“一带一路”国际科技合作对沿线国家的创新与增长效应研究

The Innovation and Growth Effect of the Scientific and Technology Cooperation between BRI Countries and China

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Contents

- Background
- Cooperation Modes, Mechanisms and Current Situation
- Theoretical model of BRI scientific and technology cooperation
- Empirical Analysis

Background

Background

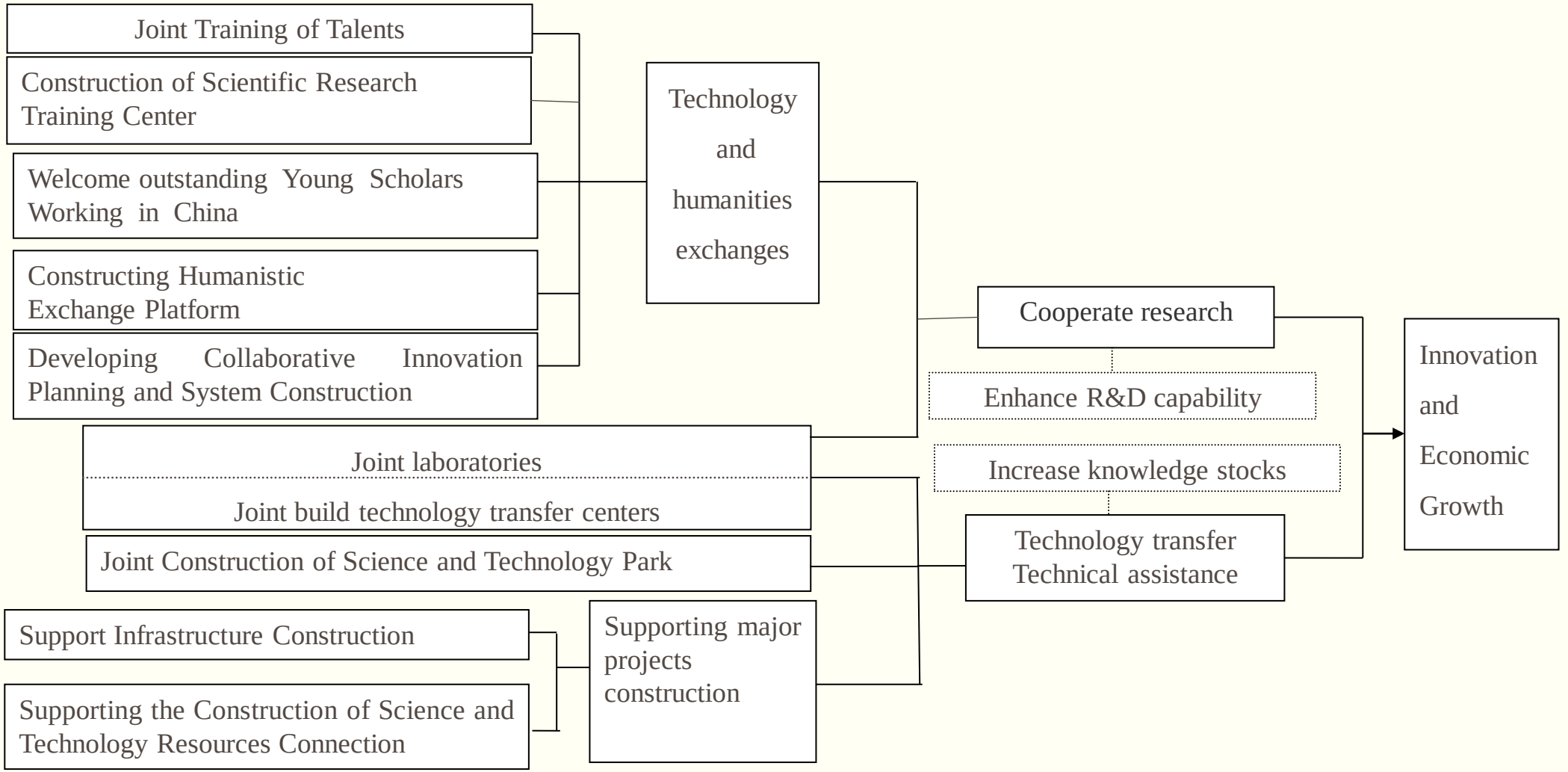
“Belt and Road” is a great initiative made by China government in accordance with the characteristics of the times and the global situation. It’s not only the road of economic and trade exchanges, cultural exchanges, but also the way of cooperation in scientific and technological innovation. In May 2017, President Xi Jinping proposed at the Belt And Road forum international cooperation that " Belt And Road" should be a road of innovation, and China is ready to work with other countries to advance scientific and technological cooperation. At the second Belt And Road forum international cooperation in April 2019, President Xi Jinping pointed out again that innovation is productivity, enterprises and the country are highly dependent on it. China will continue to promote four cooperation measures with BRI countries.

