

## Foreign direct investment and economic growth in Vietnam

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By making use of a recently released panel dataset that covers 61 provinces of Vietnam from 1996–2005, this study examines the link between foreign direct investment and economic growth. Our analysis, which is based on a simultaneous equations model, reveals that in overall terms a mutually reinforcing two-way linkage between FDI and economic growth exists in Vietnam. However, this is not the case for each and every region of Vietnam. The results presented in this study suggest that the impact of foreign direct investment on economic growth in Vietnam will be larger if more resources are invested in education and training, financial market development and in reducing the technology gap between the foreign and local firms.

**Keywords:** economic growth; foreign direct investment; globalization; Vietnam

### Introduction

Foreign direct investment (FDI) has contributed to impressive economic growth in a number of developing countries. Generally speaking, FDI not only increases the supply of capital but, given the appropriate host-country policies, it can also facilitate technology transfer. Technology transfer contributes to human capital formation which can further enhance prospects of economic growth. In other words, FDI can facilitate economic growth through direct as well as indirect channels.<sup>1</sup>

The introduction of the reform policy known as *Doi Moi* in 1986 marked the beginning of Vietnam's impressive economic growth. The reform process has resulted in a general increase in the standard of living in Vietnam as measured by real GDP per capita. Vietnam started attracting significant FDI from 1988, which can be attributed to promulgation of a liberal foreign investment law in 1987. FDI inflow into Vietnam increased from US\$0.32 billion in 1988 to approximately US\$4.0 billion in 2005, with an annual growth rate of 28% (GSO 2007).<sup>2</sup> In the early stages, the contribution of FDI to employment growth was small but there was a large increase in industrial output. In recent years, FDI inflows have played an important role, not only in providing investment capital but also in stimulating export growth. Figure 1 shows an interesting transition in Vietnamese economy; from 2001 onwards, the contribution of the manufacturing sector to GDP is consistently larger than that of the agricultural sector.

It is interesting to note that the presence of foreign firms also resulted in a significant increase in Vietnam government's tax revenue (Freeman 2002). Up until the late 1990s, most FDI was in the form of joint ventures where the local partner generally provided 30% of the total value of the investment (Binh and Haughton 2002). The entry of foreign firms

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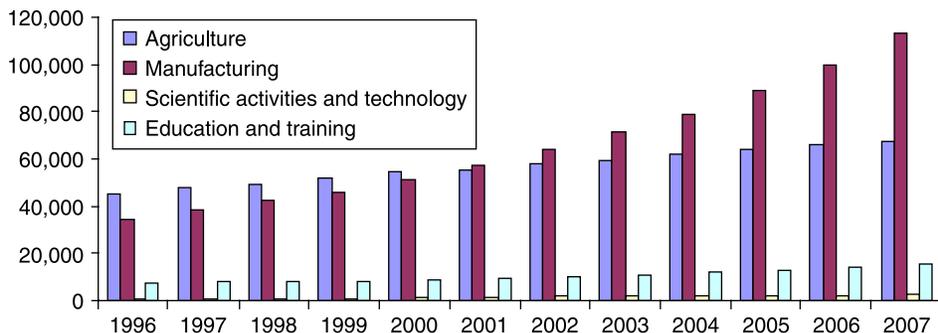


Figure 1. GDP by type of economic activity at 1994 constant prices (billion VND).  
Source: GSO (2008).

resulted in greater diversity and increased competition in Vietnam. FDI not only injected badly needed capital but also expanded the size of the private sector. In overall terms, the expansion of FDI in Vietnam can be viewed as the expansion of private sector in the country which greatly helped the economic reform process. The amount of actual investment reached its peak in 1995–1996. As highlighted by Freeman and Nestor (2004), due to the involvement of more than one government agencies and related factors, the actual investment in Vietnam has been well below the registered FDI. In addition, most FDI has been concentrated in a few regions of Vietnam. Changes to the foreign investment law in 1996 were aimed at achieving a relatively more even distribution of FDI across all regions of Vietnam. However, there has been only limited success. While the output of foreign firms in Vietnam has registered a steep rise from 1996 to 2005 and beyond, most foreign firms are still concentrated in Red River Delta and South East regions.

The flow of FDI to Vietnam was significantly affected by the Asian financial crisis of 1997–1998. Despite improvements to FDI related laws and a general improvement in foreign investor confidence, FDI activity in Vietnam remained subdued till 2001. Freeman (2001), among others, has argued that this reflects the failure of at least some aspects of government policy towards FDI. Changes to the foreign investment law, new enterprise law and signing of a free trade agreement with the US in 2001 led to substantial improvement in foreign investor sentiments toward Vietnam but there was not much increase in the FDI inflow. Other policies introduced by the Vietnamese government include the opening of a stock market and the resumption of IMF lending. These policies contributed to a slow increase in FDI during 2001–2003. Since then there has been a rapid rise in FDI in Vietnam. During the first seven months of 2008, FDI has already reached the amount of US\$45.2 billion (GSO 2008). This can also be attributed to Vietnam's accession to WTO in 2006. The accession to WTO is a clear recognition of Vietnam's economic reform policies and engagement with global economy. The process of accession to WTO started in early 1995 and ended in late 2006.

### Literature review

Endogenous growth literature (for example see Romer 1986, Lucas 1988, 1993) highlights the role of human capital in attracting foreign investment in developing countries. This literature suggests that foreign investment enhances economic growth through technology diffusion.<sup>3</sup> Multinational corporations (MNCs) that are a vehicle of FDI can have a positive impact on human capital in host countries, for example through training courses

offered to their subsidiaries' local workers. The training courses can be beneficial to all employees ranging from less skilled to highly skilled workers. Research and development activities undertaken by MNCs also contribute to human capital growth in host countries and thus enable their economies to grow in the long run (Balasubramanyam and Salisu 1991, Blomström and Kokko 2001).

On the other hand, the eclectic theory of FDI, developed by Dunning (1988), provides an alternative tool to analyse the relationship between FDI and economic growth. Based on location advantages, many empirical studies have found that economic growth is an important determinant of FDI. Chakrabarti (2001), for example, argues that higher economic growth results in higher FDI inflow. Recent empirical studies have used endogenous growth models to investigate the impact of FDI on economic growth in host developing countries. Borensztein *et al.* (1998) examine the impact of FDI on economic growth in 69 developing countries for the periods 1970–1979 and 1980–1989. They have utilized a model where economic growth is determined by FDI, human capital, government expenditure, domestic investment, inflation rate and institutions. In order to overcome the endogeneity problem, the model is estimated by two stage least squares (2SLS). They found that: (i) FDI inflows positively influence economic growth, and (ii) FDI and domestic investment were complementary.

