6-8]. Jonscher (1983) analyzed the impact of information technology input on output by establishing a partially balanced microscopic model. He believed that the higher the information input per unit output, the greater the impact on production efficiency [9].

Jorgenson and Stiroh (2000) believe that information and communication technology is a factor that promotes continuous growth of developed countries such as the United States since the 1990s [10]. However, Ranney and Gordon (2015) find that, due to integrated circuit technology has reached its limits, from 2004 since the stimulating effect of information and communication significantly reduced [11]. Existing research believes that information technology promotes economic growth mainly through capital deepening. Jorgenson (2001), as stated in “Moore’s Law”, transistor performance doubles on average every 18 months but comparable prices continue to decline [12]. Datta and Agarwal (2004) believe that it is the substitution of this information and communication equipment for other capitals to strengthen capital deepening [13]. Tenny (2022) used the granger causality approach to find the dynamics of economic growth in Liberia [14]. The proliferation or penetration of smart technology is to penetrate deep into the value chain links of R&D, production, sales, and service to increase efficiency and increase output. However, the existing statistical accounting methods are difficult to measure the proliferation effects of smart technologies. Most scholars use macroeconomic statistics to study the effects of smart technologies on economic growth. However, they are often affected by many factors, but both often present uncertainties but from the perspective of micro-enterprise, it gives empirical evidence that smart technology innovation significantly improves production efficiency.

The reason why traditional neoclassical economic growth theories cannot explain the contribution of information technology to economic growth is that they regard information technology as an exogenous variable, and regard information technology as a capital investment in the ICT industry or Hicks neutral technology. Progressive influence, ignoring the information technology as a universal technique of quasi-public nature of the product, ignoring the network economy is different from the traditional economic operation of the scale of increasing returns, network externalities, IT capital deepening and radiation, and the lagged effects of information technology. The endogenous economic growth theory incorporates information technology into the economic growth model, and at the same time discovers the external effects of the information network economy, but the research on the externalities of the network economy mostly starts from technical externalities, and the spillover of this technical knowledge is not a market. As a result of the operation, it should start with research on itself and related industries through the influence of technology spillover and diffusion on the production function of the enterprise.

3. Hypotheses

For the prediction of several economic variables, such as GDP growth rate and unemployment rate, one method is to use a univariate time series method to predict each variable separately. However, this method ignores the mutual causal interaction between the variables. Holden (1995) proposed vector autoregression methods for empirical research [15]. Regarding how to measure the information economy issues, Porat (1977) proposed that the economy of information is based on the characteristics of the information industry, the principle of division of national accounts statistical indicators, and the information department [16]. The added value of the industry is calculated by the final demand or value-added method. Therefore, we study the following two hypotheses.

Hypothesis 1: There is a causal link between the output of the intelligent service industry sector, the output of the industrial sector, and economic growth.

Hypothesis 2: There is a diffusion effect between the output of the intelligent service industry sector on the output of the industrial sector and economic growth. Moreover, the diffusion process is lagging.

4. Data and Methodology

In this study, we use the panel data from 1995 to 2016 for the intelligent services industry. The paper chooses three national economy industries in the "G Transport, Storage and Telecommunications Services “, "G Transportation, Storage, and Postal Industry", and "I Information Transmission, Computer Services, and Software Industry”. The growth rate of the industrial sector capital-output ratio, the growth rate of the industrial sector workforce, and intelligence services industrial capital-output ratio are used in the panel data. The vector autoregression measures the sustainable impact of the intelligent services industry on the macroeconomics. The above data including GDP by province, the main indicators of large and medium-sized industrial enterprises by province, the fixed capital investment of the whole society by province, the number of employees by industry by province, and other data are from the CSMAR database. The software Stata13. 0 is used for empirical research. The descriptive statistics of the key variables are presented in Table 1.

Table 1. *The description statistics of all kinds of informatization index.*

Variable	N	Mean	Standard Error	Min	Max
K_Z	682	3749.111	2463.858	182.818	15361.73
RD	682	17.015	66.913	0.0001	867.741
C_Z	682	2317.314	2507.637	23.17	13155.98
L_z	682	27.190	19.567	0.823	128.034
IDI	682	0.576	0.200	0.139	1.275
Y_Z	682	515.120	542.287	2.15	3209.72

5. Empirical Analysis

5.1. Unit Root Test

Before using the augmented Dickey-Fuller unit root test to test whether the variables contain a unit root, we first use AIC, BIC and HQIC to determine the optimal lag terms. In Table 2 Panel A, we test lag 1 to lag 4 variables. We find lag 2 variable are of the minimum value with -2.038, -0.829, -1.566 for AIC, BIC and HQIC test respectively. From the Table 2 Panel B, we can see the original value of these four variables unit root test is not smooth, but the first difference of four variables (GDP growth rate *RGDP*, capital-output ratio *K/Y*, labor force growth rate *RL* and development of information technology index *IDI)* are smooth process indicated by both HT test values and Z test values.