Background

Most BRI countries are developing countries with relatively low level of science and technology ,but have large demand for science and technology for economic development. “ Belt And Road Initiative” not only promotes regional economic cooperation among BRI countries, but also provides a good opportunity and platform for scientific and technological innovation cooperation. Technology is the source of long-term economic growth, as one of the main driving forces to break through the technological bottleneck and promote technological progress, it will undoubtedly have an impact on the economic growth of all countries. But what are the paths and mechanisms of impact still need we explore.

Cooperation Modes, Mechanisms and Current Situation

Cooperation Modes, Mechanisms and Current Situation



The mode and mechanism of " Belt and Road" international scientific and technological cooperation

Cooperation Modes, Mechanisms and Current Situation

At present, China with the BRI countries are making steady progress in four cooperation modes . In 2017, 29 937 papers and 205 patents were co-authored by scholars from China and other BRI countries. The number of Postgraduates (master's degree and doctoral degree) studying in China is about 49 000, and 21 joint laboratories and 16 technology transfer centers have been established. The number of contracts for engineering cooperation projects is 7184, involving about 142.719 billion US dollars and 47 science and technology parks have been established.

Cooperation Modes, Mechanisms and Current Situation

Based on the data of 2017, we uses the PCA method to analyze the current situation of science and technology cooperation between BRI countries and China, which can be used to judge the level of science and technology cooperation, the location of cooperation , and the regional distribution characteristics of countries with greater cooperation intensity.

KMO test was performed before analysis, and the results were 0.6571 > 0.60, PCA analysis can be used.

Cooperation Modes, Mechanisms and Current Situation

Principal Component Rotating Load Matrix

Index variables	principal component			
	F1	F2	F3	F4
Number of overseas students	0.444	-0.285	0.311	0.127
Number of papers cooperated	0.235	0.252	0.815	0.184
Number of Patent Cooperation	0.216	0.661	-0.293	0.449
Cumulative number of joint laboratories	0.471	-0.288	-0.049	-0.195
Contract Number of Major Projects	0.415	0.213	-0.137	-0.682
Cumulative number of technology transfer centers	0.307	-0.475	-0.301	0.492
Total number of Technology Park	0.462	-0.255	-0.202	0.059

Efficiency scores of scientific and technological cooperation between BRI countries and China

Ranking	Total efficacy score	F1 efficiency score	F2efficiency score	F3 efficiency score	F4 efficiency score
1	Indonesia	Indonesia	Hungary	Singapore	Hungary
2	Pakistan	Pakistan	Russia	Pakistan	Russia
3	Thailand	Thailand	India	India	Sri lanka
4	Russia	Russia	Indonesia	Bosnia and Herzegovina	Lebanon
5	India	India	Singapore	Russia	Jordan
6	Cambodia	Cambodia	Malaysia	Sri lanka	Moldova
7	Vietnam	Vietnam	Czech	Macedonia	Oman
8	Kazakhstan	Kazakhstan	Tajikistan	Iran	Afghanistan
9	Hungary	Hungary	Turkey	Turkey	Serbia
10	Lebanon	Lebanon	Macedonia	Israel	Brunei
11	Bangladesh	Bangladesh	Bosnia and Herzegovina	Bangladesh	Pakistan
12	Singapore	Singapore	Philippines	Czech	Slovak
13	Serbia	Serbia	**Cyprus**	Maldives	Emirates
14	Sri lanka	Sri lanka	Poland	Egypt	Myanmar
15	Egypt	Egypt	Georgia	Kuwait	Vietnam
16	Ukraine	Ukraine	Iran	Ukraine	Singapore
17	Malaysia	Malaysia	Israel	Bulgaria	Cambodia
18	Slovak	Slovak	Egypt	Latvia	Czech
19	Myanmar	Myanmar	Kuwait	Thailand	Macedonia
20	Macedonia	Macedonia	Romania	**Cyprus**	Bosnia and Herzegovina

Cooperation Modes, Mechanisms and Current Situation

Conclusion :

The top 20 countries in total efficiency score are mainly countries near to China.

