Chapter 3

Methodology

3.1 Model of the Study

This study examines the relationship among FDI, human capital and economic growth in China during the period 1995 to 2009. The model proposed by Borensztein et al. (1998) is employed to do the empirical work. The illustrative framework is as follows:

We assume an economy where technical progress is the result of 'capital deepening' in the form of increasing the number of varieties of capital goods available, as in Romer (1990), Grossman and Helpman (1991) and Barro and Sala-i-Martin (1995). There is only one kind of consumption good produced in the economy according to the following technology:

$$Y_t = AH_t^{\alpha}K_t^{1-\alpha} \tag{3.1}$$

$$K = \{\int_0^N x(j)^{1-\alpha}\,dj\}^{\frac{1}{1-\alpha}} \tag{3.2}$$

$$N = n + n^* \tag{3.3}$$

where Y_t denotes the total outputs, A represents the exogenous state of 'environment' which comprises various control and policy variables influencing the level of productivity in the economy, H denotes human capital which given as an endowment, K stands for physical capital which consists of an aggregate of different varieties of capital goods, and hence capital accumulation takes place through the expansion of the number of varieties, $x(j)$ denotes a continuum varieties of capital goods. The domestic firms produce n varieties out of the total number N, and the foreign firms produce n^* varieties.

Assume that specialized firms produce each variety of capital good, and rent it out to final goods producers at a rental rate $m(j)$. The demand for each variety of capital good, $x(j)$, follows from the optimality condition that equates the rental rate to the marginal productivity of the capital good in the production of the final good. This condition is:

$$m(j) = \frac{\partial y(j)}{\partial x(j)} = (1-\alpha)AH^{\alpha}x(j)^{-\alpha} \tag{3.4}$$

Assume technical progress in developing countries is mainly from learning and imitating the new technology in developed countries. The process of technology adaptation is costly, requiring a fixed setup cost (*C*) before production of the new type of capital can take place. *C* is a function of *(n*/N)* which represents the ratio of the number of foreign firms operating in the host economy to the total number of firms, and *(N/N*)* which represents the number of capital varieties produced domestically compared to those produced in the more advanced countries. The functional form for the setup cost is as follows:

$$C = C(n^*/N, N/N^*) \tag{3.5}$$

where

$$\frac{\partial C}{\partial (n^*/N)} < 0 \quad and \quad \frac{\partial C}{\partial (\mathrm{N}/\mathrm{N}^*)} > 0 \tag{3.6}$$

In other words, the fixed setup cost *C* depends negatively on the foreign capital ratio *(n*/N)* and depends positively on the 'catch-up' effect in technological progress *(N/N*)* since it is cheaper to imitate products already in existence for some time than to create new products at the frontier of innovation.

Furthermore, after the new type of capital good being introduced, it requires a constant maintenance cost per period of time. We assume that there is a constant marginal cost of production of *x(j)* equal to 1, and that capital goods depreciate fully.

Assuming a steady state where the interest rate *r* is constant, the profits function for the producer of a new variety of capital *j* is:

$$\prod(j)_t = \int_t^{\infty} [x(j)m(j) - x(j)]e^{-r(s-t)}\, ds - C(n_t^*/N_t, N_t/N_t^*)$$

(3.7)

Maximization of Eq. (3.7) subject to the demand Eq. (3.4) generates the equilibrium level for the production of each capital good *x(j)*:

$$x(j) = HA^{1/\alpha}(1-\alpha)^{2/\alpha}$$

(3.8)

Substituting Eq. (3.8) into Eq. (3.4), we can get the expression for the rental rate:

$$m(j) = \frac{(1-\alpha)AH^{\alpha}}{[HA^{1/\alpha}(1-\alpha)^{2/\alpha}]^{\alpha}} = \frac{1}{1-\alpha}$$

(3.9)

which gives the rental rate as a markup over maintenance costs.

