Spatial effect of knowledge spillover on regional economic development: an empirical study from China

Houxing Tang*

School of Business Administration, Nanchang Institute of Technology, Tianxiang Road 289, Nanchang, China

Received 22 May 2014, www.tsi.lv

Abstract

In order to measure the spatial effect of knowledge spillover on regional economic development, a spatial Durbin model, which contains the dependent variable GDP and independent variables Capital, Labour &Knowledge stock, was constructed based on C-D production function. And then an empirical study with 31 provinces of mainland China from year 2000 to 2011 was conducted. The results show that, firstly, the Capital, Labour and Knowledge-stock all have significant positive correlation with GDP. In other words, these three factors have an important impact on the local regional economic development, but the effect of Capital is the greatest and the Labour & Knowledge-stock follow suit. Secondly, the Capital and Labour have a negative spillover effect, but the Knowledge-stock has much more positive effect. Consequently, the governments of developing regions should make full use of the spatial effect of knowledge spillover from developed regions to promote the economic restructuring and great-leap-forward development, especially when they are lack of sufficient funds to support local R&D activities.

Keywords: spatial effect, knowledge spillover, knowledge sharing, regional economic development, spatial durbin model

1 Introduction

The knowledge spillover is a kind of externality originating from imperfect appropriation of R&D performances. This implies that the knowledge created by anybody could be transmitted to other related people in different ways, such as reverse engineering, patents, reading scientific papers, informal communications and so on. Because of the knowledge spillover, it not only promotes the growth of a region, but also the development of other contiguous regions. Many researchers such as Jaffe (1989), Anselin (1999) had pointed out that the R&D activities had a spillover effect [1, 2]. With the help of spatial econometrics and panel data, Seyit &Ronald (2002) conducted an empirical study with 57 regions of France, Italy and Spain in order to analyse the effect of knowledge spillover on the regional economic growth in Europe. The results showed that R&D intensity and R&D spillover have significant positive effects on regional economic growth [3]. And then, the flows of knowledge among regions can increase the production efficiency and promote the economic development. Especially, with the development of new economic geography, the spatial externality is becoming the core element and the hot topic. Therefore, many researchers have put focus on the interplay of different regions. Similarly, in Regional Economics more and more attentions are put on the effect of economic spillover of the local region on neighbouring regions.

Surely, the researchers not only hope to prove the existence of this knowledge spillover effect, but also want to measure the spatial effect and explore its characteristics. For examples, based on Griliches–Jaffe knowledge production function, Greunz (2003) proposed an improved model to investigate inter-regional knowledge spillover across European sub-national regions. The result showed that if knowledge spillover occurred within a given country, the national border turned out to seriously hamper interregional spillover on the European scale [4]. Also, an empirical study from Scherngell et al. (2007) indicated that the knowledge spillover would be local concentration when analysing the effect of knowledge spillover in Europe on the total factor productivity and the degree of knowledge spillover between industries [5]. Andrea &Chiara (2011) thought that the statistical evidence suggested that the relevance of knowledge spillover had increased over time. A region's absorptive capacity, measured by local R&D expenditure and social capital, implied a reduction of outward knowledge spillover [6]. Bernard &Lesage (2011) examined the spatial spillovers associated with public and private research expenditures in own- and other-industry sectors of 94 French regions. The empirical results showed that the largest direct and indirect effects are associated with private R&D activity which spilled across industry boundaries [7].

In China, an empirical study of the spatial pattern of China's R&D spillover at provincial level was conducted by Su (2006). The results showed that the spatial dependencies of provincial R&D knowledge production

