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Impact of Human Capital on Economic Growth Based on Spatial Economic Perspective

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Abstract: This article studies on bind of different country's human capital and its economic growth by means of spatial econometric model. Firstly, this study construct spatial model of the Cobb-Douglas production function with human capital factors and expansion spatial Benhabib and Spiegel model and then use these two models to discuss human capital and its spatial lag's contribution to economic growth. The empirical results show that, even in considering the case of spatial elements, studying human capital as a common element of production inputs, the role of human capital in the country and neighboring countries on the country's per capita income growth is not significant; there is a certain spatial relationship between the human capital and economic growth; the capability of independent innovation based on human capital and advanced technology absorptive capacity are significantly which will boost the economy.

Key words: Human capital, economic growth, regional differences

INTRODUCTION

Human capital is an important source of sustained economic growth which has been consented by the governments and scholars. Human Capital ideas come from economists' studying of human economic value. Petty (1981) said that nature is the mother of wealth and the father of labor. William Petty attaches great importance to the important role of the "art" in social production. Besides this, Petty believes that the skilled person can be more productive than people with low skills. Similar to the analysis of Petty (1978) and Smith (1976), the enhancement of the skills of workers considered to be the basic source of economic progress and growth in economic welfare. The human capital systematic study of the role of economic growth begins from Schultz (1963) who believes that well-developed human skills will be able to take full advantage of a variety of complex modern physical capital. Economists gradually introduced human capital production function model and take them endogenous. Uzawa (1965) introduced human capital model of economic growth and analysis it. Research on Human Capital and Economic Growth since the 1990s has been one of the hot issues explored by economists. Many scholars studied the human capital as determinants of economic growth (Lucas, 1988; Romer, 1986).

The innovation of this study mainly includes: (1) This study, on the basis of the spatial effect of human capital on economic growth, fill gaps in the direction, more comprehensive, more accurate and more effective analysis of the role of human capital to economic growth. This study can avoid the set deviation of the model and empirical results' imprecise which are caused by the previous studies due to the neglect of spatial factors. (2) By assuming that the spatial dependence of the national technical level, this study consider the biochemical variables spatial effect and avoid simply direct introduction of exogenous spatial variables. (3) This study construct spatial model of the Cobb-Douglas production function with human capital factors and expansion spatial Benhabib and Spiegel model and then use these two models to discuss human capital and its spatial lag's contribution to economic growth.

LITERATURE REVIEW

Human capital, as an important factor to explain the economic growth gap among countries, has got more and more attention in the theoretical and empirical research. So, far, the study on the contribution of human capital to economic growth, mainly concentrated on the application of the two types of models. One type of research is the departure from the traditional endogenous growth theory,

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human capital as a common input factors directly introduced into the production function and its contribution to economic growth. Mankiw *et al*. (1992) had made empirical study using cross-country data. Many economists propose the endogenous growth theory which believes human capital is an important factor in promoting economic growth (Nelson and Phelps, 1966; Romer, 1986; Grossman and Helpman, 1991; Aghion and Howitt, 1998). Barro (1991, 2001) and Bils and Klenow (2000) used the cross-country data and empirical methods to detect the role of human capital on economic growth. Gemmell (1996) study also found that the stock of human capital and incremental have played the important role to the economic growth. The core of the endogenous growth theory is that human capital firstly play a role in innovation and knowledge spillover, then indirectly affect economic growth. But some empirical research mostly concerned about the direct effect of human capital on economic growth, it is estimated that the impact of human capital on technological innovation and on the role of economic growth through technological innovation is relatively small.

Another type of study is to make the TFP (Total Factor Productivity) growth as a function of the human capital and endogenous growth theory and model the total factor productivity. Nelson and Phelps (1966) built the theoretical model which is an empirical study proposed by Benhabib and Spiegel (1994). Moreover, in the Benhabib and Spiegel's article, the first class of the model was also compared to the contribution of human capital. The results of the two methods of comparison show that the effect of human capital, as a simple input factor, is not significant; but the human capital contribution is significant which is proving in the theoretical model of Nelson and Phelps (1966). Since endogenous growth theory has included human capital in the model of economic growth, there are a large number of studies concerned about the role of education on the economic growth in one country, or in a region. Many studies have found that the region's economic growth miracle is closely related to the increasing investment in human capital and improving the educational level of employees (Ahlburg and Jensen, 2001; McMahon, 1999; Ito and Krueger, 1995; World Bank, 1993).