Table 2. *Determine the lag order and unit root test.*

Panel A Determine the lag order

Lag Term	*AIC*	*BIC*	*HQIC*
1	-1.822	-0.781	-1.416
2	-2.038	-0.829	-1.566
3	-1.644	-0.251	-1.099
4	-1.451	0.144	-0.825

Panel B Unit root test results

Variables	Z value for HT test	P value	$\bar{t}$ value for IPS test	P value	test results
$dRGDP$	-39.620	0.000***	-6.395	0.000***	smooth
dK/Y	-24.851	0.000***	-3.769	0.000***	smooth
dRL	-52.171	0.000***	-7.185	0.000***	smooth
$dIDI$	-47.796	0.000***	-5.735	0.000***	smooth

5.2. Granger Causality Test

In economics, it is usually necessary to determine the direction (one-way or two-way) of the causal relationship between two given variables. According to Granger, if using the historical values X and Y to predict Y is significantly more accurate than using only the historical value Y, then the two variables have a causal relationship. Table 3 shows that the GDP growth rate is the Granger cause for capital-output ratio and employment growth rate of the industry sector, and of the capital-output ratio of the intelligent service industry. The GDP growth rate also had an impact on overall economic growth. Correspondingly, the capital-output ratio and employment growth rate of the industry sector is the Granger cause of the capital-output ratio of the intelligent service industry. The empirical results revealed that the capital-output ratio of the intelligent service industry was not the primary Granger cause for GDP growth rate; however, the three-period lagged term had a significant causal effect. These findings indicated that due to the hysteresis effect of its diffusion, the intelligent service industry was yet to become one of the primary driving forces of macroeconomic growth. However, the capital-output ratio of the intelligent service industry was found to be Granger cause to both the capital-output ratio and employment growth rate of the industry sector. These findings suggested that, as a new driving force of economic growth, the current technologyoriented intelligent service industry played a positive role in promoting industrialization.

Table 3. *Grange causality test results.*

Causality (lag 2 order)	Chi2 value	Degree of freedom	P value	Test result
$dRGDP \rightarrow dK/Y$	12.682	2	0.002***	Granger causality
$dRGDP \rightarrow dRL$	40.518	2	0.000***	Granger causality
$dRGDP \rightarrow dIDI$	39.548	2	0.000***	Granger causality
$dRGDP \rightarrow ALL$	81.859	6	0.000***	Granger causality
$dK/Y \rightarrow dRGDP$	34.486	2	0.000***	Granger causality
$dK/Y \rightarrow dRL$	6.712	2	0.035**	Granger causality
$dK/Y \rightarrow dIDI$	17.024	2	0.000***	Granger causality
$dK/Y \rightarrow ALL$	55.391	6	0.000***	Granger causality
$dRL \rightarrow dRGDP$	1.721	2	0.423	Not obvious
$dRL \rightarrow \mathrm{dK}/\mathrm{Y}$	5.419	2	0.067*	Granger causality
$dRL \rightarrow dIDI$	9.018	2	0.011**	Granger causality
$dRL \rightarrow ALL$	17.546	6	0.007***	Granger causality
$dIDI \rightarrow dRGDP$	3.247	2	0.197	Not obvious
$dIDI \rightarrow dK/Y$	6.242	2	0.044**	Granger causality
$dIDI \rightarrow dRL$	5.805	2	0.055*	Granger causality
$dIDI \rightarrow ALL$	15.913	6	0.014**	Granger causality

* p<0.1, ** p<0.05, *** p<0.01.

Identifying a mutual causal relationship between the capital-output ratio and the employment growth rate of the industry sector and the capital-output ratio of the intelligent service industry demonstrated that the dual effects of intelligentization and industrialization has achieved initial results, forming a joining and interactive relationship between the two variable groups. However, the effectiveness of such integration required further examination. The findings also supported the hypothesis that the development of the intelligent service industry facilitated the improvement of productive efficiency in itself, advancement of the industry sector, and growth of the overall economy through spillover and diffusion effects.