At present, "Belt And Road" international scientific and technological cooperation is relatively poor, the depth of cooperation is insufficient.

Theoretical model of BRI scientific and technology cooperation

Theoretical model of BRI scientific and technology cooperation

Firstly ,the production function of the manufacturer can be set as(Jones， 1995；Mondal et al.， 2006):

$$Y(H_Y, K, A) = H_Y^{\alpha} A \left(\frac{K}{\eta A}\right)^{1-\alpha} = (H_Y A)^{\alpha} K^{1-\alpha} \eta^{1-\alpha}$$

$$\dot{A} = \delta H_A A^{\varphi}$$

Secondly , according to the analyses above, the international cooperation in science and technology can increase the knowledge stocks and enhance the ability of innovation along the BRI countries . So we set the Technical growth function as :

$$\dot{A} = \delta(1+\theta) H_A^{(1+\varepsilon)} A^{\varphi}$$

Theoretical model of BRI scientific and technology cooperation

Assume that the consumer has an instantaneous utility function with relatively constant risk:

$$U\big(C(t)\big) = \frac{C(t)^{1-\sigma}}{1-\sigma}$$

Lifetime utility function can be expressed as : $U = \int_{t=0}^{\infty} U\big(C(t)\big)e^{-\rho t}dt$

Therefore, assuming that the goal of social planners is to maximize the cross-temporal utility of consumers in an infinite time domain, then we are faced with a dynamic optimization problem:

Theoretical model of BRI scientific and technology cooperation

$$\begin{cases} max \quad U = \int_{t=0}^{\infty} U(C(t))e^{-\rho t}dt \\ s.t. \quad Y = (H_Y A)^{\alpha} K^{1-\alpha} \eta^{1-\alpha} \\ \dot{A} = \delta(1+\theta){H_A}^{(1+\varepsilon)} A^{\varphi} \\ \dot{K} = Y - C \\ H_Y + H_A = H \end{cases}$$

So, the following Hamilton function can be established

$$J = \frac{C(t)^{1-\sigma}}{1-\sigma} + \lambda[(H_Y A)^{\alpha} K^{1-\alpha} \eta^{1-\alpha} - C] + \mu\left(\delta(1+\theta){H_A}^{(1+\varepsilon)} A^{\varphi}\right)$$

Accroding to the first order condition and Euler equation ,it is easy to know that

$$g = \frac{\dot{C}}{C} = \frac{\dot{A}}{A} = \left(-\frac{1}{\sigma}\right)\frac{\dot{\mu}}{\mu}$$

$$\frac{\dot{\mu}}{\mu} = \rho - \delta(1+\theta)(1+\varepsilon)A^{\varphi-1}H_A^{(1+\varepsilon)-1}(H - H_A) - \delta\varphi(1+\theta)H_A^{(1+\varepsilon)}A^{\varphi-1}$$

Theoretical model of BRI scientific and technology cooperation

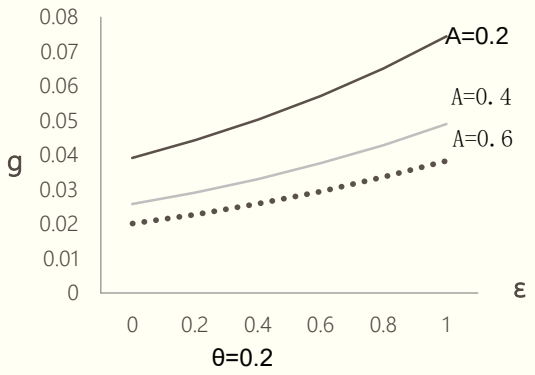
In the above formula, H_A is still unknown , but we can obtain that $-\sigma\frac{\dot{A}}{A}=\frac{\dot{\mu}}{\mu}$

