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Relationship between Technology Innovation Diffusion of Hunan High-Tech Zone and Regional Economic Growth: Empirical Research Based on Panel Data

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Abstract: The high-tech zone as the locomotive of economic growth, it plays an important pole to promote regional economic development. This paper researches empirically the relationship between technology innovation diffusion of Hunan high-tech zone and regional economic growth based on panel date. The results show that technology innovation diffusion of Hunan high – tech zone has made great progress, but there is a big difference among these high-tech zones; technology innovation diffusion of high-tech zone has a significant influence on regional economic growth, it promotes economic growth of Hunan province about 6.988% if the growth of high tech-zone GDP is 10%; however, technology innovation diffusion effect from various high-tech zones exist significant difference. 10% growth of high tech-zone GDP can drives the regional economic growth of 8.904% at most or 2.335% at least.

Keywords: High-Tech Zone, Technology Innovation Diffusion, Economic Growth, Empirical Study

1. Introduction

As we all know, technological innovation can only exert its value through diffusion. In this sense, the diffusion of technological innovation is more meaningful and valuable than the technological innovation itself. High-tech Industry Development Zone (High-tech Zone) gathered in many high-tech enterprises, with strong technological innovation ability. Practice has proved that the development of high-tech zones has made tremendous contributions to China's economic development, of which technological innovation diffusion contributed. There is 7 prefectures and cities high-tech zone in Hunan province, of which 6 are state-level high-tech zones. In the process of implement the development strategy of innovation driven economy, the high-tech zone technological innovation has made significant achievement at the same time led to rapid economic development of Hunan. This paper attempts to take Hunan High-tech Zone as the research object, through the quantitative analysis method to explore the relationship between the technological innovation diffusion and the local economic growth, which provides a reference for the further development of regional economy and the formulation of policies by relevant departments.

There are many related literatures to study the diffusion of technological innovation. The literature related to this paper mainly includes three aspects: the diffusion of high-tech innovation, the diffusion effect of technological innovation, the diffusion of technological innovation and economic growth.

(1) High-tech innovation diffusion in high-tech zone. Wang Ji-ci et al. (1996) [1] studied the enterprise derivation, agglomeration and diffusion factors of the new technology enterprise cluster in Beijing Zhongguancun, as well as the development of different places and the trend of commercial development in the region. Chen Jia-xiang, Wang Xing-ping (2007) [2] studied the spatial diffusion behavior of high-tech enterprises in high-tech zone through an empirical investigation of Nanjing hi-tech zone. Lin LAN, Zeng Gang (2007) [3] took Zhangjiang high-tech park as an example and analyzed the technical location requirements of high-tech enterprises. Wan Xiao-ling (2007) [4] conducted an empirical study on the interaction between the diffusion power and the

economic hinterland in China's high-tech zones. Yang Su and Zhu Zi-liang (2008) [5] took Xi'an Hi-tech Development Zone as an example to study the role of technological innovation diffusion in the economic growth in the surrounding areas. Liu Jing and Zhong Wei-zhou (2011) [6] think that the reason for the insufficient function of high-tech zones in China lies in the fact that the high-tech zones are not in a high economic situation, the diffusion channels are poor and the capacity of the surrounding areas to undertake in high-tech zones is not strong enough. Wang et al. (2012) [7] constructed a multi-task incentive model for the diffusion of technological innovation in high-tech zones. Salvador E et al. (2013) [8] found that firms' physical location in high-tech zones and virtual places in innovative clusters are complementary instead of substitute. Motohashi K (2013) [9] takes Tsinghua Science and Technology Park as an example to empirically analyze the role of science and technology parks in the innovation performance of entrepreneurial enterprises. Li rong (2015) [10] constructed the index of polarization and diffusion superimposed spillover effect of the national high-tech zone, and calculated the spillover effect of high-tech enterprises in the national high-tech zone in 2008 and 2013. Lian Junwei (2016) [11] combined with Xinchang High-tech Industrial Park, analyzed the spillover approach and spillover effect of the innovative network structure after Enterprise Research Institute was embedded in the high-tech zone. Dong Hui-mei et al (2016) [12] took Zhongguancun Industrial Park as an example to study the issue of innovation and diffusion of high-tech industrial clusters under the perspective of complex networks. Yang Guo-zhong (2016) [13] took Changsha High-tech Zone as an example, and explored the path of multi-technological innovation diffusion in High-tech Zone based on the perspective of technology flow. Feng Bing-bing (2016) [14] took advantage of the relevant data of Wuhan east lake high-tech zone from 2005 to 2013, and studied the influence of foreign direct investment technology spillover effect on the technological innovation ability of China's high-tech industrial park.

