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FISCAL STRUCTURE, HUMAN CAPITAL AND INNOVATION IN CHINA: PATTERN AND REGIONAL HETEROGENEITY

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Abstract

This paper investigates the primary factors that determine the regional innovation of China, a key engine related to the economy growth. We try to understand whether and to what extent fiscal structure and human capital stock helps to stimulate the innovation behavior. By employ provincial panel data from 2007 to 2016, we find that government expenditure structure is essentially important to boost local innovation behavior, more specifically, we find that government expenditure on technology and education is significantly associated with innovation, every unit increase in the government expenditure on technology and research is associated with 0.41 unit increase in innovation. We also find that human capital plays an important role in determining local innovation, these results are robust after considering other factors such as economy growth, industry structure etc. We then explore regional heterogeneity of this relationship, we divide our sample into western, middle and eastern region according to geographic location, the regression results show that that the relationship between fiscal structure (human capital) and innovation is different across regions, more specifically, government expenditure on technology is more promising and significant in eastern areas, less significant in other two areas, which means public finance is more efficient in eastern areas to support innovation behavior. Our research has provided solid empirical evidence that helps us to understand local government's role to promote regional innovation, in areas that are less developed, a proactive fiscal policy maybe very efficient to promote innovation, while in well developed areas, fiscal policies are less efficient than human-capital-boosting policies in promoting regional innovation.

Keywords: Regional Innovation, Fiscal Structure, Technology Expenditure, Educational Expenditure, Human Capital

JEL Classification: I22, I30, J40

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1. Introduction

This project tackles an extremely important issue confronting citizens of all the advanced societies: How local communities can, with fewer economic resources at their disposal, prosper in the ever changing and increasingly open global economy. How can these communities better their economic prospects for the foreseeable future? For over a decade, a roiling debate about the effects of globalization have cut across the industrialized world. This debate has focused on the role of national governments as champions for promoting the advantages of globalization or, more frequently, ameliorating its negative impacts. National governments have found themselves on the receiving end as anxious constituents seek protection against what is seen as the plundering of global corporations, global capital flows, and the integration into the global economy of massive pools of low-wage labor in the developing world.

In retrospect, the predictions of some early punditry of globalization that national governments would become essentially irrelevant, powerless to set or enforce the rules and at the mercy of rootless corporations moving productive assets across territorial borders at will, have turned out to be exaggerated. It is actually too soon to write off the national governments as players in the global economy. Despite some encroachments on governmental authority, national borders still do matter in economic affairs. But from the perspective of local communities the sense of vulnerability to the forces of globalization is acute, and most likely guaranteed. From the local perspective, the guidelines of approach are mostly set elsewhere. Local communities have fewer resources available to cope with the impacts of globalization. Indeed, local leadership has itself often been eroded as the fundamental pillars of the local economy – banks, manufacturing sector, law firms, accountancy, retailing, and others – have been merged or displaced by large national or multinational organizations with no particular interest in or commitment to the society.

For many local communities, the notion of a 'borderless world' is uncomfortably inches closer to the truth; certainly these communities have little or no ability to cushion themselves from the adverse effects of global economic forces, but local communities are neither without recourse. Much of the hard work needed to keep pace with the obstacles of globalization – setting up infrastructure, elevating educational performance, strengthening co-operation between public and private institutions – is often better undertaken at the local level than through centralized directive.
In this project we focus on one such response: strengthening local capabilities for innovation. By 'capabilities for innovation', we mean the ability to conceive, develop, and/or deliver new products and services, employ new production processes, and improve on those already in existence. The ability firms making the local economy adapt to new market and technological advancements through innovation is the key to sustainable growth and prosperity at the local level. The involvements of innovation are essential for productivity growth, sustenance and improvement of wage rates, and are themselves associated with appealing, better remunerating jobs. The network between innovation, sustainable growth and prosperity are increasingly well recognized across the world. To date, most policy initiatives geared towards improving innovation

performance have been assumed by the national governments. But there is increasing attention towards this issue at the regional and local levels too.

Local community leaders throughout the industrialized world would surely nod with the view recently expressed by one official about the U.S.A economy in general: "America must never compete in the battle to pay their workers least, and it will take sustained innovation to ensure that we don't have to. Local innovative capabilities are themselves subject to the pressures of globalization, however. Even regions with high concentrations of innovative activities these days cannot assume that they will be able to sustain them indefinitely. The whole scope of possibilities is bracketed by two limiting possibilities.