5.3. Forecast Variance Decomposition

The results of the forecast error variance decomposition (FEVD) revealed that the impact of the capital-output ratio of the intelligent service industry on other variables became greater as the period increased. Specifically, the capital-output ratio of the intelligent service industry was found to have almost no effect on the growth rate and on the capital-output ratio and employment growth rate of the industry sector in the first period; however, the regression coefficients became positive in the second period and increased significantly in the third to fifth periods. Table 4 shows that, in the fifth period, the effect of the GDP growth rate on itself accounted for 83.9% of the variance, while the effect of the capital-output ratio of the intelligent service industry accounted for 8.4% of the variance, greater than that of the capital-output ratio of the industry sector (5.3%). These results demonstrated that the intelligent service industry has a replacement effect on traditional industry sectors as an economic growth driver. The effect of the capital-output ratio of the industry sector on itself accounted for 61.6% of the variance, while the capital-output ratio of the intelligent service industry accounted for 23.8% of the variance, greater than that of the GDP growth rate (13.7%). These findings further demonstrate that the integrated development of intelligentization and industrialization is conducive to the improvement of factor productivity, which not only affected the intelligent service industry, but also had a spillover effect on the industry sector, reinforcing the possibility that intelligent manufacturing is a future trend for industry development. When the period is increased, the impact of GDP growth rate, capital-output ratio and employment growth rate of the industry sector on the capital-output ratio of the intelligent service industry increased from 0.3%, 5.6%, and 0%, in the first period to 8.9%, 10.6%, and 0.3% respectively in the fifth period. These findings implied that the intelligent service industry was also affected by other production factors and that the singular effect of industrialization counteracted the integrated development of intelligentization and industrialization.

Table 4. *Forecast the effect of variance decomposition.*

Shock variable / Response variable	period	$dRGDP$	dK/Y	dRL	$dIDI$
$dRGDP$	1.000	1.000	0.000	0.000	0.000
dK/Y	1.000	0.091	0.909	0.000	0.000
dRL	1.000	0.013	0.021	0.966	0.000
$dIDI$	1.000	0.003	0.056	0.000	0.941
$dRGDP$	2.000	0.885	0.035	0.011	0.069
dK/Y	2.000	0.090	0.795	0.007	0.109
dRL	2.000	0.054	0.081	0.852	0.012
$dIDI$	2.000	0.004	0.060	0.002	0.934
$dRGDP$	3.000	0.864	0.049	0.011	0.076
dK/Y	3.000	0.122	0.677	0.005	0.196

Response variable \ Shock variable	period	$dRGDP$	dK/Y	dRL	$dIDI$
dRL	3.000	0.081	0.084	0.824	0.012
$dIDI$	3.000	0.037	0.101	0.002	0.860
$dRGDP$	4.000	0.859	0.047	0.022	0.071
dK/Y	4.000	0.122	0.674	0.007	0.197
dRL	4.000	0.081	0.093	0.814	0.012
$dIDI$	4.000	0.058	0.104	0.002	0.836
$dRGDP$	5.000	0.839	0.053	0.025	0.084
dK/Y	5.000	0.137	0.616	0.010	0.238
dRL	5.000	0.082	0.108	0.773	0.036
$dIDI$	5.000	0.089	0.106	0.003	0.802

The results of the Granger causality test supported; thus, it can be stated there were causal relationships between the output of the intelligent service industry and the output of the industry sector and economic growth. The results of the impulse response analysis and FEVD also supported; the output of the intelligent service industry had a diffusion effect on the output of the industry sector and on economic growth, and these diffusion effects were lagged. The effect of the output of the intelligent service industry was not limited by the law of diminishing marginal returns of the traditional economy, which would exhibit a linear decay; rather, the change presented in a curve. There was also a notable network externalities effect, which revealed a cumulative superimposed influence. Specifically, the impulse response analysis showed that the development of the intelligent service industry had a dynamic impulse effect on the GDP growth rate—initially decreasing and subsequently increasing—while the FEVD demonstrated that the development of the intelligent service industry accounted for 8.4% of the total variance of the GDP growth rate in the fifth period, greater than that of the industry sector's development (5.3%). Moore's Law points out that the update and iteration speeds of the ICT industry is accelerating due to technological progress. Moreover, the spillover effect of information technology is realized through the transformation of traditional production and the improvement of total-factor productivity and economies of learning within human capital. Although such impact has a time lag, the influence is far-reaching.