At the same time, with the spatial econometrics in the direction of regional economic growth, it has been confirmed that the validity and necessity of the spatial variables prove the differences in the interpretation of regional economic growth and regional economic development which has deepen the research in this field. Arbia *et al*. (2005) has made the panel data spatial econometric study on regional economic growth and convergence. Ertur and Koch (2007) has built a room for improvement in the equilibrium state Solow model which was taken into account the interdependence of technology between countries and made the empirical research to measure the equilibrium capital spillover strength. Human capital, as one of the mainstream theory of economic growth theory, has naturally become the space measurement direction. Ertur and Koch (2007), by assuming the presence of interdependence between the economies has established of the extended MRW model which have confirmed the spillover the existence of the interdependence of technology and human capital. Several economists use the same models and methods to analyze and come to similar conclusions. What the difference is about to make the more accurate interpretation of the indirect effects of capital (including human capital) (Fischer, 2009; Ertur and Koch, 2006). Pede *et al*. (2006), basing on the Nelson and Phelps (1966) and Benhabib's model which is the exogenous spatial weight matrix, considers the impact of the spatial dependence between the human capital and technology gap space and then establishes a modified space model to test the spatial dependence of human capital.

This article follows the Nelson and Phelps (1966), Benhabib and Spiegel (1994) empirical model, then assumes there is spatial dependence among regional technical level changes in total, finally establishes spatial expansion Benhabib and Spiegel model and do empirical research using data for 50 countries. This model is different from Valerien O. Pede's spatial econometric model, then improves the Benhabib and Spiegel (1994) model from a new angle and finally reaches a strong empirical conclusion. This study hope that a more comprehensive, accurate and effective method which is used to analyze the role of human capital on economic growth based on the space effect, can be eventually achieved.

SELECTING THE VARIABLES AND SETTING THE MEASUREMENT MODEL

After taking into account the availability of data on indicators, general studies mainly begin with the education and vocational training investment in human capital. It is believed that human capital is different from the general sense of the labor force. It is a special labor force after being in the general labor education, training formed with different qualitative skills, technical level and proficiency of the workforce. Since education is the primary means to improve the human capital, so, the investment in education is actually the investment in human capital. Human capital investment in vocational training will have the "learning by doing" effect which make human capital have a certain time lag effect. So, the selecting method about human capital variables in this study will focus on the education years of workers.

At present, domestic and foreign human capital metrics include degree index, technical grade, education funding and years of education law. More general indicator measure consists of two categories: one is early in the higher education level of employees in the total proportion of employees; the other is focused on the average years of schooling. The level of workers' education as an indicator of human capital is widely used and is considered superior to the school population data at all levels in common. The latter data is better to reflect the real level of human capital in a region which is more affected by historical reasons. As a result, this article select the average years of education to represent the stock of human capital. This method is also used by Benhabib and Spiegel (1994) and Kyriacou (1991), who also enable the analysis of the different articles comparability.

The sample data is consisted of the data coming from 50 countries in 1980 to 2010. The sample countries are coming from Benhabib and Spiegel's article. All the variable data comes from the Penn World Tables (PWT version 6.2) and the UNESCO Institute for Statistics data calculated. The following further information will be expanded on the selection and calculation of this variable. The spatial weight matrix W applied in this model is the matrix of national or regional spatial dependence modeling which is commonly used in spatial econometrics. This method, basing on the proposed method in the Anselin (2009) article, reconstruct each element in the matrix W according to the following principles and then standardize matrix W:

$$w_{ij} = \begin{cases} 0(i = j) \\ d_{ij}^{-2}(i \neq j) \end{cases}$$

d_{ij} represents the distance between the different regions.

According to Anselin (2009), for the estimates of the spatial lag model, if the method of least squares (OLS) is still used, the coefficient estimates will be biased or invalid. Therefore, the maximum likelihood method should be estimated (LeSage and Pace, 2009).

