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The Differentiated Influence of Technology Absorption on Regional Economic Growth in China

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Abstract: Technology absorption based on technology input–output is a main source of regional economic growth, and it can be one of the mechanisms to achieve regional sustainable development. In order to explore the influence mechanism and effects of regional technology absorption on economic growth, this paper classifies 30 provinces (including municipalities and autonomous regions) in China into technology input areas and technology output areas. With economic data from 2000 to 2016, this paper adopts the Hausman test and conducts an empirical study using regression analysis of fixed effect and random effect. The result shows that: (1) compared to technology output areas, technology absorption has a greater effect on economic growth in technology input areas; and (2) in general, all of these different types of technology transactions contribute to promoting regional economy. In technology output areas, the promoting effects of four different technology transactions on economic growth are sequenced from strong to weak as following: technology development, technology consultation, technology service, and technology transfer, while in the technology input areas, the promotion effect on economic growth from strong to weak is technology development, technology service, technology consultation, and technology transfer.

Keywords: technology absorption; technology transaction; economic growth; technology input-output

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1. Introduction

Regional technology absorption is a sustainable process of technology evaluation, introduction and assimilation, transformation practice, and re-development. Technology absorption can be driven by universities, scientific research institutions, enterprises, governments, and technology intermediary service agencies. Regional technology absorption has the characteristics of resource integration, spatial heterogeneity, high adaptability to the enterprise, and center openness, and is seen as an important driving force for economic growth [1].

Sustainable development requires that development meets present needs without imposing a threat to the needs of future generations. It is a harmonized development of economy, resources, and environmental protection. The ability and effect of a region's sustainable development and resilience to shocks are restricted and influenced by many factors. Among them, technology is one of the important driving forces for region resilience and sustainable development. On one hand, it plays a huge role in expanding economic scale, improving labor productivity, and economic benefits. In addition, technology innovation and transfer help accelerate the adjustment of industrial structure that promote the optimization and upgrading of industrial structure and contribute to the sustainable development of the economy. On the other hand, various technologies have been used to improve the urban resilience in the process of building a smart city [2,3]. For example, resource and energy consumption can be reduced fundamentally through the application of alternative energy technologies, new energy exploration technologies, and energy-saving clean technologies, thus providing guarantees for the urban energy resilience [4] and improved resource utilization efficiency.

However, the development of technology may harm the environment as well. Not all technologies bring about sustainable development. For example, solar photovoltaic power generation is a source of green power, but the production of photovoltaic panels generates a large amount of wastewater and gas, which is harmful to the environment. But specifically, new technologies have started being recognized in the environmental conservation phase [5]. The application of high technology has brought about more advances in environmental pollution control technologies and enhanced the ability to deal with pollution. With the improved energy consumption structure and reduced pollutant emissions through technology application, environmental sustainability can be achieved. With the sustainable development of economy, resources, and environment, regional sustainability can be achieved.

In recent years, the scale of China's technology market has expanded greatly. There are 29 major standing technology (property rights) trading institutions and 11 national technology transfer regional centers currently. In 2016, a total of 320,437 technology contracts were signed. The transaction volume of technology market increased from 7.25 billion Yuan in 1988 to 1140.7 billion Yuan in 2016. Major technology contracts accounted for more than 70% of the total volume of nationwide technology contracts. The motivation of the study is that there are still problems in the process of technology transfer and transaction in China, such as low efficiency in technology conversion, imperfect trading mechanism, and inefficiency in promoting economic growth. All of the above can attribute to low absorption capacity of regional technology.

As regard to regional technology absorption research, Yifu Lin believes that in a relatively short period of time, technology introduction and its spillover effect can bridge the technological gap between underdeveloped and developed countries [6]. Cantwell et al. point out that, in a relatively underdeveloped economy, technology absorption, through which economic development can be achieved, plays a dominant role in technology transaction. In a developed economy, the technology market can be advanced through technology output [7]. When choosing the indicators, the regional flow of the volume of technology transaction contract is used to reflect regional technology absorption capability. Different types of technology trading contracts in different regions have diverse effects on economic growth. For example, technology development contracts have the greatest impact on economic growth in China's eastern region, and technology service contracts have the least impact on economic growth in China's western region [8]. In general research, the use of extensive panel data always leads to a universal rule that the location of the subject and intermediary in the technical network will often affect the speed and convenience of access to technical resources [9]. Therefore, when analyzing the relationship between regional technology absorption and economic growth, in order to eliminate the heterogeneity of technology transactions in various regions, the classification of technology input areas and output areas can better predict the effects of technology absorption on economic growth [10].

