Chapter 4

Empirical Results

In this section, the existence of long-run relationship among these variables will be 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 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.

4.1 Panel Unit Root Tests

Panel data unit root tests in this study are conducted by using Fisher-type unit root tests---both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) since the availability of dealing with unbalanced panel data. For both of the tests, the null hypothesis is that there is a unit root, while the alternative hypothesis is that there is no unit root. The determination of stationarity of the data is based on both the Fisher Chi-square and the Choi Z-statistic. For both statistics, if the null hypothesis is rejected, the variable will be considered to be stationary. Table 4.1 displays the results of panel unit root tests in levels as well as in the first differences for all the variables. Tests for each variable are performed in three types: test with individual intercept, test with intercept and trend, and test with neither intercept nor trend.

According to Table 1, both tests of the ADF and PP cannot reject the null hypothesis in their levels, which indicate that all the variables are non-stationary in their levels. However, after taking first difference of each variable, all statistics of these four variables rejected the null hypothesis at the 1% level. This indicates that all the variables become stationary in their first differences. These results imply that all these variables are integrated of order one, i.e.; I (1).

Table 4.1 *Fisher-type panel unit root tests results.*

Variable		Method	Fisher type test-ADF			Fisher type test-PP		
			Individual Intercept	Intercept and Trend	None	Individual Intercept	Intercept and Trend	None
LNGDP	Level	Fisher Chi-square	0.35	26.75	8.29	0.31	5.64	0.00
		Choi Z-stat	19.64	7.76	12.93	20.36	11.01	23.38
	First difference	Fisher Chi-square	74.04	99.32***	34.25	77.19*	100.47***	44.92
		Choi Z-stat	-0.77	-3.65***	2.30	-1.67**	-3.12***	0.67
LNFDI	Level	Fisher Chi-square	16.33	55.89	5.19	13.31	36.16	4.48
		Choi Z-stat	7.23	1.28	9.77	7.83	3.14	11.27
	First difference	Fisher Chi-square	187.57***	163.54***	230.23***	199.63***	203.66***	252.69***
		Choi Z-stat	-8.41***	-7.50***	-10.11***	-8.87***	-8.51***	-11.55***

*Note: ***, ** and * indicate the rejection of the null hypothesis at 1%, 5% and 10% level of significance, respectively. The lag lengths are selected by using SIC. The maximum number of lags is set to be two.*

Table 4.1 *Fisher-type panel unit root tests results (con).*

Variable		Method	Fisher type test-ADF			Fisher type test-PP		
			Individual Intercept	**Intercept and Trend**	**None**	**Individual Intercept**	**Intercept and Trend**	**None**
LN(FDI*H$_1$)	**Level**	Fisher Chi-square	17.24	77.02 *	1.94	9.74	81.58 **	0.89
		Choi Z-stat	7.95	-1.42 *	15.03	10.07	-1.35 *	16.70
	First difference	Fisher Chi-square	186.96 ***	150.20 ***	152.18 ***	231.86 ***	201.56 ***	185.68 ***
		Choi Z-stat	-8.04 ***	-5.53 ***	-6.44 ***	-9.62 ***	-7.33 ***	-8.46 ***
LN(FDI*H$_2$)	**Level**	Fisher Chi-square	21.03	57.44	4.09	19.35	47.59	3.30
		Choi Z-stat	7.22	0.93	10.28	7.84	2.56	11.75
	First difference	Fisher Chi-square	187.51 ***	172.50 ***	241.91 ***	222.81 ***	227.53 ***	260.28 ***
		Choi Z-stat	-8.68 ***	-7.79 ***	-10.83 ***	-9.52 ***	-8.95 ***	-11.80 ***

*Note: ***, ** and * indicate the rejection of the null hypothesis at 1%, 5% and 10% level of significance, respectively. The lag lengths are selected by using SIC. The maximum number of lags is set to be two.*

4.2 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 with two kinds of human capitals can be checked by the panel cointegration tests. Table 4.2 presents the results of panel cointegration tests. The Pedroni tests are conducted in three types: test with no deterministic trend, test with deterministic intercept and trend, and test with neither deterministic intercept nor trend.