CONSTRUCTING SPATIAL MODEL OF THE COBB-DOUGLAS PRODUCTION FUNCTION WITH HUMAN CAPITAL FACTOR

As mentioned before, there are two models used to measure the effect of human capital on economic growth. This section will firstly use the first method to make the ordinary human capital as a production inputting factor and then transform the standard economic growth model to the spatial economic growth model. The Cobb-Douglas production function model is selected. The technical level, physical capital, labor and human capital are chosen as the input factors.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} I \quad (1)$$

is output per capital A_t is technical level K_t^{α} is capital L_t^{β} is labor H_t^{γ} is human capital.

Take the logarithm on both sides of the formula and do differential equations:

$$(\text{Log } Y_t\text{-log } Y_0) = (\log A_t\text{-log } A_0)+\alpha(\log K_t\text{-log } K_0) +\beta(\log L_t\text{-log } L_0)+\theta(\log H_t\text{-log } H_0) \quad (2)$$

The model (2) is called as the standard economic growth model. DX represents the variable logarithmic differential. Simplify the formula as:

$$dy = dA+\alpha(dK)+\beta(dL)+\theta(dH) \quad (3)$$

As the Ertur and Koch (2007), the region's per capita income growth tends to have spatial dependence. It is necessary to do spatial dependence test on the dependent variable. In this study, the dependent variable Moran I index confirms that the presence of spatial dependent on the per capita income growth. Therefore, the Spatial Lag Model (SLM) which contains spatial lag of the dependent variables, is established:

$$dy = dA+\alpha(dK)+\beta(dL)+\theta(dH)+\rho(dY)$$

Firstly, the Moran's I index is always used to measure the relevant space degree. The spatial dependence of the index makes the overall portrait of the different national and regional spatial dimensions and variables. The index is calculated as follows:

$$\text{MoranI} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}$$

$$S^2 = \frac{1}{n}\sum_{j=1}^{n} W_{ij}(Y_j - \bar{Y}),\ \ \bar{Y} = \frac{1}{n}\sum_{i=1}^{n}(Y_i)$$

where, Y_i is the observed value of the region i (the average years of education in the region i), n is the total number of regions, w_{ij} is the spatial weighting matrix using of neighboring standard, two-dimensional matrix:

$$dy = dA+\alpha(dK)+\beta(dL)+\theta(dH)+\rho(dY) \quad (4)$$

Table 1: Index testing argument Moran I

Detection items	Moran I	P
dK	0.1768	0.0300
dL	0.5841	0.0000
dH	0.4759	0.0000

The detection items, such as dK, dL, dH, are defined in formula 4

After has been tested the spatial dependence of the variables, Table 1 shows that the argument has significant spatial dependence. Accordingly, the formula 4 is modified so that it can include the independent variable lags:

$$dy = dA+\alpha(dK)+\beta(dL)+\theta(dH)+\lambda(WdK) +\delta(WdH)+\zeta(WdH)+\rho(dY) \quad (5)$$

Model (5) can be seen as a standard economic growth model (2) spatial version which is called the spatial economic growth model.

EMPIRICAL ANALYSIS THE SPATIAL ECONOMIC GROWTH MODEL

The space economic growth model (5) regression results which can be seen in Table 2, confirm there is a positive correlation between physical capital growth and per capita income growth; the labor coefficient estimates symbol is negative which is as same as Pede *et al.* (2006). As this study has concerned about, the human capital change and its spatial lag are not significant. Benhabib and Spiegel has derived that human capital's contribution to the growth of per capita income is not significant if it is treated as a simple factor of production. So, as opposed to the Benhabib and Spiegel's standard economic growth model of human capital, this space economic growth model is not only to maintain but to validate the conclusion. It proves that if the human capital was treated as simple production factor input, the spatial spillover would not significant.

In addition, due to the variable spatial lag item's (Wd) significant, it is confirming that the per capita income growth in the country is a significant spatial dependence. The spatial dependence of the physical capital is significant, but the spatial dependence is not significant.

