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THREE EMPIRICAL ESSAYS ON FOREIGN DIRECT INVESTMENT, RESEARCH AND DEVELOPMENT, AND INSURANCE

by

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ABSTRACT

FACULTY OF LAW, ART & SOCIAL SCIENCES
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This dissertation consists of three independent essays, all of which are empirical treatments of different determinants of economic growth.

The first essay, which is in Chapter 2, evaluates the role economic freedom plays in mediating the effect of foreign direct investment (FDI) on growth. It tests whether countries with sufficiently high level of economic freedom can exploit FDI more efficiently. It uses cross-country observations from 84 countries for the 1976-2005 period. It applies a threshold regression which is flexible enough to accommodate the possibility that the impact of FDI on growth 'kicks in' only when the level of economic freedom exceeds some unknown threshold. The results show that FDI has no direct (linear) effect on output growth. Instead, its impact is conditional on the level of economic freedom in the host countries. Only countries whose level of economic freedom has exceeded the threshold level of economic freedom benefited from FDI inflows. In countries below the threshold level, FDI deliver no beneficial effects. The findings are robust to several sensitivity checks and consideration of endogeneity.

The second essay (Chapter 3) tests the channels and magnitude of R&D spillovers from developed countries to East Asian countries (China, Korea, Malaysia, Singapore, and Thailand). It examines three possible spillover channels - imports, inward FDI, and outward FDI - using panel data for the period 1984-2005. It uses a novel panel estimator which allows for cross-sectional dependence and provides country-specific estimates of R&D effects. There are several important conclusions emerge. First, both domestic and foreign R&D are important for productivity improvements. Second, imports are the most important channel of spillovers while spillover effects via FDI in uncertain. Third, there is some evidence that domestic R&D helps to increase the incidence of R&D spillovers, especially via import channel. Fourth, the U.S. is a relatively stronger provider of spillovers than Japan.

Chapter 4, which is the final essay, examines the impact of insurance sector development on output growth, capital accumulation and productivity improvement. It uses panel data from 52 countries for the period 1981-2005, and applies a recent generalized-method-of moments (GMM) dynamic panel estimator. The results show that the development of insurance sector is important for long-run output growth, capital accumulation and productivity growth. For developing countries, insurance affects growth predominantly through capital accumulation while in developed countries it enhances productivity growth. The findings are robust to biases introduced by unobserved country-specific effects, simultaneity, weak or numerous instruments. It remains valid even after controlling for bank and stock market developments.

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List of Abbreviations

2SLS	Two-Stage Least Square
ASEAN	Association of Southeast Asian Nations
DOLS	Dynamic Ordinary Least Square
DSUR	Dynamic Seemingly Unrelated Regression
EF	Economic Freedom
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Square
G-5	France, Germany, Japan, United Kingdom, United States
GDP	Gross Domestic Product
GMM	Generalised Method of Moments
IMF	International Monetary Funds
LM	Lagrange Multiplier
MNCs	Multinational Corporations
MSE	Mean Square Error
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PPP	Purchasing Power Parity
TFP	Total Factor Productivity
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
U.S.	United States of America

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Declaration of Authorship

I, **Wan Azman Saini Wan Ngah**

Declare that the thesis entitled

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and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this university;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this university or any other institutions, this has been clearly stated;
- where I have consulted the published work of other, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed: ………………………………

Date: …………………………………

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1. INTRODUCTION

Ever since the publication in 1776 of Adam Smith's seminal work, *An Inquiry into the Nature and Causes of the Wealth of Nations*, understanding economic growth has been at the forefront of the research agenda. Throughout history, economists have inquired into the causes of growth and on the policies that countries can implement to maintain and promote it. However, explaining why some countries grow faster than others is a complex matter, and the literature on the subject is filled with controversies, either technical or ideological in nature. Nevertheless an overwhelming number of recent studies identify more than sixty different variables (put forward by theorists) that empirically contribute to our understanding of long term economic growth (Durlauf *et al.*, 2005, Sala-i-Martın, 1997).

For example, there is little agreement amongst researchers concerning the impact of foreign direct investment (FDI) on economic growth, despite a strong theoretical prediction theoretical prediction that FDI contributes to economic growth through the diffusion of superior technologies. There is however substantial empirical support for the positive effects of technological improvements on economic growth through its positive impact on productivity. There is also broad empirical support for the positive contribution of financial markets development in sustaining and promoting it. However, there is a difference between both: financial markets exert an indirect influence on growth rates, mainly by improving the efficiency of investment allocations.

This dissertation contributes to the empirical literature by deepening our understanding on the three growth-related factors mentioned in the previous example. In chapter 2, economic freedom is shown to condition the impact of foreign direct investment (FDI) on output growth. Chapter 3 examines the impact of foreign research and development (R&D) activity on domestic productivity. Chapter 4 studies the effect of insurance sector development on economic growth.

Chapter 2 is inspired by recent empirical findings pointing towards an ambiguous effect of FDI on growth. Although FDI has been traditionally understood as making a superior technology available, economists have yet to empirically agree on the benefits of attracting more FDI. One key explanation for this mixed finding is that the existing research fails to account for contingency effects in the FDI-growth relationship. Several recent models suggest that the diffusion of knowledge depends on other intervening factors, broadly defined as the absorptive capacity of the recipient country. In the current context, absorptive capacity refers to factors that help FDI recipients to optimize the absorption and internalization of FDI-generated externalities. Several factors have been put forward as essential to absorptive capacity: financial markets, human capital, and recipient countries' trade policy. In line with this view, this paper takes a step forward by proposing economic freedom as an additional channel through which FDI enhances output growth. The main insight is that in economically freer societies, economic agents have more incentive to carry out productive activity. Also, in such environment many obstacles that limit the efficient diffusion of knowledge have been abolished. To provide empirical support for this hypothesis, this paper uses a regression model based on the concept of threshold effects.

This paper contributes to the literature in two important ways. First, it provides the first empirical evidence on the significant role of economic freedom in moderating the impact of FDI on output growth. Second, it departs from the existing literature from a methodological standpoint by explicitly allowing for the possibility that the impact of FDI on growth is nonlinear and can be characterized by threshold effects. Most studies on absorptive capacity have used interaction specifications which restrict the impact of FDI on growth to be monotonically dependent on absorptive capacity indicators. Threshold regression is more flexible and provides a better way of understanding the links between absorptive capacity and FDI spillovers. In particular, it can accommodate the economically meaningful possibility that FDI 'kicks in' on growth only after host countries reach a certain level of economic freedom.

Chapter 3 examines empirically the impact of foreign R&D on the productivity of East Asian countries. Economic theory predicts that innovative activity such as R&D is one of the most important sources of productivity growth. However, only a few developed countries being responsible for a large fraction of world's total R&D expenditure. Since the benefits of R&D cannot be completely internalized, third countries can benefit from their effort in R&D through economic interactions. Two important channels through which R&D spillovers may spread are imports and FDI. A large body of the literature empirically confirms that cumulative foreign R&D is an important determinant of productivity growth in the home country. However, most of the studies have focused on spillovers within developed countries (especially OECD countries). Little is known about how OECD R&D activities affect the productivity of less developed countries. This chapter constitutes an attempt to fill this gap by assessing R&D spillovers from G-5 countries to East Asian countries. East Asian countries were chosen because of their remarkable growth performance over the past three decades; furthermore they are increasingly open to both trade and FDI. Taking advantage of recent developments in nonstationary panel data techniques, a dynamic seemingly unrelated regression (DSUR) estimator is implemented to generate consistent estimates of the impact of R&D stocks (i.e.

both domestic and foreign) on total factor productivity (TFP). Specifically, this chapter answers the following questions:

(i) What are the channels of R&D spillovers from G-5 countries to East Asian countries?

(ii) Does absorptive capacity help to increase the incidence of spillovers?

(iii) For East-Asian countries, does R&D spill over more from Japan or from the United States?

This paper contributes to the literature addressing North-South R&D spillovers. In particular, it is in the spirit of Coe *et al.* (1997) or Madden *et al.* (2002) extending the literature along the following dimensions. First, in addition to the trade channel that they analyze, two additional channels are simultaneously considered: inward and outward FDI. Second, this study uses R&D data provided by the United Nations Educational, Scientific and Cultural Organization (UNESCO) which is harmonized, i.e. the data is not subject to potential biases arising from differences in the R&D definition adopted by each country. Third, it examines how important absorptive capacity is for international R&D spillovers. Finally, it exploits recent developments in nonstationary panel data techniques by applying the DSUR panel estimator, which has the advantages of (i) taking into account cross-sectional dependence in estimation and of (ii) generating one cointegrating vector for each country.

Chapter 4 re-examines the finance-growth literature from the perspective of financial intermediaries other than banks. Well-functioning financial markets are important for long-run economic growth, contributing to the economic development process through their role in the efficient allocating of scarce funds among productive activities, including investment in new plant and equipment, working capital for firms, etc. This role has been thoroughly researched and is well documented in the empirical literature. Ang (2008) provides an excellent up-to-date overview of the vast empirical literature that finds support for financial development as a robust explanation of cross-country differences in economic growth. Nevertheless, the aforementioned literature has almost exclusively focused on the role of banks, while other important intermediaries such as insurance institutions have been largely ignored. The main objective of this chapter is thus to show that the rapid development of this sector can significantly contribute to understand the overall finance-growth nexus. More precisely, we examine empirically the effect of insurance sector development on economic growth, exploiting longitudinal data for 52 countries over the period 1981-2005. We take advantage of recent econometric estimation methods (GMM panel estimator) particularly suited to answer the following important questions:

(i) Does insurance sector development promote output growth?

(ii) What are the channels of the insurance effect on growth? Is it capital accumulation, productivity improvement, or both?

(iii) Do the effects vary across developed and developing countries?

This paper contributes to the existing literature in several important aspects. First, it provides panel evidence on the insurance-growth nexus. Second, it does so by disentangling the relative importance of the two main channels: capital accumulation and productivity growth. Evidence is also provided on the relative importance of each of the channels across developed and developing countries. Finally, recent dynamic panel data techniques (the GMM estimator) are implemented to account for country-specific effects and simultaneity biases, which are pervasive problems when estimating growth equations.

2. FOREIGN DIRECT INVESTMENT AND ECONOMIC GROWTH: THE ROLE OF ECONOMIC FREEDOM

2.1 Introduction

The impact of foreign direct investment (FDI) on economic growth has been debated extensively in the literature. The rising interest in this area of research is consistent with the shift in emphasis of policy makers towards attracting more FDI. Since the early 1980s, many countries have progressively lifted restrictions on foreign capital flows.[1] As a result, global FDI inflows rose from $57 billion in 1982 to $1271 billion in 2000 and the growth rate of world FDI has exceeded the growth rates of both world trade and GDP (UNCTAD, 2001). The motivation for increased efforts to attract more FDI stems from the expectation of an overall positive impact of FDI resulting from productivity gains, transfers of new technology, the introduction of new processes, management techniques, and know-how in the local market, employees' training and international production networks.

Although economic models (e.g. Findlay (1978); Wang and Blomstrom (1992)) predict that FDI inflows are important for economic development, empirical evidence on the impact of FDI on output growth is far from conclusive. Some studies find that FDI exerts a positive growth effect, while others find no evidence or even a negative effect (Gorg and Greenaway, 2004). A possible explanation behind this mixed finding may be the failure to account for contingency effects in the relationship between FDI and growth. A number of economic models suggest, for instance, that the relationship between FDI and growth may be contingent on absorptive capacity.[2] For example, Lapan and Bardan's (1973) model emphasizes that technology spillovers from developed to developing countries require the latter to have sufficient investment in capital-intensive projects. The models by Griffith *et al.*(2003) and Cohen and Levinthal (1989) predict that by investing in research and development (R&D) activity, firms (or countries) are more able to absorb technologies developed by others. These models suggest that FDI spillovers are a complex process and not a granted consequence of the presence of foreign capital. It requires that sufficient absorptive capacity of advanced technologies is available in the host country. Several elements of absorptive capacity have

[1] According to UNCTAD (2002), 208 changes in FDI laws were made by 71 countries in 2001. Of these changes, 194 (93 per cent) created a more favourable climate in an effort to attract more FDI.
[2] Cohen and Levinthal (1989) have offered the most widely cited definition of absorptive capacity. They view it as the firm's ability to value, assimilate and apply new knowledge.

been highlighted in the literature, such as the quality of human capital, the development of financial markets, and trade policy.