By making use of panel data for the period 1970–1990 involving OECD and non-OECD countries, De Mello (1997) examined the impact of FDI on capital accumulation, output and total factor productivity growth. De Mello suggests that FDI provides a boost for economic growth in the long run through technological progress and knowledge spillovers. However, de Mello emphasises that FDI-led growth depends on the degree of complementarity and substitution between FDI and domestic investment. By using panel data for 18 countries in Latin America during the period 1970–1999, Bengoa and Sanchez-Robles (2003) found that the impact of FDI on economic growth is positive only when host countries had adequate human capital, economic stability and liberalized markets. Alfaro *et al.* (2004), using cross-country data for the period 1975–1995, found that FDI plays an important role in contributing to economic growth. However, countries with well-developed financial markets tend to gain more from FDI. This means that countries with relatively well-developed financial systems can better exploit FDI. As a result, FDI can make a larger contribution to economic growth. This finding is supported by Hermes and Lensink (2003) and Aghion *et al.* (2006). Moreover, these studies also emphasise that less developed countries should reform their domestic financial system before liberalizing the capital account to allow for enlarged FDI inflows.

Tsai (1994) employed a simultaneous system of equations to test two-way linkages between FDI and economic growth for 62 countries for the period 1975–1978 and for 51 countries for the period 1983–1986. His work supports the view that two-way linkages exist between FDI and growth. Berthelemy and Démurger (2000) used a simultaneous equation model involving 24 Chinese provinces for the period 1985–1996. They found that FDI inflows play an important role in promoting provincial economic growth. Bende-Nabende *et al.* (2001) investigated whether FDI caused economic growth in the ASEAN-5 economies during the period 1970–1996 and if that was so, whether economic growth had a significant affect in attracting FDI to the region. Their analysis shows that FDI promotes economic growth most effectively through human capital and learning by doing effects and, in turn, economic growth influences FDI.

Using panel data involving 84 countries over the period 1970–1999, Li and Liu (2005) utilized both single and simultaneous equation models to examine the relationship between FDI and economic growth. They found that only from the mid-1980s, FDI and

economic growth became significantly complementary to each other. Moreover, they show that FDI not only directly promotes economic growth but also, indirectly, through its interaction with other variables. There is a strong positive interaction effect, for example, involving FDI and human capital and a strong negative interaction effect involving FDI and technology gap. Wang and Gu (2006) have investigated the impact of absorptive capacity in the context of FDI in Canadian manufacturing industries. Wang and Gu found that FDI promotes economic growth only when host countries have an adequate level of human capital. Driffield and Love (2007), among others, have shown that through spillover effects, FDI can also boost productivity.

Although these studies provide ample evidence of a link between FDI and economic growth in both developed and developing countries, few studies have considered the role of FDI in promoting economic growth within different regions of developing countries. Mai (2003) has considered the impact of FDI on economic growth in Vietnam for the period 1988–1998. He concludes that FDI flows have resulted in enhancing domestic saving and investment. While providing a review of earlier studies on the role of FDI in Vietnam, Nguyen and Nguyen (2007) have conceded that the literature on Vietnam is still in its infancy. Moreover, the two-way linkage between FDI and economic growth in which FDI promotes economic growth and, in turn, economic growth is viewed as a tool to attract FDI is not thoroughly investigated. This study attempts to fill this gap in the existing literature.

By making use of panel data on 61 Vietnamese provinces for the period 1996–2005, this study attempts to empirically examine the two-way linkage between FDI and provincial economic growth in Vietnam. Most available empirical studies that deal with the effect of FDI in Vietnam have been severely limited due to the lack of appropriate data.<sup>4</sup> This study makes use of the most detailed annual dataset that has been recently released by the Vietnam government. Figure 2 shows the output of foreign and domestic firms for the period 1996–2005. It is clear that both foreign and domestic firms have experienced strong growth during the sample period.

## Hypotheses

The hypotheses tested in this study are as follows:

H<sub>1</sub>: A mutually reinforcing two-way linkage between FDI and economic growth exists in Vietnam.

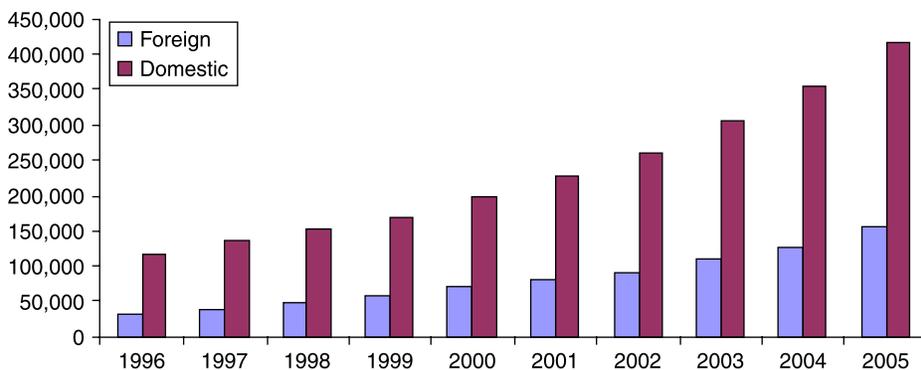


Figure 2. Output of foreign and domestic firms in Vietnam – 1994 constant prices (VND billion). Source: GSO (2008).

- H<sub>2</sub>: A mutually reinforcing two-way linkage between FDI and economic growth exists in all seven regions of Vietnam.
- H<sub>3</sub>: Regions with better infrastructure, more skilled labour and larger market size are relatively more attractive to foreign investors.
- H<sub>4</sub>: FDI significantly affects Vietnam's economic growth through its absorptive capacity.
- H<sub>5</sub>: Education and training enhances the impact of FDI on economic growth in Vietnam.
- H<sub>6</sub>: A smaller technology gap between the foreign and local firms enhances the impact of FDI on economic growth in Vietnam.

### **Empirical model and data sources**

In order to test the above hypotheses, this study makes use of panel data. Analysis of panel data yields more reliable statistical results because such data takes into account variation over time, as well as variation across all subjects (which in the present case are the 61 provinces of Vietnam). A good introduction to panel data techniques can be found in Greene (2008).

Based on the existing literature, it can be argued that economic growth and FDI depend on a number of factors. Some of the main determinants are discussed below. The discussion is used to develop an empirical model.