At one end of the tunnel, local companies, having recognized the importance of their own innovative processes of tapping into the global network of knowledge and ideas, reach progressively farther afield to do so, and eventually relocate these activities and perhaps ultimately all of their operations out of the region regardless. At the other end of the tunnel, local companies seek to establish their innovation performance by bonding their ties with other local firms, local public research and education institutions. In this scenario the local economy emerges as an epitome of new knowledge creation and application, attracting firms from around and beyond, and stimulating the establishment of new local businesses. The primary goal of the Local Innovation Systems project is to study the range of possible outcomes delimited by these two scenarios. We strive to study the consequences of the different outcomes for local economic development, and to gain insight into the actions.

2. Data

Mostly, under such circumstances it's vitally important to find any key factors that could ensure the improvement of local innovative capabilities. We found that local innovative capabilities were in accordance to the region's annual patent statistics. Hence, we used patent-relevant statistics as parameters for innovative capabilities. To guarantee numerical stability, we chose four categories of patent data as dependent variables to cater for innovative capabilities, namely the application and authorization numbers of all types of patents, and those of invention patents. The reason as to why we took into consideration both the numbers of patent applications and authorizations was to find out whether all contributory factors could lead to increase in the number of patent authorizations, or just in the number of patent applications.

Our information came from the National Bureau of Statistics' records of 31 provinces in China from 1997 to 2016 where in terms of explanatory variables, we considered the state's financial expenditures in education, science and technology, the recruitment and enrollment of lecturers of higher learning institutions. Funds allocated for education, science and technology are mostly directed to talent development and the R&D, which directly affect patent statistics. Moreover, enrollment and recruitment of institutions of higher education are in relation to the number of people entering the R&D field, which also have an impact on patent statistics. Therefore, we settled on these four sets of data as main explanatory variables. For control variables, we chose the GDP per capita, the section of population above 6 years old and with a college degree, and the shares of the

first and third industries in the GDP to investigate the effects of indirect variables on dependent variables. Statistics of all independent variables were also drawn from the National Bureau of Statistics' record of 31 provinces from 1997 to 2016 (the time span of some statistics is from 2007 to 2016, but this won't have effect on the reliability of the result.)

We log transformed (ln) all the statistics (dependent variables, explanatory variables and control variables) to rule out the interferences emanating from extreme numbers and different orders of magnitude. In addition, to guarantee numerical stability, we calculated the proportion of the population above 6 years old and with a college degree in total population, and the proportions of education and technology expenditures in total local financial expenditures.

3. Econometric Model

The article applies the Ordinary Least Squares (OLS) to produce the following Linear Regression Model (LRM):

$$\log(Y_{it}) = \beta_0 + \beta_1 * \log(hr_{it}) + \beta_2 \log(scicost_{it}) + \beta_3 \log(educost_{it}) + \beta_4 \log(gdpper_{it}) + \beta_5 \log(college_{it}) + \beta_6 \log(firstratio_{it}) + \varepsilon_{it} \quad (1)$$

"i" stands for the region, "t", year, "hr", enrollment of institutions of higher education, key explanatory variables "$educost_{it}$" and "$scicost_{it}$" stand for education expenditure, and science and technology expenditure respectively.

4. Empirical analysis

To analyze the local innovative capabilities in a comprehensive and objective manner, the article uses four types of statistics, namely; 1. The number of invention patent authorizations. 2. All the results of the regression analysis. 3. Comparative statistics. 4. The factors with the greatest influence to innovative capabilities.

Table 1

	(1) lpatent	(2) lpatent	(3) lpatent	(4) lpatent	(5) lpatent	(6) lpatent	(7) lpatent	(8) lauthorpat	(9) linventpat	(10) lauthinvent
lhr	0.0759	0.7742***	1.0406***	0.6827***	0.7144***	0.5474***	0.5069**	0.0074	0.9227***	0.2547
	(0.0932)	(0.1866)	(0.1876)	(0.1910)	(0.1958)	(0.2044)	(0.2080)	(0.2022)	(0.2359)	(0.2041)
lscicost		0.4696***		0.4553***	0.4577***	0.4126***	0.4143***	0.4300***	0.4429***	0.2831***
		(0.0773)		(0.0793)	(0.0802)	(0.0824)	(0.0827)	(0.0804)	(0.0937)	(0.0811)
leducost		0.1715		0.2631	0.2560	0.1432	0.1818	0.3009	-0.4069*	-0.2985
		(0.1695)		(0.1759)	(0.1782)	(0.1873)	(0.1902)	(0.1849)	(0.2157)	(0.1867)

eduratio			-0.6518 (1.3728)							
sciratio			18.0130*** (3.8874)							
lcollege				0.2185** (0.0932)		0.2105** (0.0929)	0.2217** (0.0933)	0.0587 (0.0907)	0.2571** (0.1058)	0.0167 (0.0916)
collegeratio					-12.9138 (46.3004)					
lgdpper						0.4276*	0.5412*	0.5101*	0.8950***	0.2101
						(0.2371)	(0.2859)	(0.2779)	(0.3241)	(0.2805)
firstratio							2.0804	2.4307	-0.5258	-5.8411***
							(1.5384)	(1.4955)	(1.7444)	(1.5096)
thirdratio							-0.0547	0.6434	0.0263	0.3792
							(0.7639)	(0.7426)	(0.8662)	(0.7496)
Constant	7.2390***	4.5975***	5.8937***	2.7733**	4.3495***	-0.2957	-1.8332	-0.6256	-4.7459	4.4203
	(0.0977)	(0.8450)	(0.5509)	(1.0888)	(0.8918)	(2.0173)	(2.8564)	(2.7767)	(3.2388)	(2.8029)
Observations	620	310	310	279	279	279	279	279	279	279