In an effort to further understand the nature of the FDI-growth relationship, this paper takes its cue from the recent literature that emphasizes the importance of institutions in economic development (Demetriades and Law, 2006, Rodrik *et al*., 2004). In particular, it aims to highlight the importance of economic freedom in mediating the impact of FDI on growth and to formally test whether countries with higher level of freedom can exploit FDI more efficiently. Enhancing economic freedom is expected to reduce obstacles that hinder the efficient transfer of technology from multinational corporations (MNCs) to domestic firms. There are several reasons to believe why countries that promote freedom of economic activity will benefit from FDI inflows. It is generally agreed that more freedom (i.e. less regulation) in general will be good for growth. For example, when financial markets are not excessively regulated, firms may find it easier to access external funds in order to finance new expensive technologies. Access to external finance has been highlighted as an important pre-condition for FDI spillovers (Alfaro *et al*., 2004). Employment laws may also have implications for FDI spillovers. If the laws for the hiring and firing of employees are less restrictive, spillover effects through labor mobility are more likely to occur because workers who have previously worked with MNCs are more able to transfer their knowledge and experience of new technologies to domestic firms (Fosfuri *et al*., 2001). The model by Acemoglu *et al*. (2006) shows that firms that have a strong incentive for innovation are very selective of managers that can achieve their goal. Other things being equal, reducing constraints that limit freedom of employment may ease the selection process and lead to greater labour mobility between firms. Competition in local market may also affect technology spillovers via backward linkages. The model by Lin and Saggi (2005) implies that competition with local rivals is expected to push MNCs for a greater transfer of technology to local suppliers of intermediate goods. The transfer of technology is needed in order for MNCs to secure intermediate inputs at a competitive price. In turn, local production of more specialized inputs allows the production of more complex goods (i.e., goods that use specialized inputs with high intensity) at competitive costs which benefit downstream sector (Rodriguez-Clare, 1996).[3] The protection of property rights is another integral element of economic freedom. Countries that provide better protection of property rights are expected to benefit more from MNCs presence because they can not only attract FDI of a higher technological content (Javorcik, 2004) but are also more likely to encourage MNCs to expand their R&D activities locally (Nunnenkamp and Spatz, 2003). Freedom of exchange across borders may help domestic firms penetrate international markets for exporting purposes (Aitken *et al*., 1997). One may argue that FDI spillovers could

[3] The model by Rodriguez-Clare (2001) is particularly novel as it formalizes both backward and forward linkages. In this model the backward linkages is a necessary condition for forward linkages to materialize.

be negatively related to the level of economic freedom because MNCs may be more willing to transfer technology if the level of competition in the industry in which they operate is low (i.e. low level of economic freedom). However, whether economic freedom helps to foster FDI spillovers is an empirical matter and this is precisely the question that we attempt to answer.

This paper contributes to the literature in two important aspects. First, it provides the first empirical evidence on the significant role of economic freedom in mediating the impact of FDI flows on growth. Second, it departs from the existing literature from a methodological standpoint by explicitly allowing for the possibility that the impact of FDI on growth is nonlinear and characterized by threshold effects. More specifically, our model allows the impact of FDI on growth to be regime specific, with the level of economic freedom acting as a regime switching trigger. In this way, our econometric specification is able to accommodate the possibility that the impact of FDI on growth "kicks in" only when the level of economic freedom exceeds a certain unknown threshold. Furthermore, the model allows the data to endogenously determine whether the threshold effects exist or not.

Our main findings suggest that economic freedom increases the positive impact of FDI on output growth. The impact is characterized by threshold effects in that only countries whose level of economic freedom has exceeded a given level (threshold) benefit from FDI inflows. These findings are consistent with the views that only in countries promoting freedom of economic activity, firms are more able to absorb and internalize new foreign technologies. By doing so, many market frictions that hinder the efficient transfer of technology are abolished. These findings are robust to different sample periods (1981-2005) and endogeneity concerns.

The rest of this paper is structured as follows. Section 2.2 reviews the existing literature. Section 2.3 explains the model specification. Section 2.4 outlines the estimation procedures. Section 2.5 highlights the data set. Section 2.6 reports the empirical results and their interpretation. Conclusions are presented in section 2.7.

2.2 Review of the literature

In most countries, FDI is considered to be an important element of development strategy and policies are designed accordingly to attract more FDI. The provision of incentives and the adoption of FDI-stimulating policies are motivated by the expectation that FDI bring tremendous benefits to the recipient countries. MNCs have been linked to superior technologies, patents, trade secrets, brand names, management techniques and marketing strategies (Dunning, 1993). MNCs are known to be among the most technologically advanced firms as they are responsible for a large part of world's R&D expenditures (Borensztein *et al.*, 1998). They also hire a large number of technical and professional workers (Markusen, 1995). Once a multinational has set up a subsidiary, some of these advantages may not be totally internalized and thus spill over to domestic firms.

There is at least five channels through which spillovers can occur. First, demonstration/ imitation is probably the most evident spillover channel (Das, 1987, Wang and Blomstrom, 1992). New technology may be too expensive and risky for domestic firms to adopt due to high acquisition cost and uncertainty of the results that may be obtained. However, if a technology is successfully used by MNCs, domestic firms will be encouraged to adopt it. The second channel is labour mobility which is related to the possibility that workers who have previously worked for MNCs join domestic firms. These workers are able to apply their knowledge and experience of new technology in the domestic firms (Fosfuri *et al.*, 2001). The third channel is associated with export promotion. MNCs are known for having well-established international distribution networks. By following the export processes of MNCs (through imitation or collaboration), domestic firms may reduce the entry costs into foreign markets (Aitken *et al.*, 1997). This may have favorable implications for the productive efficiency of domestic firms. The fourth channel is competition. The competitive pressures exerted by MNCs may force domestic firms to improve their efficiency (Markusen and Venables, 1999, Wang and Blomstrom, 1992). In order to stay competitive in the market, increased competition may encourage domestic firms to adopt new technology earlier than what would otherwise have been the case (Blomstrom *et al.*, 1994). The final channel concerns the relationship that MNCs establish with domestic firms. MNCs may create backward and forward linkages with domestic suppliers and customers of intermediate inputs produced by MNCs (Rodriguez-Clare, 1996). In the case of backward linkages, MNCs may give technical assistance to domestic suppliers in attempts to maintain a certain quality standard for the inputs supplied to them. Regarding the forward linkages, the most evident link is observed in the MNCs' supply of higher quality inputs and at a lower price to domestic producers of final consumer goods (Markusen and Venables, 1999).

Despite the numerous benefits linked to FDI flows, economists have yet to reach a consensus on the usefulness of FDI. In a survey on firm-level studies on productivity spillovers in the developing, developed and transition economies, Gorg and Greenway (2004) reported that only six out of 25 studies find some positive evidence of spillovers running from foreign-owned to domestic-owned firms. This finding is further supported by Crespo and Fontoura (2007) who point out that FDI spillovers depend on many factors but frequently with undetermined effects. One possible explanation for these mixed results may be due to model misspecification induced by the failure to account for the host country's absorptive capacity. This issue has been highlighted by a number of theoretical models. For example, Lapan and Bardhan (1973) argue that developing countries need a certain level of absorptive capacity before they can benefit from technologies developed by others. Similarly, the model by Cohen and Levinthal (1989) emphasized the importance of absorptive capacity for technology spillovers. Their model postulates that the research and development (R&D) activities help to increase the incidence of spillovers by enhancing the firm's capacity to identify, assimilate, and exploit outside knowledge. They find strong evidence supporting the idea that more R&D intensive firms are more successful when it comes to absorbing R&D spillovers. The model presented by Griffith *et al*. (2003) predicts that by engaging in R&D, countries increase their ability to assimilate and understand the discoveries of others.

Several studies on FDI spillovers have tested the absorptive capacity hypothesis. For instance Blomstrom *et al*.(1994) find that FDI has a stronger positive growth-effect in countries with a higher level of development (i.e. when the country is sufficiently rich in terms of per capita income). Balasubramanyam *et al*. (1996) assess the impact of FDI given the trade policy of recipient countries. They find that the effect of FDI on growth is stronger in countries with a policy of export promotion than in countries that pursue import substitution. In fact, the effect of FDI on growth is non-existent in the case of developing countries that pursue import substitution policies. They argue that these policies reduce the efficiency of FDI by distorting the social and private return to capital.

Borensztein *et al*.(1998) argue that the adoption of new technologies requires workers that are able to understand and work with the new technology. The authors find that FDI have only a marginal direct effect on growth but the conditional effect is substantial (when FDI is interacted with a proxy of human capital). However, the conditional effect is insignificant in the case of domestic investment (i.e., interaction between domestic investment and human capital proxy), which may reflect the nature of technological differences between FDI and domestic investment. Since developed countries have a higher level of human capital, they are expected to receive more benefits from FDI than developing countries. This has been supported by Xu (2000) who find that technology transfer by the U.S. MNCs contributes to the productivity growth in developed countries but not in developing countries. However, Ram and Zhang (2002) and Alfaro *et al*. (2004) find that human capital is unimportant in facilitating the effect of FDI on growth. Instead, Alfaro *et al*. (2004) provide financial development explanation.

A number or recent papers have assessed the impact that the financial markets have on FDI spillovers. For instance, Hermes and Lensink (2003), Alfaro *et al*.(2004), and Durham (2004) find that the success of technology spillovers requires well-functioning financial institutions. A more developed financial system positively contributes to the process of technology diffusion associated with FDI. Financial markets reduce the risks inherent in the investment made by domestic firms seeking to imitate the MNCs' technologies or to upgrade the qualifications of their employees. They find that both well functioning banks and stock markets are important pre-conditions for FDI to have a positive impact on growth.

Most of the studies that explored the impact of absorptive capacity on the relationship between FDI and growth have relied on the use of a linear regression model augmented with interaction terms[4]. A major limitation of this type of specifications is that they impose à priori restrictions on the effect of FDI on growth. The interaction term restricts the effect of FDI on growth to increase (or decrease) monotonically with absorptive capacity.[5] One major implication from this specification is that the presence of significant and positive interaction terms implies that all countries benefit from FDI inflows but with different magnitude, depending on the level of absorptive capacity. Although this specification can greatly expand our understanding of the effect of FDI, it rules out a more dynamic possibility where a certain level of absorptive capacity is required before FDI can have any effect on output growth. World Bank (2001) points out that only countries with the greatest absorptive capacity will benefit from foreign capital. In contrast, the benefits is muted (or non-existence) in countries with low absorptive capacity. This implies that a minimum level of absorptive capacity is required before host countries can benefit from FDI-generated externalities. In other words, the positive effect of FDI on growth is likely to 'kick in' only after a minimum required level of absorptive capacity has been attained.

Although the documented link between FDI and growth is weak, evidence on the effect of institutional development on growth is more convincing. Institutions can be defined as the rules of the game in a society by which the members of a society interact and shape the economic behaviour of agents (North, 1990). A number of recent papers provide empirical

[4] Some studies, including Blomstrom *et al*. (1994) and Balasubramanyam *et al*. (1996), have used exogenous sample splitting in which sample is divided into sub-sample according to some perceived proxies for absorptive capacity. Hansen (2000) demonstrates that this procedure can run into serious inference problems.