In summary, the existing research about the impact of regional technology on economic growth needs to be further deepened and expanded. First, the research on the influence mechanism of technology absorption on regional economic growth needs to be enhanced. Second, insufficient consideration is given to the regional heterogeneity in technology absorption. In most existing studies, geographical regions are classified through provincial and municipal dimensions, which leads to the inability of relating findings in interpreting regional differentiation phenomenon, and thus hinders both the research and the formulation of regional innovation policies.

In view of this, the main research questions in the study are as follows: first, based on the NR relationship theory, the influence mechanism of technology absorption on the economic growth in China's technology input and output areas are analyzed. Second, how do the different types of technology transactions of technology absorption affect the economic growth in China's technology input and output areas. From the above research, we can understand the overall situation of technology input and output in the technology market of China. Based on empirical results and relevant expert opinions, we propose policy recommendations at the end of the paper, which are conducive to the enhancement of regional technology absorption capacity, the improvement of technological innovation capability and regional economic resilience capability, and the realization of sustainable economic development goals.

2. Theoretical Construction

The theoretical analysis of technology transfer is the basis for constructing the mechanism of regional technology absorption on economic growth. In the areas of technology transfer research, Montebbio and Sterzi point out that regional technology transfer is not the movements of technology in time and space, but independent input and output of technology, and redevelopment that can facilitate transformation of technology achievement into productivity [11]. Geographical distance, the level of economic development, inter-regional technology homogeneity levels, and social and cultural similarity can affect regional technology absorption and transfer [12–15]. Since the 1960s, the idea of "the co-evolution" has gradually been applied to the study of building technology transfer networks [16,17]. Subsequently, Criscuolo and Narula [18] suggested that different stages of technological development need to be achieved through technology transfer, but the technology transfer strategies required at each stage are different.

Saito Yu, a Japanese scholar, put forward the hypothesis of demand and resource relationship when doing a research on international technology transfer, which is also called "NR relationship theory". This hypothesis made a reasonable explanation for the driving mechanism of research technology absorption. The theory holds that the demand for a certain technology or product is the main motivation for a country to engage in international economic transactions. In addition, the mismatch between N (need) and R (resource) will restrict national economic development. There are two ways to resolve this contradiction: domestic technology innovation or absorption of advanced foreign technology [19]. Although the theory is based on international technology transfer, its viewpoint can serve as a reference when study the driving mechanism of regional technology absorption: the incompatibility between demand and resources is an important motivation for regional technology absorption. In this paper, regional technology absorption is divided into technology input and technology output, while, at the same time, the objects of technology input and output which are also the objects of technology transaction, are divided into four types: technology development, technology transfer, technology consultation, and technology service. The mechanism of regional technology absorption on economic growth from the perspective of technology demand side (enterprise) is shown in Figure 1.

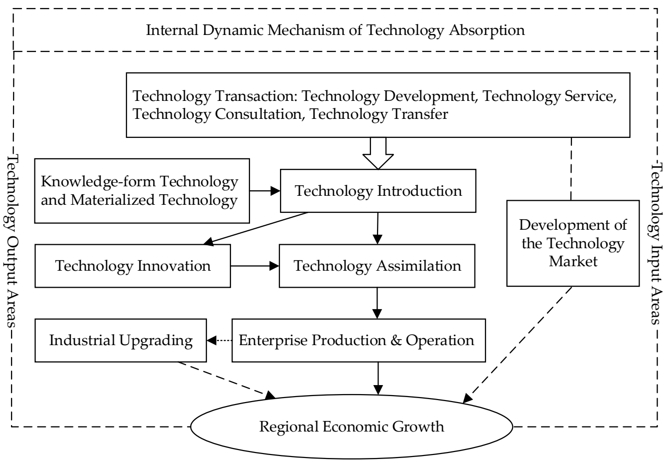

Figure 1. The influence mechanism of regional technology absorption on economic growth.

First of all, technology absorption is an important way for the two sides of technology supply and demand to coordinate and adapt to each other, and it has a positive effect on regional economic growth (theoretical assumption 1). The reason is that enterprises, as a demand side of technology, need to introduce new technologies to achieve economic goals such as better economic scale, larger regional market share, and to pursue social and environmental goals. The introduction of technology asks for scientific findings support and talent support from universities or scientific research institutions. The introduced technologies are mainly materialized technologies and knowledge-form technologies [20]. The assimilation and innovation of technology is the core part of regional technology absorption. The level of capital, talents, industrialization level of scientific research findings, and the technology itself all together determine the ability of technology assimilation and innovation. As seen from Figure 1, the three stages of technology absorption are technology introduction, technology innovation, and technology assimilation.