So, we have

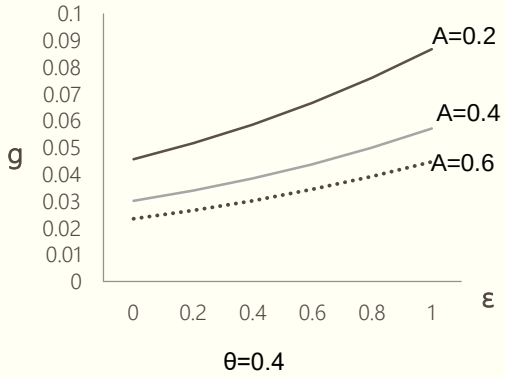
$$\rho-\delta(1+\theta)(1+\varepsilon)A^{\varphi-1}H_A^{(1+\varepsilon)-1}(H-H_A)-\delta\varphi(1+\theta)H_A^{(1+\varepsilon)}A^{\varphi-1}=-\sigma\delta(1+\theta){H_A}^{(1+\varepsilon)}A^{\varphi-1}$$

The equation is nonlinear, and the explicit function expression of H_A cannot be obtained. Therefore, it’s necessary to discuss the characteristics of economic system by means of numerical simulation.

Theoretical model of BRI scientific and technology cooperation



(a)



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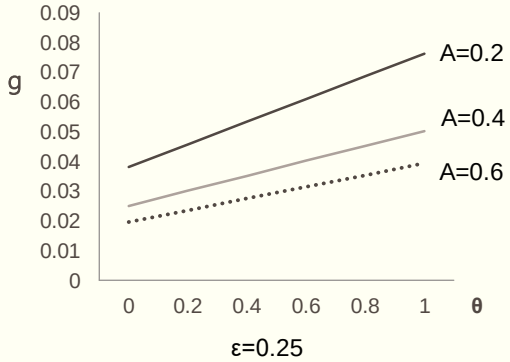

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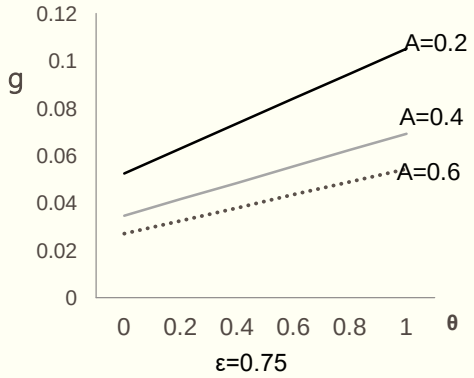

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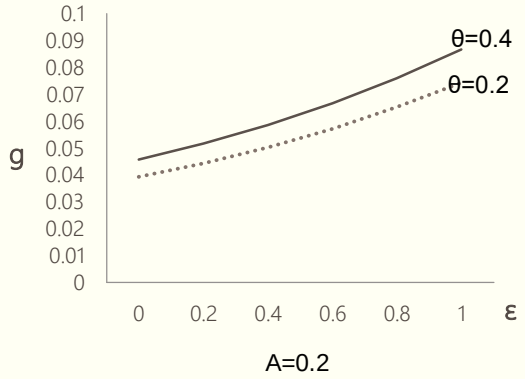

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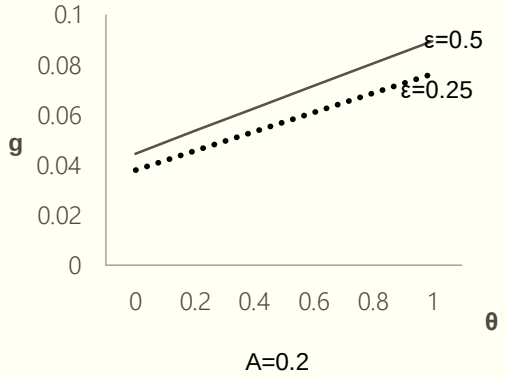

(f)

Theoretical model of BRI scientific and technology cooperation

Conclusion :

(1)International scientific and technological cooperation, focusing on technology transfer and technology assistance, can promote innovation and economic growth of BRI countries, and this effect is more significant for countries with relatively low technology level and small knowledge stock.