[5] In the linear specification, an interaction term constructed as a product of FDI and absorptive capacity indicator is added as an additional regressor in growth regression. The importance of absorptive capacity in mediating FDI effect on growth is established when the interaction term is positive and statistically significant.

evidence that confirms the importance of institutions for economic development. For instance, Demetriades and Law (2006) show that better institutions are more important than financial developments in explaining output per capita in low-income countries. Rodrik *et al.* (2004) show that quality of institutions overrides geography and integration (international trade) in explaining cross-country income levels. Easterly and Levine (1997) note that conventional factors, such as physical and human capital and labor supply, do not explain completely growth in Africa and instead emphasize institutional explanations. Knack and Keefer (1995) find a positive and significant relationship between institutional development (i.e. bureaucracy, property rights, and political stability) and economic growth.

Recently, a number of papers have examined the links between economic freedom and growth. Economic freedom can be defined as the '*absence of government coercion or constraint on the production, distribution, or consumption of goods and services beyond the extent necessary for citizens to protect and maintain liberty*' (HeritageFoundation, 2004). Economists agree that economic freedom, along with political freedom and civil liberties, is one of the pillars of a country's institutional structure. Since the time of Adam Smith, economists have recognized that the freedom to choose and supply resources, competition in business, free trade with others and secure property rights are key elements for economic development. Economic freedoms are a reflection of institutional arrangement, which makes business operations and the realization of business ideas easier for entrepreneurs and managers. A large number of papers suggest that economic freedom is important in explaining cross-country differences in economic performance [see de Haan *et al.* (2006) for a survey]. However, the effect may differ across various components of economic freedom (Heckelman and Stroup, 2000, Carlsson and Lundstrom, 2002).

The argument for the importance of economic freedom for economic growth is not without criticism. One popular criticism is that why China and more generally several other developing nations, have high growth rates but relatively low level of economic freedom. China started with very high poverty and very low economic freedom. In 2007, China's economic freedom measures just 54 percent. But in 1977, the measure would have been near zero. By quietly setting aside Maoist dogma in 1978, the introduction of property rights for small farmers by Deng Xiaopeng initiated a revolution in economic freedom. This reform had has dramatic and positive effects on the Chinese economy. Over the past 30 years, China's economic freedom has grown by 1 or 2 percentage points every year, and the economy grew along with it. Output growth may slow if the reforms do not continue.[6]

[6] Other criticisms relate to the way the index is constructed and the inclusion of dubious variables. Refer to de Haan *et al.* (2006) for a detailed discussion on these issues. Despite these criticisms, the index has been a popular choice among researchers because literature has not come up with a better alternative.

With this backdrop, this study makes a novel contribution to the FDI literature by exploring the impact of economic freedom as a channel via which FDI impacts economic growth. This is achieved through the use of a flexible nonlinear econometric specification which explicitly allows the data to dictate the presence of economic freedom induced threshold effects in the relationship linking FDI and growth.

2.3 Model specification

The following specification is motivated by the models developed in Borensztein *et al*. (1998) and Ram and Zhang (2002) and forms the basis for the empirical models that are estimated in this paper

$$GROWTH_i = \alpha_o + \alpha_1 RYPC76_i + \alpha_2 GPOP_i + \alpha_3 (I/Y)_i + \alpha_4 LIFE_i + \alpha_5 EF_i + \alpha_6 FDI_i + \varepsilon_i \quad (2.1)$$

where, *GROWTH* is the growth rate of real GDP over the period 1976-2005, *RYPC76* is the logarithm of real GDP per capita at the beginning of 1976 (initial income), *GPOP* is the population growth rate, *I/Y* is investment-output ratio, *LIFE* is life expectancy (i.e. a proxy for human capital), *EF* is the index of economic freedom, and *FDI* is the FDI inflows-output ratio.

2.4 Estimation procedures

2.4.1 Interaction specification

In order to assess the impact of economic freedom on the relationship between FDI and growth we initially follow the recent literature on absorptive capacity (e.g. Borenzstein *et al*., 1998; Alfaro *et al*., 2004; Durham, 2004) and proceed by introducing a simple interaction term to a specification such as 2.1. The interaction term is given by the product of FDI and EF and to ensure that the interaction term does not proxy for FDI or the level of economic freedom, both variables are also included in the regression. The model may be written as follows:

$$GROWTH_i = \beta_o + \beta_1 RYPC76_i + \beta_2 GPOP_i + \beta_3 (I/Y)_i + \beta_4 LIFE_i + \beta_5 EF_i + \beta_6 FDI_i + \beta_7 [FDI_i \times EF_i] + \varepsilon_i \quad (2.2)$$

With this specification, we rely on β_7 to establish the contingency effect of FDI/Y on growth. The total effect of FDI on output growth will be given by $\hat{\beta}_6 + \hat{\beta}_7 EF_i$. Since the effect of FDI on growth is a function of EF_i, the presence of a significant and positive $\hat{\beta}_7$ implies that FDI is beneficial for all countries but its impact on growth differs across countries depending on the level of economic freedom. In other words, the higher the level of economic freedom the greater will be the impact of FDI on growth. Clearly, this specification forces the impact of FDI on growth to take a particular functional form such that it increases (or decrease) monotonically with economic freedom. However, this specification is unable to capture a more dynamic FDI-growth relationship where the impact of FDI on growth exists only after a certain level of economic freedom has been attained, and this is precisely the type of phenomenon that we are interested in.

2.4.2 Threshold regression

In this paper we argue that a model that is particularly well suited to capture the presence of contingency effects and to offer a rich way of modeling the influence of economic freedom on the dynamics of FDI and growth is the following threshold specification:

$$GROWTH_i = \begin{cases} \theta_0^1 + \theta_1^1 RYPC76_i + \theta_2^1 GPOP_i + \theta_3^1 (I/Y)_i + \theta_4^1 LIFE_i + \theta_5^1 FDI_i + e_i, & EF \le \gamma, \\ \theta_0^2 + \theta_1^2 RYPC76_i + \theta_2^2 GPOP_i + \theta_3^2 (I/Y)_i + \theta_4^2 LIFE_i + \theta_5^2 FDI_i + e_i, & EF > \gamma, \end{cases} \quad (2.3)$$

where EF (i.e. economic freedom index) is the threshold variable used to split the sample into regimes or groups and γ is the unknown threshold parameter. This specification allows the role of *FDI* to be different depending on whether EF is below or above some unknown level γ. The impact of FDI on growth will be θ_5^1 (θ_5^2) for countries in low (high) regime. Obviously, under the hypothesis $\theta^1 = \theta^2$ the model becomes linear and reduces to (2.1). The model such as (2.3) has been used in the analysis of trade-growth nexus (Khoury and Savvides, 2006), finance-growth nexus (Deidda and Fattouh, 2002), knowledge spillovers (Falvey *et al.*, 2007), among others.

The starting point of our investigation is to formally test the null hypothesis of linearity $H_o : \theta^1 = \theta^2$ against the threshold model in (2.3). This is a non-standard inference problem since under H_o the threshold parameter γ is unidentified and thus the Wald or LM test statistics will not have their conventional chi-square limits (see Hansen, 1996; Hansen, 2000).

Instead, inferences are conducted by computing a Wald or LM statistic for each possible value of γ and subsequently basing inferences on the supremum of the Wald or LM across all possible γ's. The limiting distribution of this supremum statistic is non-standard and depends on numerous model specific nuisance parameters. Since tabulations are not possible inferences are conducted via a model based bootstrap whose validity and properties have been established in (Hansen, 1996). It is also worth pointing out that the estimation of (2.3) is performed via conditional least squares since given γ the model is linear in its parameters. Once an estimate of γ has been obtained (as the minimiser of the residual sum of squares computed across all possible values of γ) estimates of the slope parameters follow trivially as $\hat{\theta}(\hat{\gamma})$.

To sum up, our goal here is to first test for the presence of threshold effects and if the latter are supported by the data to estimate (2.3) so as to assess the statistical significance of θ_5^1 and θ_5^2.

2.5 Data set

The data set consists of cross-country observations for 84 countries over the 1976 – 2005 period.[7] FDI figures represent the net inflows of foreign investment to acquire a lasting management interest (i.e. 10 percent or more of voting stock) in domestic enterprises, and is expressed as a ratio to GDP.

There are two main sources of economic freedom indices. The *Fraser Institute* (Gwartney and Lawson, 2006) and the *Heritage Foundation*. Both indices quantify aspects such as government intervention, distortion in the economy, the degree of openness, and various aspects of market regulations. In many respects the index of the *Heritage Foundation* is similar to the *Fraser institute* (Holmes *et al*., 1998). However, the index from the *Heritage Foundation* is available only for a shorter period of time. For this reason, we employ the index from the *Fraser Institute*. The index is based on three key notions: individual choice and voluntary transaction, free competition, personal and property protection. The index has five underlying components, namely government intervention, legal structure and security of property rights, access to sound money, freedom to trade with foreigners and regulation of credit, labour and business. The first component indicates the extent to which countries rely on individual choice and market rather than political mandate in the allocation resources, goods

[7] Refer to Appendix 2.1 for a list of countries.

and services. The second component measures the protection of persons and their rightfully acquired assets. It consists of several measures such as rule of law, security of property rights, an independent judiciary and an impartial court system. The third component measures an access to sound money. This is particularly important for economic agents as the absence of sound money may undermine gains from trade. A high and volatile rate of inflation distorts relative prices and makes it difficult for individuals and business to plan for the future. The freedom of exchange across national boundaries is an important element of EF, and the fourth measure is the freedom to exchange internationally. Finally, the fifth component measures various regulatory restraints that limit freedom of exchange in credit, labour and product markets. The index is scaled from 0 to 10 with 10 representing the highest level of freedom. Table 2.1 provides the summary of data sources.

Table 2.1: Sources of Data

Variables	Sources	Unit of Measurement
Foreign Direct Investment	World Development Indicators	% of GDP
Real GDP	Penn World Table	PPP price
Real GDP per capita	Penn World Table	PPP price
Life expectancy	World Development Indicators	Years
Population	World Development Indicators	Growth rates
Investment ratio	Penn World Table	% of GDP
Economic Freedom	Fraser Institute	Index (0 – 10 scale)

Table 2.2 provides summary statistics for the three key variables in this analysis: FDI (over GDP), growth rates of real GDP and the index of economic freedom. Statistics are based on data averaged over the 1976-2005 period. One apparent feature of these statistics is that there is considerable variation in the share of FDI in GDP across countries, ranging from 0.06% in Japan to 5.32% in Trinidad and Tobago. GDP growth also shows similar levels of variation, ranging from -1.23% for the Dem. Rep of Congo to 6.32 % for Malaysia. Finally, the economic freedom index ranges from 3.71 (Dem. Rep of Congo) to 8.01 (United States of America).

Table 2.2: Summary Statistics

Variables	Mean	Std. Dev	Min	Max
FDI/Y	1.541	1.095	0.060	5.327
Growth rates	2.925	1.374	-1.233	6.320
Economic Freedom Index	5.861	0.968	3.710	8.010

2.6 Empirical results

This section discusses our empirical results which are presented in Tables 2.3–2.7. Table 2.3 reports a preliminary analysis of the effects of FDI and EF on output growth. Table 2.4 presents coefficient estimates obtained from the interaction specification. Table 2.5 reports the estimated coefficients obtained using our threshold specification in which economic freedom is used as a threshold variable. Table 2.6 reports the estimated coefficients obtained using instrumental variable threshold regression. Finally, Table 2.7 presents the results of testing the threshold effects using each of the index components.

The first step of our analysis is to estimate Equation (2.1). The results are presented in Table 2.3. As shown in the table, FDI alone has no direct effect on output growth as the estimated coefficient is insignificant at the usual level.[8] This finding is consistent with Alfaro *et al*. (2004) and Durham (2004) who also find that FDI has no direct impact on output growth.[9] This nicely summarizes the problem that exists in the literature: although various models provides strong basis for expecting FDI to positively affect growth, empirical evidence shows that such impact is non-existent. This ambiguity is what forms part of the motivation for this paper. Additionally, the coefficient on economic freedom is positive and significant at the 5 percent level. This is consistent with the previous literature as surveyed in de Haan *et al*.(2006). However, the estimated coefficient on investment ratio is insignificant, in contrast to the findings reported in previous literature (see Durlauf *et al*., 2005). One possible explanation may be due to the potential effect of outlier observations. As we will show later (in the discussion on the robustness of the interaction specification), the coefficient on investment ratio turns out to be significant when the outliers are removed (see Appendix 2.2).[10]

[8] We have tested various configurations and the findings remain robust.