* ***Corresponding author*** e-mail:tanghouxing@aliyun.com

existed, and R&D spillover were also locally bounded. Under the given conditions, spatial lag model showed that an average increase of 0.22 percent in a regional patent production was caused by one percent increase in neighbouring regional patent production. Moreover, a decay process of provincial innovation was found to be existed by considering the research effort made by neighbouring regions [8]. Based on an empirical study of BRICs from year 1980 to 2008, Li &Han (2010) had proved the weak tacit knowledge spillover was positive correlation with an output of region [9]. There were knowledge spillover among the provinces and the knowledge stock had a positive effect on regional economical growth. Especially, Xu et al. (2010) pointed that the efficiency of growth was affected by regional capital and labour and absorbing capacity [10]. Zhou &Lan (2012) thought that the knowledge spillover effect weakened the profit of originated region from new knowledge, but it was good to reduce the gap among regions and promote the coordinated development of regional economy [11]. Addition to, in common theory, the effect of knowledge spillover will gradually decrease with the increasing of distance. However, Liu &Tang (2010) proved that the effect of knowledge spillover did not always descent strictly with the increasing order of contiguity matrix, and there maybe existed an optimal distance for spillover [12].

Based on these literatures review, we find that on one side, the spatial econometric model provides a useful way to measure and evaluate the effect of knowledge spillover on agglomeration, innovation and regional economic growth. However, Lesage &Pace (2009) had pointed that the ordinary regressive method would get inaccurate coefficients and we need to change a new method [13]. On the other side, there are lack of empirical studies on the effect and characteristics of knowledge spillover on the regional economic development. In other words, we not only hope to prove the existence of spatial effect of knowledge spillover, but also explore the nature of such effect. Therefore, we can deeply understand the regular pattern of knowledge sharing among regions. This will help us to make effective regional policies to promote the regional development soundly and rapidly.

Therefore, based on [14] and [12], in the section II, a spatial Durbin model is transformed from a production function whose dependent variable is GDP and independent variables are Labour, Capital and Knowledge-stock, In the section III, the data are collected and reprocessed firstly, and then, the Moran Index is calculated to roughly test the existence of spatial correlation. We use the toolbox of Matlab R2010b to calculate the model and give a detailed analysis. In the section IV, a stability analysis is conducted in order to test whether the change of parameter affect the results. In section V, the conclusions and police recommendations are given.

2 Constructing the spatial Durbin model

2.1 ANALYSIS AND SELECTION OF VARIBLES

Now, the GDP is a very important index to evaluate the regional economic development. Therefore, we use the GDP (G) as depended variable. From the perspective of knowledge production function, we select *the total investment in fixed assets in the whole country* as the capital input variable (K), and select the *number of employed persons* as the labour input variable (L). How to measure the knowledge stock (S)? In most literatures, the patent is a good choice. But it has many defects. Kesidou (2004) showed that the patent was often treated as a proxy of innovation, but it only contains a formal output and neglects other complex activities useful for knowledge accumulation [15]. In other words, the patent only stands for the measurable knowledge. So, we also divide the knowledge variable *S* into *S1* and *S2*, which stand for the measurable knowledge and un-measurable knowledge respectively. Surely, the patent is a proxy of the *S1*.

As the other goods, the value of knowledge is also depreciation. Therefore, we will measure the present value of knowledge stock through *perpetual inventory method*. The formula is as follows

$$S1_t = N_t + S1_{t-1}(1-d)\,, \qquad (1)$$

where t stands for time (year), S_t stands for the knowledge stock at t, N_t stands for the knowledge added-value at t, and d stands for depreciation rate. In other literatures, the d is set to 12% [14] and set to 15% [16]. Considering the data is from China, we also set the d to 15%. Surely, it may be quite arbitrary. Therefore, a stability analysis will be provided in section IV.

In Equation (1), we need to get the initiative knowledge stock $S1_0$, which is calculated as follow

$$S1_0 = N_0(1+g)/(g+d)\,, \qquad (2)$$

where $S1_0$ stands for the knowledge stock of base year, N_0 stands for number of patent application and authorized of base year, and g stands for average growth rate per year of patent application and authorized.

2.2 MODELLING

According to the selected variables, we suppose that they meet the function as follow

$$G = f(K, L, S1, S2)\,, \qquad (3)$$

where G stands for GDP; K stands for capital input that is the total investment in fixed assets in the whole country; L stands for labour input that is the number of employed persons; S1 stands for measurable knowledge that is number of patent application accept and granted; S2 stands for un-measurable knowledge. According to the C—D production function, we get

$$G = AK^{\alpha} L^{\beta} S1^{\gamma} S2^{\lambda}, \tag{4}$$

where $\alpha, \beta, \gamma, \lambda$ need to be estimated; and A is constant and using logarithm in the formula (4), we get $LnG = \alpha LnK + \beta LnL + \gamma LnS1 + \lambda LnS2 + LnA$, then let

$$G' = \alpha K' + \beta L' + \gamma S_1' + \lambda S_2' + c. \tag{5}$$

Many literatures have confirmed that the measurable knowledge and un-measurable knowledge both had spatial dependence [17, 14, 13].