R^2	0.922	0.906	0.897	0.913	0.911	0.914	0.915	0.917	0.921	0.941

Ulttotpat Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ ulttotpat

We started first by finding out the relation between the number of invention patent authorizations and enrollment of institutions of higher education.The following table shows that from the simplest form of the model (1), we add in the control variables step by step for each time of the regression analysis. The first line simply demonstrates the relation between education levels and the number of invention patent authorizations. Line 2 and 3 add in the government's investments in relevant fields. Based on line 3, Line 4 adds in another variable, the education level. Line 5 further adds in the GDP statistics. Line 6 and 7 add in variables of industrial structures. Based on the former analysis, the last line adopts Random Effect Model at the same time to test the sensibility of the results.

The results show that, the coefficient of government's financial expenditure is positive at around 0.334 and is significant at the 1% level. When control variables are added, the coefficient reduces to around 0.286, and is significant at the 5% at least. In general, the coefficient of government's financial expenditure varies when new control variables are added, which is significant at the 5% level at least. Therefore, the results prove our hypothesis that the increase in the government's financial expenditure will facilitate the improvement of local innovative capabilities.

In terms of control variables, the coefficient of the GDP per capita is positive, which indicates that the higher the level of production, the closer the relations between regions, the fewer the barriers in innovative exchanges, and the higher the level of innovation. It's worth noting that the coefficient of the share of the first industry in the GDP is negative and it is significant at the 10% level, which follows from the decline of the first industry. That is the adjustment of the first industry which leads to an optimal distribution of resources and further contributes to the improvement of innovative capabilities.

We arranged all the statistics according to year and region, and then made a regression analysis.

The regression analysis was made up of three parts (3 tables).

4.1.Part one

We made regression analysis on dependent variables, that is, the number of patent applications, and all the 9 independent variables for 9 times with every independent variable added one at a time from one independent variables at first time to the 9 independent variables calculated at the same time as the last round of the regression analysis. Through this process, we could clearly see the variation trend of each explanatory variables. Besides this, we added the results of regression analysis of the other 3 dependent variables and all the 9 dependent variables.

4.2.Part two

We subdivided the statistics into 3 sets according to region, namely; region 2 Eastern China, region 3 Central China, and region 4 Western China. Through the regression analysis of the 4 dependent variables and all the independent variables of the 3 regions, we produced 3 tables with each having 4 sets of data. Eastern China includes Beijing, Tianjin, Hefei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning, Jilin and Heilongjiang. Central China includes Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. Western China includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Huizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

4.3.Part three (Numerical stability improvement).

We calculated the proportions of the 4 dependent variables in the country's GDP and population, and made regression analysis of the 4 ratios and all the variables to produce 2 tables of stability data.
We established that local innovative capabilities of the 3 regions of China are influenced by different factors. China is a nation with a vast territory and heavy population, therefore the results may vary with different regions. The article will thereby analyze such differences.

4.4.Findings.

We started by finding out the relation between the number of invention patent authorizations and enrollment of institutions of higher education.

The table below shows that starting from the simplest form of the model (1), we add in the control variables bit by bit for each time of the regression analysis. The first line simply shows the relation between education level and number of invention patent authorizations. Line 2 and 3 add in the government's investments in relevant fields. Based on line 3, line 4 adds in another variable, the GDP statistics. Line 5 and 6 further add in another variable, industrial structure. Based on the former analysis, the last line adopts random effect model at the same time to prove the credibility of the results.

The result indicates that the main factors affecting local innovative capabilities in Eastern China are education expenditure, the share of the first industry in the GDP, and population above 6 years old with a college degree, with coefficients of each one being 0.6, 5 and 0.3 respectively. The main factors that affect local innovative capabilities in Central China are science and technology expenditure, and the enrollment of institutions of higher education, with coefficients of each one being 0.5 and 0.4 respectively. The main factors affecting local innovative capabilities in Western China are the share of the first industry in the GDP, education expenditure and the enrollment of institution of higher education, with coefficients of each one being 3, 0.8 and 0.6 respectively. In general, the factors that affect local innovative capabilities across the country are mainly the government's science and technology, and education expenditures.