At the technology introduction stage, taking into consideration product technology demands and adaptability, research abilities of universities and research institutions, as well as technology level, enterprises decide which partnering institutions to work with and what technologies to bring in; at the technology innovation stage, enterprises improve and optimize technology by considering their own product characteristics, thus promoting technological innovation, and further enhancing the core competitiveness of products; at the technology assimilation stage, the operating processes of the enterprise, for example, strategic positioning of product markets, process innovation, personnel management and product production, are integrated with new technologies. Finally, the redeveloped technology is applied to the production and operation, and ultimately promotes the growth of the regional economy. In addition, the productization of technology will promote industrial upgrading and affect regional economic development indirectly. The process of technology introduction itself can enhance the development of the technology market, indirectly promoting regional economic development and construction of a national innovation system [21].

Secondly, in both scenarios of technology input and technology output, technology absorption can promote regional economic growth, but the influence mechanism is different (theoretical assumption 2). The reason is that for the technology input areas, there is not only the input of the technology but also the output of the technology, and the technology input capability is stronger than the technology output capability. Most of the technology input areas are characterized by lack of local technical resources, low transformation efficiency of local technological achievements, and deficiency in industrial upgrading. Therefore, it is urgent for enterprises to absorb technology to achieve integration in traditional industries, and to make the product market more competitive, so as to realize sustainable regional economy growth. Similarly, for the technology output areas, the capability of technology output is stronger than the capability of technology input. Most of the technology output areas are characterized by strong technological independent innovation capability, large proportion of scientific and technological talents, and high scientific and technology input support. The enterprises in the areas of technology output face tighter competition and higher risk with insufficient local technology resources. According to "NR relationship theory", strong technology input capability is also required in technology output areas. Theoretically, technology absorption, in both the technology input and output areas, plays an important role in regional economic growth.

Finally, there are many types of transaction objects in the technology market, all of which have positive effects on regional economic growth (theoretical assumption 3). The technological progress in developing economies are realized mainly through domestic R&D, inter-regional technology purchase, introduction of foreign technology, and foreign direct investment [22]. In addition, patents may facilitate transactions in technology by either: the appropriation effect and the disclosure effect [23]. Among them, technology development is the core carrier of enterprise technology innovation, which is conducive to the advent of new materials, new processes, and new products. In addition, it also plays an important role when enterprises cooperate with universities and scientific research institutions, governments, intermediaries, etc. Technology transfer can make the product upgrade more efficient and help to protect the technology rights of the transfer parties, and thus guarantee the interests of both parties. Technology consultation is a fundamental element of technology transaction activities, which requires a high level of specialty. Enterprises can conduct assessment of new technology through technology consultation, and risks incurring from development and adoption of new technology can thus be alleviated effectively. Technology service runs through the entire technology operation process from pre-sales service to after-sales services, making full use of social intellectual resources to solve various technical problems in the transformation of technological achievements. Theoretically, in the chain of technology transaction, the technology diffusion in patent trading will present a mode of cooperation [24]. In addition, technology development, technology transfer, technology consultation, and technology service all contribute to economic growth.

3. Model and Data

3.1. Model Building

Based on the above theoretical analysis and combined with the Solow economic growth model, this study constructs a model of technology absorption affecting regional economic growth. According to the general form of the Cobb–Douglas production function: $Y = AK^{\alpha}L^{\beta}$, where Y is the output, A is the technical level, K is the capital stock, L is the labor, α is the output elasticity of capital, and β is the output elasticity of the human input. On the basis of the general form of Cobb–Douglas, Solow separated the contribution rate of technological progress to economic growth. The logarithm is taken on both sides of the equation, and the equation becomes: $G_Y = G_A + \alpha G_K + \beta G_L$, where G_Y represents the growth rate of output, G_A represents the growth rate of technological progress, indicating the growth rate of capital investment, G_L represents the growth rate of labor input, and α represents the production elasticity of capital, and β represents the output elasticity of human input. Based on the Solow economic growth model, this paper builds model 1 for technology absorption of economic growth as follows:

$$Y_{it} = \alpha_{it} + \beta_{1i}K_{it} + \beta_{2i}L_{it} + \beta_{3i}TA_{it} + \varepsilon_{it} \tag{1}$$

where Y_{it} represents the regional GDP, K_{it} represents the capital stock, L_{it} represents the human input, TA_{it} represents the technology absorption, α_{it} represents the cross-sectional coefficient of different cross-sectional heterogeneity, β_i represents the regression coefficient, and ε_{it} represents the random error.

In order to further distinguish the degrees of influence of different types of technology trading contracts in different areas on economic growth, the panel model 2 is constructed as follows:

$$\begin{gathered} Y_{it} = \alpha_i + \varphi_i TA_{it} + \varepsilon_{it} \\ TA_{it} = TD_{it} + TT_{it} + TC_{it} + TS_{it} \end{gathered} \tag{2}$$

where TD_{it} indicates technology development, TT_{it} indicates technology transfer, TC_{it} indicates technology consultation, and TS_{it} indicates technology service. Since the natural logarithmic transformation of the data does not change the nature of the original data, the trend can still be linearized, and because the above units of the selected variables have large differences, to avoid the influence of heteroscedasticity, natural logarithmic is applied to all variables.