Therefore, there is a simple hypothesis as follows:

$$S_1' = \varphi_1 W S_1' + u_1 \qquad u_1 \sim N(0, \sigma_{u_1}^2 I_n), \tag{6}$$

$$S_2' = \varphi_2 W S_2' + u_2 \qquad u_2 \sim N(0, \sigma_{u_2}^2 I_n), \tag{7}$$

where W stands for spatial contiguity matrix; φ_1, φ_2 stands for the spatial dependence of measurable knowledge stock and un-measurable knowledge stock respectively, which reflect the spatial dependence of sample data and measure the average effect of neighbouring regions on local region; u_1, u_2 are stochastic error respectively.

Obviously, the measurable knowledge and un-measurable knowledge is different but there is a correlation between them. This relationship can be reflected from stochastic error, so we suppose that the u_1, u_2 meet a simple linear equation as follows:

$$u_1 = \omega u_2 + \varepsilon \qquad \varepsilon \sim N(0, \sigma_{\varepsilon}^2 I_n). \tag{8}$$

According to the Equations (5–8), we get

$$\begin{aligned} G' &= \theta_1 W G' + \theta_2 K' + \theta_3 L' + \theta_4 S_1' + \theta_5 I + \\ &\tilde{\theta}_2 W K' + \tilde{\theta}_3 W L' + \tilde{\theta}_4 W S_1' + \tilde{\theta}_5 W I + \tilde{\varepsilon} \end{aligned}, \tag{9}$$

where $\theta_1 = \varphi_2$, $\theta_2 = \alpha, \tilde{\theta}_2 = -\alpha\varphi_2$, $\theta_3 = \beta, \tilde{\theta}_3 = -\beta\varphi_2$, $\theta_4 = r + \lambda\omega^{-1}$, $\tilde{\theta}_4 = -(\gamma\varphi_2 + \lambda\omega^{-1}\varphi_1)$, $\theta_5 = c, \tilde{\theta}_5 = -\varphi_2 c$, $\tilde{\varepsilon} = -\omega^{-1}\lambda\varepsilon$.

Now, we have found that the Equation (9) is just a spatial Durbin model.

3 Empirical results and analysis

3.1 DATA COLLECTION AND PRE-PROCESS

In this paper, the panel data set contains 31 provinces in mainland of China with 4 variables over the period from 2000 to 2011. In the State Intellectual Property Office of the People's Republic of China, the statistical reports start from 1985, but the data in most regions are zero. Addition to, Hainan province was founded in 1988 and had data from 1989. Chongqing became a municipality directly under the Central Government in 1997, but it has independent statistic since 1985. Generally speaking, there are complete and effective statistical data from 1989. Therefore, we set 1989 as the base year to calculate the knowledge stock. Especially, when we calculate the average growth rate per year of the patent (i.e. variable *g*), the base year of Xizang is 1990, because the corresponding data is zero in 1989.

In addition to, considering the availability of data, the GDP is collected from "Gross Regional Product and Indices" in statistical yearbook from 2001 to 2012. The Labour is collected from "Number of Engaged Persons in Private Enterprises and Self-employed Individuals" from 2001 to 2012. The Capital is collected from "Total Investment in Fixed Assets in the Whole Country by Status of Registration and Region" from 2001 to 2012. The patents are collected from "Patents Application Accepted and Granted by Region" from 1985 to 2011. (Data source: Statistics Annual Report 1985-2011 from State Intellectual Property Office of the People's Republic of China, China Statistical Yearbook 2001-2012 from National Bureau of Statistics of China).