Pedroni (1999, 2004) proposed seven statistics to test for the null of no cointegration in heterogeneous panels. These tests comprise of two types. The first type is the panel cointegration tests (within-dimension) and the second is the groups mean panel cointegration tests (between-dimension). There are four statistics in the within-dimension tests, namely, panel v-statistic, panel rho-statistic, panel PP-statistic, and panel ADF-statistic. The between-dimension tests include three statistics, namely, group rho-statistic, group PP-statistic, and group ADF-statistic. All seven tests are distributed asymptotically as standard normal (Hamit-Haggar, 2010).

According to the Pedroni tests in Table 4.2, two of the four panel-based statistics show evidence of panel cointegration among the variables at a 5% level of significance. Additionally, two of the three group test statistics also reveal evidence of panel cointegration. In sum, four of the seven tests indicate that the null hypothesis of no cointegration is rejected at the 5% significance level among all the three types' tests. The Kao test also confirms panel cointegration at a 1% level of significance. Overall, there is strong statistical evidence in favor of panel cointegration among economic growth, FDI, and the interactions of FDI and knowledgeable human capital as well as technical human capital.

Table 4.2 *Panel cointegration tests results.*

Pedroni Test			
Test statistics	**No deterministic trend**	**Deterministic intercept and trend**	**No deterministic intercept or trend**
Panel v-statistics	3.097***	30.256***	-3.925
Panel rho-statistics	2.345	4.417	1.200
Panel PP-statistics	-0.102	-1.040	-1.919**
Panel ADF-statistics	-3.683***	-2.749***	-5.064***
Group rho-statistics	4.485	5.623	3.776
Group PP-statistics	-1.745**	-4.155***	-3.093***
Group ADF-statistics	-4.429***	-6.664***	-7.083***
Kao Test			
ADF	-4.739***		

*Note: ***, ** and * indicate the rejection of the null hypothesis at 1%, 5% and 10% level of significance, respectively. The test statistic is distributed N (0, 1) under null no cointegration.*

4.3 Panel Long-run Elasticities

To deal with the endogeneity bias in regressors, this paper employs the dynamic ordinary least squares (DOLS) approach to estimate the long-run relationship among FDI, human capital and economic growth in a panel context. Hausman test is employed to choose between fixed effect model and random effect model estimations. The null hypothesis in the Hausman test is that the correlated random effect model is appropriate (Hsiao and Hsiao, 2006). If the null hypothesis is rejected, fixed effect model will be confirmed to be the better estimation. The Chi-square statistic of the Hausman test for this model is 15.61 with probability of 0.016, which indicates that it is better to use the fixed effect model to estimate the long-run relationship between the four integrated variables. Table 4.3 presents the estimations of fixed effect model based on DOLS approach.

According to Table 4.3, the estimation of the fixed effect model shows that most of the variables have the expected signs; FDI positively affects the economic growth of

China during the period 1995-2009; FDI together with knowledgeable human capital exerts a more positive effect on economic growth compared with only FDI; knowledgeable human capital performs better than technical human capital when it is interacting with FDI. However, the coefficient of the positive effect of FDI on economic growth is not statistically significant at 10% significance level.

Table 4.3 *Fixed effect model estimation results.*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFDI	0.0125	0.0399	0.3136	0.7540
LN(FDI*H_1)	0.4497***	0.0237	18.9739	0.0000
LN(FDI*H_2)	-0.1832***	0.0326	-5.6141	0.0000
D(LNFDI(-1))	-0.0795*	0.0432	-1.8390	0.0668
D(LN(FDI*H_1(-1))	-0.2860***	0.0543	-5.2707	0.0000
D(LN(FDI*H_2(-1))	0.2532***	0.0496	5.1009	0.0000
Constant term	15.3036***	0.4873	31.4056	0.0000
Dependent var.: LNGDP	Mean Standard deviation		19.8469 0.9880	
Model size	Observation Parameters Degree of freedom		388 7 381	
Residuals	Sum of squares Standard error of regression		11.0739 0.1773	
Fit	R-squared Adjusted R-squared		0.9707 0.9678	
Model test	F-statistic F (prob.)		332.9912 0.0000	
Diagnostic	Log likelihood		139.3961	
Information criterion	Schwarz Criterion Akaike Info. Criterion		-0.1655 -0.5330	