Finally, we assume the free entry, and hence, the rate of return *r* will be such that profits are equal to zero. Solving for the zero profits condition we obtain:

$$r = \alpha HA^{1/\alpha}(1-\alpha)^{2-\alpha/\alpha}C^{-1}(n^*/N, N/N^*)$$

(3.10)

To close the model, we need to describe the process of capital accumulation, which is driven by saving behavior. We assume that households maximize standard intertemporal utility function by choosing consumption (*C*):

$$U_t = \int_t^{\infty} \frac{C_s^{1-\sigma}}{1-\sigma} e^{-\rho(s-t)} ds$$

(3.11)

Given a rate of return *r*, the optimal consumption path is given by the standard condition:

$$\frac{\dot{C}_t}{C_t} = \frac{1}{\sigma}(r - \rho)$$

(3.12)

In the long-run steady state equilibrium, growth rate of consumption is equal to the growth rate of output, which denoted by g.

Substituting Eq. (3.10) into Eq. (3.12), we obtain the expression for the rate of economic growth:

$$g = \frac{1}{\sigma}\left(\alpha H A^{1/\alpha}(1-\alpha)^{2-\alpha/\alpha} C^{-1}(n^*/N, N/N^*) - \rho\right)$$

(3.13)

Eq. (3.13) shows that foreign direct investment, which is measured by (n^*/N), reduces the costs of introducing new varieties of capital goods, thus increasing the rate at which new capital goods are introduced. The cost of introducing new capital goods is also smaller for more backward countries; that is, countries with lower N/N^* enjoy lower costs of adoption of technology, and will tend to grow faster. Furthermore, the effect of FDI on economic growth is positively associated with the level of human capital, that is, the higher the level of human capital in the host country, the higher the effect of FDI on the growth rate of the economy.

To assess empirically the effect of FDI on economic growth, Borensztein et al. (1998) utilized the model as follows:

$$\mathrm{g} = c_0 + c_1 FDI + c_2 FDI * H + c_3 H + c_4 Y_0 + c_5 A$$

(3.14)

where g is the growth rate of GDP per capita, FDI is the foreign direct investment, H is the stock of human capital, $\mathrm{FDI} * \mathrm{H}$ is the interaction term of FDI and human capital, Y_0 is the initial GDP per capita, and A is a set of other variables that affect economic growth.

To investigate the long-run relationship among FDI, human capital and economic growth, the model proposed by Borensztein et al. (1998) is employed to do the empirical work. Since panel cointegration test will be employed in this study, it requires all serial data to be integrated of order one, i.e.; I (1). Single human capital variables are excluded in the model since both of knowledgeable human capital and technical human capital are stationary in their levels, i.e.; I (0). From the above growth equation, the long-run relationship among these variables can be written as follows:

$$LNGDP_{it} = \alpha_{it} + \alpha_{1i}LNFDI_{it} + \alpha_{2i}LN(FDI * H_1)_{it} + \alpha_{3i}LN(FDI * H_2)_{it} + \mu_{it} \tag{3.15}$$

where the subscript $i = 1, \ldots, N$ denotes the individual provinces while $t = 1, \ldots, T$ denotes the time periods. *LNGDP* is the logarithmic form of real gross domestic products at constant price of 2000. *LNFDI* is the logarithmic form of actual utilized foreign direct investment. H_1 represents knowledgeable human capital which measured by the share of the enrollment of university and college students over the total employed people, H_2 represents technical human capital which measured by the share of enrollment of specialized secondary school (including vocational school and technical school) students over the total employed people. *LN(FDI*H)* represents the logarithmic form of the interaction of FDI and human capital. μ_{it} is the white noise error term. α_{1i}, α_{2i} and α_{3i} are parameters, which represent the long-run FDI elasticity, interaction of FDI and knowledgeable human capital elasticity, and interaction of FDI and technical human capital elasticity, respectively. All the variables employed in the model are presented by the natural logarithmic form since taking the natural logarithmic form of data cannot change the entire original association and causality but can cause the tendency linearization, which may eliminate the different influence of variance in the time series to a certain extent, enhance the fitting degree to the model (Zhang and Zhu, 2007).

3.2 Hypotheses of the Study

The aim of this study is to quantify and explain how FDI affects economic growth in China. Furthermore, it exams the impact of FDI on China's economic growth through two different kinds of human capitals. There are four testable hypotheses as follows:

Hypothesis 1: FDI generates a positive impact on economic growth through the past 15 years in China.