### ***Determinants of economic growth***

#### *Human capital*

Human capital is long regarded as a determinant of economic growth (see Barro and Sala-i-Martin 2004 and references therein). Human capital also affects growth through its interaction with FDI. A number of proxies have been used to measure human capital. This study uses the number of university and college enrolment per thousand persons as a proxy for human capital in Vietnam.

#### *Learning by doing*

Another well-known determinant of economic growth is learning by doing. Grossman and Helpman (1991) among others have emphasised that learning by doing can have a positive effect on growth during economic transition, as well as in the long term. Bende-Nabende *et al.* (2001) found that technological learning by doing has stimulated economic growth in the ASEAN-5 economies from 1970–1996. They used annual manufacturing value added as a percentage of GDP as a proxy for learning by doing. This study uses the same proxy to measure the extent of learning by doing in Vietnam.

#### *Exports*

The endogenous growth theory pioneered by Romer (1986) and Lucas (1988) has provided persuasive evidence for the proposition that an increase in exports as a percentage of GDP has a positive effect on economic growth. Grossman and Helpman (1991) and Barro and Sala-i-Martin (2004) have argued that a more open trade regime leads to a greater ability to absorb technological progress and export goods that stimulates economic growth. Grossman and Helpman (1991) and Rodrik (1992) have pointed out that exports can potentially create growth-accelerating forces.

*Macroeconomic stability*

While early studies, such as Friedman (1977) have highlighted the role of the inflation rate, recent studies have used the real exchange rate as an indicator of macroeconomic stability. The real exchange rate volatility is regarded as an indicator for poor macroeconomic policies that lead to real exchange rate misalignment thereby hindering economic growth (Kamin and Rogers 2000, Husain *et al.* 2005). This study uses the real exchange rate as an indicator of macroeconomic stability in Vietnam.

*Level of financial development*

Barro (1991) has argued that financial development has a significant positive impact on economic growth. King and Levine (1993) have suggested that higher levels of domestic investment are positively related to faster economic growth. Hermes and Lensink (2003) have argued that the development of the financial system of a host country is an important precondition for FDI to have a positive effect on economic growth. They further argue that a well-developed financial system positively contributes to the process of technological diffusion associated with FDI. Since the data on the usual measures of financial development is not available for Vietnam, this study uses domestic investment, as a percentage of GDP, as a proxy for financial development in Vietnam.

*Public investment*

In the case of developing countries, the effect of public investment on economic growth can be negative. Durham (2004) argues that when public investment is financed by increasing taxes, it could further raise distortions in developing countries and increase input costs and hence, its effect on output growth can be negative. Public investment is likely to have a positive effect on output growth if it is directed towards activities such as infrastructure improvement and human capital accumulation. Blankenau and Simpson (2004) have argued that governments play an essential role in human capital accumulation by providing funds for formal schooling. Public education expenditures directly affect human capital accumulation and consequently influence long-term growth. Accordingly, an increase in public investment spending is expected to have a positive effect on economic growth. This study uses the annual government investment expenditure as a percentage of GDP as a measure of public investment in Vietnam.

*Other determinants*

Recent studies by Sachs (2003) and Presbitero (2006) have argued that geography plays a direct and essential role in promoting economic growth through many channels including human health, agricultural productivity, physical location, and proximity and ownership of natural resources. Presbitero further argues that geographical conditions, especially climate and natural endowment, could directly influence the level of current income through the availability of natural resources as well as enabling access to international trade and commercial routes. On the other hand, geography also influences the disease ecology such as malaria and other tropical diseases, which hamper social and economic growth in different ways. The other well-known determinants of economic growth are labour force growth rate and FDI, both of which have been included as determinants of economic growth in Vietnam. While the above is not an exhaustive list, we believe that we have covered all major determinants of economic growth.

## ***Determinants of FDI***

### *Market size*

Market size which is one of the most important determinants of FDI is usually measured by GDP per capita. Several empirical studies have shown that an increase in GDP per capita is associated with increased FDI inflows into host countries. Rising income levels are a signal of an increase in the market size and purchasing power. Kravis and Lipsey (1982) found a positive relationship between the market size in host nations and the location decision of US multinationals. Chakrabarti (2001) found a strong positive relationship between the market size of a host country and FDI. Following the existing literature, this study uses GDP per capita as a measure of Vietnamese market size.

### *Infrastructure development*

Availability of international standard infrastructure is a major determinant of FDI in host countries. A number of empirical studies have used different proxies to measure the level of infrastructure development in host economies. For example, expenditure on road transport was used as a proxy by Hill and Munday (1992). Per capita usage of energy by Mudambi (1995), telephones per thousand of population by Asiedu (2002), railway transport by Bengoa and Sanchez-Robles (2003) and a general transportation/urbanization index by Glickman and Woodward (1988). This study utilizes telephones per thousand of population as a measure of infrastructure development in Vietnam. This choice is dictated by data availability constraints.

### *Labour market conditions*

Availability of cheap labour is a major determinant of FDI in developing countries. Moore (1993) and Lucas (1993) have suggested that FDI inflows tend to dry up as the cost of labour increases. The empirical studies by Biswas (2002) and Brainard (1997) found a negative relationship between the cost of labour and FDI inflows. This study uses the monthly average wage of employees as a measure of the labour cost in Vietnam. The other aspect of the labour market is the availability of skilled labour which is widely accepted as a determinant of FDI. This study uses the percentage of skilled labour in the total labour force as an additional labour market factor.

### *The level of openness*

A decrease in the level of openness (that is, more trade restrictions) tends to increase horizontal FDI in host countries. However, vertical FDI that is viewed as a non-market seeking investment may prefer to locate in more open economies (that is, where trade barriers are few). Balasubramanyam and Salisu (1991), Jackson and Markowski (1995) and Chakrabarti (2001) have used export volume as a measure of the openness of an economy. They have found a positive relationship between exports and FDI inflow. Buckley *et al.* (2007) has used a similar measure. This study uses exports per capita as a measure of openness of the Vietnamese economy.

### *Other determinants*

The other well-known determinants of FDI in host developing countries include the GDP growth rate, macroeconomic stability and domestic investment per capita. These three variables are also regarded as the determinants of FDI in Vietnam. A recent study by

Buckley *et al.* (2007) highlights the importance of many of the above determinants of FDI. Once again it is perhaps worth mentioning that the above is not an exhaustive list of the determinants of FDI.