3.2 CALCULATING AND ANALYZING THE SPATIAL DURBIN MODEL

Spatial regression models exploit the complicated dependence structure between observation units, which represent countries, regions and so on. Because of this, the parameter estimates contain a wealth of information on relationships among the regions [12]. A change on any given explanatory variable of a region will impact the region itself (e.g. a direct impact) and potentially impact all other regions indirectly (e.g. an indirect impact). That is to say, the indirect impact is just the spillover effect. It implies that the ordinary regression method is not accurate. And then we need other ways to estimate the actual spillover effect rather than use the ordinary regression coefficient $\tilde{\theta}_4$ of Equation (9). The new way is called *partial derivative summation method* in this paper.

With the help of spatial econometric toolbox and Matlab R2010b, we get the results as follows in Table 1 and Table 2.

Firstly, from the Table 1, we find that the value of t-tests of all variables surpass 2. This indicates that all the variables have significant linear correlation with GDP.

An interesting result is that the Capital and Labour have positive correlation with GDP but the W-Capital and W-Labour have negative correlation with GDP. However, the Knowledge-stock and W-Knowledge-stock have both positive correlations with GDP. As we all know, the W stands for the spatial effect. Therefore, this result shows that the capital and labour of a region make negative spillovers effect for neighbouring regions.

Secondly, because the regression coefficients are not to reflect the actual spillover effect, we will evaluate the spatial effect by Table 2. The first, in direct effect, the values of Capital and Labour reach to 0.745436 and 0.252985 respectively, and exceed greatly the value of Knowledge-stock, which equal to 0.076793. This implies that the capital (e.g. fixed asset investment) and labour rather than technology innovation are still the main driving force of regional economic development. In Table 3, the contribution share of gross capital formation to the increase of the GDP is given from year 1978 to 2011, which approves the above conclusion.

The second, in the indirect effect, there is also an interesting result. The spatial spillover effect of Capital and Labour are negative while the effect of Knowledge-stock is positive. How to understand this phenomenon? We think that the capital is treated as a kind of homogeneous and excludable resource. Once it is invested into a region, it can not be used in other regions. And similarly, the labour is a kind of heterogeneous and excludable resource. Because of its quick flowing in present China, the growth of labour (especially the advanced workers) in a region will inevitably reduce the supply of labour in other regions in a fixed period. Consequently, this indicates that it will lower the GDP in local region because of the increasing of capital and labour in neighbouring regions. Otherwise, the knowledge is a kind of non-rivalry and partially excludable resource. And it is reused by others. This implies that the growth of knowledge stock in one region will indirectly increase the growth of knowledge stock in neighbouring regions. Consequently, this will increase the GDP in neighbouring regions. Therefore, it is acceptable that the spillover effect of Capital &Labour is negative and that of Knowledge-stock is positive. Moreover, the significant consequence of the characteristic is that how to make full use of the spatial spillover effect of knowledge.

The third, for the total effect, we find that the effect of Knowledge-stock exceed the effect of Labour. This implies that the knowledge-stock (i.e. innovative knowledge or high-tech) rather than more pure labour is playing a stronger role in regional economic development. The knowledge intensive industry will gradually substitute the labour intensive industry with the increasing input on education.

Thirdly, all these analysis indicate that knowledge spillover will play a more and more important role in regional economic development. One side, each region should put much more attention on the knowledge production. For example, increasing the science and technology innovation input. One the other side, many regions maybe are lack of necessary capital or labour, so they can efficiently utilize the knowledge spillover effect from other regions in order to promote own region powerful. For instance, they can engage in extensive technological exchanges and cooperation with other regions.

TABLE 1 Model estimation based on linear regression

Variable	**Coefficient**	**Asymptot t-stat**	**z-probability**
Constant	0.500267	3.664145	0.000248
Capital	0.763673	28.422736	0.000000
Labour	0.258725	10.255035	0.000000
Knowledge-stock	0.060986	5.569024	0.000000
W-Capital	-0.467287	-10.256821	0.000000
W-Labour	-0.144594	-4.362333	0.000013
W-Knowledge-stock	0.159103	7.904632	0.000000
rho	0.328976	5.726039	0.000000