Table 2: Eastern China region1

	(1) lpatent	(2) lauthorpat	(3) linventpat	(4) lauthinvent
lhr	-0.3729	-0.4993	-0.5456	0.2462
	(0.3295)	(0.3739)	(0.3368)	(0.1748)
lscicost	0.1763	0.2246	0.2447*	0.4299***
	(0.1259)	(0.1429)	(0.1287)	(0.0969)
leducost	0.7249***	0.7615***	0.4620*	0.6246***
	(0.2530)	(0.2871)	(0.2586)	(0.1616)
lgdpper	0.4252	0.2275	0.8835***	0.3107
	(0.2827)	(0.3208)	(0.2889)	(0.1922)
firstratio	5.9158***	3.1160	5.3481***	-1.8704
	(1.9805)	(2.2475)	(2.0242)	(1.1361)
thirdratio	-1.3707	-0.5812	0.7328	2.5856***
	(0.8531)	(0.9681)	(0.8720)	(0.4325)
lcollege	0.3297**	0.2752	0.4010**	0.0634**
	(0.1503)	(0.1706)	(0.1536)	(0.0286)
Constant	0.2595	1.4966	-5.9098*	-3.2747*
	(3.3163)	(3.7634)	(3.3895)	(1.8847)
Observations	117	117	117	117
R^2	0.992	0.990	0.991	0.964

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
region1

Table 3: Central China region2

	(1) lpatent	(2) lauthorpat	(3) linventpat	(4) lauthinvent
lhr	2.3520***	2.1220***	0.6129	0.6800**
	(0.6586)	(0.6003)	(0.7397)	(0.3230)
lscicost	0.5366***	0.4393***	0.4968***	0.7532***
	(0.1583)	(0.1443)	(0.1778)	(0.1295)
leducost	0.7273	0.3861	-0.9876	-0.0054
	(0.6363)	(0.5800)	(0.7147)	(0.2602)
lgdpper	-3.0058*	-1.2660	0.1294	0.6571*
	(1.5979)	(1.4563)	(1.7946)	(0.3872)
firstratio	-17.4043***	-13.2496***	-6.2412	1.6392
	(6.1471)	(5.6027)	(6.9039)	(2.8381)
thirdratio	-6.3912*	-2.5939	-4.1843	3.9073***
	(3.2670)	(2.9776)	(3.6692)	(1.1698)
lcollege	0.4592*	0.4435*	1.1165***	0.0443
	(0.2482)	(0.2262)	(0.2787)	(0.0523)
Constant	26.1477	9.5010	1.6204	-6.4702**
	(17.4241)	(15.8809)	(19.5691)	(2.8258)
Observations	54	54	54	54
R^2	0.976	0.980	0.975	0.910

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
region2

Table 4: Western China region3

	(1) lpatent	(2) lauthorpat	(3) linventpat	(4) lauthinvent
lhr	0.6378	-0.1706	1.9381***	0.4046***
	(0.3998)	(0.3573)	(0.4513)	(0.1081)
lscicost	0.1887	0.0396	0.5034*	0.8879***
	(0.2250)	(0.2011)	(0.2540)	(0.1975)
leducost	0.1560	0.0754	-0.3134	0.6299***
	(0.3332)	(0.2978)	(0.3761)	(0.1669)
lgdpper	0.5135	1.5504**	-0.2821	-0.6527***
	(0.6776)	(0.6056)	(0.7649)	(0.1885)
firstratio	2.9373	6.1584**	-8.4818**	-14.6734***
	(3.0335)	(2.7111)	(3.4243)	(1.8940)
thirdratio	2.3173	3.0971**	-0.2024	0.2665
	(1.4405)	(1.2873)	(1.6260)	(0.8229)
lcollege	0.2384	0.1130	-0.1171	0.0434
	(0.1535)	(0.1372)	(0.1733)	(0.0399)
Constant	-3.4308	-11.6878*	6.8540	7.1681***
	(6.7255)	(6.0105)	(7.5918)	(1.9604)
Observations	108	108	108	108
R^2	0.982	0.984	0.979	0.948

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
region3

5. Conclusion and recommendations

As a result of China including the improvement of local innovative capabilities into the state's development strategy, local governments all rush to formulate strategies on how to improve their innovative capabilities. This article is designed to highlight some practical recommendations based on the conclusions drawn from the regression analysis of China's provinces in the last 20 years. For Eastern China, the government should

expand education expenditure to attract top notch talent, and adjust industrial structures to emphasize more relevance on developing innovation-driven industries. For Central China, the government should allocate more funds on science and technology to draw more innovative enterprises and advanced technologies, and set a strong foundation as well as create a friendly environment for regional innovation. For Western China, the government should make the adjustment of industrial structures its priority, and in the meantime put more money in education.

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