Hypothesis 2: FDI together with knowledgeable human capital exerts a more positive effect on economic growth compared with only FDI.

Hypothesis 3: FDI together with technical human capital exerts a more positive effect on economic growth compared with only FDI.

Hypothesis 4: FDI together with knowledgeable human capital exerts a more positive effect on economic growth compared with FDI together with technical human capital.

3.3 Research Methodology

In this study, the existence of long-run relationship among the variables in Eq. (3.15) is examined. The utilization of the vector error correction model (VECM) captures the short-run dynamics of the variables. The analysis is conducted in four steps. The first step is to verify the order of integration for the variables because the various cointegration tests are valid only if the variables have the same order of integration. In the second step, the Pedroni (1999, 2004) tests and the Kao (1999) test are employed to examine the panel cointegration relationship, which are based on the estimated residuals of Eq. (3.15) when all the series are integrated into the same order. Step three is the estimation of the long-run structural coefficients. The long-run structural coefficients are estimated by using the panel dynamic ordinary least squares (DOLS) approach. Finally, panel Granger causality tests associated with vector error correction model (VECM) are conducted between the variables to examine the existence of both short-run and long-run causations.

3.3.1 Panel Unit Root Tests

Before proceeding to the possible long run relationship, it is necessary to verify that all variables are stationary by employing the panel unit root tests to avoid the spurious regression. For the unavailability of some data, the model will be built up based on an unbalanced panel. Fisher-type unit root tests (Maddala and Wu, 1999, and Choi, 2001) are employed in the study since they have ability to handle unbalanced panel data. In Fisher type tests, the null hypothesis is that of a unit root. Dependent variable $LNGDP_{it}$ and independent variables $LNFDI_{it}$, $LN(FDI * H_1)_{it}$ and $LN(FDI * H_2)_{it}$ will be checked by employing the Fisher type tests, respectively.

Fisher-ADF and PP tests are all characterized by the combining of individual unit root tests to derive a panel-specific result. For the sample of 30 provinces over 15 years data, the panel unit root regressions of ADF test can be written as:

$$\Delta LNGDP_{it} = \alpha_i + \beta_i LNGDP_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij} \, \Delta LNGDP_{it-j} + e_{it},$$
$$i = 1,\ldots,30, t = 1,\ldots,15 \tag{3.16}$$

$$\Delta LNFDI_{it} = \alpha_i + \beta_i LNFDI_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij} \, \Delta LNFDI_{it-j} + e_{it},$$
$$i = 1,\ldots,30, t = 1,\ldots,15 \tag{3.17}$$

$$\Delta LN(FDI * H_1)_{it} = \alpha_i + \beta_i LN(FDI * H_1)_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij} \, \Delta LN(FDI * H_1)_{it-j} + e_{it},$$
$$i = 1,\ldots,30, t = 1,\ldots,15 \tag{3.18}$$

$$\Delta LN(FDI * H_2)_{it} = \alpha_i + \beta_i LN(FDI * H_2)_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij} \, \Delta LN(FDI * H_2)_{it-j} + e_{it},$$
$$i = 1,\ldots,30, t = 1,\ldots,15 \tag{3.19}$$

where i denotes for the different provinces and t denotes the number of observations over time; Δ is the first difference operator; α_i, β_i and γ_{ij} are the coefficients to be estimated; e_{it} is the error term. The null hypothesis of a unit root in the panel data is defined as

$$\beta_i = 0, \quad \text{for all } i \qquad (H_0)$$

(3.20)

against the alternatives that all series are stationary processes

$$\beta_i < 0, \quad i = 1,2,\ldots,N_1; \quad \beta_i = 0, \quad i = N_1+1, N_2+2,\ldots,N \qquad (H_1)$$

(3.21)

Fisher-type tests have been proposed by Maddala, Wu and Choi by using Fisher's (1932) results to derive tests that combine the *p*-values from individual unit root tests. Define π_i as the *p*-value from any individual unit root test for cross-section *i*, under the null of unit root for all *N* cross-sections, we have the asymptotic result that:

$$-2\sum_{i=1}^{N}\log(\pi_i) \rightarrow \chi^2_{2N}$$

(3.22)

In addition, Choi demonstrates that:

$$Z = \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\Phi^{-1}(\pi_i) \rightarrow N(0,1)$$

(3.23)

where Φ^{-1} is the inverse of the standard normal cumulative distribution function (Maddala and Wu, 1999, and Choi, 2001; Eviews 7 Help Topic).