(2) Diffusion effect of technological innovation. Zhao Ke-jie, Liu Chuan-zhe (2007) [15] used the input-output model to measure the diffusion effect of innovation in various industries. Zhang Qing-bin (2008) [16] studied the diffusion effect of technological innovation in regional innovation system. Liu Xuan (2009) [17] used the impulse response function based on the VAR model to measure the intensity and effect of diffusion in Beijing and Shanghai. Shen Zheng-shun and He Wei (2009) [18] empirically analyzed the diffusion effects of technological innovation in the eastern region from 1996 to 2006 on the overall economy in the western region and the three major industries. Wang Rui-qi (2012) [19] empirically analyzed the spatial correlation and diffusion effects of regional technological innovation capability in China based on the 1997-2008 spatial panel data. King Kong and Shen Kun-rong (2016) [20] measured the technical efficiency and technological progress of industrial enterprises above designated size in 31 provinces in China from 2003 to 2010 by means of stochastic frontier models that surpass the logarithmic production function, which in turn based on exploratory spatial data analysis method (ESDA) studied the provincial industrial enterprises above designated size technical efficiency and technical progress space-time evolution characteristics of spatial diffusion effect. Ye Qian-qian (2016) [21] verified the spatial spillover effect of Internet financial technology innovation diffusion based on the data of P2P lending.

(3) Technological innovation diffusion and economic growth. Zhang Yan-rui, Hao Yong-fa (2002) [22] studied the impact of technological innovation diffusion on economic growth. Dou Li-chen and Li Guo-ping (2004) [23] analyzed the differences in regional productivity growth caused by the diffusion of technological innovation. Pi Yong-hua (2008) [24] analyzed the diffusion of technological innovation in the Yangtze River Delta region and found that technological innovation in Shanghai has obvious diffusion effects on Jiangsu and Zhejiang provinces and has led to the economic growth in the surrounding areas. The empirical results of Gao Li-na and Jiang Fu-xin (2011) [25] show that the diffusion of interval innovation has a significant positive effect on the economic development of Ningzhenyang. Zhang Di (2013) [26] analyzed the impact of international technology diffusion on economic growth based on the panel data of the Yangtze River Delta and Beijing-Tianjin-Hebei during 1997-2011. Victor Hugo T P et al. (2014) [27] Empirical studies show that technological innovation and its proliferation have a positive effect on Mexico's local economic growth. Rainer A and Strohmaier R (2014) [28] describe the diffusion of common technologies to several ways of influencing the economy and their impact on the economy from the 1966-2007 Danish communication technology. Based on the data of China's green technology innovation and economic growth from 1991 to 2010, Chen Yan-chun et al. (2014)[29] conducted empirical analysis using panel data fixed-effects model, revealing that there is a "U" -shaped relationship between green technology innovation and economic growth in China. He Xing-lang (2015) [30] discussed the influence of knowledge heterogeneity, inter-regional knowledge diffusion intensity, technology absorption effect and environmental pollution transmission effect on the evolution and steady state of economic space and the dynamic changes of regional welfare. Collins, T (2015) [31] believes that the dynamics between imitation, innovation and economic growth are important because it can lead to more effective industrial policies.

To sum up, judging from current domestic and foreign research status, there is little literature on the diffusion effect of technological innovation in high-tech zones and on economic growth. Based on the panel data, the relationship between the diffusion of technological innovation in high-tech zones and regional economic growth has not been found.

2. Research Design

2.1. Variable Selections

As the main body of technological innovation diffusion, high-tech zones include many high-tech enterprises and intermediary organizations; meanwhile, each high-tech enterprise often has many innovative technologies and products. Therefore, high-tech zone is a typical diffusion of multiple technological innovations. For this main body of technological innovation spread, there are multiple channels and multiple forms. It includes the independent diffusion of enterprises and the promotion of government, both the sales of products and the output of technology. How to measure the proliferation of high-tech zones of technological innovation, technological innovation from high-tech zones can be achieved, such as the annual patent applications, the output of technological innovation. However, considering the commercial success of patents or innovative technologies and the availability of data, we choose the high-tech industrial output value of high-tech zone as a measure of the diffusion of technological innovation.

There are many indicators for measuring regional economic growth, but people often measure it as gross domestic product (GDP). This indicator can be either an absolute or relative increase in the total GDP of the entire region or an increase in GDP per capita in the region. There is no substantial difference between the two indexes, depending on the model requirements. We choose the total annual real GDP of all regions.