3.2. Division of Study Areas

The 30 provinces (municipalities and autonomous regions) in China (excluding Tibet and Taiwan) are classified into two areas: technology output areas and technology input areas. This division can help to further analyze the influence of technology absorption on economic growth with consideration to technology itself. It has practical value for developing technology markets and emerging innovative economies. The standard for classifying the technology input and technology output areas in this paper is based on the technology transaction contracts in various regions of China in the period of 2001 to 2017 (National Technical Market Statistics Annual Report). By deducting the average transaction volume of input technology from the average transaction volume of output technology in each region, this article classifies the regions of a positive value as technology output areas, and the regions of a negative value are classified as technology input areas. According to the above method, as shown in Figure 2, the areas of technology output includes Beijing, Shanxi, Shanghai, Hubei, Tianjin, Anhui, and Heilongjiang; regions such as Fujian, Jiangsu, Inner Mongolia, and Hebei are classified into technology input areas.

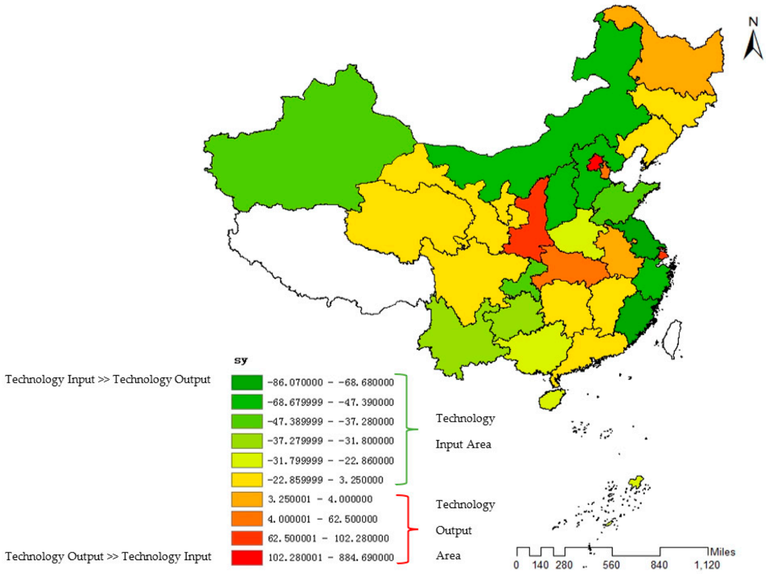

Figure 2. Division of technology input and output areas.

3.3. Data

First, the regional GDP (Y). In order to eliminate the influence of price factors, the GDP deflator will be used to deflate the nominal GDP, and the actual GDP of 30 provinces (municipalities and territories) in 2000–2016 (excluding Tibet and Taiwan) will be obtained with a base year of 2000.

Second, the capital stock (K). In this paper, the calculation method of capital stock refers to the estimate of K by Haojie Shan [25]. First, the year 2000 is selected as the base period and actual capital stock in 2000 is estimated using the following:

$$K_{2000} = \frac{I_{2001}/P_{2001}}{\left[\left(\frac{I_{2005}/P_{2005}}{I_{2001}/P_{2001}}\right)^{0.2} - 1\right] + \delta} \tag{3}$$

Then, the actual capital stocks for each year during 2001 to 2016 in each region are estimated through Equation (4):

$$K_t = K_{t-1}(1-\delta) + \frac{I_t}{P_t} \tag{4}$$

where the depreciation rate, δ, is 10.96%, I_t represents the nominal fixed capital formation amount, and P_t represents the fixed asset investment price index (2000 = 1).

Third, the human resources investment (L) is expressed by the total number of employees in each region in each year. Compared to the labor force population of previous studies, the total number of employees in this paper is easy to obtain and more accurate in reflecting factor input of economic growth.

Fourth, the technology absorption (TA) is expressed by the transaction volume of technology inflow region. The reason to use contract transaction volume is that it can reflect the capability of a region to introduce and digest technology through the technology market.

Finally, the technology development (*TD*) is expressed by the transaction volume of technology development contract for technology inflow area. The technology transfer (*TT*) selects the transaction amount of technology transfer contract for technology inflow area. The technology consultation (*TC*) is expressed by the transaction volume of technology consultation contract for technology inflow area. The technology service (*TS*) is expressed by the transaction amount of technology service contract for technology inflow area. Similarly, these indicator data also remove the impact of price factors.