3.3.2 Panel Cointegration Tests

Having established that each of the four variables is I (1), the panel cointegration among economic growth and FDI as well as the interactions of FDI and two kinds of human capitals can be checked by the panel cointegration tests. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary data may be stationary. If such a stationary linear combination exists, these non-stationary data are said to be cointegrated. The stationary linear combination is called the cointegration equation and may be interpreted as a long-run equilibrium relationship among the variables (Eviews 7 Help Topic). To test for cointegration among these variables, both the Pedroni (1999, 2004) tests and the Kao (1999) test are employed to confirm these variables are cointegrated.

Pedroni's panel cointegration allowing for individual-specific fixed effects and deterministic trends can be expressed as:

$$LNGDP_{it} = \alpha_{it} + \delta_i t + \alpha_{1i} LNFDI_{it} + \alpha_{2i} LN(FDI * H_1)_{it} + \alpha_{3i} LN(FDI * H_2)_{it} + \mu_{it} \tag{3.24}$$

where $\mu_{it} = \rho_i \mu_{it-1} + \varepsilon_{it}$ are the estimated residuals from the panel long-run relationship. The parameters α_{it} and δ_i allow for the possibility of individual-specific fixed effects and deterministic trends, respectively. The null hypothesis of no cointegration is $\rho_i = 1$. If the null hypothesis is rejected, panel cointegration among dependent variable and independent variables will be confirmed. The Kao (1999) test follows the same basic approach as the Pedroni tests but specifies cross section specific intercepts and homogeneous coefficients during the first stage (Hsiao and Tsai, 2010).

3.3.3 Panel Long-run Elasticities

Having confirmed a long-run relationship exists among the dependent variable and the explanatory variables by the cointegration tests. The long-run elasticities estimation will be conducted. Kao and Chiang investigated the finite sample properties of the ordinary least squares (OLS), fully modified ordinary least squares (FMOLS), and dynamic ordinary least squares (DOLS) estimators. They found that (i) the OLS estimator has a nonnegligible bias in finite samples, (ii) the FMOLS estimator does not improve over the OLS estimator in general, and (iii) the DOLS estimator may be more promising than OLS and FMOLS estimators in estimating the cointegrated panel regressions (Baltagi, 2008). The DOLS technique will be applied to ensure that the estimate Eq. (3.15) does not lead to a spurious regression result.

$$LNGDP_{it} = \alpha_{it} + \alpha_{1i}LNFDI_{it} + \alpha_{2i}LN(FDI * H_1)_{it} + \alpha_{3i}LN(FDI * H_2)_{it} + \sum_{j=-q_i}^{q_i} \alpha_{4i}\Delta LNFDI_{it+j} + \sum_{j=-q_i}^{q_i} \alpha_{5i}\Delta LN(FDI * H_1)_{it+j} + \sum_{j=-q_i}^{q_i} \alpha_{6i}\Delta LN(FDI * H_2)_{it+j} + \mu_{it}$$

(3.25)

where α_{it} indicates the province-specific effects and q_i is the leads and lags of the independent variables in the first difference. Term μ_{it} denotes the disturbance terms. α_{1i}, α_{2i} and α_{3i} are the long-run FDI elasticity, interaction of FDI and knowledgeable human capital elasticity, and interaction of FDI and technical human capital elasticity, respectively.