2.2. Model Settings

Take the annual real GDP of each region as explained variable, the annual real GDP of the high-tech zones in the region as the explanatory variable to establish econometric model, or establish the corresponding double logarithm model. Taking into account the individual differences between regions and their hi-tech zones and the randomness of time, corresponding random effects variables are added to the model. The following two models will be selected by empirical test.

$$GDP_{ti} = \alpha_i + \beta_i \cdot TR_{ti} + \mu_i + v_i + \varepsilon_{ti} \quad (1)$$

$$Ln(GDP_{ti}) = \alpha_i + \beta_i \cdot Ln(TR_{ti}) + \mu_i + v_i + \varepsilon_{ti} \quad (2)$$

$GDP_{ti}, TR_{ti}, \mu_i, v_i$ represents respectively the GDP of the t year, the annual GDP of the high - tech zone, the individual effect and the time effect in the i region, and α_i, β_i is the model variable coefficient, ε_{ti} is the random error term of the model.

2.3. Research Methods

According to the historical statistics of relevant areas in Hunan and its high-tech zones, we use the econometric software Eviews7.0 for empirical test. The main steps are: (1) trend analysis of GDP of all regions and GDP of each high-tech zone; (2) stationary test of panel data; (3) test of equilibrium of variables; (4) random type test of the model; and (5) Model parameter estimation and result analysis.

3. Empirical Test

3.1. Data

There are 14 cities in Hunan Province, but only 7 cities have high-tech zones. Statistical Yearbook of Hunan Province started to count the high-tech industries only in 2002. Therefore, based on the Statistical Yearbook of Hunan Province from 2002 to 2015, we selected the statistics of 2001-20014 in seven cities and areas of Changsha, Zhuzhou, Xiangtan, Hengyang, Yueyang, Yiyang and Chenzhou and their respective high-tech zones (the Yiyang high-tech zone and Chenzhou high-tech zone only have statistics from 2002 and 2003 respectively).

3.2. The Trend of GDP and GDP in Each Region

In 2001, the GDP of Hunan high-tech zone was 34.792 billion Yuan and 6524.75 billion Yuan respectively, with an average annual growth rate of 25.59%. From 2001 to 2014, the total GDP of the seven cities in Hunan province (unit: 100 million yuan) is shown in figure 1. As can be seen from the figure, the GDP of each city is increasing continuously. In addition to the sharp increase in the growth of Changsha, six other prefecture-level cities have been relatively stable. In 2014, the total GDP of Changsha City reached 782.48 billion yuan, while the GDP of the other 6 cities was less than 300 billion Yuan. The seven high-tech zone's GDP (Figure 2, unit: billion).

In addition to Yueyang High-tech Zone in 2006, Hengyang High-tech Zone in 2008, Chenzhou High-tech Zone in 2006 and 2009 decreased, the other three high-tech zones are growth in other years, the other four high-tech zones are sustained growth, of which Changsha High-tech Zone, the largest growth rate, followed by Zhuzhou High-tech Zone.In 2014, the GDP of Changsha High-tech Zone exceeded 350 billion yuan, Zhuzhou High-tech Zone reached 100 billion Yuan and the output value of the other five high-tech zones was less than 50 billion Yuan. Statistics show that Changsha High-tech Zone is the leader of Hunan High-tech Zone. From 2001 to 2014, its GDP accounted for 55% -64% of the total GDP of Hunan High-tech Zone.

In terms of the GDP of each high-tech zone in the region's GDP (Table 1), Changsha High-tech Zone is the highest, followed by Zhuzhou High-tech Zone and the lowest in Chenzhou High-tech Zone.

Table 1. *Proportion of the total area of GDP in each high-tech zone in 2001-2014 (unit:%).*

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Changsha	30.05	33.91	37.89	40.60	36.26	38.00	38.55	35.08	33.11	37.08	43.55	45.71	46.08	47.00
Zhuzhou	19.82	27.41	28.22	28.69	26.52	32.14	35.98	41.69	47.87	50.29	52.16	44.20	45.91	48.37
Xiangtan	7.63	9.03	10.76	10.43	12.79	15.55	15.86	18.54	21.45	28.36	31.89	21.47	26.20	23.34
Hengyang	4.15	5.15	6.29	7.52	9.08	11.45	13.37	10.59	11.07	12.53	17.77	18.39	21.96	12.82

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Yueyang	7.60	7.75	8.87	7.32	8.07	4.17	4.71	6.61	7.43	7.29	6．35	14.60	14.83	14.36
Yiyang	-	1.10	4.05	4.06	5.70	7.29	9.36	13.95	10.63	11.80	12.93	13.96	18.26	20.35
Chenzhou	-	-	0.42	0.42	0.52	0.39	0.46	0.45	0.35	0.47	0.46	0.46	22.06	26.16