[9] An alternative explanation is provided by Blonigen and Wang (2005) who argue that inappropriate pooling of developed countries and developing countries is responsible for producing insignificant estimated effect of FDI on output growth. The authors find that FDI only works in developing countries but requires a certain level of human capital. Nevertheless, they find that the direct effect of FDI on growth is non-existence which is consistent with our empirical results.

[10] However, the variable is insignificant in models that include private credit. This may be due to a high correlation between investment and private credit as most investment would require external financing (measured by private credit).

Table 2.3: FDI and Growth

	Coefficient	S.e.	*p*-value
Initial Income	-0.012	0.002	0.000
Population growth	0.450	0.204	0.031
Investment ratio	0.032	0.028	0.258
Life expectancy	0.058	0.012	0.000
FDI	0.062	0.132	0.641
Economic Freedom	0.004	0.001	0.030
Constant	-0.147	0.046	0.002
R^2	0.47		
Number of observations	84		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the log of percapita income in 1976. All other regressors are the average values over 1976-2005 period. Life expectancy is in the logarithmic form.

2.6.1 *Interaction specification*

The next step of our analysis involves estimating the relevant specification 2.2. It is worth noting that the addition of an interaction term may lead to multicollinearity problems as the interaction term tends to be strongly correlated with the original variables used to construct them (Darlington, 1990). In order to alleviate this problem, the interaction term is orthogonalised using the following two-step procedure: First, the interaction term FDIxEF is regressed on the FDI and EF variables. Second, the residuals from the first step regression are used to represent the interaction term (Burill, 2007). As shown in Table 2.4, the estimated coefficient on FDI remains insignificant. However, the interaction term is positive and statistically significant at the 5% level ($\hat{\beta}_7 = 0.293$). This suggests that the marginal impact of FDI on growth is increasing in the level of economic freedom. This finding is consistent with other studies who also find that the growth-effect of FDI depends on other intervening factors (Alfaro *et al*., 2004, Borensztein *et al*., 1998).

Table 2.4: Linear interaction model

	Coefficient	S.e.	*p*-value
Initial Income	-0.012	0.002	0.000
Population growth	0.445	0.185	0.019
Investment ratio	0.027	0.026	0.308
Life expectancy	0.060	0.011	0.000
FDI	0.055	0.122	0.650
Economic Freedom (EF)	0.004	0.001	0.031
FDI x EF	0.293	0.112	0.011
Constant	-0.157	0.042	0.000
R^2	0.51		
Number of observations	84		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the log of percapita income in 1976. All other regressors are the average values over 1976-2005 period. Life expectancy is in the logarithmic form. Interaction term is orthogonalised to remove multicollinearity effect. S.e. denotes heteroskedasticity-robust standard error.

We perform several sensitivity analyses to ascertain the robustness of the above results (see Appendix 2.2). First, the possible effect of outlier observations on the estimation results is assessed. It is worth noting that a single or a small group of observations which is significantly different from others can make a large difference in the estimation results. Following a strategy advocated by Besley *et al.* (1980), the so-called DFITS statistic is used to flag countries with high combinations of residual and leverage statistics. The test suggests Democratic Republic of Congo, Cyprus, Gabon, Haiti, Jamaica, and Rwanda are potential outliers.[11] Interestingly, the exclusions of outliers did not alter our results. The coefficient on FDI remains insignificant but the ones on EF and FDIxEF retain their statistical significance and signs. This provides further support to the importance of economic freedom for output growth. A second issue of robustness concerns is the interaction between FDI and financial market indicator since this was shown to have a significant positive effect on output growth in earlier research.[12] For this purpose, an interaction term constructed as a product of FDI and private sector credit (PRC) is added to the estimated model. PRC is used because it accurately reflects the efficiency of banking sector in the allocation of funds and it has been a preferred measure of financial development (Beck *et al.*, 2000).[13] The results show that while PRC registers significant positive effect on growth, the interaction between the two does not. Importantly, adding private credit does not change the significance of EF and FDIxEF. As a final robustness check, the interaction between FDI and life expectancy is added to the

[11] Refer to Appendix 2.3 for the calculation of DFITS statistic.
[12] For example Alfaro *et al.* (2004) and Hermes and Lensink (2003).
[13] PRC measures the value of credit issued by financial intermediaries to the private sector and is expressed as a ratio to GDP. PRC isolates credit issued to the private sector, as opposed to credit issued to governments, government agencies, and public enterprises. Furthermore, it excludes credit issued by the central bank.

estimated model since previous studies showed that human capital is important for FDI spillovers.[14] Although life expectancy remains strongly correlated with growth, the interaction with FDI shows no impact on output growth. However, this paper uses a different human capital proxy for a slightly different time period and therefore the finding may not be completely comparable with previous findings. The overall findings suggest that there is robust evidence suggesting that the level of economic freedom in the host country is an important pre-condition for FDI to affect growth.

The results of our interaction specification presented above suggest that the effect of FDI on output growth is conditional on the level of freedom. However, the interaction term restricts the impact of FDI on growth to be monotonically increasing (or decreasing) with economic freedom. This finding implies that all countries benefit from FDI inflows but its magnitude differs across countries depending on the level of economic freedom. The higher the level of economic freedom, the greater is the impact of FDI on growth. However, it may be the case that a certain level of economic freedom is needed before FDI can have any impact on growth. This suggests the need for a different modelling strategy, and threshold regression provides an excellent alternative to consider.

2.6.2 Threshold regression

Before we formally test for the threshold effects, there is one issue that need to be addressed here. One problem faced by empirical economists when estimating a model like (2.3) is that the theory is not explicit enough about what variables should be allowed to switch across regimes. For example, some studies allow all variables to switch (e.g. Deidda and Fattouh, 2002) while others allow only the variable on interest to switch (e.g. Falvey *et al.*, 2007). To deal with this uncertainty, we rely on model selection process to determine the optimal specification. As Kapetanios (2001) point out, this approach provides a clear-cut solution as one model is always accepted as the preferred specification at the end of the selection process.

For this purpose, we utilize information criterion due to Gonzalo and Pitarakis (2002). The authors propose a sequential model selection approach for threshold model where the selection of the 'best' model is made via the minimization of a penalized objective function. The function has two components. The first component is a monotonic function of the model

[14] For example Borensztein *et al.* (1998) and Xu (2000).

dimension and the second component penalizes the changes in the first component caused by the increase in the model dimension. The objective function is given as follows:

$$IC = \log S_T + \frac{\lambda}{N} k \qquad (2.4)$$

where, S_T is the concentrated sum of square errors, λ is a deterministic function of the sample size, N is the number of cross-section, and k is a number of estimated parameters. It is clear that an increase in the number of regime will lead to a reduction in S_T. However, this reduction will be penalized due to the resulting increase in the number of estimated parameters.

To find the 'best' model, we calculate the information criterion (2.4) for various possible specifications, ranging from a model that allows all regressors to switch across regimes (i.e. Equation [2.3]) to a model that allow only FDI to vary. We also evaluate several linear models and models with smaller number of regressors. In total, 162 models were estimated (see Appendix 2.3). Based on the AIC and SBC, λ is set to equal 2 and ln*N*, respectively. The AIC results indicates that Equation (2.3) is the optimal specification while the SBC point to a linear model that includes initial income, life expectancy, and FDI. However, the latter is mis-specified as far as FDI-growth specification is concerned as it omits two core regressors, i.e. investment ratio and population growth. Therefore, based on the AIC results, we use Equation (2.3) as a basis for testing the threshold effects.

We next examine the threshold regression model (2.3). Our goal is to determine whether the impact of FDI on growth can be characterized as a nonlinear process where the impact of FDI on growth could be positive, negative, or neutral depending on some unknown critical level of economic freedom. The significance of the threshold parameter $\hat{\gamma}$ is evaluated using bootstrap methods with 1000 replications and 10% trimming percentage. Results in Table 2.5 show that the threshold estimate of EF is 5.6517 with a *p*-value of 0.024. Thus, the sample can be split into two EF groups (i.e. low-EF and high-EF groups).[15] For the high-EF group, the coefficient on FDI is positive and significant while for the low-EF group it is negative. This suggests that there exist a nonlinear pattern in which FDI affect growth. The effect "kicks in" only after the level of economic freedom exceeds the threshold level of 5.6517. For countries below this critical level, FDI exerts a negative effect on growth. This finding is consistent with the view that freedom of economic activity promotes the diffusion of technology

[15] Refer to Appendix 2.1 for countries classification into high- and low-EF groups.

from MNCs to domestic firms. It is worth noting that population growth and investment ratio on output growth also display threshold-type nonlinearities. Both variables are found to be positive and significant only in the high-EF regime. These findings exemplify that freedom of economic activity does not only facilitate FDI spillovers but also the efficiency of domestic inputs. This is consistent with de Haan *et al*. (2006) who argue that market liberalisation that foster freedom of economic activity enhances efficient allocation of resources.

Table 2.5: Threshold regression (1976-2005)

	Low-EF (EF≤5.6517)			High-EF (EF>5.6517)		
	Coeff.	s.e.	t-stat	Coeff.	s.e.	t-stat
Initial income	-0.011	0.002	-6.249	-0.009	0.004	-2.422
Population Growth	-0.235	0.379	-0.618	0.946	0.223	4.250
Investment ratio	-0.028	0.027	-1.058	0.133	0.026	5.172
Life Expectancy	0.069	0.013	5.180	0.036	0.022	1.674
FDI	-0.379	0.175	-2.160	0.350	0.106	3.320
Threshold estimate	5.6517					
LM-test for no threshold	29.145					
(*p*-value)	(0.024)					
Number of countries	40			44		
R^2	0.52			0.62		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the logarithm of per capita income at the beginning of 1976. All other regressors are the average values over 1976-2005 period. Life expectancy is in the logarithmic form. EF is economic freedom index used as a threshold variable. *p*-value was bootstrapped with 1000 replications and 10% trimming percentage. Standard errors (s.e) are corrected for heteroskedasticity.

Several sensitivity checks are implemented to gauge the robustness of the above findings. First, the LM test is used to verify whether each group (i.e. high EF and low EF groups) can be split further into sub-groups. For both groups, the split produced insignificant *p*-values of 0.162 and 0.573 respectively for low- and high-EF groups (see Appendix 2.5). Thus, there is reasonably good evidence for two-regime specification. Second, the sensitivity of the *p*-values is assessed using different trimming percentage and bootstrap replications. The *p*-values are re-calculated for different combinations of trimming percentages and bootstrap replications. Interestingly, our results show that the null of no threshold can be consistently rejected (see Appendix 2.6). Third, we assess the sensitivity of the results to different time period. We choose the 1981-2005 period because most countries began to ease restriction on FDI flows in the early 1980s. This may well capture the period during which FDI flows is an important element of globalization. The test results show that the threshold effects remain intact as the null of no threshold can be rejected at the 1% level of significance (see Appendix

2.7). Interestingly, we find that the estimate of the threshold parameter $\hat{\gamma}$ is quite similar. Fourth, the growth rates of the EF index is used as a threshold variable as some studies show that changes in EF also matters for output growth. Our results show that there is no difference in the impact of FDI across high- and low-growth groups (see Appendix 2.8). The coefficients on FDI are positive and significant in both groups. Finally, we replicate the analysis using the economic freedom index from the Heritage Foundations and find that the threshold effects of FDI on output growth remain intact (see Appendix 2.9). In short, there is strong support for the importance of economic freedom in fostering the impact of FDI on output growth, where only countries that have exceeded the threshold level of economic freedom benefited from FDI-generated externalities.