The data of China's *Y*, *K*, *L*, *TA*, *TD*, *TT*, *TC*, and *TS* during the period of 2000 to 2016 are selected to perform analysis. The statistics are shown in Table 1.

Table 1. Descriptive statistics.

Variable	Technology Output Areas				Technology Input Areas			
	Obs	Mean	Max	Min	Obs	Mean	Max	Min
LNY	119	8.263	8.835	7.402	391	8.045	9.718	5.574
LNK	119	9.609	10.991	7.942	391	9.417	11.779	6.399
LNL	119	6.575	7.455	5.330	391	6.242	8.253	3.347
LNTA	119	13.536	16.408	11.107	391	12.739	15.781	8.940
LNTD	119	12.551	15.327	10.027	391	11.662	14.904	7.936
LNTT	119	11.507	14.301	9.295	391	9.614	13.073	5.370
LNTC	119	10.209	13.332	8.031	391	10.589	14.779	5.998
LNTS	119	12.473	15.897	9.833	391	11.791	14.907	7.474

Note: *Y* represents the regional GDP (Data source: China Statistical Yearbook (2001–2017) from www.stats.gov.cn) (Unit: 100 million yuan); *K* represents the capital stock (Data source: China Statistical Yearbook (2001–2017) and China City Statistical Yearbook (2001–2017), from www.stats.gov.cn) (Unit: 100 million yuan); *L* represents the human resources investment (Data source: China Statistical Yearbook (2001–2017) from www.stats.gov.cn) (Unit: 10,000 people); *TA* represents the technology absorption (Data source: National Annual Report on Technical Market Statistics (2001–2017), from www.chinatorch.gov.cn) (Unit: 10,000 yuan); TD, TT, TC, TS represent the technology development, the technology transfer, the technology consultation, and the technology service (Data source: China Science and Technology Statistical Yearbook (2001–2017), from National Bureau of Statistics of China (NBS)) (Unit: 10,000 yuan) respectively. All variables have been transformed using natural logarithms.

4. Results

4.1. Multicollinearity Test

In the setting of the model, there may appear multiple co-linearity, resulting in an insignificant regression result. Therefore, the data needs to be co-linearity diagnosed before the regression. The collinearity diagnosis results of the data are shown in Table 2.

Table 2. Collinear statistics.

Variable	Technology Output Areas				Technology Input Areas			
	Model 1		Model 2		Model 1		Model 2	
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
K	0.507	1.972			0.212	4.707		
L	0.497	2.012			0.213	4.689		
TA	0.642	1.558			0.293	3.410		
TD			0.154	6.485			0.378	2.649
TT			0.770	1.299			0.450	2.223
TC			0.180	5.557			0.567	1.764
TS			0.100	9.970			0.607	1.648

Note: "Blank" in the table means no such item. VIF = variance inflation factor.

In general, the multiple co-linearity between data can be determined by observing the tolerance and the variance inflation factor (VIF) of the variables. It can be seen from Table 2 that the tolerances of the variables in both models are greater than 0.1 and the VIF is less than 10, indicating that there is no multiple co-linearity between the data, and can be directly added to the regression model.

4.2. Model Estimation and Hausman Test

In the empirical study of panel data, there are three commonly used models: mixed effect model, fixed effect model, and random effect model, while fixed effect model and random effect model are the two most used models. The Hausman test is a test method that weighs consistency and validity in the significance test of the difference in parameter estimators. This study finds that the results of the mixed estimation model are poor, and the results of the fixed effect model and the random effect model are better. Therefore, the Haussmann test was performed on model 1 and model 2 of the technology output areas and the technology input areas. The null hypothesis for Hausman test is:

Hypothesis 1 (H1). *Difference in coefficients not systematic.*

The results are shown in Table 3.

Table 3. Hausman test.

Test Type	Chi-Sq. Statistic	Chi-Sq. Df	Prob.
Technology output areas (Model 1)	23.647	3	<0.001
Technology output areas (Model 2)	1.391	4	0.846
Technology input areas (Model 1)	824.811	3	<0.001
Technology input areas (Model 2)	65.635	4	<0.001

4.3. Results of the Fixed-Effect Regression and the Random-Effect Regression

According to the Hausman test results, except for model 2 in the technology output areas, the significance p-values of the other three models were less than 0.001, that is, the null hypothesis is rejected. All of the three models adopted the fixed effect model, while the p-value of model 2 of the technology output areas was 0.846, so this model needs to adopt a random effect model. The results are shown in Tables 4 and 5.

Table 4. Results of fixed-effect regression in technology output and input areas (model 1).