TABLE 2 The estimation of spatial effect based on partial derivative summation

Direct	Coefficient	t-stat	t-prob	Lower 01	Upper 99
Capital	0.745436	29.528766	0.000000	0.674685	0.807168
Labour	0.252985	10.742312	0.000000	0.192955	0.314691
Knowledge-Stock	0.076793	7.342959	0.000000	0.047858	0.105268
Indirect	Coefficient	t-stat	t-prob	Lower 01	Upper 99
Capital	-0.304283	-8.638289	0.000000	-0.400282	-0.216711
Labour	-0.083380	-2.420611	0.015973	-0.169920	-0.000575
Knowledge-Stock	0.251915	9.882188	0.000000	0.180004	0.325630
Total	Coefficient	t-stat	t-prob	Lower 01	Upper 99
Capital	0.441153	12.948609	0.000000	0.352705	0.530985
Labour	0.169605	6.991557	0.000000	0.106852	0.227901
Knowledge-stock	0.328708	11.209642	0.000000	0.255210	0.404317

TABLE 3 Contribution share of Gross Capital Formation to the increase of the GDP

Year	**Contribution Share (%)**	**Year**	**Contribution Share (%)**
1978	66.0	2004	54.5
1980	26.4	2005	38.5
1985	80.9	2006	43.6
1990	1.8	2007	42.5
1995	55.0	2008	46.9
2000	22.4	2009	87.6
2001	49.9	2010	52.9
2002	48.5	2011	48.8
2003	63.2	--	--

Data source: China Statistical Yearbook 2012 from National Bureau of Statistics of China.

4 Stability of Model

In our model, the parameter *d* is set to 15%, which seems arbitrary. So, in this section, a stability analysis is taken for different *d*. We set d to 10%, 12%, 18% and 20% respectively to test whether the change of *d* will impact the stability of the model. The detailed results are as follows in Table 4 and Table 5. From Table 4, we find that the changes of *d* do not change the linear correlation between GDP and other independent variables. It only changes the regression coefficients a little. From the Table 5, we find that there is a little change on indirect effect of Labour including its value and direction. However, the absolute values of all t-test are far less than 2, which show that there is not a linear correlation between GDP and W-Labour. In Table 3, although it passes to the t-test, the indirect effect of Labour only reaches to -0.08, which is much lower compared with Capital and Knowledge-stock. All these indicate that the Labour only has much weak negative spillover effect on GDP, and the changes of the parameter *d* do not change this situation. So, the model in our paper is stability.

TABLE 4 Model estimation with the changes of parameter d

	d=10%		d=12%		d=18%		d=20%	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Constant	0.19269	1.36682	0.20914	1.48247	0.24148	1.70667	0.24584	1.73765
Capital	0.84978	33.84629	0.84799	33.60750	0.84406	33.09362	0.84337	33.01704
Labour	0.17954	7.05091	0.18067	7.05531	0.18462	7.11745	0.18631	7.16648
Knowledge-stock	0.03635	3.27409	0.03636	3.27657	0.03575	3.23700	0.03520	3.19848
W-Capital	-0.59899	-13.30724	-0.59093	-13.02385	-0.57818	-12.60055	-0.58011	-12.68296
W-Labour	-0.09875	-3.12122	-0.09533	-2.97931	-0.08982	-2.73716	-0.09085	-2.75603
W-Knowledge-stock	0.10631	5.06790	0.10601	5.06654	0.10324	4.98099	0.10141	4.91478
rho	0.51400	10.37155	0.50396	10.04316	0.49099	9.62029	0.49596	9.76483

TABLE 5 The spatial effect with changes of parameter d

	***d*=10%**		***d*=12%**	
Direct	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	0.824719	34.608679	0.823463	34.412799
Labor	0.177917	7.602651	0.179406	7.616899
Knowledge-Stock	0.056386	4.931707	0.055722	4.899498
Indirect	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	-0.309845	-6.675854	-0.306349	-6.700182
Labor	-0.012401	-0.325573	-0.008038	-0.211120
Knowledge-Stock	0.238665	5.943980	0.232735	5.944784
Total	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	0.514874	10.513328	0.517114	10.753491
Labor	0.165516	5.202213	0.171368	5.408059
Knowledge-stock	0.295051	6.457783	0.288456	6.472558