For the purposes of the present study, we make use of a recently released panel dataset which provides annual data on 61 provinces of Vietnam for the period 1996–2005. Unfortunately, comparable provincial data on relevant variables is not available for previous years. The choice of the determinants of FDI and economic growth used in the empirical model specified below is dictated by the availability of data. Most of the data are collected from the General Statistics Office (GSO), the Ministry of Planning and Investment (MPI), the Ministry of Labour Invalids and Social Affairs (MOLISA) and the Ministry of Industry (MOI). See Table 1 for variable definition and data sources.

Based on the existing literature and given the data availability constraints, the two-way linkage between GDP growth and FDI in Vietnam is empirically examined by making use of the following system of equations, where  $FDI_{it}$  is FDI in province  $i$  in period  $t$  and so on, and  $\alpha_i$  and  $\beta_i$  are the unknown population coefficients.

$$G_{it} = \alpha_0 + \alpha_1 FDI_{it} + \alpha_2 SI_{it} + \alpha_3 XG_{it} + \alpha_4 HC_{it} + \alpha_5 DIG_{it} + \alpha_6 LA_{it} + \alpha_7 LD_{it} + \alpha_8 RER_{it} + \varepsilon_{it} \quad (1)$$

$$FDI_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 Y_{it} + \beta_3 DI_{it} + \beta_4 X_{it} + \beta_5 SKILL_{it} + \beta_6 WA_{it} + \beta_7 TEL_{it} + \beta_8 RER_{it} + \mu_{it} \quad (2)$$

Table 1. Variable definitions and data sources.

Abbreviations	Variable definition	Source
G	Provincial economic growth rate (annual %)	GSO
Y	GDP per capita (in thousands of VND at constant prices)	GSO
FDI	Stock of FDI per capita (in thousands of VND at constant prices)	MPI
SI	The ratio of annual government expenditure to GDP	GSO
X	Export of goods and services per capita (thousands of VND at constant prices)	GSO
XG	Ratio of exports to GDP	GSO
HC	Number of university and college students per thousand persons	GSO
DIG	The ratio of gross domestic investment to GDP	GSO
DI	Gross domestic investment per capita (thousands of VND at constant prices)	GSO
TEL	Telephones per thousand persons	GSO
LD	Learning by doing (annual manufacturing value added as a percentage of GDP is used as a proxy)	MOI
RER	Real exchange rate	GSO
SKILL	Percentage of skilled labour in total labour force	MOLISA
WA	Monthly average wage of employee (in thousands of VND at constant prices)	MOLISA
LA	The growth rate of labour (annual %)	MOLISA
DUMMY	Dummy = 1 if cities and provinces located in the key economic regions; zero otherwise	
$\varepsilon_{it}, \mu_{it}$	Error terms	

Table 2. The expected signs of the estimated coefficients.

	Dependent variables	
	Provincial economic growth rate (G)	FDI
G	n.a	+
FDI	+	n.a
SI	+/-	n.a
XG	+	n.a
HC	+	n.a
DIG	+	n.a
LA	+	n.a
LD	+	n.a
RER	-	+
Y	n.a	+
DI	n.a	+
X	n.a	+
SKILL	n.a	+
WA	n.a	-
TEL	n.a	+

Based on the existing literature, the expected signs of the estimated coefficients are described in Table 2.

The above simultaneous equations were estimated by making use of two-stage least squares (2SLS), three stage least squares (3SLS) and the generalized method of moments (GMM). In the following, we only report the results of GMM estimation (with and without a regional dummy variable). While the parameter estimates remained similar in magnitude and sign, the GMM estimation results were generally found to be statistically more robust.<sup>5</sup>

### Data analysis

While estimating the two-way linkage between FDI and economic growth, SI, XG, HC, DIG, LA, LD, RER, Y, DI, X, WA, SKILL, TEL and RER were used as instrumental variables. The Durbin-Wu-Hausman test was used to test for endogeneity. The null hypothesis was rejected, suggesting that ordinary least squares (OLS) estimates might be biased and inconsistent and hence OLS was not an appropriate estimation technique. In addition, the Pagan-Hall test was used to test for the presence of significant heteroskedasticity. The null hypothesis of homoscedasticity was rejected, suggesting that the GMM technique is consistent and efficient (see Greene 2008).

Based on the diagnostic tests (see Tables 3, 4, 5 and 6), the GMM results were found to be reliable in relative terms. The estimated coefficients are given in Tables 3 and 4.

Table 3 suggests that FDI is an important determinant of the provincial economic growth in Vietnam. The estimated coefficient of FDI in Table 3 is significant at 1% level. In other words, one can argue with 99% confidence that increase in FDI in Vietnam increases economic growth. Specifically, it is possible to argue that, other things remaining constant, a one thousand Vietnamese *dong* (VND) increase in FDI in Vietnam would contribute to an approximate 0.000054% increase in economic growth.

Other important determinants of economic growth in Vietnam are exports, government expenditure, the level of financial market development, the growth of labour force, learning

Table 3. Estimated results for Equation (1).

Dependent variable: provincial economic growth		
Independent variables	GMM estimation without regional dummy variable	GMM estimation with regional dummy variable
FDI	0.000054 (4.80)*	0.000049 (3.99)*
Exports (XG)	0.243119 (1.95)**	0.245129 (1.92)**
Government expenditure (SI)	0.068351 (0.29)	0.417532 (0.41)
Financial development (DIG)	1.256011 (2.93)*	1.184253 (2.71)*
Labour growth (LA)	0.157515 (2.58)*	0.408601 (2.88)*
Learning by doing (LD)	0.018336 (3.05)*	0.017551 (3.08)*
Human capital (HC)	0.038917 (2.64)*	0.037175 (2.58)*
Real exchange rate (RER)	-0.094108 (-4.27)*	-0.136351 (-4.82)*
Regional dummy (DUMMY)		0.391238 (1.13)
Constant	18.706020 (6.34)*	19.005950 (6.46)*
Hansen test ( <i>p-value</i> )	0.15	0.29
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.00	0.05
Pagan-Hall test ( <i>p-value</i> )	0.01	0.02
Observations	563	563

Note: Robust standard errors in parentheses. \*\*\*Significant at 10%; \*\*significant at 5%; \*significant at 1%.

by doing, human capital and the real exchange rate. The ratio of exports to GDP is significant at 1% level. The growth of the labour force is significant at 1% level. The estimated coefficient of government expenditure in Equation (1) is not statistically significant. The estimated coefficient of learning by doing is statistically significant at a 1% level and its sign is consistent with expectations. The significance of learning by doing perhaps reflects the fact that some production activities involve assembling only. In addition, the Vietnamese labour force is benefiting from knowledge spillovers thereby improving its productivity and hence, stimulating economic growth. The estimated coefficient of the real exchange rate has an expected negative sign and it is significant at the 1% level. The impact of human capital and

Table 4. Estimated results for Equation (2).