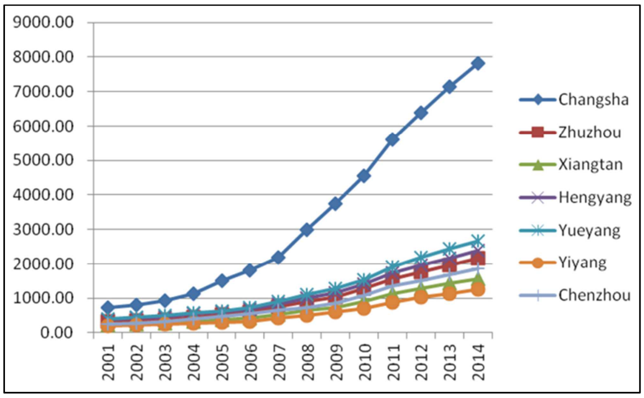

Figure 1. *GDP comparison of 7 cities of Hunan in 2001-2014.*

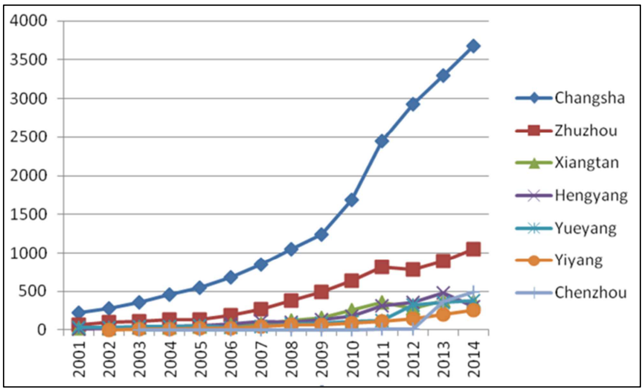

Figure 2. *Total output value Comparison of 7 high-tech zones of Hunan in 2001-2014.*

3.3. Stability of Panel Data

Table 2. *The results of unit test.*

Variable	level			1st difference		
	LLC	IPS	ADF-Fisher	LLC	IPS	ADF-Fisher
GDP	12.7676	12.2605	0.0689	-0.0558	2.2326	3.1530
	(1.0000)	(1.0000)	(1.0000)	(0.4778)	(0.9872)	(0.9988)
TR	7.7178	9.3019	0.1837	-2.5081	-0.6457	19.7763
	(1.0000)	(1.0000)	(1.0000)	(0.0061)	(0.2592)	(0.1374)
LnGDP	3.5493	6.6594	0.1342	-4.5804	-2.7631	29.2367
	(0.9998)	(1.0000)	(1.0000)	(0.0000)	(0.0029)	(0.0097)
LnTR	-0.4434	2.1857	6.5791	-12.6206	-8.1776	69.9912
	(0.3287)	(0.9856)	(0.9497)	(0.0000)	(0.0000)	(0.0000)

Note: the first row data of each variable in the table is the value of the unit root test statistic. The corresponding bracket data is the probability of rejecting the original hypothesis.

The results of unit root test of *GDP*、*TR*、*LnGDP*、*LnTR* are shown in table 2. The results show that the horizontal and first-order difference of *GDP*、*TR* have the unit roots. The horizontal value of *LnGDP*、*LnTR* exists in the unit root, and the first-order difference does not have the unit root. Thus, the model (2) is better than the model (1), and the *LnGDP*、*LnTR* is a single order, which can be tested by co-integration.

3.4. Balance of Variables

This paper selects the Kao test method to carry out the co-integration test of *LnGDP* and *LnTR*. The t-statistic value corresponding to the ADF is -2.77420 and the accompanying probability is 0.0050, which indicates that there is a cointegration relationship between *LnGDP* and *LnTR*, that is, there is a long-term and stable equilibrium relationship, and a econometric model can be established.

3.5. The Type of Regression Model

When considering the individual effect only, the Hausman test has the accompanying probability of 0.0010, which indicates that the model should select the fixed effect model. The three different fixed effect models are shown in table 3. As can be seen from the table, the measurement of the three cases can be passed, in contrast, the time fixed effects model and the individual, the time fixed dual-effect model has the same statistical value, slightly better than the individual fixed effects model. However, the result of fixed-point model of time-point effect shows that the significance test of $\ln TR\_CZ$ does not pass; The individual and time double-fixed effect model estimation results show that the significance tests of the other six variables except $\ln TR\_CZ$ have not passed; The results of individual fixed effects estimation showed that all equations passed the significance test of variables. So we choose the time-point fixed effect model.