CONSTRUCTING SPATIAL BENHABIB AND SPIEGEL MODEL:

In accordance with the second model estimating human capital effect, this study will no longer treat human capital as a simple factor input, but as the elements affecting of productivity change. Specifically, the technical level of the total change is treated as a function

Table 2: Spatial economic growth model estimation results

	Spatial economic growth model	
	W1	W2
Constant	0.0597	0.0609
	(0.2672)	(0.2824)
dK	0.2952***	0.3198***
	(0.0634)	(0.0657)
dL	-0.3214	-0.4655**
	(0.2291)	(0.2330)
dH	0.1147	0.1208
	(0.1382)	(0.1491)
WdK	-0.1641**	-0.2640***
	(0.0765)	(0.0736)
WdL	0.1215	0.4402
	(0.3095)	(0.3095)
WdH	-0.2564	-0.1967
	(0.1585)	(0.1685)
WdY	0.7304***	0.8063**
	(0.0593)	(0.0449)

All the constants, including dK, dL, dH, WdK, WdL, WdH, WdY, are defined in formula 5.**, *** represent the 5% and 1% significance level test is significant

of human capital. The same Cobb-Douglas production function model is selected. The technical level, physical capital and labor are chosen as the input factors:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \quad (6)$$

Make differential equations:

$$(\text{Log } Y_t\text{-log } Y_0) = (\log A_t\text{-log } A_0)+\alpha(\log K_t\text{-log } K_0) +\beta(\log L_t\text{-log } L_0)+(\log \varepsilon_t\text{-log } \varepsilon_0)w_{ij} \quad (7)$$

In the Benhabib and Spiegel model, it is assumed that the level of technology depends on the level of human capital and "catch up" items. These items mean the per capita income gap between the level of domestic human capital and the technical lead countries. The following formula is as:

$$(\log A_t - \log A_0)_i = c + gH_i + mH_i(\frac{Y_{max} - Y_i}{Y_i}) \quad (8)$$

where, i means country, H means human capital Y_{max} means per capita income of technology leading country; $H(Y_{max}/Y)$ means "catch up" items. The Eq. 8 can be transformed to:

$$(\frac{A_t}{A_0})_i = \exp\left[c + gH_i + mH_i(\frac{Y_{max} - Y_i}{Y_i})\right] \quad (9)$$

According to the spatial econometric point of view, it is assumed that the level of technology change spatial dependence is existence. The equation can be transformed to:

$$\left(\frac{A_t}{A_0}\right)_i = \exp\left[c + gH_i + mH_i\left(\frac{Y_{max} - Y_i}{Y_i}\right)\right]\prod_{j=i}^{N}\left(\frac{A_t}{A_0}\right)_j^{\gamma w_{ij}}$$
$$= \Omega \exp\left[gH_i + mH_i\left(\frac{Y_{max} - Y_i}{Y_i}\right)\right]\prod_{j=i}^{N}\left(\frac{A_t}{A_0}\right)_j^{\gamma w_{ij}} \quad (10)$$

This function describes the ratio of any country i at time t technical level and technical level of the initial value, (A_t/A_0)i which depends on the second part. Firstly, a country i's technical level varies depending on the gap between the country's level of human capital and technology leading the national per capita income. Secondly, a country's level of technology change would be adjacent national or regional technology spillovers and then technology spillover effects will decrease due to the existence of economic and social differences in the systems of different countries. This assumption is the second of model (10). W_{ij} (j = 1,2,…,N) is the geographically weighted matrix elements which means the technology changing level of country I is close to the level of national technical changing in geographical weighted average. The degree of technology dependence is symbolized with γ, $0 \le \gamma \le 1$.

These parameter assumptions are the same for all countries, but a country's technology changing level in the net spillover effecting depends on the geographic relationship between the country and neighboring countries.