2.6.3 Endogeneity Issue

It should be highlighted that one important underlying assumption of the Hansen's (2000) methodology is that all regressors are exogenous. However, this assumption is rather restrictive for FDI because FDI itself may be influenced by innovations in the stochastic process governing growth rates. For instance, any omitted variables that raise the rate of return on capital will also increase both the growth rate and the inflow of FDI simultaneously. This suggests a possible correlation between FDI and the error term, which could lead to biased estimated coefficients. Therefore, it could be that the strong impact of FDI on growth that we found for the high-EF group is due to an endogenous determination of FDI.

To deal with this problem, we deploy an instrumental variables threshold regression due to Caner and Hansen (2004). This estimator is similar to Hansen's (2000) procedure in many aspects except that the instrumental variables are used to remove endogeneity bias. One limitation of this estimator is that the theory for deriving *p*-values for testing the significance of the threshold parameter $\hat{\gamma}$ has not yet been developed. The estimation involves three important steps. The first step is to estimate the predicted values of FDI using instrumental variables by least square estimation. Following Alfaro *et al*. (2004) and Borensztein *et al*. (1998), the lagged values of FDI (i.e. average of FDI over the 1971-1975 period) and total GDP are used as instrumental variables.[16] [17] Next, using the predicted values

[16] The fundamental problem with instrumental variable regression is that there are no ideal instruments available. A good instrument would be a variable which is highly correlated with FDI but not with the error term in these regressions. We use lagged FDI is because many studies (e.g. Wheeler and Mody, 1992) show that FDI is a self-reinforcing, i.e. existing stock of foreign investment is a significant determinant of current investment decisions. We include total GDP as instrument because it represents the effect of market size. The growth-driven FDI hypothesis emphasizes the importance of market size for attracting FDI (Markusen *et al*., 1996). Other things being equal, a country market size (as measured by GDP) rises with economic growth and thus encouraging MNCs to increase their investment.

of FDI in the first step plus all other regressors, we obtain $\hat{\gamma}$ as a minimiser of the residual sum of squares computed across all possible values of γ. Finally, we estimate the slope parameters by two-stage least square estimator on the split samples implied by $\hat{\gamma}$.[18] The results of these exercises are summarized in Table 2.6. Although the threshold parameter $\hat{\gamma}$ is slightly lower than the one produced by the Hansen's (2000) method, the previous conclusions remain unchanged as the coefficient on FDI is positive and significant only for the high-EF group. These results suggest that the strong link between FDI and growth for the high-EF group is not due to simultaneity bias and can be interpreted as the effect of the exogenous component of FDI on output growth.

Table 2.6: Instrumental variables threshold regression

	Low-EF (EF≤5.1817)			High-EF (EF>5.1817)		
	Coeff.	s.e.	t-stat	Coeff.	s.e.	t-stat
Initial income	-0.006	0.003	-2.188	-0.013	0.002	-5.049
Population Growth	-1.401	0.830	-1.687	0.487	0.208	2.339
Investment ratio	-0.001	0.034	-0.024	0.134	0.026	5.077
Life Expectancy	0.025	0.007	3.465	0.025	0.006	4.459
FDI	0.512	0.884	0.580	0.320	0.177	1.805
Threshold estimate	5.1817					
Number of countries	23			61		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the log of percapita income in 1976. All other regressors are the average values over 1976-2005 period. Life expectancy is in the logarithmic form. The lagged values of FDI and a log value of total GDP are used as instruments for FDI.

2.6.4 Threshold regression using EF index components

Our final analysis is to examine which components of economic freedom index are important in linking FDI and growth. The use of an aggregate index, which is constructed using 40 independent variables, may be less useful for policy formulation purposes. These variables, however, can be grouped into five major components namely, government size (*GOVT*), legal structure and security of property rights (*LEGAL*), access to sound money (*SMONEY*), freedom to trade with foreigners (*TRADE*) and market regulations (*REGULATIONS*). The next

[17] It is also worth pointing out that this procedure relies on the assumption that the threshold variable is exogenous. Theoretically, it is possible that the level of economic freedom increases with higher growth and thus suggesting potential endogeneity of the threshold variable. However, the theory for the case of endogenous threshold variable has not been developed. Future works in econometrics would certainly fill this gap.
[18] Alternatively, one can use generalized method-of-moments estimator.

logical step is therefore to examine which index components are important in the FDI-growth relation. The finding on the interplay between FDI, growth and different aspects of freedom should be more useful for policymakers in devising specific policies to facilitate FDI spillovers. Table 2.7 presents our empirical results and the upshot of this analysis is that *GOVT*, *LEGAL, SMONEY* and *REGULATIONS* are found to be important intervening factors for FDI to have positive impacts on growth. The LM tests of no threshold suggest that there are threshold effects. The coefficients on FDI for the high-EF group are positive and significant while for the low-EF group they are either negative or insignificant. In the case of *TRADE*, the LM test reveals that the null cannot be rejected at the usual level. Our findings are consistent with others [e.g. Heckelman and Stroup (2000), Carlsson and Lundstrom (2002)] who reveal that economic freedom has different effects across components.

Table 2.7: Threshold regression by components

	Low-EF (EF ≤ γ)			High-EF (EF > γ)		
	Coeff.	s.e.	t-stat	Coeff.	s.e.	t-stat
Panel A: EF = GOVT						
Initial income	-0.008	0.002	-3.572	-0.014	0.003	-5.446
Population Growth	0.255	0.210	1.213	0.426	0.312	1.367
Investment ratio	-0.007	0.029	-0.231	0.097	0.030	3.201
Life Expectancy	0.071	0.016	4.333	0.042	0.013	3.366
FDI	-0.217	0.174	-1.247	0.293	0.128	2.282
Threshold estimate	5.3131					
LM-test (*p*-value)	21.312 (0.097)					
Panel B: EF = LEGAL						
Initial income	-0.011	0.002	-5.430	-0.017	0.003	-5.774
Population Growth	0.337	0.360	0.936	0.749	0.185	4.056
Investment ratio	0.001	0.028	0.045	0.050	0.027	1.819
Life Expectancy	0.065	0.015	4.240	0.096	0.018	5.381
FDI	-0.479	0.239	-1.998	0.221	0.095	2.327
Threshold estimate	4.4595					
LM-test (*p*-value)	30.750 (0.034)					
Panel C: EF= SMONEY						
Initial income	-0.008	0.001	-5.358	-0.022	0.003	-6.752
Population Growth	0.017	0.333	0.050	0.395	0.181	2.183
Investment ratio	0.020	0.039	0.511	0.073	0.017	4.342
Life Expectancy	0.048	0.013	3.702	0.119	0.018	6.754
FDI	-0.406	0.186	-2.183	0.289	0.089	3.248
Threshold estimate	6.7769					
LM-test (*p*-value)	35.796 (0.002)					
Panel D: EF= TRADE						
Initial income	-0.011	0.002	-4.966	-0.013	0.003	-4.630
Population Growth	0.076	0.268	0.284	0.837	0.184	4.542
Investment ratio	-0.006	0.028	-0.203	0.108	0.039	2.798
Life Expectancy	0.065	0.012	5.596	0.009	0.029	0.310
FDI	-0.006	0.153	-0.041	0.198	0.155	1.276
Threshold estimate	6.7684					
LM-test (*p*-value)	16.899 (0.351)					
Panel E: EF = REGULATIONS						
Initial income	-0.012	0.003	-3.635	-0.010	0.002	-4.409
Population Growth	-0.654	0.702	-0.932	0.762	0.226	3.364
Investment ratio	-0.013	0.035	-0.359	0.077	0.030	2.544
Life Expectancy	0.085	0.017	4.946	0.053	0.015	3.579
FDI	-0.986	0.295	-3.337	0.174	0.101	1.718
Threshold estimate	4.9220					
LM-test (*p*-value)	28.511 (0.055)					

Notes: *p*-values were bootstrapped with 1000 replications and 10% trimming percentage. Standard errors (s.e) are corrected for heteroskedasticity. *GOVT*=government size, *LEGAL*=legal structure and security of property rights, *SMONEY*=access to sound money, *TRADE*= freedom to trade with foreigners *REGULATIONS*=market regulations.

2.7 Conclusions

The ambiguous effect of FDI on growth has been largely documented. One key explanation of this ambiguity appears to be the failure to accommodate the absorptive capacity of the host country in the FDI-growth specification. It has been widely recognized that FDI spillovers require sufficient absorptive capacity of new technologies to be available in the host countries. Although absorptive capacity may embody different institutional and economic factors, in this paper we considered a broader indicator, that we called “economic freedom”. It presents the advantage of encompassing those advanced in the literature, and we show that the impact of FDI on host countries’ growth is contingent on it. Our explanation is that many obstacles limiting the efficient diffusion of new technologies have been removed in countries that have promoted enough freedom of economic activity. Methodologically, the contribution of this paper consists in adopting a regression model based on the concept of threshold effects. This novel estimator allows FDI to exert a non-linear effect on output growth and is flexible enough to accommodate the possibility that FDI affects growth only once a certain level of economic freedom has been attained. Based on cross-country observations from 84 countries over the 1976-2005 period, two important conclusions emerge. Firstly, FDI has no direct (linear) effect on output growth. Secondly, there are threshold effects in the FDI-growth relationship which are induced by economic freedom. More precisely, we find that only countries whose level of economic freedom has exceeded a given threshold have benefited from FDI-generated externalities. In countries below this critical level, FDI inflows have no beneficial effects on growth (and might even be negative in some cases). This finding is consistent with the growing view that only countries with a sufficient absorptive capacity benefit from MNCs presence. Firms which operate in countries that sufficiently promote economic freedom appear to be more able to absorb and adopt new technologies as well as other benefits associated with FDI inflows. The findings are robust different sensitivity tests as well as to potential endogeneity considerations.

Our findings indicate that economic freedom mediates the positive impact of FDI on growth and thus becomes an integral element to a country’s absorptive capacity. FDI spillovers require active efforts by the government to stimulate technology diffusion. Therefore, it is essential for policymakers to weigh the cost of policies aimed at attracting FDI versus those seeking to improve the level of economic freedom. The adoption of policies pro-FDI should go hand in hand with, not precede, the policies that aim at promoting economic freedom. However, institutional reform towards greater freedom of economic activity is a difficult process and requires a long-term commitment. It may be politically difficult in the short run, but the long-run economic benefits appear to outweigh short-run costs.

3. RESEARCH AND DEVELOPMENT SPILLOVERS: EVIDENCE FROM EAST ASIAN COUNTRIES

3.1 Introduction

It is now widely accepted that factor accumulation (including human capital) alone cannot adequately explain differences in growth performance across countries. Productivity differences appear to be one of the key explanations in the recent literature, and technology plays a key role in determining productivity (Easterly and Levine, 2001, Hall and Jones, 1999). The neoclassical model treated technological progress as exogenous but recent endogenous growth models have provided novel ways of dealing with technological progress (Romer, 1990, Grossman and Helpman, 1991, Aghion and Howitt, 1992). These models view innovation efforts, such as research and development (R&D), as a major source of productivity growth. Other factors, such as macroeconomic shocks, can affect productivity in the short and medium term but only improvements in technology can affect economic growth permanently in the long term.

Investment in R&D has been highlighted as a major source of productivity growth. However, R&D has performed disproportionately across countries as only a handful of rich countries are responsible for the most of the world's total R&D investment.[19] The variations in R&D investment across countries explain a large part of cross-country differences in productivity, and countries are said to benefit enormously from international spillovers (Klenow and Rodriguez-Clare, 2005). In fact, the major source of productivity growth for many countries came from abroad (Keller, 2004). This implies that a less developed country that lags behind the technology frontier and hardly invests in R&D can increase its productivity by interacting with R&D leaders. The theory suggests various channels by which technology can be transmitted across countries. Technology is embodied in capital and intermediate goods and the direct import of these is but one of the possible channels of transmission (Grossman and Helpman, 1991, Caselli and Wilson, 2004, Eaton and Kortum, 2001). The theory also emphasizes foreign direct investment (FDI) as a potential channel for the international transmission of technology (Findlay, 1978, Wang and Blomstrom, 1992). However, technology

[19] The G-5 countries (France, Germany, Japan, United Kingdom and United States) account for about 77% percent of the world's R&D spending in 2005.

diffusion is a complex process and may require the recipients to have a certain level of absorptive capacity (Griffith *et al.*, 2003).