TABLE 5 The spatial effect with changes of parameter d (continued)

	***d*=18%**		***d*=20%**	
Direct	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	0.820461	33.584064	0.819707	33.477667
Labor	0.184482	7.656494	0.186647	7.715160
Knowledge-Stock	0.053744	4.644222	0.053164	4.598221
Indirect	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	-0.297518	-6.984009	-0.296769	-6.913834
Labor	0.002505	0.064312	0.003888	0.098670
Knowledge-Stock	0.220095	5.684304	0.218575	5.614861
Total	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capital	0.522944	11.549711	0.522938	11.439479
Labor	0.187347	5.691958	0.190534	5.681662
Knowledge-stock	0.273840	6.298379	0.271740	6.212776

5 Conclusions and recommendations

With the development of knowledge-based economy, the knowledge will substitute other production factors such as capital and land to become the main driving force of regional economic development. The spatial spillover of knowledge is becoming more and more widespread because different regions become more and more closed with each other. The knowledge and such spatial effect will play more and more important role in regional economic development. The question is that how to measure and evaluate the spatial spillover effect of knowledge and understand its characteristics.

In this paper, knowledge is divided into two parts: measurable knowledge and un-measurable knowledge. With the help of knowledge production function, a spatial Durbin model is formed. The empirical study containing 31provinces over the period from 2000 to 2011 in China shows that there is spatial dependence among regions. The knowledge spillovers go beyond the administrative boundary and have an impact on neighbouring regions. The interesting phenomenon is that capital and labour have a negative spatial effect, but knowledge has positive spatial effect. This result indicates that spatial knowledge spillover will play a more and more important role in regional economic development especially in developing regions. In other words, although the fixed asset investment is the main driving force of regional economic development, but these regions have insufficient money. Also, from the perspective of sustainable development, these regions cannot depend on labour-intensive industry for long term. The knowledge has become the strategic resource to achieve and keep competitive advantages, but the knowledge resources are mainly concentrated in developed regions rather than developing regions because of location, history, finance supporting and so on. Fortunately, the knowledge has the characteristic of public good. Therefore, a meaningful question is that how to make full use of the spatial spillover effect of knowledge.

In this paper, many policy recommendations are given as follows. Firstly, it is essential to increase expenditure on the knowledge production such as R&D and improve the contribution share of technology innovation to GDP. Since knowledge is the most important resource to achieve competitive advantages. Therefore, it is essential to guarantee a certain amount of knowledge stock. At present, the average ratio of R&D expenditure to GDP has reached to 1.84% in 2011 and ranked third in the world. However, according to statistical bulletin in 2011 of national science &technology funds, the R&D expenditure of eight provinces (e.g. Jiangsu, Guangdong, Beijing, Shandong, Zhejiang, Shanghai, Liaoning and Hubei) accounts for 66.5% of national expenditure. In other words, most other provinces are lack of sufficient input on knowledge production.

Secondly, it may be a good way to construct a virtual alliance of knowledge production and promote the development of collaborative innovation. The knowledge has the characteristics of stickiness and the locality. Obviously, it is a slow and difficult process for developing regions to achieve the knowledge through spillover. Therefore, it is an effective way to construct knowledge alliance and promote the collaborative innovation. It is useful to break the administrative boundary and promote spatial knowledge spillovers quickly. According to the reports, the ministry of education and ministry of finance have implemented collaborative innovation plan in 2012 in China.

Thirdly, it is essential to promote the flow of knowledge through an effective mechanism of talent flow in order to balance the knowledge gap between regions. In fact, innovative knowledge comes from innovative talent and the knowledge spillover is achieved mainly by the flow of talent. Unfortunately, the developed regions attract too many talents because of the *black hole effect*. Although the governments of developing regions provide the talents many preferential policies in order to get them stay in the locality, it still fails. Therefore, in the present situation, the most practical way is to make effective mechanism of talent flow. The developing regions can get innovative knowledge from such flow rather than being entangled in a local production of knowledge.