So, the dependence on the technical changing level between countries reflects that studying on a country can not be isolated, but should be seen as an inter-national system. The Eq. 10 in the form of matrix can be rewritten to:

$$\frac{A_t}{A_0} = c + gH + mH\left(\frac{Y_{max} - Y_i}{Y_i}\right) + \gamma W \frac{A_t}{A_0} \quad (11)$$

where, A_t/A_0 is a technical level the ratio of the number (N×1) vector; H is human capital (N×1) vector; W is Spatial weight matrix (N×N) vector; Solving Eq. 11, Seeking about function expression (Assumptions: $\gamma \neq 0$ and $1/\gamma$ is not a characteristic value of the matrix W):

$$\frac{A_t}{A_0} = \frac{1}{(1-\gamma W)}\left[c + gH + mH\left(\frac{Y_{max} - Y_i}{Y_i}\right)\right] \quad (12)$$

Equation 12 can be expressed as:

$$(\log A_t - \log A_0)_i = \frac{1}{(1-\gamma W)}\left[c + gH + mH\left(\frac{Y_{max} - Y_i}{Y_i}\right)\right] \quad (13)$$

Finally, take Eq. 13 into Eq. 7, multiplied by $(1-\gamma W)$ and on both sides of the equation, finally obtain:

$$\begin{aligned}(\log Y_t - \log Y_0)_i &= c + (g-m)H_i + mH_i\left(\frac{Y_{max}}{Y_i}\right)\\ &+ \alpha(\log K_t - \log K_0)_i + \beta(\log L_t - \log L_0)_i\\ &- \phi\sum_{j=i}^{N} w_{ij}(\log K_t - \log K_0)_j - \Psi\sum_{j=i}^{N} w_{ij}(\log L_t - \log L_0)_j\\ &+ \gamma\sum_{j=i}^{N} w_{ij}(\log Y_t - \log Y_0)_j + (\log \varepsilon_t - \log \varepsilon_0)\end{aligned} \quad (14)$$

Basing on the theory about the total technical level change is the idea of the human capital function, the model (14) is established. It is the extension special version of the Benhabib and Spiegel model. In order to distinguish itself from the simple spatial economic growth model, in which human capital is put into its elements, the model (14) is called the spatial Benhabib-Spiegel model. In this model, c is a constant, ε is the error term and the model satisfy the constraints ($\varphi = \alpha\gamma$, $\Psi = \varphi\lambda$).

EMPIRICAL ANALYSIS SPATIAL BENHABIB AND SPIEGEL MODEL

In order to contrast with the Benhabib and Spiegel model, the first column of Table 3 is the Benhabib and Spiegel model estimation result, the 2 and 3 columns as space Benhabib and Spiegel are corresponding to the different spatial weight matrix model estimation results. The results prove the correctness of the model (14) from several strong evidence.

First of all, in the spatial Benhabib and Spiegel model estimation results, the coefficient of human capital item H and "catch-up" item $H(Y_{max}/Y)$ estimated values were

Table 3: Spatial Benhabib and Spiegel model and Model estimation results

		Spatial benhabib and Spiegel model	
	Benhabib-Spiegel	W1	W2
Constant	-1.1086***	-0.7418***	-0.6646**
	(0.2655)	(0.2753)	(0.2641)
H	0.0842***	0.0579***	0.0376***
	(0.0164)	(0.0168)	(0.0111)
$H(Y_{max}/Y)$	0.0102***	0.0089***	0.0056***
	(0.0017)	(0.0017)	(0.0017)
dK	0.3115***	0.2729***	0.2794***
	(0.0604)	(0.0568)	(0.0559)
dL	-0.5053***	-0.4255**	-0.4671**
	(0.1786)	(0.1974)	(0.1944)
WdK		-0.1289*	-0.1506**
		(0.0682)	(0.0667)
WdL		0.1630	0.1681
		(0.2518)	(0.2493)
WdY		0.5147***	0.5866***
		(0.0846)	(0.0759)
Test of restriction	0.07465	0.07954	
Implied α		0.2504-0.2729	0.2567-0.2794
Implied β		-0.4255--0.3167	-0.4671--0.2866
Implied γ		0.5147	0.5866
Adj R^2	0.598494	0.634608	-0.63829

All the constants, including dK,dL,dH,et,al, are defined in formula 14.*, **, *** represent the 10, 5 and 1% significance level test is significant significantly. Their signs are also expected, the estimated value and significance of the coefficient are superior to the Benhabib and Spiegel estimation result. From the Nelson and Phelps's explanation, the "catch-up item" is a measure of the ability of foreign advanced technology absorption application. And the empirical results give us a good proof. In addition, compared with the spatial Benhabib and Spiegel regression results, the Benhabib and Spiegel's coefficient value is too large. This is mainly because the spatial lag variable coefficient estimate of the Benhabib and Spiegel model is biased which prove the necessity of consideration of the spatial effect.