The main purpose of this study is to examine the channels and magnitude of R&D spillovers from developed countries to East Asian countries. Most empirical studies of R&D spillovers have focused on the R&D effects across OECD countries and relatively little attention has been paid to whether less developed countries benefit from developed countries' R&D.[20] East Asian countries are known for their outward orientation policies. The trade promotion policies were first initiated in the 1970s, and during the 1980s these policies were launched on a full scale (Sakurai, 1995). As a result, trade openness (i.e. the ratio of exports plus imports to GDP) has increased from 37% in 1970 to 108% in 2005.[21] At the same time, many East Asian economies have made their rules and regulations surrounding FDI less restrictive in an effort to attract more foreign investment. In the first half of the 90s, nine leading East Asian economies had attracted together more than US$ 200 billion in FDI flows (Hsiao and Hsiao, 2006).[22] The main investors in the region are the United States, Japan, and the European Union. Recently, outward FDI from Asian countries has been growing steadily as well. Asian multinational corporations (MNCs) have grown in size and have made their presence abroad strong (UNCTAD, 2006). Policy reform towards greater openness has significantly contributed to the growth performance of these countries. In 1950, the average real GDP per capita of the East Asian countries was far below the world average as well as below the average of Latin-American economies, but it surpassed the world average by 1978, Latin America's by 1983. In the mid-1980s, they began to grow faster relative to other regions, becoming the most dynamic region in the world (Hsiao and Hsiao, 2006).

This study is related to Coe *et al.* (1997) and Madden *et al.* (2001) who examine R&D spillovers from developed to developing countries via import channels. The work by Coe *et al.* (1997) examines 77 developing countries while Madden *et al.* (2001) evaluate R&D spillovers to six Asian countries. This study differs from the aforementioned surveys in several crucial aspects. First, in addition to the import channel that they analyze, two additional channels are examined here: inward and outward FDI. For East Asian countries, FDI has been an important element in their development strategy, so we cannot neglect it as one of the potential channels of knowledge transmission. Second, unlike Madden *et al.* (2001) who use R&D data for Asian countries from national statistical records, this study uses an R&D database compiled by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and which is harmonized across countries (the data is not subject to potential bias arising from differences

[20] Keller (2004) provides an in-depth survey of the existing empirical evaluations of international R&D spillovers.
[21] Author's own calculations using WDI data for China, Indonesia, Korea, Malaysia, Singapore, Philippines, and Thailand.
[22] These are China, Hong Kong, Indonesia, South Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.

in the R&D definition adopted by each country). Moreover, our sample of Asian countries is different from Madden *et al.* (2001). Thirdly, we formally test the absorptive capacity hypothesis, i.e. whether domestic R&D helps to increase the incidence of spillovers. Finally, for the first time the impacts of R&D spillovers are examined by exploiting cross-sectional dependence. Specifically, we use a dynamic seemingly unrelated regression (DSUR) panel estimator proposed by Mark *et al.* (2005) which is also able to provide country-specific effects of R&D.

Our main findings are that (i) both domestic and foreign R&D are important for productivity growth in East Asian countries (ii) imports are the main spillover channel of foreign technology to the region, (iii) investment in domestic R&D increases the incidence of spillovers, and (iv) although the U.S. is a relatively stronger spillover provider, our empirical results also suggest that close economic cooperation between Japan and the ASEAN member countries has contributed to significant spillover effects.

The rest of the paper is structured as follows. Section 3.2 provides a review of the literature. Section 3.3 highlights our model specification. Section 3.4 explains the construction of our TFP and R&D data. Section 3.5 outlines the econometric estimation methodology. Section 3.6 discusses the empirical findings and section 3.7 concludes.

3.2 Review of the literature

Empirical research on R&D spillovers has been inspired by the theoretical models presented in Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). Romer's (1990) model predicts that an expansion of the range of available inputs raises total factor productivity. Thus, investment in the development of new inputs raises the stock of knowledge and results in lower future R&D costs. This suggests that there are spillover effects from current to future R&D activities. In an international setting these spillovers imply that R&D of one country impacts not only the future R&D costs of domestic firms but also those of foreign firms. The degree to which domestic firms benefit from these spillovers may depend on the economic interaction between the countries such as their bilateral trade and characteristics of the traded products.

The quality ladder models by Grossman and Helpman (1991) and Aghion and Howitt (1992) assume that consumers are willing to pay a premium for high-quality products. As a result, firms always have an incentive to improve the products quality through R&D. One important assumption of this model is that every successful innovation allows all firms to study the attribute of the newly invented product and improve upon it. Patent right restricts other firms from producing the products invented by others but not the use of knowledge that is embodied in that product. Consequently, as soon as the product is created, its production knowledge becomes available to other firms. This allows other firms to begin their own improvements from a higher level of quality. Naturally, these knowledge spillovers apply to all firms (both domestic and foreign) and the extent to which foreign firms can improve the domestic product will depend on the bilateral economic relations between the two.

Much of the earlier policy debate about R&D effects is based on the presumption that a country's productivity depends on domestic investment in R&D. In line with this emphasis, earlier empirical work focused on the impact of domestic R&D on productivity growth. The analysis has been performed at all levels of aggregation– business units, firms and industries – and for many different countries (especially the United States). All these studies reach the conclusion that cumulative domestic R&D is an important determinant of productivity. Indeed, they find that the estimated elasticity of output with respect to R&D is high, varying from 10% to 30% (see the survey of the earlier literature by Nadiri (1993)).

As a result of globalization, the productivity growth of a country does not depend only on domestic R&D but also on foreign R&D, through economic interactions with foreign economies. Several recent papers have addressed this issue by estimating the impact of foreign R&D on domestic productivity. This is typically done by regressing total factor productivity (TFP) on the stock of both domestic and foreign R&D. The pioneering work of Coe and Helpman (1995) (henceforth, CH) assessed R&D spillovers across 21 OECD countries plus Israel and provides empirical evidence of a positive relationship between R&D expenditures and TFP. The authors find that not only domestic R&D contributes significantly to productivity growth but also (trade-embodied) foreign R&D. Trade can boost domestic productivity by making available products that embodies trading partners' state of technological knowledge. By enabling a country to employ a larger variety of intermediate products and capital equipment, trade enhances the productivity of resources at home. Trade also improves domestic productivity by making available useful information that would otherwise be costly to acquire (through imitation). These findings have inspired several subsequent papers [see for example, Lichtenberg and van Pottelsberghe (1998), Kao *et al.*(1999), van Pottelsberghe and Lichtenberg (2001), and Lee (2005) among many others].[23]

[23] See Keller (2004) for a recent survey.

Although research on international R&D spillovers has been growing, it remains limited particularly with respect to North-South spillovers. Most of the literature discussed above focuses on spillovers across developed countries and only a few studies have addressed the North-South spillovers including Coe *et al.*(1997) and Madden *et al.* (2001). Following a similar strategy as in CH, Coe *et al.* (1997) have estimated the impact of foreign R&D on the TFP of 77 developing countries. Coe *et al.* (1997) assume that less developed countries R&D is negligible and thus is ignored in their specification. This assumption is largely due to the unavailability of R&D data. They regress TFP on the import-weighted foreign R&D and find that R&D spillovers to less developed countries are substantial. On average, a 1% increase in R&D capital stock in developed countries contributes to a 0.06% increase in the productivity of developing countries. However, in the case of Asian countries the estimated elasticity is 0.11%. Among the developed countries, the United States contributes the most to the productivity of developing countries because of: (i) its large trade share with developing countries, and (ii) its huge R&D capital stock as compared to other developed countries. Also, the spillover effect emanating from Japan is weak. However, the assumption of a negligible investment in R&D by less developed countries is clearly unrealistic for some East Asian countries. For instance, Korea's R&D expenditures (as a proportion of GDP) had reached 2.6 percent by 2002, surpassing many of Western European countries (Mahadevan and Suardi, 2008). Therefore, omitting domestic R&D suggests a possible omitted variable bias in the estimated elasticity. Madden *et al.* (2001) correct this potential bias by adding domestic R&D in their specification for a selected group of Asian economies.[24] Using a generalised least square estimation technique, they find that domestic R&D has a large impact on productivity growth but that foreign R&D has no clear pattern as only three (out of six) Asian countries benefit from foreign R&D. However, the use of R&D data from individual country statistical publications to capture domestic R&D may have led to biased results due to differences in the R&D definitions adopted by each country.

Although Coe *et al.* (1998) and Madden *et al.* (2002) have made important contributions to the literature on North-South spillovers, several problems remain. For instance, Lichtenberg and van Pottelsberghe (1997) criticize the CH's method of constructing foreign R&D capital stock, which was also adopted in Coe *et al.* (1998). They argue that the method is subject to aggregation bias. They show that the foreign R&D capital stock increases when the trading partners are hypothetically merged although the trading flows between them are unchanged. They propose an alternative measure of foreign R&D stock that is theoretically less biased and find a stronger impact of foreign R&D on domestic productivity. Moreover, the

[24] The six Asian economies are Chinese Taipei, India, Indonesia, Korea, Singapore and Thailand. The OECD countries are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, United Kingdom and the US.

explanatory power of the estimated model (indicated by the adjusted R^2) is higher than the one based on CH's specification.[25]

Several studies such as Kao *et al.*(1999) and Lee (2005) criticize the use of inappropriate estimation techniques in analyzing R&D spillovers. CH first show that both TFP and R&D exhibit clear time trends, and are non-stationary. By applying the panel unit root test of Levin *at al.* (2002)[26] to the residuals of the estimated model, CH subsequently establish that TFP and R&D capital stocks are cointegrated. This prompts them to estimate the impact of R&D on TFP by applying conventional OLS techniques to the pooled cointegrating regression. This estimation strategy was also adopted in Coe *et al*. (1997). The difficulty with the above research is that the properties of panel data estimators under the presence of unit roots and possibly cointegration were not very well known during the early to mid 90s. Although applying OLS (or its variant such as generalised least square estimator) could have been fine, for instance in terms of obtaining consistent estimators, inferences would have been misleading under the likely presence of endogeneity. Recently, several techniques (e.g. Fully Modified OLS (FMOLS), Dynamic OLS (DOLS)) aiming to bypass these difficulties have been proposed in the literature (see Kao and Chiang, 2000; Pedroni, 2000). Both FMOLS and DOLS aim to render N(0,1) based inferences valid for the t-ratios of the panel cointegrating regression despite of the presence of endogeneity. Applying the DOLS estimator of Kao and Chiang (2000), Kao *et al*.(1999) reject the existence of positive spillovers across OECD countries.[27] However, using a newly improved manufacturing industry data set for 17 OECD countries and the FMOLS estimator of Pedroni (2000), Lee (2005) finds that the positive spillover effects via imports are significant.[28]

Advances in panel data econometric techniques have provided more reliable approaches for analyzing cointegrated variables.[29] It should be emphasized however that the DOLS and FMOLS estimators discussed above have two major limitations, at least in the present context. First, they assume that all cross-sectional units are independent. This assumption is clearly unrealistic in many applications based on multi-country data sets such as R&D spillovers. There is no reason to believe that the spillover process across countries is independent. For instance, MNCs' decision to invest in a particular country inevitably affects the amount of FDI flows to other countries. In this respect, the dynamic SUR (DSUR)

[25] Using an alternative weighting scheme, Lichtenberg and van Pottelsberghe (1998) show that the R&D capital stock changes only marginally.
[26] CH refer to working paper versions of this paper dated 1992 and 1993.
[27] Kao *et al.* (1999) refers to the working paper version of Kao and Chiang (2000).
[28] Lee (2005) also uses DOLS and FMOLS within-dimension estimator proposed by Kao and Chiang (2000) and finds that the international R&D spillover effect remains robust, in contrast to the finding by Kao *et al.* (1999). He attributed this finding to the improvement in the quality of the data used.
[29] Breitung and Pesaran (2008) provide a summary of recent panel cointegration literature.

estimator proposed by Mark *et al*. (2005) provides an excellent alternative. The estimator accounts for cross-sectional dependence by exploiting the information in the variance–covariance matrix of residuals. The second limitation of the DOLS and FMOLS is that they provide one cointegrating vector for all countries and the slope estimates are interpreted as average long-run effects. This notion of 'one size fits all' may be restrictive in the present context because many studies have highlighted the diverse impacts of R&D on productivity across countries. For instance, CH show that domestic R&D had a larger impact on the TFP of G-7 countries than on other smaller OECD countries. Moreover, Madden *et al*. (2001) shows that some countries benefits from foreign R&D while others do not.[30] In contrast to DOLS and FMOLS, the DSUR estimator computes one cointegrating vector for each single equation and thus allows us to evaluate country-specific effects of R&D.