(2) International scientific and technological cooperation based on joint R&D of human capital cooperation can also promote innovation and economic growth of BRI countries. This promotion effect is more significant for countries with relatively low technological level and small knowledge stock.

(3) Cooperation research and technology transfer can reinforce each other in innovation and growth of BRI countries.

Empirical Analysis

Empirical Analysis

International Trade and other economic behaviors make the economic development among countries dependent on each other. The BRI countries will have frequent economic and trade exchanges when they cooperation with China on technology and economic. Therefore, ignoring the spatial correlation between economies may lead to errors in model setting. So , we set the spatial econometric model as

$$lnPGDP_{it} = \rho W * lnPGDP_{it} + \alpha l_n + \theta COP_{it} + \sum_i \beta_i x_{it} + u_{it} \quad , \quad u_{it} = \lambda W u_{it} + \epsilon_{it} \tag{1}$$

If $\lambda = 0$, is model SAR model

If $\rho = 0$, is model SEM model

Empirical Analysis

Consider the mutual influence of cooperation research and technology transfer:

$$lnPGDP_{it} = \rho W * lnPGDP_{it} + \alpha l_n + \theta CR_{it} + \gamma CR_{it} \times TR_{it} + \sum_i \beta_i x_{it} + u_{it}$$
$$u_{it} = \lambda W u_{it} + \epsilon_{it} \quad (2)$$

$$lnPGDP_{it} = \rho W * lnPGDP_{it} + \alpha l_n + \varepsilon TR_{it} + \gamma CR_{it} \times TR_{it} + \sum_i \beta_i x_{it} + u_{it}$$
$$u_{it} = \lambda W u_{it} + \epsilon_{it} \quad (3)$$

Explained variables and Explanatory variable

Explained variables	Explanatory variable	**concrete content**	weight
Ln PGDP	Cooperation research (CR)	The number of cooperative papers between china and BRI countries scholars	0.3422
		The number of patent cooperation between china and BRI countries scholars	0.1806
		Number of postgraduate students studying in China from BRI countries	0.0908
		The cumulative number of joint laboratories between China and BRI countries	0.3864
	Technology transfer (TR)	The cumulative number of science and technology transfer centers established between China and BRI countries	0.0930
		The cumulative number of science and technology parks established between China and BRI countries	0.1765
		The number of projects China has cooperated with BRI countries	0.7304

Empirical Analysis

Moran's I of lnPGDP

Year	Moran's I	p	Year	Moran's I	p
2009	0.147	0.000	2014	0.108	0.000
2010	0.128	0.000	2015	0.103	0.000
2011	0.122	0.000	2016	0.122	0.000
2012	0.110	0.000	2017	0.122	0.000
2013	0.107	0.000			