Dependent variable: FDI		
GMM estimation without regional dummy variable	GMM estimation with regional dummy variable	
Economic growth (G)	992.8359 (2.73)*	802.3072 (2.34)**
Market size (Y)	1.451904 (11.32)*	1.460676 (12.53)*
Domestic investment (DI)	0.050031 (5.71)*	0.052338 (6.64)*
Exports (X)	0.934665 (7.00)*	0.934665 (7.47)*
Labour skills (SKILL)	141.1244 (2.70)*	120.3292 (2.44)**
Labour cost (WA)	-5.460528 (-4.64)*	-4.867383 (-4.41)*
Infrastructure (TEL)	49.79898 (6.62)*	47.9732 (4.90)*
Real exchange rate (RER)	161.6789 (3.05)*	145.9019 (3.05)*
Regional dummy (DUMMY)		1179.619 (3.05)*
Constant	-34,870.23 (-3.86)*	-31,513.77 (-3.83)*
Hansen test ( <i>p-value</i> )	0.13	0.12
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.00	0.00
Pagan-Hall test ( <i>p-value</i> )	0.01	0.01
Observations	543	543

Note: Robust standard errors in parentheses. \*\*\*Significant at 10%; \*\*significant at 5%; \*significant at 1%.

Table 5. Impact of FDI on economic growth via absorptive capacity.

Dependent variable: provincial economic growth		
Independent variables	GMM estimation with interaction between FDI and human capital	GMM estimation with interaction between FDI and financial development
FDI	-0.000089 (-1.83)	0.000084 (4.53)*
Exports (XG)	0.264740 (2.16)**	0.334157 (2.22)**
Government expenditure (SI)	-0.390307 (-0.69)	-0.569683 (-0.57)
Financial development (DIG)	1.419888 (3.30)*	1.747579 (3.89)*
Labour growth (LA)	0.165762 (2.69)*	0.167893 (2.73)*
Learning by doing (LD)	0.020171 (3.42)*	0.018908 (3.01)*
Human capital (HC)	0.028890 (1.90)**	0.036969 (2.50)*
Real exchange rate (RER)	-0.096025 (-4.39)*	-0.094292 (-4.30)*
FDI* Human capital	0.000004 (2.25)**	
FDI* Financial development		-0.000059 (-2.22)**
Constant	19.19335 (6.54)*	18.59838 (6.34)*
Hansen test ( <i>p-value</i> )	0.21	0.34
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.01	0.00
Pagan-Hall test ( <i>p-value</i> )	0.00	0.01
Observations	563	563

Note: Robust standard errors in parentheses. \*\*\*Significant at 10%; \*\*significant at 5%; \*significant at 1%.

Table 6. Economic growth and FDI (impact of education and training and technology gap).

Dependent variable: provincial economic growth in Vietnam			
Independent variables	GMM estimation with education and training and technology gap	GMM estimation with interaction between FDI and education and training	GMM estimation with interaction between FDI and technology gap
FDI	0.000028 (2.81)*	0.000053 (3.19)*	-0.000006 (-0.05)
Exports (XG)	0.139887 (1.28)	0.148923 (1.25)	0.133530 (1.23)
Government expenditure (SI)	-1.592068 (-1.99)**	-1.628443 (-2.04)**	-1.574779 (-2.00)**
Financial development (DIG)	0.957675 (2.42)*	1.033599 (2.66)*	0.999145 (2.62)*
Labour growth (LA)	0.124454 (2.31)**	0.120881 (2.25)**	0.127988 (2.43)*
Learning by doing (LD)	0.018639 (3.73)*	0.018457 (3.27)*	0.021126 (4.47)*
Education and training	0.153391 (1.64)**	0.167511 (1.83)**	0.169995 (1.86)**
Technology gap	-2.178576 (-3.83)*	-2.210997 (-4.00)*	-1.442873 (-2.70)*
Real exchange rate (RER)	-0.064482 (-3.65)*	-0.063214 (-3.25)*	-0.056075 (-3.23)*
FDI*Education and training		-0.000025 (-2.01)**	
FDI*Technology gap			-0.000225 (-4.07)*
Constant	17.05742 (7.33)*	16.87612 (7.21)*	15.74285 (6.88)*
Hansen test ( <i>p-value</i> )	0.19	0.19	0.25
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.00	0.01	0.00
Pagan-Hall test ( <i>p-value</i> )	0.04	0.00	0.00
Observations	563	563	563

Note: Robust standard errors in parentheses. \*\*\*Significant at 10%; \*\*significant at 5%; \*significant at 1%.

financial market development on economic growth is statistically significant at the 5% level and the signs are positive.

Table 4 shows that economic growth has a significant positive effect on FDI in Vietnam. The estimated coefficient is significant at 5% level. The estimated coefficient indicates that, other things remaining constant, a 1% increase in economic growth would lead to an increase in the stock of FDI per capita by approximately VND993,000. This suggests that higher economic growth in Vietnam does send positive signals to prospective foreign investors. It also shows an increasingly larger market size for investment in Vietnam. GDP per capita, which is used as a measure of market size, has a positive and significant effect on FDI (GMM estimation yields an estimated coefficient which is significant at a 1% level, see column 1, Table 3). The estimated coefficient of domestic investment is positive and statistically significant at 1% level, implying that FDI and domestic investment in Vietnam are complements. In other words, increase in domestic investment increases FDI in Vietnam and vice versa. The coefficient of exports is consistent with expectations and statistically significant at the 1% level. The skill level of the labour force is an important determinant of FDI in Vietnam. An increase in the proportion of the skilled labour force leads to a significant increase in FDI in Vietnam. The negative coefficient of the labour cost is significant at 1% level. This suggests that an increase in the cost of labour in Vietnam can reduce FDI. The impact of infrastructure development on FDI is positive and statistically significant at 1% level. Finally, depreciation of the real exchange rate in Vietnam tends to raise FDI and this effect is statistically significant at 1% level.