Variable	Technology Output Areas				Technology Input Areas			
	Coef.	Std. Err.	t	$p > \lvert t \rvert$	Coef.	Std. Err.	t	$p > \lvert t \rvert$
C	5.786 ***	0.222	26.041	<0.001	5.949 ***	0.071	83.296	<0.001
LNK	0.142 ***	0.042	3.380	0.001	0.173 ***	0.010	16.930	<0.001
LNL	0.086 *	0.050	1.722	0.088	−0.003	0.019	−0.159	0.874
LNTA	0.041	0.033	1.234	0.220	0.038 ***	0.009	4.255	<0.001
R^2	0.953				0.995			
Ra^2	0.950				0.995			
F	247.577				2856.572			
F. Prob	<0.001				<0.001			

Note: *, *** denote the results at 10% and 1% significance level.

Table 5. Results of fixed-effect regression in technology input areas and random effect in technology output areas (model 2).

Variable	Technology Output Areas				Technology Input Areas			
	Coef.	Std. Err.	t	$p > \lvert t \rvert$	Coef.	Std. Err.	t	$p > \lvert t \rvert$
C	6.054 ***	0.211	28.675	<0.001	5.760 ***	0.081	71.096	<0.001
LNTD	0.090 ***	0.018	4.973	<0.001	0.091 ***	0.010	8.789	<0.001
LNTT	0.012	0.015	0.834	0.406	0.021 ***	0.008	2.723	0.007
LNTC	0.044 **	0.020	2.225	0.028	0.025 ***	0.009	2.789	0.006
LNTS	0.039 *	0.020	1.975	0.051	0.065 ***	0.008	8.114	<0.001
R^2	0.747				0.990			
Ra^2	0.738				0.990			
F	84.059				1452.219			
F. Prob.	<0.001				<0.001			

Note: *, **, *** denote the results at 10%, 5%, and 1% significance level.

It can be seen from observation of Table 4 that capital stock has a significant positive impact on economic growth. The model regression coefficient of technology absorption and regional economy in technology input areas is 0.038 (1% significance level), indicating that in the technology input areas, technology absorption can promote regional economic growth. This is consistent with the theoretical assumption 1 and theoretical assumption 2 in the section of theoretical construction. However, in technology output areas, the effect of technological absorption on economic growth cannot be determined.

The possible reasons for this result are, firstly, in the technology market in technology output areas, the transaction contracts which reflect technology absorption capability are mainly the ones that can obtain instant short-term effects. The long-term economic growth will depend more on capital and technology output; secondly, technology output regions such as Beijing, Shanghai, Anhui, Hubei, and other provinces tend to show knowledge spillover effects, which have slowed down the effect of technology absorption on economic growth in the long run; thirdly, in recent years, a series of regional innovation and coordinated development strategies aimed at creating new regional innovation cores and promoting regional collaborative innovation were adopted at the national level, such as "Beijing–Tianjin–Hebei coordinated development", "Yangtze Economic Belt", and the construction of the "National Science and Technology Innovation Center" and the "Innovative City". Scientific and technological concentration regions and economic belts are gradually formed, which has a radiation effect on their surrounding provinces, resulting in higher demand for technology, thus in turn, further enhancing the technology absorption capacity of technology input areas. The contribution of technology absorption to economic growth has gradually increased.

By observing the results of Table 5, it can be seen that all of the different technology transaction activities in the technology output areas and technology input areas have positive effects on economic growth, which is consistent with the theoretical assumption 3 in the section of theoretical construction. Among them, technology development plays the most significant role. In technology output areas, the effect of technology transfer on economic growth is not obvious, and technology consultation and technology service have a certain positive effect on economic growth. In technology input areas, all of four types of contracts have greatly promoted regional economic growth.

In addition, by observing Tables 4 and 5, it can be concluded that most of the independent variables in the model passed the *t*-test with significance levels of 90%, 95%, and 99%. After observing the F test results of the model, a significance level α of 0.05 was chosen. As can be seen from Table 4 to Table 5, the significance *p*-values (F. Prob) of the four model F statistics were less than 0.001, so the hypothesis is rejected. All of the regression equations of the four models pass the 95% significance level F test. Finally, in order to observe the goodness-of-fit of the model, the significance of the regression effect of the model can be observed through the coefficient of determination R^2 statistic. The closer the value is to 1, the smaller the proportion of random error, and the better the fitness of regression equation to the sample observation value. It can be seen from Tables 4 and 5 that the adjusted R^2 (Ra^2) of the four models are all good. The two regression models in technology output areas are superior to models in technology input areas.