5.4. Robustness Test

In this section, we compare the traditional information technology industry with the intelligent service industry. We replace panel data and time series for China from 1995 to 2013 based on 30 provinces in GDP growth rate, capital-output ratio K/Y, labor force growth rate RL and development of information technology index IDI of the panel using panel data PVAR calculation on non-information related departments and the overall macroeconomics. Kien and Heo (2009) adopt the system GMM method to study the impacts of trade liberalization on employment. Yao and Song (2021) use a dynamic panel generalized method of moments to analyze the Fintech industry in China [17]. The Generalized Moment Estimation (GMM) of PVAR is still used to determine the lag order of 3rd order and a single integer *I*(1). In the Granger causality test, the GDP growth rate, capital-output ratio and labor growth rate are all Grangers of information development. The reason is shown in Table 5 which includes the upper part (information communication industry) and the lower part (intelligent services industry).

Table 5. *Comparison of causality test between ICT industry and intelligent services industry.*

Causality（Lag 3 Order）		Chi2 Value	Degree of freedom	*P* Value	Test Results
ICT industry	$dRGDP \rightarrow dIDI$	15.968	3	0.001***	Granger causality
	$dK/Y \rightarrow dIDI$	8.672	3	0.034**	Granger causality
	$dRL \rightarrow dIDI$	8.821	3	0.032**	Granger causality
	$dIDI \rightarrow dRGDP$	7.347	3	0.062*	Granger causality
	$dIDI \rightarrow dK/Y$	1.731	3	0.630	Not obvious
	$dIDI \rightarrow dRL$	10.967	3	0.012**	Granger causality
	$dIDI \rightarrow ALL$	31.845	9	0.000***	Granger causality
Intelligent services industry	$dRGDP \rightarrow dIDI$	39.548	2	0.000***	Granger causality
	$dK/Y \rightarrow dIDI$	17.024	2	0.000***	Granger causality
	$dRL \rightarrow dIDI$	9.018	2	0.011**	Granger causality
	$dIDI \rightarrow dRGDP$	3.247	2	0.197	Not obvious
	$dIDI \rightarrow dK/Y$	6.242	2	0.044**	Granger causality
	$dIDI \rightarrow dRL$	5.805	2	0.055*	Granger causality
	$dIDI \rightarrow ALL$	15.913	6	0.014**	Granger causality

* p<0.1, ** p<0.05, *** p<0.01.

It is consistent with the verification results of this paper. The only difference is that the development of the intelligent services industry that lags behind the second - tier has less impact on GDP growth than informatization, but the development of the intelligent services industry has a greater impact on the industrial output ratio. The effect is more significant than informatization.

In the impulse response function analysis, although the impact trend has changed greatly, no matter the GDP growth rate, capital-output ratio and labor growth rate have an impact on informatization (intelligent services industry). Similarly, the impulse response changes shown by the data of the intelligent services industry are more abundant.

6. Conclusion

Our research aims to study whether there is a casual link between the output of the intelligent service industry sector, the output of the industrial sector, and economic growth. After confirming the relationship, we further examine the diffusion effect among the sectors. We adopt Granger causality test, forecast variance decomposition, system GMM, and vector auto regression to study the impact. Granger causality test can determine whether it is a one-way causal relationship or a two-way interactive causal relationship. The nonlinear Granger causality test confirmed the two-way interactive causal relationship between intelligent service industry, industrial sector and economic growth. We use impulse response analysis further study the effect over time. We find the GDP growth rate has a positive and then negative impulse effect on the capital-output ratio of the intelligent services industry. Forecast variance decomposition shows that when the forecast periods pass, intelligent services industry capital-output ratio impact on all the variables gradually pronounced. The system GMM and vector auto regression show that it is necessary to improve the diffusion effect of information technology to improve the digital economic environment for the development of the intelligent services industry. The intelligent service industry has developed rapidly and has become an important industry to promote regional economic growth.

The paper intends to explain the principal and mechanism of the intelligent services industry. We use the medium-level industry data which may not cover the whole intelligent services industry or omit some firm differences. On the other hand, panel vector autoregressive and dynamic panel regression could not solve the endogeneity inhered in the Fader model. The potential further research will use micro-data to cover the listed firms instead of the medium-level industry data. Therefore, propensity score match and difference in difference can be used to compare the differences between the information service industry and intelligent service industry at firm level.

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