*Note: *** and * indicate the rejection of the null hypothesis at 1% and 10% level of significance, respectively.*

Evidence of cointegration among variables also confirms the impossibility of spurious estimation. The panel DOLS estimation based on fixed effect model can be written as

$$LNGDP_{it} = \underset{(31.4056)^{***}}{15.3036} + \underset{(0.3136)}{0.0125}LNFDI + \underset{(18.9739)^{***}}{0.4497}LN(FDI * H_1)_{it} - \underset{(-5.6141)^{***}}{0.1832}LN(FDI * H_2)_{it}$$

$$-\underset{(-1.8390)^{***}}{0.0795}\Delta LNFDI_{it-1} - \underset{(-5.2707)^{***}}{0.2860}\Delta LN(FDI * H_1)_{it-1} + \underset{(5.1009)^{***}}{0.2532}\Delta LN(FDI * H_2)_{it-1} \quad (4.1)$$

where the numbers in parentheses denote *t*-ratios of the coefficients, *** indicates 1% level of significance.

The panel result indicates that FDI by itself does not generate positive effect on China's economic growth, whereas the interaction of FDI and knowledgeable human capital reveals a relatively high positive effect on economic growth. Result shows that a 1% increase in FDI together with knowledgeable human capital increases the GDP by 0.4497%. It confirms that knowledgeable human capital plays an important role in economic growth when it is interacting with FDI, the more knowledgeable human capital in the host economy, the stronger technological spillover effect generated by FDI. The panel elasticity of GDP with respect to the interaction of FDI and technical human capital reveals a significant negative sign with the coefficient of -0.1832. This indicates that technical human capital interacting with FDI cannot enhance economic growth in China. Evidence also implies that knowledgeable human capital is much more efficient than technical human capital together with FDI. This result may explain the reason why people paid more attention to academic high education instead of secondary technical education.

According to the above empirical results, Hypothesis 1 and Hypothesis 3 are rejected while Hypothesis 2 and Hypothesis 4 are accepted. The results show that FDI by itself does not play an important role in China's economy, while the interaction term of FDI and knowledgeable human capital reveals a relatively high positive impact on China's economic growth. The negative coefficient of the interaction term of technical human capital and FDI confirms that high academic education does play a more efficient role in the economy compared with secondary technical education.

4.4 Panel Granger Causality Tests

To examine the causal relationships of both short-run and long-run, panel Granger causality tests associated with vector error correction model (VECM) is estimated. The Engle and Granger two-step procedure is undertaken by first estimating the cointegration equation to obtain the estimated residuals. Next, defining the lagged residuals from the cointegration equation as the error correction term, the following dynamic error correction model is estimated:

$$\Delta LNGDP_{it} = \alpha_{1i} + \lambda_{1i} ECT_{i,t-1} + \sum_{k=1}^{q} \theta_{11i,k} \Delta LNGDP_{i,t-k} + \sum_{k=1}^{q} \theta_{12i,k} \Delta LNFDI_{it-k} + \sum_{k=1}^{q} \theta_{13i,k} \Delta LN(FDI * H_1)_{i,t-k} + \sum_{k=1}^{q} \theta_{14i,k} \Delta LN(FDI * H_2)_{i,t-k} + \mu_{1i,t} \quad (4.2)$$

$$\Delta LNFDI_{it} = \alpha_{2i} + \lambda_{2i} ECT_{i,t-1} + \sum_{k=1}^{q} \theta_{21i,k} \Delta LNGDP_{i,t-k} + \sum_{k=1}^{q} \theta_{22i,k} \Delta LNFDI_{it-k} + \sum_{k=1}^{q} \theta_{23i,k} \Delta LN(FDI * H_1)_{i,t-k} + \sum_{k=1}^{q} \theta_{24i,k} \Delta LN(FDI * H_2)_{i,t-k} + \mu_{2i,t} \quad (4.3)$$