4.4. Robust Test

Considering that the estimation method may affect the model, this paper will not follow the Hausmann test results. Random effect analysis was applied to model 1 in the technology output areas, and to model 1 and model 2 in the technology input areas. Fixed-effect analysis was applied to model 2 in the technology output areas. Regression analysis was done after the above steps, and the regression result was observed after the replacement of estimation method. It was found that the overall significance of the model was still high, and the *t*-test of most variables had a high overall fit, while the random effect model was slightly lower than the fixed-effect model. In summary, the regression model selected in this paper considers the variable and model estimation, and the overall robustness was high, indicating that the results of the above model were good and had analytical significance.

5. Conclusions and Policy Recommendations

Based on the sample data of 30 provinces (municipalities and autonomous regions) in China (excluding Tibet and Taiwan) from the year of 2000 to the year of 2016, this study combines a Hausman test with an empirical study on fixed-effect regression and random-effect regression. This study compares the impact of technology absorption on regional economic growth in China's technology output areas and technology input areas. The main conclusions are as follows.

The empirical results of this paper are not quite consistent with the results of some other scholars. The results of some other scholars show that technology absorption will promote GDP growth in both technology input and output areas [10,26]. While the results of this paper show that, in the technology input areas, technology absorption can promote regional economic growth, in technology output areas, the effect of technological absorption on economic growth cannot be determined. The possible reasons are technology output areas appear to have more knowledge spillover effects, which drags the effect of technology absorption on economic growth in the long run. Besides, major strategies such as scientific and technological innovations formulated at the national level help form scientific and technological concentration regions and economic belts geographically, and the radiation effect has promoted the demand for technology in neighboring provinces, which has increased the contribution of technology absorption to economic growth in technology input areas.

Different types of technology transaction contracts have different contributions to the economic growth in these two areas, and it is consistent with the empirical results of previous studies [8]. Generally speaking, the overall effect of technology development is the strongest, while the effect of technology transfer is the weakest. The reason may be that technology development is the source of technology absorption, which plays an important role in developing new products and new business scopes, keeping and expanding market share, and accelerating talent training. In addition, technology transfer is most complicated in four types of technology transactions. Restricted by legislation and obligation, and by scope of objects, the contribution rate of technology transfer to economic growth is the smallest [27].

In addition, policy recommendations also arise from this study.

Firstly, in order to improve the capability of regional technology innovation and economic resilience, regional technology transfer agglomeration and diffusion centers should be established to optimize technology transfer and transaction market environment, and to increase the quantity and quality of different technologies. At the same time, the long-term mechanism of transforming technology resources or advantages into economic advantages should be studied positively. It is important to combine the regional innovation environment with innovation resource endowments to fully push forward the "five chains integration", which are the innovation chain, the industry chain, the capital chain, the talents chain, and the policy chain.

Secondly, the promoting effect of technology absorption on economic growth should be enhanced in technology input areas. This can help make up for the deficiency of technology absorption chain, improve service system of technology transfer, and promote dynamic integration of absorbed technology with local innovation resources. It is noted that for the technology output areas, a sound technology transfer platform should be established to strengthen local transfer of technology resources. Narrow-minded local protectionism on technology innovation should be abandoned to facilitate integration of cross-regional technology transfer into industry technology transfer.

Thirdly, quality of technology absorption is as important as quantity of technologies. Policies that are conducive to resource conservation and environmental protection should be carefully made. Policy-making support tools can be used when making policies. For example, the Future-Oriented Technology Assessment will be beneficial to building possible alternative technologies that can be applied to the future, and make better-informed decisions regarding the shape of the trajectory of technological development of a particular region.

In the end, the limitation of this paper is that there are few evaluation methods for the classification of technology input areas and technology input areas, and there is a lack of comparison between them.

Besides, it is difficult to know the advantages and disadvantages of the selected evaluation methods. In addition, this paper does not analyze technology absorption in internal provinces of technology input areas and technology output areas and the model design could be improved. Furthermore, this paper does not predict the development model of future technology absorption. Future research could be done based on the above information.