3.3.4 Panel Granger Causality Tests

To examine the direction of causality between the variables in a panel context, Granger causality tests associated with panel vector error correction model (VECM) will be estimated. A panel VECM (Pesaran et. Al., 1999) is estimated following the two step procedure described in Engle and Granger (1987). The steps consist of first estimating the long-run equilibrium model specified in the cointegration equation in order to obtain the estimated residuals, and then using these residuals lagged one period as the error correction term (Hamit-Haggar, 2010). VECM is used for correcting disequilibrium in cointegration relationship, captured by the error correction term. The panel based VECM is specified as follows:

$$\Delta LNGDP_{it} = \alpha_{1i} + \lambda_{1i}ECT_{i,t-1} + \sum_{k=1}^{q} \theta_{11i,k}\,\Delta LNGDP_{i,t-k} + \sum_{k=1}^{q} \theta_{12i,k}\,\Delta LNFDI_{it-k} + \sum_{k=1}^{q} \theta_{13i,k}\,\Delta LN(FDI * H_1)_{i,t-k} + \sum_{k=1}^{q} \theta_{14i,k}\,\Delta LN(FDI * H_2)_{i,t-k} + \mu_{1i,t}$$

(3.26)

$$\Delta LNFDI_{it} = \alpha_{2i} + \lambda_{2i}ECT_{i,t-1} + \sum_{k=1}^{q} \theta_{21i,k}\,\Delta LNGDP_{i,t-k} + \sum_{k=1}^{q} \theta_{22i,k}\,\Delta LNFDI_{it-k} + \sum_{k=1}^{q} \theta_{23i,k}\,\Delta LN(FDI * H_1)_{i,t-k} + \sum_{k=1}^{q} \theta_{24i,k}\,\Delta LN(FDI * H_2)_{i,t-k} + \mu_{2i,t} \tag{3.27}$$

where Δ is the first-difference operator; α_{ji} (j = 1, 2) represents the fixed-province effect; k (k = 1, …, q) is the optimal lag length determined by the Schwarz Criterion; $ECT_{i,t-1}$ is the estimated lagged error correction term derived from the long-run cointegration relationship; λ_{ji} (j = 1, 2) is the speed of adjustment; $\mu_{i,t}$ is the serially uncorrelated error term with mean zero. The interaction terms of FDI and two kinds of human capitals are omitted because the aim of this study is to examine causality between FDI and economic growth. The short-run causality is determined by the statistical significance of the partial F-statistic associated with the corresponding right hand side variables. Long-run causality is revealed by the statistical significance of the respective error correction terms using a t-test.

For the short-run causality, the null hypothesis is H_0: $\theta_{12i,k} = 0$; H_0: $\theta_{13i,k} = 0$; and H_0: $\theta_{14i,k} = 0$ for all i and k in Eq. (3.26) or H_0: $\theta_{21i,k} = 0$; H_0: $\theta_{23i,k} = 0$; and H_0: $\theta_{24i,k} = 0$ for all i and k in Eq. (3.27). For the long-run causality, the null hypothesis is H_0: $\lambda_{1i} = 0$ for all i in Eq. (3.26) or H_0: $\lambda_{2i} = 0$ for all i in Eq. (3.27).

3.4 Data of the Study

3.4.1 Data Collection

The study employs the annual data of 30 provinces in China during the period 1995 to 2009. China has 31 provinces and municipalities, but Tibet is excluded because it does not attract significant FDI throughout the period. Since the unavailability of some data, the study will employ an unbalanced panel. All of the data and information needed have been collected from *China Statistical Yearbooks* and various *Provincial Statistical Yearbooks* which were published by the National Bureau of Statistics of China from 1996 to 2010 and the World Development Indicators and Global Development Finance (WDIGDF).

3.4.2 Data Description

Table 3.1 shows that descriptive statistics of the data used in the study.

Table 3.1 *Descriptive statistics of variables.*

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
1. The logarithmic form of real gross domestic products					
LNGDP	448	19.74	1.01	16.89	22.14
2. The logarithmic form of actual utilized foreign direct investment					
LNFDI	448	20.50	1.75	15.41	23.95
3. The logarithmic form of the interaction of FDI and knowledgeable human capital					
LN(FDI*H_1)	448	16.08	2.29	10.00	20.68
4. The logarithmic form of the interaction of FDI and knowledgeable human capital					
LN(FDI*H_2)	448	16.28	2.05	10.92	20.27

Source: Calculated from China Statistical Yearbooks and various Provincial Statistical Yearbooks (2006-2010).