Fourthly, it is very important to improve the knowledge absorption capacity of developing regions. If the developing regions do not have such absorption capacity, then facing the knowledge spillover will only lead to frustration and little innovation will take place. We can take an example to explain it. Why do so many multi-national corporations invest the mainland China rather than other developing countries? Except the cost of labour, one of the critical factors is that the China has enough knowledge employees to meet the need of production. Undeniably, this brings China an opportunity for rapid development compared with other developing countries.

Acknowledgement

The author acknowledge the financial support by National Natural Science Foundation of China (grand: 71261019), the Youth Fund Project of College Humanities and Social Sciences of Ministry of Education (grand: 11YJC630193) and the Youth Fund Project of College Humanities and Social Sciences of Jiangxi Province (grand: GL1244).

References

[1] Jaffe AB 1989 Real effects of academic research *American Economic Review* **79(**5) 957–70

[2] Anselin L 1999 Spatial Econometrics *Working Paper School of Social Science University of Texas at Dallas* Richardson 26 April

[3] Seyit K, Ronald M 2002 Knowledge Spillovers and Regional Growth in Europe European Regional Science Association ERSA

available at http://www-sre.wu-wien.ac.at/ersa/ersaconfs/ersa02/cd-rom/papers/373.pdf (accessed 15 June 2009)

[4] Greunz L 2003 Geographically and Technologically Mediated Knowledge Spillovers between European Regions *Annals of Regional Science* **37(**4) 657-80

[5] Scherngell T, Manfred M F, Reismann M 2007 Total Factor Productivity Effects of Interregional Knowledge Spillovers in Manufacturing Industries across Europe *Romanian Journal of Regional Science* **1**(1) 1-16

[6] Andrea C, Chiara D B 2011 Determinants of spatial knowledge spillovers in Italian provinces, *Socioeconomic Planning Sciences* **45**(1) 28-37

[7] Corinne A B, Lesage J P 2011 Quantifying Knowledge Spillovers using Spatial Econometrics Models *Journal of Regional Science* **51**(3) 471-96

[8] Su F L 2006 An analysis on the spatial pattern of China s provincial R&D spillovers *Studies in Science of Science* **5** 696-700

[9] Li Y, Han B T 2010 The impact of weak tacit knowledge spillover on economic growth based on paper cooperation *Studies in Science of Science* **28**(10) 1547-54

[10] Xu Y Z, Zhu Y X, Sun J 2010 Knowledge spillover and regional economy growth: A spatial empirical analysis *Science Research Management* **31**(6) 105-12

[11] Zhou G F, Lan Y N 2012 Spatial Cluster Knowledge Spillovers and Regional Economy Increasing Discrepancy Based on a Spatial Econometric Analysis in the Perspective of Cities *Journal of Industrial Technological Economics* **3** 31-9

[12] Liu M F, Tang H X 2010 Empirical Study on Effect of Knowledge Spillovers Based on Spatial Durbin Model *Science &Technology Progress and Policy* **27**(18) 28-33

[13] Lesage J P, Pace R K 2009 *Introduction to Spatial Econometrics* CRC Press New York.

[14] Lesage J P, Fischer M M 2008 Using Dependence to Measure the Impact of Tacit Knowledge Stocks on Regional Total Factor Productivity available at: http://www.stanford.edu/group/SITE/archive/SITE_2008/segment_7/papers/lesage.pdf (accessed 15 June 2009)

[15] Kesidou E 2004 Knowledge Spillovers in High-tech Clusters in Developing Countries" available at: http://www.globelicsacademy.net/pdf/EffieKesidou_paper.pdf (accessed 15 June 2009)

[16] Lv Z W 2009 Research on the R&D Spatial Spillover and Regional Knowledge Production *Statistical Research* **26**(4) 44-51

[17] Corinne A B 2001 Science and Knowledge Flows: Evidence from the French Case *Research Policy* **30**(7) 1069-78

Authors

Houxing Tang, July, born in 1982, Anhui Province in China

Current position, grades: associate professor
University studies: PH.D for Management Science and Engineering from School of Information Management, Jiangxi University of Finance and Economics in 2010.
Scientific interest: knowledge management and regional innovation.
Publications: 15.
Experience: School of Business Administration, Nanchang Institute of Technology.