Empirical Analysis

Explanatory variable	SAR				SEM			
	（1）	（2）	（3）	（4）	（5）	（6）	（7）	（8）
CR	0.2927** （0.1307）		0.1208 （0.1394）		0.2737* (0.1407)		0.0679 (0.3474)	
TR		0.1094** (0.0485)		0.0623* (0.0380)		0.1245** (0.0519)		0.0890* (0.0498)
CR*TR			0.3019 (0.1976)	0.3094** (0.1412)			0.3358 (0.4060)	0.2448* (0.1310)
INV	0.0074*** （0.0026）	0.0071*** (0.0026)	0.0070*** (0.0018)	0.0069*** (0.0017)	0.0076*** (0.0028)	0.0073*** (0.0027)	0.0074*** (0.0028)	0.0071*** (0.0027)
EP	0.0273*** （0.0062）	0.0267*** (0.0063)	0.0281*** (0.0045)	0.0275*** (0.0045)	0.0279*** (0.0082)	0.0279*** (0.0075)	0.0276*** (0.0082)	0.0285*** (0.0074)
HC	0.0009 (0.0020)	0.0005 (0.0019)	0.0002 (0.0108)	0.0004 (0.0011)	0.0011 (0.0017)	0.0005 (0.0017)	0.0010 (0.0016)	0.0005 (0.0017)
IND	-0.0145 (0.0116)	-0.0159 (0.0061)	-0.0135** (0.0149)	-0.0139** (0.0061)	-0.0203* (0.0124)	-0.0211* (0.0118)	0.0197 (0.0125)	-0.0196 (0.0123)
TRD	0.0003 (0.0009)	0.0004 (0.0019)	0.0003 (0.0006)	0.0003 (0.0005)	0.0002 (0.0014)	0.0001 (0.0015)	0.0007 (0.0014)	-0.0001 (0.0014)
ρ / λ	0.8401*** (0.0240)	0.8452*** （0.0236）	0.8474*** (0.04315)	0.8485*** (0.04255)	0.8572*** (0.0218)	0.8631*** (0.0185)	0.8649*** (0.0259)	0.8633*** (0.0182)
σ^2	0.0121*** (0.0023)	0.0121*** (0.0023)	0.0119*** (0.0009)	0.0119*** (0.0009)	0.0122*** (0.0024)	0.0120*** (0.0023)	0.0121*** (0.0024)	0.0119*** (0.0024)
log-likelihood	299.202	298.941	300.363	301.326	295.924	298.231	297.350	299.747
Number of obs	396	396	396	396	396	396	396	396

Explanatory variable	SAR				SEM			
	Slow Innovation Club		Innovation chasers club		Slow Innovation Club		Innovation chasers club	
CR	0.4215*** (0.1029)		0.1130 （0.1391）		0.1864* （0.1053）		0.1207 (0.1490)	
TR		0.1278** (0.0493)		0.1228*** (0.0443)		0.0069* (0.0043)		0.1331*** (0.0429)
INV	0.0065** (0.0026)	0.0061** (0.0024)	0.0057** (0.0025)	0.0066*** (0.0025)	0.0054** （0.0022）	0.0052** (0.0022)	0.0058** (0.0024)	0.0056** (0.0023)
EP	0.0236** (0.0101)	0.0238** (0.0104)	0.0316*** (0.0055)	0.0285*** (0.0052)	0.0074 （0.0102）	0.0123 (0.0104)	0.0353*** (0.0059)	0.0356*** (0.0057)
HC	0.0007 (0.0021)	0.0006 (0.0023)	0.0002 (0.0014)	0.0006 (0.0014)	0.0029 （0.0019）	0.0033* (0.0019)	0.0008 (0.0013)	0.0017 (0.0013)
IND	-0.0186* (0.0014)	-0.0256** (0.0014)	-0.0103 (0.0085)	-0.0088 (0.0091)	-0.0471*** (0.0086)	- 0.0524***(0 .0082)	0.0030 (0.0085)	0.0043 (0.0084)
TRD	0.0027** (0.0011)	0.0022** (0.0011)	-0.0006 (0.0009)	-0.0004 (0.0008)	0.0018** (0.0008)	0.0019** (0.0009)	- 0.0046***(0 .0009)	- 0.0042***(0 .0009)
ρ / λ	0.6938*** (0.0585)	0.7162*** (0.0486)	0.8087*** (0.0561)	0.8163*** (0.0543)	0.8167*** (0.0495)	0.8297*** (0.0463)	0.8478*** (0.0419)	0.8535*** (0.0405)
σ^2	0.0118*** (0.0026)	0.0125*** (0.0032)	0.0122*** (0.0011)	0.0118*** (0.0011)	0.0098*** (0.0012)	0.0099** (0.0013)	0.0105*** (0.0009)	0.0101*** (0.0009)
log-likelihood	101.704	96.938	180.526	184.008	109.891	108.328	197.146	201.524
Number of obs	135	135	243	243	135	135	243	243

Empirical Analysis

Conclusion:

(1)Cooperation research and technology can promote economic growth of BRI countries , but at present, the effect of technology transfer is more significant in statistics.

(2) Cooperation research and technology transfer can be mutually reinforce in innovation and growth of countries along the route.

(3) Cooperation research and technology transfer play an increasingly important role in promoting economic growth , especially for these countries with relatively low technological level and small knowledge stocks.

Thanks !