Secondly, the constraint conditions of the model coefficients are met. Corresponding to different matrix, because the constraints Wald test of the model coefficients are not significant, the original assumptions can be accepted and constraints ($\varphi = \alpha\gamma$, $\Psi = \varphi\lambda$) can be established. Accordingly, α estimated value is between 0.2504-0.2794, very close to 1/3 and which is matching with the actual statistical results of most countries of the world.

Furthermore, the technology spatial dependence evidenced is proved, dependent degree γ is about 0.5 which is significant in 1% level. The estimated results of this value are approximately similar with Ertur and Koch (2006) which also shows the importance of the interdependence of technological change in countries in the process of economic growth. Thus, a national technical level and per capita income growth should not be regarded as a separate entity analysis, but should be a local area interdependent system.

The estimation value of WdK obtains the desired symbols and the average is significant at 1% level. This conclusion suggests that a change of the national capital stock has a significant impact with the per capita income changing in neighboring countries which means the capital has a significant spatial spillover. This result consists with the results of the space economic growth model coming from Part 3 of this article. State J change of the physical capital stock net effect on the growth of per capita income of country i is, $\alpha(1-\gamma)\sum_{r=1}^{\infty} w_{ij}^{r}\gamma^{r}$ W1 is 0.1405 and W2 is 0.1637, this means that country j physical capital stock increase of 1%, corresponding to country i's per capita income will increase by 0.1405% (0.1637%).

In addition, labor coefficient estimating the value of the symbol is negative.

Finally, the empirical results of Part 3 of this study show that, even in considering the growth model of the spatial elements, the human capital, as a simple input factor to measure the contribution to economic growth, is inappropriate. Human capital is to promote economic growth through the promotion of Total Factor Productivity (TFP) increasing which can be seen from the spatial Benhabib and Spiegel model results.

CONCLUSION

About the role of human capital on economic growth, respectively, bases on two types of models: standard economic growth model and Benhabib and Spiegel model; the spatial economic growth model and the spatial Benhabib and Spiegel model. The study confirms that, even in considering the case of spatial elements, the significant role of human capital as a common element of production inputs, the role of human capital in the country and neighboring countries and human capital of the country's per capita income growth are not significant. All these prove that the country can promote economic growth through the promotion of technological progress.

Moreover, compared to the Benhabib and Spiegel model, this study has the following important conclusions: firstly, spatial Benhabib and Spiegel model is more realistic than the Benhabib and Spiegel model, the better the regression results, human capital items H and "catch-up items" coefficient estimates are significant to obtain the expected sign; secondly, there is the spatial dependence among state technical level; thirdly, the state should not be seen as a individual space to analyze, but should consider the spatial correlation between the countries and the technology-dependent countries, a certain range of countries as a system to analyze; finally, physical capital has a significant spatial dependence. A country's per capita income will increase significantly by the impact of changes in the physical capital in other neighboring countries.

In order to give full play to the interdependence between countries and capital spillover, to further promote multi-national economic development within a certain range, the further improvement role of human capital should be promoted. The following measures can be adopted: firstly, technological innovation and introduction should be strengthened, investment in human capital should be absorbed, the goals is to continuously improve their own technological innovation capability and efficient absorption of advanced technology, to promote the rapid growth of the national economy; secondly, the relevance of the economic activities in the neighboring countries should strengthen, the physical capital's significant spillover and technical interdependence between countries should be used to improve the positive interaction of national economic development.

In addition, the national government's policies should be improved in the following ways:

- Firstly, the government should strengthen the human capital investment and promote long-term growth of the national economy. Even in financial constraints, the government should also encourage investment in human capital. Government should strengthen public education funding and the focus should be placed on the secondary and higher education, to ensure high-quality human capital required by the state
- Secondly, the government should increase institutional innovation, improve the efficiency of the allocation of human capital. The government needs to actively cultivate the national human capital market and guide human capital to flow rationally, enable each person to develop his talents

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