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 hypotheses are as follows:

1) H_0: $\theta_{12i,k} = 0$ for $\Delta LNFDI$, H_0: $\theta_{13i,k} = 0$ for $\Delta LN(FDI * H_1)$, H_0: $\theta_{14i,k} = 0$ for $\Delta LN(FDI * H_2)$ for all i and k in Eq. (4.2);
2) H_0: $\theta_{21i,k} = 0$ for $\Delta LNFDI$, H_0: $\theta_{23i,k} = 0$ for $\Delta LN(FDI * H_1)$, H_0: $\theta_{24i,k} = 0$ for $\Delta LN(FDI * H_2)$ for all i and k in Eq. (4.3).

The coefficient of the error correction terms, λ_{ji} (j=1, 2), is called speed of adjustment, which represents how fast deviations from the long-run equilibrium are eliminated following changes in each variable. For the long-run causality, the null hypotheses: H_0: $\lambda_{1i} = 0$, H_0: $\lambda_{2i} = 0$, for all i are tested in Eq. (4.2) to Eq. (4.3), respectively. For example, if $\lambda_{1i} = 0$, then economic growth (GDP) does not respond to a deviation from the long-run equilibrium in the previous period. The panel Granger causality results are presented in Table 4.4.

Table 4.4 *Panel causality tests results.*

Dependent variable	Sources of causation (Independent variables)				
	Short-run				Long-run
	$\Delta LNGDP$	$\Delta LNFDI$	$\Delta LN(FDI * H_1)$	$\Delta LN(FDI * H_2)$	ECT
$\Delta LNGDP$		6.5792 [0.00]***	5.1718 [0.01]**	4.2031 [0.02]**	-5.3368 [0.00]***
$\Delta LNFDI$	24.434 [0.00]***		49.689 [0.00]***	0.663 [0.42]	-1.9448 [0.05]*

*Note: Partial F-statistics reported with respect to short-run changes in the independent variables while t-statistics reported with respect to long-run. Probability values are in brackets. Significance at the 1%, 5% and 10% levels denoted by ***, ** and *, respectively.*

Table 4.4 presents the results of panel Granger causality tests in both short-run and long-run. For the short-run causality, the coefficients of $\Delta LNFDI$, $\Delta LN(FDI * H_1)$, and $\Delta LN(FDI * H_2)$ are significant at 10% level, 5% level, and 5% level in Eq. (4.2), respectively, which rejected the null hypothesis of no short-run causation. It indicates that there is a short-run causality from FDI, the interaction of FDI and knowledgeable human capital as well as the interaction of FDI and technical human capital to GDP. In Eq. (4.3), the coefficients of $\Delta LNGDP$ and $\Delta LN(FDI * H_1)$ are both significant at 1% level, while the coefficient of $\Delta LN(FDI * H_2)$ is not statistically significant. It implies that there is a short-run causality from GDP and the interaction term of FDI and knowledgeable human capital to FDI but no short-run causality from the interaction term of FDI and technical human capital to FDI.

For the long-run causality, the coefficient of the lagged error correction term in Eq. (4.2) is -0.07 which statistically significant at 1% level. It indicates that there is a long-run causality from FDI, the interaction of FDI and knowledgeable human capital as well as the interaction of FDI and technical human capital to GDP. In other words, the economic growth responds to a deviation from the long-run equilibrium in the previous period. It also confirms the cointegration relationship among these four variables. In Eq. (4.3), the coefficient of the lagged error correction term is -0.13 which statistically significant at 10% level. It reveals that there is a long-run causality from GDP, the interaction of FDI and knowledgeable human capital as well as the interaction of FDI and technical human capital to FDI.

In summary, the results imply that there is a bi-directional Granger causality between GDP and FDI both in the short term and the long term.