The geographical distribution of FDI in Vietnam is characterized by its concentration in the key economic cities and provinces in the South such as Ho Chi Minh City, Dong Nai, Binh Duong and Baria Vung Tau, and in the North such as Hanoi, Hai Duong, Vinh Phuc, Hai Phong and Quang Ninh. Thus, we extended our model by introducing a dummy variable for provinces in the key regions including Red River Delta and South East, which have the highest inflows of FDI. It is expected that cities and provinces in the key economic regions with better infrastructure, skilled workers, and higher income tend to attract more FDI and grow faster. Column 3 of Table 3 and Table 4 show the estimated results when Equations (1) and (2) are re-estimated by GMM after inclusion of a regional dummy variable. The regional dummy variable has a positive sign in both the economic growth and FDI equations. In economic growth equation, it is not significant. In FDI equation, the regional dummy variable is significant at 1% level. The introduction of the dummy variable leads to a minor change in the magnitude of the estimated coefficients without affecting their significance level. The estimated results suggest that cities and provinces in the key economic regions such as Red River Delta and South East with better infrastructure, more skilled labour and larger market size tend to attract more FDI.

Recent empirical studies have argued that the impact of FDI on economic growth also depends on the existence of adequate absorptive capacity in host economies. Absorptive capacity of an economy can be measured by factors such as the stock of human capital, the level of financial market development and the extent of technology gap between the foreign and local firms. It has been argued that FDI has a direct and indirect effect on economic growth. The direct effect arises from a FDI-led increase in the supply of capital which increases the overall production capacity of the host economy. The indirect effect on economic growth arises from FDI's interaction with factors such as the level of financial development, the stock of human capital and the extent of technology gap. In order to examine the effect of FDI on economic growth through Vietnam's absorptive capacity, Equation (1) is re-estimated after introducing: (i) the interaction of FDI and

human capital, and (ii) the interaction of FDI and the level of financial market development, as additional independent variables.

Table 5 shows the estimated results when absorptive capacity has been explicitly taken into account. As can be seen in Table 5, the estimated coefficient of the interaction between FDI and human capital is positive and statistically significant at 5% level. This implies that as far as the stock of human capital is concerned, Vietnam has reached the minimum required threshold. Table 5 shows that the estimated coefficient of the interaction between FDI and the level of financial market development is negative and statistically significant at 5% level. This suggests that as far as the level of financial market development is concerned, Vietnam has not reached the required minimum threshold. In other words, by further developing its financial markets, Vietnam can take additional advantage of FDI inflows.

The endogenous growth theory suggests that expenditure on education and training and the extent of technology gap affects the capacity of host countries to absorb externalities from FDI (Lucas 1988, 1993). Thus, we further investigate the effect of real spending on education and training and the extent of technology gap on provincial economic growth in Vietnam, as well as their effect on economic growth via the absorptive capacity. Since human capital and spending on education and training are highly correlated, we replace human capital variable with real spending on education and training in Equation (1) and introduce the technology gap as an additional independent variable (the estimated results are shown in column 2, Table 6). The impact of the interaction between the new measure of human capital and FDI on economic growth (the estimated results are shown in column 3, Table 6) is also investigated. Column 4 of Table 6 shows the estimated results when the interaction between FDI and technology gap has been explicitly taken into account. The technology gap is measured as the percentage difference between the average growth of foreign and domestic firms in Vietnam. The estimated coefficient of the education and training variable was expected to be positive, while the estimated coefficient of the technology gap variable is expected to be negative.

Column (2) of Table 6 indicates that the estimated coefficient of education and training is positive and statistically significant at a 10% level. This means investment in education and training contribute positively to provincial economic growth in Vietnam. The estimated coefficient of the technology gap is negative and significant at the 1% level. This confirms that Vietnamese provinces with lower technology gap experience a higher rate of economic growth. We also investigate the effects of FDI on economic growth via absorptive capacity (see column 3 and 4 in Table 6). The estimated coefficient of the interaction between FDI and education and training is found to be negative and statistically significant at 5% level. This suggests that as far as education and training is concerned, Vietnam has not reached the required minimum threshold. In other words, a certain level of investment in education and training is an important prerequisite for FDI to have a positive effect on economic growth in Vietnam. The coefficient of the interaction between FDI and technology gap is negative and statistically significant at 1% level. This suggests that technology gap between the foreign and local firms in Vietnam remains very large. In other words, an increase in FDI will lead to a larger positive effect on economic growth as the technology gap narrows.

Finally in order to focus on the link between FDI and regional economic growth in Vietnam, the dataset was divided into seven regions namely Red River Delta, North East, North Central Coast, South Central Coast, Central Highland, South East and Mekong River Delta. Equations (1) and (2) were estimated for each region. The estimated results are reported in Tables 7 and 8.

Table 7. FDI and economic growth across regions of Vietnam – estimation of Equation (1).