Another limitation of Coe *at al*. (1998) and Madden *et al*. (2002) is that they consider imports as the only channel through which new knowledge may spill over to other countries. Over the past few decades, FDI by multinational corporations (MNCs) has grown substantially. The growth rate of world FDI has exceeded the growth rates of both world trade and GDP (UNCTAD, 2001). Since MNCs are responsible for a large share of global R&D expenditure, FDI by MNCs could be an important channel via which less developed countries gain access to technologies available at the world frontier. van Pottelsberghe and Lichtenberg (2001) extend CH's work by incorporating inward and outward FDI channels. They analyze only 13 out of 22 countries covered in CH's study and find that foreign R&D spills over across borders via imports and outward FDI channels but not through inward FDI. They argue that outward FDI is a more effective channel than inward FDI in gaining access to world technology, because the former involves 'total immersion'. By setting up production and research facilities in countries that have accumulated substantial scientific and technological capabilities, a technology follower can have better access to leading technologies. The finding that technology diffuses via outward but not inward FDI is consistent with Dunning's (1994) paradigm where companies prefer to invest abroad in order to take advantage of their own technology base instead of diffusing it internationally. However, several recent works provide empirical support to inward FDI as a channel for R&D spillovers, e.g. Bitzer and Kerekes (2008), Zhu and Jeon (2007) or Savvides and Zachariadis (2005).

A number of economists are sceptical about the benefits of outward FDI for domestic economy. One central argument is that outward FDI substitutes foreign activities for domestic activities and thus domestic investment is reduced when MNCs shift part of their investment abroad (Herzer and Schrooten, 2008). Using the U.S MNCs data, Feldstein (1994) shows that

[30] They differentiate the effects across countries using dummy variables interacted with each country's R&D capital stocks.

FDI outflows reduce domestic investment on dollar-for-dollar basis. Another argument relates to potential substitution between FDI and exports as a method for serving foreign markets. Therefore, an increase in outward FDI may result in lower exports and for export-driven East Asian countries this can dampen their growth performance.

Several models predict that R&D can have a dual role. Apart from generating new information, R&D also develop firm's absorptive or learning capacity, i.e. the ability to identify, assimilate, and exploit knowledge from the environment (Cohen and Levinthal (1989).[31] Investment in R&D is a crucial determinant of technical competence of the labor force. They find strong evidence supporting the idea that more R&D intensive firms are more successful when it comes to absorbing R&D spillovers. Griffith *et al.*'s (2003) model predicts that by engaging in R&D, countries increase their ability to assimilate and understand the discoveries of others. In the present context, domestic R&D is not only important in generating new information which directly contributes to productivity growth, but also in facilitating international R&D spillovers from developed countries (both domestic and foreign embodied R&D are complements).

With this background, this study contributes to the literature by examining both imports and FDI as potential channels via which R&D activities in developed countries affect the productivity of East Asian countries. It also examines the role of absorptive capacity in mediating R&D spillovers. Moreover, it tests whether the United States or Japan is the most important source of R&D spillovers. This is achieved by utilizing the DSUR estimation approach of Mark *et al.* (2005) which has numerous advantages over other estimators when it comes to analyzing R&D spillovers.

3.3 Model specification

This study uses a generalized version of the model employed by Coe and Helpman (1995), as modified by Lichtenberg and van Pottelsberghe (1998) and van Pottelsberghe and Lichtenberg (2001). This model can be used to test whether trade and FDI serve as channels for the international diffusion of technology. Equation (3.1) provides the basic econometric model. It states that the domestic total factor productivity of a country is a function of its domestic R&D capital stock and of different types of foreign R&D capital stocks:

$$TFP_{it} = \beta_i + \beta_1 SD_{it} + \beta_2 SF_{it} + e_{it} \qquad (3.1)$$

[31] Crespo and Fontoura (2007) provide a summary of absorptive capacity literature.

where i is an index of Asian countries (China, Korea, Malaysia, Singapore, and Thailand). *TFP* is the total factor productivity, *SD* is the stock of domestic R&D, and *SF* is the stock of foreign R&D. All variables are in logarithmic form. β_i is a country-specific intercept, β_1 is the elasticity of TFP with respect to domestic R&D, β_2 is the elasticity of TFP with respect to foreign R&D, and e is the random error term.

Following van Pottelsberghe and Lichtenberg (2001), we use three procedures for constructing different foreign R&D capital stocks. The import-weighted R&D capital stock S_i^{fm} is constructed as follows:

$$S_i^{fm} = \sum_{j \neq i} \frac{m_{ij} S_j^d}{y_j} \tag{3.2}$$

where j is an index of G-5 countries (France, Germany, Japan, United Kingdom, and United States), m_{ij} is the flow of imports of goods and services of country i from country j, and y_j is country $j's$ GDP.

The inward FDI-weighted foreign R&D capital stocks S^{ff} is computed using the following formula:

$$S_i^{ff} = \sum_{j \neq i} \frac{f_{ij}}{k_j} S_j^d \tag{3.3}$$

where f_{ij} is the flow of FDI from country j towards country i, and k_j is the gross fixed capital formation of country j, both expressed in constant dollars.

Finally, we construct the outward FDI-weighted foreign R&D capital stock S^{ft} as follows:

$$S_i^{ft} = \sum_{j \neq i} \frac{t_{ij}}{k_j} S_j^d \tag{3.4}$$

where t_{ij} are the FDI flows of country i towards country j. It states that foreign R&D capital stock of country i corresponds to the sum of all its outward FDI embodied in the R&D capital stock of the target countries.

We would also like to test the absorptive capacity hypothesis suggested by Cohen and Levinthal (1989) and Griffith *et al.* (2003). They predict that investment in R&D increases the incidence of technology spillovers by enhancing the firm's capacity to identify, assimilate, and exploit outside knowledge. In the present context, investment in domestic R&D is expected to improve technical competence of the workforce and this will facilitate R&D spillovers from the G-5 countries. To conduct an empirical test of this hypothesis, an interaction term is included (constructed as a product of domestic R&D and foreign R&D capital stock) as an additional regressor in Equation (3.1) as follows:

$$TFP_{it} = A_i + A_1 SD_{it} + A_2 SF_{it} + A_3 (SF_{it} \times SD_{it}) + \varepsilon_{it} \qquad (3.5)$$

In this specification, if the coefficient A_3 is positive and significant, this would imply that knowledge spillovers from the G-5 countries is conditional on the level of domestic R&D. This will be interpreted as evidence supporting the absorptive capacity hypothesis.

Finally, we examine whether R&D spills over more from Japan or from the United States. For this purpose, we estimate a variant of Equation (3.1) as follows:[32]

$$TFP_{it} = \alpha_i + \alpha_1 SD_{it} + \alpha_2 [(m_{ijt} / y_{jt}) S^d_{jt}] + \alpha_3 [(f_{ijt} / k_{jt}) S^d_{jt}] + e_{it} \qquad (3.6)$$

where j= Japan or the United States, and all other variables are as defined above.

3.4 Estimation procedures

Our empirical analysis involves three important stages. First, we evaluate the stationarity properties of both dependent and independent variables. Second, we test whether these variables are cointegrated. This typically translates into testing whether the residuals from Equation (3.1) are stationary. Finally and most importantly, our objective is to obtain reliable estimates of the slopes in Equation (3.1) and to test their statistical significance. The following section explains the econometric methodology used in this paper.

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[32] We exclude the outward FDI channel due to restricted data availability.

3.4.1 Panel unit root tests

Im *et al*. (2003) (hereafter IPS) propose the $\bar{t}$ -statistic for panel unit root test under the assumption of cross-sectional independence. They consider a panel specification of the form:

$$\Delta y_{it} = \beta_i y_{i,t-1} + \sum_{j=1}^{p_i} \phi_{ij} \Delta y_{i,t-j} + \varepsilon_{i,t} \qquad i = 1,....N, \quad t = 1,.....T \tag{3.7}$$

where $\Delta y_{it} = y_{it} - y_{i,t-1}$, p_i is the required degree of lag augmentation to whiten the residuals.

The null hypothesis of a unit root may be written as,

$$H_o = \beta_i = 0 \text{ for all } i \tag{3.8}$$

While the alternative hypothesis is given by:

$$H_1 = \beta_i < 0, \; i = 1,2,...,N_1, \qquad H_1 = \beta_i = 0, \; i = N_1 + 1, N_1 + 2,....,N. \tag{3.9}$$

The formulation of the alternative hypothesis is more flexible than the homogeneous alternative hypothesis, namely $\beta_i = \beta < 0$ for all i which is implicit in the testing approach of Levin *et al*.(2002). This condition allows β_i to differ across countries and only a fraction of panel member is required to be stationary under the alternative.

The $\bar{t}$ -statistic is computed as an average of individual *t*-statistics from a standard ADF specification as follows:

$$\bar{t}_{IPS} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} \tag{3.10}$$

where t_{iT} is the individual t-statistic for β_i from the individual ADF regressions. Then, the standardized statistic is given by:

$$Z_{\bar{t}_{IPS}} = \frac{\sqrt{N} \quad \{\bar{t}_{NT} - E(t_T \mid \beta_i = 0)\}}{\sqrt{Var(t_T \mid \beta_i = 0)}} \tag{3.11}$$

where $E(t_T \mid \beta_i = 0)$ and $Var(t_T \mid \beta_i = 0)$ are the common mean and variance of t_{iT} for i=1,2,…,N, obtained under the null, β_i=0. As discussed in IPS, this test has a standard normal distribution when $N \to \infty$. When N is fixed as in the present study, the sample distribution of $\bar{t}_{NT}$ is non-standard. As a result, the critical values and p-values could not be obtained from the standard normal distribution. However, this can be solved by using simulations as discussed in IPS. IPS tabulate simulated critical values for different magnitudes of N and T, and for models containing either intercepts, or intercepts and linear trends.

The assumption of cross-sectional independence of the IPS test is however a rather restrictive, particularly in the context of cross-country regression. Pesaran (2007) shows that the IPS test tends to over-reject the null when the cross sections are highly correlated. Pesaran proposes the modified version of the IPS test (known as *CIPS* test) which control for cross-section dependence induced by an unobserved common factor. Pesaran suggests augmenting Equation (3.7) with cross-section averages of lagged levels and first-differences of the individual series as follows:

$$\Delta y_{it} = b_i y_{i,t-1} + \sum_{j=1}^{p_i} c_{ij} \Delta y_{i,t-j} + \varphi_i \bar{y}_{t-1} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta \bar{y}_{t-j} + u_{i,t} \tag{3.12}$$

where $\bar{y}_t$ is the cross-sectional mean of y_{it}. Pesaran notes, that under certain assumptions, the cross-sectional averages in (3.12) are shown to act as proxies for unobserved common factor. Then, the *CIPS* test is calculated as an average of t-statistics of the OLS estimate of b_i ($\hat{b}_i$) from individual regression (3.12).