Table 3. *The comparison of three different fixed effects models.*

	R^2	Adjusted R^2	S. E.	F-statistics
Cross-section Fixed	0.8875	0.8677	0.2831	44.8987
Period Fixed	0.9985	0.9980	0.0351	1705.1750
Cross-section & Period Fixed	0.9985	0.9980	0.0351	1705.1750

The model is divided into variable coefficient model, fixed influence model and invariant parameter model and so on, which needs to be determined according to the F test. Assuming H_1: $\beta_1=\beta_2=\cdots=\beta_N$ and H_2: $\beta_1=\beta_2=\cdots=\beta_N$

and $\alpha_1 = \alpha_2 = \cdots = \alpha_N$ corresponding F statistic value and critical value are: $F_1 = 4.3911$, $F_2 = 428.3720$, $F_{0.05}(6,77) = 2.2188$, $F_{0.05}(12,77) = 1.8802$, respectively, due to various statistic value is greater than the corresponding critical value so rejected the hypothesis H1 and H2 at the same time, that is to say model should be taken to variable coefficient model.

3.6. Parameter Estimation and Result Analysis

The use of Eviews7.0 variable coefficient model parameter estimation, the results are as follows:

$$\ln GDP\_HN = 4.0746 + 0.6988 \ln TR\_HN$$

$$\ln GDP\_CS = 1.7086 + 0.8904 \ln TR\_CS$$

$$\ln GDP\_ZZ = 2.8313 + 0.6792 \ln TR\_ZZ$$

$$\ln GDP\_XT = 3.6756 + 0.5702 \ln TR\_XT$$

$$\ln GDP\_HY = 4.2058 + 0.5745 \ln TR\_HY$$

$$\ln GDP\_YY = 5.1655 + 0.4162 \ln TR\_YY$$

$$\ln GDP\_YY1 = 4.6453 + 0.4264 \ln TR\_YY1$$

$$\ln GDP\_CZ = 6.2599 + 0.2335 \ln TR\_CZ$$

$R^2 = 0.9493$, $S.E. = 0.2751$, $F = 116.1694$, $\Pr ob(F) = 0.0000$, the concomitant probabilities of the corresponding parameters of all the variables are less than 0.05, and the goodness of fit of the model estimation is high and the overall linear relationship is significant.

It can be seen from the above estimates that the GDP of high-tech region has a significant impact on GDP in the region. Hunan High-tech zone GDP growth of 10% per cent, can drive Hunan economic growth of 6.988%. From the perspective of impact, in turn, Changsha High-tech Zone, Zhuzhou High-tech zone, Hengyang Hi-tech zone, Chenzhou Hi-tech zone, Xiangtan Hi-tech zone, Yiyang Hi-Tech District and Yueyang Hi-tech zone. Each of the high tech zones has a growth rate of 10% per cent, and the above-mentioned hi-tech zones can boost the region's economic growth by 8.904%, 6.792%, 5.702%, 5.745%, 4.162%, 4.264% and 2.335%.

4. Conclusions and Recommendations

Due to geographical location and historical reasons, different high-tech zones and prefectures GDP and its growth rate have some differences. In addition to the low level of Chenzhou high-tech zone, the proportion of GDP of each high-tech zone is higher than that of Chenzhou. In particular, the proportion of Changsha high-tech zones is as high as 38.14%. The GDP of the high-tech zone has a significant impact on the GDP of the region where it is located. For every 10% increase in the GDP of Hunan High-tech Zone, it can boost the economic growth of Hunan by 6.988%. Judging from the degree of influence, there is a big difference. With every 10% increase in the GDP of the high-tech zone, the above high-tech zones can bring the economic growth of the region to 8.904%, less can reach 2.335%.

Based on the above conclusions, the government departments should take the corresponding measures. First of all, the high-tech Zone management Committee should learn from each other, provides a good service platform for High-tech Enterprises, establishes a scientific incentive mechanism, promote the technological innovation of enterprises, and continuously improve the innovation ability and innovation efficiency of High-tech zone through innovation Drive. Secondly, the government departments in Hunan province and all over the state should fully understand the effect of technological innovation diffusion on regional economic development and regional economic differences, adjust measures to local conditions, through various preferential policies such as taxation, investment and so on, it will stimulate the diffusion of technological innovation in high-tech zones, promote the development of High-tech industries in high-tech areas and drive the regional economic development.

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