Independent variables	Dependent variable: provincial economic growth													
	Red River Delta		North East		North Central Coast		South Central Coast		Central Highlands		South East		Mekong River Delta	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
FDI	0.00014 (1.77)***	0.00012 (1.73)***	0.00023 (2.53)*	0.00017 (2.47)**	0.00014 (0.31)	0.00022 (0.44)	-0.00010 (-0.91)	-0.00004 (-0.64)	0.00005 (0.34)	0.00001 (0.09)	0.00005 (2.53)**	0.00004 (1.75)***	0.00021 (2.42)**	0.00011 (1.79)***
Exports	6.42506 (1.90)***	5.20811 (1.92)***	0.08556 (0.74)	0.04785 (0.47)	1.26410 (0.25)	-1.46854 (-0.40)	0.90797 (0.88)	1.29376 (1.57)	12.85454 (2.19)**	12.07474 (2.43)**	-0.33064 (-0.78)	0.38598 (1.04)	-0.88852 (-0.67)	-1.03949 (-1.04)
Government expenditure	-1.10107 (-0.24)	-4.69388 (-0.85)	0.28395 (0.13)	-1.30221 (-0.82)	2.01699 (0.84)	2.01335 (1.08)	-2.36012 (-0.48)	-0.19845 (-0.07)	5.05208 (0.87)	-3.61032 (-0.56)	0.77686 (0.22)	4.44505 (1.36)	8.83748 (1.02)	-0.42617 (-0.08)
Financial development	-0.14261 (-0.13)	0.25519 (0.32)	1.51797 (1.80)***	0.39584 (0.67)	-1.12959 (-0.81)	1.29045 (1.16)	3.99309 (1.81)***	2.43389 (1.49)	2.61229 (2.00)***	2.98583 (2.31)**	-0.08251 (-0.08)	-0.17981 (-0.25)	4.52427 (1.45)	2.05649 (1.04)
Labour growth	0.46764 (2.45)*	0.45587 (2.74)*	0.23917 (1.80)***	0.22345 (2.18)**	0.48521 (2.51)**	0.41823 (2.23)**	-0.22503 (-0.70)	0.09818 (0.42)	-0.18133 (-0.87)	-0.22505 (-1.55)	0.34520 (2.53)**	0.43912 (3.33)*	0.07403 (0.37)	0.12387 (0.87)
Learning by doing	0.06731 (3.19)*	0.02357 (1.57)***	0.01858 (1.10)	0.01471 (1.07)	0.02984 (2.43)**	0.02041 (1.55)	0.04942 (2.04)**	0.02118 (1.26)	0.26953 (3.94)*	0.19977 (4.03)*	0.02560 (2.08)**	0.03464 (2.98)*	-0.01125 (-0.71)	-0.00213 (-0.19)
Human capital	0.20041 (4.17)*	0.02785 (0.78)			0.04928 (1.18)		0.08575 (1.18)		-0.07627 (-0.69)		0.08841 (2.20)**		0.11025 (1.82)***	
Education and training		-0.08913 (-0.20)		0.37265 (3.82)*		-0.13639 (-0.59)		0.08318 (0.24)		0.52046 (0.95)		0.98549 (2.82)*		0.52633 (0.76)
Technology gap		-5.33767 (-6.64)*		-2.25395 (3.82)*		-2.73439 (-5.64)*		-3.04810 (-5.02)*		-0.87227 (-5.87)*		-2.41062 (-3.39)*		-3.19066 (-4.89)*
Real exchange Rate	-0.02963 (-0.60)	-0.07732 (-2.25)**	-0.06106 (-1.51)	-0.07811 (-2.41)**	-0.13964 (-3.83)*	-0.11399 (-3.74)*	-0.12597 (-3.06)*	-0.08180 (-2.61)*	-0.33944 (-2.46)**	-0.30676 (-2.61)**	-0.08565 (-2.00)**	-0.06054 (-2.03)**	0.01439 (0.22)	-0.02301 (-0.43)
Constant	3.87943 (0.59)	20.65596 (4.25)*	14.54761 (2.48)**	18.65215 (4.22)*	23.46286 (4.18)*	23.71362 (5.74)*	19.83040 (3.95)*	17.68807 (4.03)*	46.38253 (2.78)*	42.72019 (2.96)*	16.72060 (2.91)*	17.72980 (4.36)*	7.76355 (0.87)	12.02118 (1.67)***
Hansen test ( <i>p-value</i> )	0.30	0.12	0.15	0.38	0.11	0.13	0.15	0.48	0.26	0.33	0.38	0.16	0.24	0.25
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pagan-Hall test ( <i>p-value</i> )	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Observations	114	114	99	99	59	59	52	52	52	52	72	72	126	126

Note: Robust t-statistics in parentheses. \*\*\*Significant at 10%, \*\*significant at 5%, \*significant at 1%. (1) refers to estimation without human capital but with education and training and technology gap; (2) refers to estimation without human capital.

Table 8. FDI and economic growth across regions of Vietnam – estimation of Equation (2).

Independent variables	Dependent Variable: FDI						
	Red River Delta	North East	North Central Coast	South Central Coast	Central Highlands	South East	Mekong River Delta
Economic growth (G)	357.1346 (2.13)**	1420.024 (2.14)**	16.1933 (0.10)	1752.165 (1.84)***	1092.428 (3.43)*	800.5879 (2.24)**	1359.939 (4.36)*
Market size (Y)	-0.35611 (-0.73)	1.17561 (2.13)**	0.57826 (2.60)**	0.09475 (0.07)	-3.16549 (1.28)	1.48112 (11.20)*	2.35996 (4.69)*
Domestic investment (DI)	0.06045 (4.45)*	-0.00144 (-0.12)	0.00791 (1.66)***	0.19618 (5.10)*	0.01204 (0.51)	0.09811 (4.88)*	-0.01034 (-0.33)
Exports (X)	3.52437 (5.64)*	0.00055 (0.09)	1.61541 (2.84)*	0.41549 (0.59)	3.32545 (1.49)	1.12183 (6.99)*	1.31494 (5.89)*
Labour skills (SKILL)	-20.5079 (-0.27)	-61.04864 (-0.29)	-8.31117 (-0.17)	21.98845 (0.09)	908.0682 (1.56)	-53.01174 (-0.64)	264.8906 (3.96)*
Labour cost (WA)	-3.98111 (-2.05)**	-9.00163 (-3.29)	0.16291 (0.18)	4.76716 (1.06)	-3.74196 (-2.74)*	-9.36981 (-4.38)	-5.67121 (-2.95)*
Infrastructure (TEL)	29.8732 (1.66)***	46.58105 (2.10)**	1.62203 (0.15)	4.51481 (0.15)	252.2178 (4.04)*	63.50253 (5.05)*	67.3222 (2.35)**
Real exchange rate (RER)	111.8684 (2.21)**	72.02627 (1.02)	14.28568 (0.50)	546.9898 (3.54)*	-4.09019 (-0.03)	207.5025 (2.80)*	71.84067 (0.87)
Constant	-17,005.18 (-2.37)**	-19,180.60 (-1.61)***	-2169.047 (-0.42)	-966,643.58 (-3.56)*	6673.767 (0.28)	-36,870.3 (-3.19)*	-8555.537 (-0.67)
Hansen test ( <i>p-value</i> )	0.11	0.38	0.63	0.79	0.19	0.21	0.44
Durbin-Wu-Hausman test ( <i>p-value</i> )	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Pagan-Hall test ( <i>p-value</i> )	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	114	99	59	52	52	72	126

Note: Robust t-statistics in parentheses. \*\*\*Significant at 10%; \*\*significant at 5%; \*significant at 1%.

The estimated results indicate that the effect of FDI on economic growth is positive and significant only in Red River Delta, North East, South East and Mekong River Delta which can be attributed to the fact that infrastructure, financial system and education systems in these regions are relatively more developed. Table 8 shows that except for North Central Coast, the effect of economic growth on FDI in all regions is positive. This implies that the hypothesis of a two-way linkage between FDI and economic growth holds only in Red River Delta, North East, South East and Mekong River Delta regions. In summary, except for  $H_2$ , data analysis supports all hypotheses.

## Discussion

The growth of FDI in Vietnam and its desired effect on economic growth appear to support the Vietnamese government policy, specifically the Law of Foreign Investment which was introduced in 1987. Our analysis suggests that in the case of Vietnam, exports and FDI are complementary which explains why FDI in Vietnam is mainly concentrated in

the export-oriented manufacturing sector. Other factors, such as the stock of human capital, investment in education and training, the level of financial market development and the extent of technology gap between foreign and local firms are also important determinants of economic growth in Vietnam. The results presented in this study also highlight the role of the level of infrastructure development, the availability of skilled labour and market size in attracting FDI to the Red River Delta and South East regions of Vietnam.