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References

1. Fu, Y.; Pietrobelli, C.; Soete, L. The role of foreign technology and indigenous innovation in the emerging economies: Technological change and catching-up. *World Dev.* **2011**, *39*, 1204–1212. [CrossRef]
2. Meerow, S.; Newell, J.P.; Stults, M. Defining urban resilience: A review. *Landsc. Urban Plan.* **2016**, *147*, 38–49. [CrossRef]
3. Sitinjak, E.; Meidityawati, B.; Ichwan, R.; Onggosandojo, N.; Aryani, P. Enhancing Urban Resilience through Technology and Social Media: Case Study of Urban Jakarta. *Procedia Eng.* **2018**, *212*, 222–229. [CrossRef]
4. Sharifi, A.; Yamagata, Y. Principles and criteria for assessing urban energy resilience: A literature review. *Renew. Sustain. Energy Rev.* **2016**, *60*, 1654–1677. [CrossRef]
5. Wang, J.Y.; Zhao, J.; Deng, S.; Sun, T.; Li, K. Application potential of solar-assisted post-combustion carbon capture and storage (CCS) in China: A life cycle approach. *J. Clean. Prod.* **2019**, *208*, 1009–1021. [CrossRef]
6. Lin, Y.F. Development strategy, viability and economic convergence. *China Econ. Q.* **2002**, *2*, 269–300. [CrossRef]
7. Cantwell, J.; Janne, O. The role of multinational corporations and national states in the globalization of innovatory capacity: The European perspective. *Technol. Anal. Strateg. Manag.* **2000**, *12*, 243–262. [CrossRef]
8. Liu, J.; Zhang, J.L. Research on the development status and economic effect of China's technology market. *Stat. Decis.* **2012**, *24*, 144–146. [CrossRef]
9. Gonzalez-Brambila, C.N.; Veloso, F.M.; Krackhardt, D. The impact of network embeddedness on research output. *Res. Policy* **2013**, *42*, 1555–1567. [CrossRef]
10. Pan, X.F.; Peng, X.X.; Liu, Q. Technology absorption and economic qrowth in China: From the view of technology import and export. *Stud. Sci. Sci.* **2016**, *34*, 867–873. [CrossRef]
11. Montobbio, F.; Sterzi, V. The globalization of technology in emerging markets: A gravity model on the determinants of international patent collaborations. *World Dev.* **2013**, *44*, 281–299. [CrossRef]
12. Cohen, W.M.; Levinthal, D.A. Absorptive capacity: A new perspective on learning and innovation. *Strateg. Learn. Knowl. Econ.* **1990**, *35*, 128–152. [CrossRef]
13. Cao, W.L.; Tan, M. Influence factors of cross-regional technology transfer performance from social network perspective. *Forum Sci. Technol. China* **2012**, *1*, 89–95. [CrossRef]
14. Marrocu, E.; Paci, R.; Usai, S. Proximity, networking and knowledge production in Europe: What lessons for innovation policy. *Technol. Forecast. Soc. Chang.* **2013**, *80*, 1484–1498. [CrossRef]
15. Nepelski, D.; Prato, G.D. International technology sourcing between a developing country and the rest of the world: A case study of China. *Technovation* **2015**, *35*, 12–21. [CrossRef]
16. Murray, F. Innovation as co-evolution of scientific and technological networks: Exploring tissue engineering. *Res. Policy* **2002**, *31*, 1389–1403. [CrossRef]
17. Pelikan, P. Bringing institutions into evolutionary economics: Another view with links to changes in physical and social technologies. *J. Evolut. Econ.* **2003**, *13*, 237–258. [CrossRef]
18. Criscuolo, P.; Narula, R. A novel approach to national technological accumulation and absorptive capacity: Aggregating Cohen and Levinthal. *Eur. J. Dev. Res.* **2008**, *20*, 56–73. [CrossRef]
19. Rao, Y.L. *International Technical Trade*; Nankai University Press: Tianjin, China, 1999; pp. 43–44.

20. Marcotte, C.; Niosi, J. Technology transfer to China: The issues of knowledge and learning. *J. Technol. Transf.* **2000**, *25*, 43–57. [CrossRef]
21. Zoltán, J.A.; Audretsch, D.B.; Lehmann, E.E. National systems of innovation. *J. Technol. Transf.* **2016**, *42*, 1–12. [CrossRef]
22. Hu, A.G.Z.; Jefferson, G.H.; Qian, J. R&D and technology transfer: Firm-level evidence from Chinese industry. *Rev. Econ. Stat.* **2004**, *87*, 780–786. [CrossRef]
23. De Rassenfosse, G.; Palangkaraya, A.; Webster, E. Why do patents facilitate trade in technology? Testing the disclosure and appropriation effects. *Res. Policy* **2016**, *45*, 1326–1336. [CrossRef]
24. Huang, H.C.; Shih, H.Y.; Ke, T.H. The technology diffusion in patent transaction network: An example of TFT-LCD industry. In Proceedings of the Portland International Conference on Management of Engineering & Technology, Honolulu, HI, USA, 4–8 September 2016. [CrossRef]
25. Shan, H.J. Reestimating the capital stock of China: 1952~2006. *J. Quant. Tech. Econ.* **2008**, *10*, 17–31. [CrossRef]
26. Li, G.S.; Xu, X. Technology Imports and Regional Economic Convergence. *China Econ. Q.* **2008**, *3*, 983–996. [CrossRef]
27. Ungureanu, M.; Pop, N.; Ungureanu, N. Innovation and technology transfer for business development. *Procedia Eng.* **2016**, *149*, 495–500. [CrossRef]