Our empirical analysis suggests that as far as the level of financial market development, spending on education and training and technology gap are concerned, the Vietnamese economy has not reached the required minimum threshold that would ensure that the indirect effect (also known as the spillover effect) of FDI on economic growth is positive. In other words, the empirical evidence suggests that Vietnam is unable to take full advantage of FDI inflows because: (i) its financial market is insufficiently developed, (ii) spending on education and training is insufficient, and (iii) technology gap between the foreign and local firms is too large.

Region wise, analysis reveals that a two-way linkage between FDI and economic growth exists only in four regions: Red River Delta, North East, South East and Mekong River Delta. This suggests that Vietnam is facing the problem of uneven economic development. This problem is not specific to Vietnam. Other fast developing economies, such as China and India, are facing the same problem. Indeed, the ruling party in India lost the general election held in 2004 due to public dissatisfaction arising from income distributional concerns.

The issue that is not explicitly considered by this study is the lack of focus in FDI in Vietnam. Freeman (2002) and Kokko *et al.* (2003), among others, have argued that FDI in Vietnam is largely unfocused. While the government of Vietnam has been inviting foreign investment in all sectors, during the first seven months of 2008, the real estate and tourism sectors received more than 47% of FDI (GSO 2008). There is also evidence that FDI is contributing to the trade deficit in Vietnam. Rapid globalization has resulted in a situation where MNCs are dispersing production activities to various locations around the globe. Based on its comparative advantage, Vietnam needs to recognize its place in the value chain. A policy which directs FDI to industries where Vietnam has cost advantage over competing locations is highly desirable.

### **Implications**

The empirical analysis presented in this study confirms that, in overall terms, an increase in the stock of FDI increases Vietnam's economic growth rate which attracts further FDI into Vietnam. FDI boosting policies are likely to lead to further increase in exports and hence the rate of economic growth. Policy makers in Vietnam need to develop long-term strategies that would increase the country's rate of human capital accumulation. Human capital growth (for example, through increased spending on advanced education and training) contributes to economic growth by facilitating the adoption of foreign technologies. Additional investment in infrastructure development (including transportation and telecommunication systems) and education are likely to result in a higher level of foreign investment in Vietnam. The empirical analysis presented in this study also suggests that the Vietnamese government needs to take immediate steps to: (i) further develop the local financial market; (ii) increase spending on education and training; and (iii) reduce the technology gap between the foreign and local firms. These steps will allow the Vietnamese economy to take greater advantage of FDI-related spillover effects.

In other words, policy makers need to develop strategies that will enhance the country's absorptive capacity. Singapore has been very successful in this regard and policy makers in Vietnam should consider utilizing some of the successful Singaporean strategies in Vietnam.

Regional analysis shows that FDI is a significant determinant of economic growth in only four out of seven regions of Vietnam. This suggests that policy makers need to develop strategies that would help to attract more FDI to the three regions that are presently not very attractive to foreign investors. This, among other things, requires better coordination among different levels of government and industry involvement.

For MNCs, the implication is that while investment in four regions, where there is a strong mutually reinforcing link between FDI and economic growth, is likely to continue to result in excellent returns on investment at least in the short term, investment in the remaining three regions through first mover advantage is likely to lead to handsome returns in the long-term.

## **Conclusions**

The causal relationship between FDI and economic growth remains an issue of intense debate among researchers. While this debate has provided rich insights into the relationship between FDI and economic growth in a number of developing countries, few empirical studies have considered the case of Vietnam.

By making use of a recently released panel dataset which covers 61 provinces of Vietnam over the period 1996–2005, this study attempts to examine a series of hypotheses concerning the link between FDI and economic growth and related issues. The empirical analysis, which is based on a simultaneous equations model, supports the view that in overall terms a mutually reinforcing two-way linkage between FDI and economic growth exists in Vietnam. While the direct effect of FDI on economic growth in Vietnam is positive, the indirect effect through the economy's absorptive capacity (as measured by factors such as the level of financial market development, spending on education and training and the extent of technology gap) was found to be negative. Finally, we also explored the link between FDI and economic growth across seven regions of Vietnam. The empirical analysis reveals that a two-way linkage between FDI and economic growth exists only in four regions: Red River Delta, North East, South East and Mekong River Delta.

## ***Limitations and future research***

While the sample size, which is in excess of 500 observations, is sufficiently large for the present study, comparable provincial data for the period 1988–1995 is not available. It is therefore not possible to compare the impact of FDI on economic growth during the pre- and post-Asian crisis periods. The quality of data as highlighted by Freeman and Nestor (2004) is also an issue that has to be kept in mind. However, such problems are common in most developing countries. Due to the lack of data, it was not possible to consider other variables such as the quality of local government and the level of corruption which remains a serious concern.

It may also be worthwhile to re-examine the two-way linkage hypothesis and related issues by using the growth rate of total factor productivity (TFP), instead of the growth rate of total production. This study uses proxies for some variables such as the level of financial development and infrastructure development. Future studies should consider using better proxies. An emerging area of research which has started to receive some attention is

measurement of the spillover (that is, indirect) effect of FDI. In other words, most existing studies on Vietnam have solely considered the direct effect of FDI on economic growth. Spillover effect can be horizontal, vertical-forward or vertical-backward. It will be useful to investigate the impact of FDI-related spillovers on total factor productivity. This will allow one to evaluate the impact of FDI on technological progress in Vietnam. Finally, this research can be further extended by examining the impact of FDI-led economic growth on income distribution in Vietnam.

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### Notes

1. See Keller (2004), Meyer (2003, 2004), Lipsey (2002) and Marino (2002) for an interesting survey.
2. From 1 January 2008 to 22 April 2008, Vietnam has already attracted FDI in the amount of US\$7.22 billion (GSO 2008).
3. Prior to this, Findlay (1978) has argued that FDI increases the rate of technological progress in host economies through a 'contagion' effect arising from the introduction of more advanced technology, management practices, and so forth.
4. See Nguyen and Nguyen (2007) and references therein.
5. It is well-known that the GMM method provides consistent and efficient estimates in the presence of arbitrary heteroskedasticity (Greene 2008). Moreover, most of the diagnostic tests discussed in this study can be cast in a GMM framework. Hansen's *J*-test was used to test for over-identification of GMM (that is the null hypothesis of correct model specification and valid over-identifying restrictions was tested and the results were found to be satisfactory).

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