3.4.2 Panel cointegration tests

Pedroni (1999) suggests two types of test statistics for the models with heterogeneous cointegrating vectors under the assumption cross-sectional independence. These are (i) the ''panel statistics" that is equivalent to the unit root test statistic against homogeneous alternatives, and (ii) the 'group mean statistics' that is analogous to the panel unit root tests against heterogeneous alternatives. Let $\hat{e}$ denote the OLS residual of the cointegrating regression (3.1), the test statistics are defined as follows:

Panel v-Statistic:

$$Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \tag{3.13}$$

Panel ρ-Statistic:

$$Z_{\rho} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \tag{3.14}$$

Panel t-Statistic (non-parametric):

$$Z_{t} = \left(\tilde{\sigma}_{N,T}^{2} \sum_{t=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \tag{3.15}$$

Panel t-Statistic (parametric):

$$Z_{t}^{*} = \left(\tilde{s}_{N,T}^{*2} \sum_{t=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{*2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*} \tag{3.16}$$

Group ρ-Statistic:

$$\tilde{Z}_{\rho} = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \tag{3.17}$$

Group t-Statistic (non-parametric):

$$\tilde{Z}_{t} = \sum_{i=1}^{N} \left(\hat{\sigma}_{i}^{2} \sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \tag{3.18}$$

Group t-Statistic (parametric):

$$\tilde{Z}_{t}^{*} = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{s}_{i}^{*2} e_{i,t-1}^{*2} \right)^{-1/2} \sum_{t=1}^{T} \hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*} \tag{3.19}$$

where, $\hat{\lambda}_i$ is a consistent estimator of the long run variance, $\hat{L}_{11i}^{2} = \frac{1}{T}\sum_{t=1}^{T}\hat{\eta}_{i,t}^{2} + \frac{2}{T}\sum_{s=1}^{k_i}\left(1 - \frac{s}{k_i+1}\right)\sum \hat{\eta}_{i,t}\hat{\eta}_{i,t-s}$, $\hat{\sigma}_{i}^{2} = \hat{s}_{i}^{2} + 2\hat{\lambda}_{i}$, $\hat{s}_{i} \equiv \frac{1}{T}\sum_{t=1}^{T}\mu_{i,t}$, $\tilde{\sigma}_{N,T}^{2} \equiv \frac{1}{N}\sum_{i=1}^{N}\hat{L}_{11i}^{-2}\hat{\sigma}_{i}^{2}$, $\hat{s}_{i}^{*2} \equiv \frac{1}{t}\sum_{t=1}^{T}\hat{\mu}_{i,t}^{*2}$, $\tilde{s}_{N,T}^{*2} \equiv \frac{1}{N}\sum_{i=1}^{N}\hat{s}_{i}^{*2}$, and the residuals $\hat{\mu}_{i,t}$, $\hat{\mu}_{i,t}^{*}$ and $\hat{\eta}_{i,t}$ are obtained from the following regressions: $\hat{e}_{i,t} = \hat{\gamma}_i \hat{e}_{i,t-1} + \mu_{i,t}$, $\hat{e}_{i,t}^{*} \hat{\gamma}_i e_{i,t-1} + \sum_{k=1}^{K_i}\hat{\gamma}_{i,k}\Delta\hat{e}_{i,t-k} + \hat{u}_{i,t}^{*}$, $\Delta y_{i,t} = \sum_{m=1}^{M}\hat{b}_{mi}\Delta x_{mi,t} + \hat{\eta}_{i,t}$.

Westerlund (2007) shows that the Pedroni's test statistics tend to over-reject the null and thus are unreliable when the cross section units are correlated. Alternatively, the author proposes four new tests based on error-correction model and uses a bootstrap method to account for cross-sectional dependence. In this study we use only two tests namely, panel and group mean τ-statistics which are more robust to cross-sectional correlation. Following Westerlund (2007), the error-correction model for Equation (3.1) is given as follows:

$$\Delta TFP_{it} = \delta_i^{'} d_t + \alpha_i \left(TFP_{it-1} - \beta_i^{'} x_{it-1} \right) + \sum_{j=1}^{p_i} \alpha_{ij} \Delta TFP_{it-j} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta x_{it-j} + \varepsilon_{it} \tag{3.20}$$

where $d_t^{'}$ is a vector of deterministic components, $x = (SD, SF)$ is a vector of regressors, α_i is the error-correction parameter which forms the basis of the tests. Within this framework, the test statistics are designed to test the null on no-cointegration by inferring whether the α_i is equal zero. Therefore, testing the null of no cointegration is equivalent to testing of no error-correction. The τ-statistics are defined as follows:

Panel τ-Statistic:

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \tag{3.21}$$

Group τ-Statistic:

$$G_\tau = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \tag{3.22}$$

where SE($\hat{\alpha}$) is the standard error of $\hat{\alpha}$. To preserve the cross-sectional correlation structure of ε_{it}, Westerlund (2007) proposes a bootstrap approach to derive the distribution of the τ-statistics.[33] Simulation evidence shows that these bootstrapped test statistics maintain good size accuracy and are more powerful than the Pedroni's test statistics when the cross sections are correlated.

3.4.3 *Dynamic seemingly unrelated regression estimator*

Once the cointegrating properties are examined, the next step is to generate long-run coefficient estimates for Equation (3.1) and test their statistical significance. For this purpose, we use the DSUR estimator due to Mark *et al.* (2005) which allows for heterogeneous cointegrating vectors and cross-sectional dependence in the residuals. The DSUR estimator applied to Equation (3.1) can be written over *i* (*i*=1,…,5) as follows:

[33] See Westerlund (2007) for the details of the bootstrap procedure.

$$TFP_{it} = \alpha_i + \varphi_i SD_{it} + \theta_i SF_{it} + \sum_{i=1}^{5}\sum_{j=-p}^{p} \delta_{ij}\Delta SD_{it-j} + \sum_{i=1}^{5}\sum_{j=-p}^{p} \psi_{ij}\Delta SF_{it-j} + \varepsilon_{it} \quad (3.23)$$

where p is the number of leads and lags of the first difference to correct for possible endogeneity of the errors. From Equation (3.23), it is clear that endogeneity in equation i is corrected by incorporating leads and lags of the first difference not only of the regressors of equation i but also of the regressors of all the other equations in the system. However, this results in a proliferation of leads and lags in the system which reduces degrees of freedom. Consequently, the DSUR estimator is only applicable for samples where N is substantially smaller than T. Due to the limitations of our sample size and for the purpose of preserving degree of freedom, we set p=1.[34] The DSUR accounts for cross-sectional dependence by exploiting the off-diagonal elements of covariance matrix $\mathbf{\Omega} = E(\varepsilon_{it}\varepsilon_{it}^{'})$. Mark *et al.* (2005) show that the DSUR estimator achieves significant efficiency gains over non-system estimators such as DOLS when heterogeneous sets of regressors enter into the regressions and when errors are correlated across cointegrating regressions.

3.5 Data set

This study focuses on R&D spillovers from the G-5 countries (France, Germany, Japan, United Kingdom and United States) to a group of East Asian countries (China, Malaysia, Singapore, South Korea and Thailand) for the period 1984-2005. R&D data were collected from two sources. Data for the G-5 countries were collected from the OECD's *Main Science and Technology Indicators.* Data for East Asian countries were collected from the UNESCO Institute for Statistics. Both databases adopt a common definition of R&D which is total intramural expenditure on R&D on the national territory. It includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D. The database provides information on R&D expenditures and personnel for 115 countries (including OECD countries). The data are further classified into sectors - business enterprises, government, universities, and non-profit private institution. However, sectoral data are less complete than the aggregate data. At present, it covers the period 1996-2006 but for some countries the data are not available over the full period. Since R&D data for East Asian countries are not available over our full sample period, we extrapolate the data using real GDP and investment series (Coe and Helpman, 1995).

[34] Mark *et al.* (2005) point out that there is no standard method for selecting p. The *ad hoc* rule by Stock and Watson (1993) that sets p=1 for T=50, p=2 for T=100, and p=3 for T=300 is commonly used in many Monte Carlo and empirical studies.

It should be pointed out that the R&D definition adopted by both OECD and UNESCO excludes R&D activity by domestic firms performed in foreign countries. Recently, many developing countries have established R&D centers in other countries - especially in developed countries – to have better access to leading technology. For instance, Chinese firms make substantial investment for establishing R&D centers in the United States. According to the U.S. Bureau of Economic Analysis (BEA, 2005), as of 2002, Chinese firms had established 646 R&D centers or affiliates in the United States. Ideally, this aspect of R&D investment should be included in constructing domestic R&D stocks because it reflects more precisely a country's level of investment in R&D. However, this is not an option due to restricted data availability.

Bilateral data on imports and FDI (both inward and outward) were taken from the IMF's Direction of Trade database and the OECD database, respectively. A glance at the data reveals that FDI flows are highly volatile and some observations are missing. To deal with these problems, FDI series were computed within a four-year moving average (i.e. the average of current and three preceding years). Moreover, due to restricted availability of FDI outflow series, the sample used to examine spillover effects via outward FDI is limited to three countries (Korea, Malaysia, and Singapore) covering the period 1991-2005.

R&D capital stocks (S) were computed using the perpetual inventory method as follows:

$$S_t = (1-\delta)S_{t-1} + R_t \tag{3.21}$$

where δ is the depreciation rate, which is assumed to be 5 percent and R denotes R&D expenditures.[35] The benchmark (i.e. initial capital stock) for S was calculated following:

$$S_o = R_o/(g+\delta) \tag{3.22}$$

where g is the average annual logarithmic growth of R&D expenditures over the period for which published R&D data were available, R_o is the R&D expenditure at the beginning of the sample period, and S_o, is the benchmark R&D capital stock.

[35] In the literature, values for the depreciation rate range between 0% and 10 % but the 5% is commonly used (see Keller 2004).

The TFP series of each Asian country was obtained from:

$$TFP = Y / K^{\beta}L^{1-\beta} \qquad (3.23)$$

where Y is the final output (base year 2000), L is the total labor force, K is the stock of physical capital, and β is the share of capital income in GDP which is set to 0.4, following Chenery *et al.* (1986). All the data for the construction of TFP were obtained from the World Development Indicators. The stocks of physical capital were constructed using gross fixed capital formation series following the perpetual inventory method with a 5% depreciation rate.[36]

Our measure of TFP has been a subject of intense debate in the literature. Many economists have identified problems, of both concept and measurement associated with this measure. For instance, Griliches (1987) outlines the following problems linked to the production function approach of TFP measure: (1) a relevant concept of capital, (2) measurement of output, (3) measurement of inputs, (5) the place of R&D and public infrastructure, (5) missing or appropriate data, (6) weight for indices, (7) theoretical specifications of relations between inputs, technology, and aggregate production functions, and (8) aggregation over heterogeneity. Moreover, Diewert (1987) show that very restrictive assumptions have to be satisfied to generate the indices of output and input. Lipsey and Carlaw (2004) point out that this approach requires a very strong assumption that such that the production functions remain stable over long period of time.

An alternative to the production function approach is the index number approach where the TFP is measured as a ratio of output index to input index. This approach is very similar to the production function approach but does not require an aggregate production function. Nevertheless, it involves other similar problems associated with production function approach (Lipsey and Carlaw, 2004). One application of the index method approach is data envelopment analysis (DEA), which makes a strong claim of being able to separate TFP into two parts, one due to increased efficiency in resource use and one due to technological change. The method uses a Malmquist index and compares ratios of outputs with input across units. However, it requires a strong assumption that all units being compared have identical production functions. This assumption is clearly not credible in our heterogeneous set of countries. There is no reason to believe why China and Korea have similar production functions.

[36] Alternatively, one can use estimated residuals from the standard Cobb-Douglas production function. These two approaches of measuring TFP and other alternative methods are discussed in Lipsey and Carlaw (2004).

Another approach to TFP measurement is based on econometric models that measure TFP using output and input volume. It avoids many shortcomings associated with the production function or index number approach and may allow for adjustment cost and variations in capacity utilisation. It also allows investigation of different form of technical change other than Hicks-neutral formulation implied by the other approaches. An example can be found in Nadiri and Prucha (2001). However, all these advantages come at a cost. A full-fledged model raises complex econometrics issues and sometimes put a question mark on the robustness of results. Moreover, limited data availability as in our case may have negative implication on the degrees of freedom and make this approach not an option. Furthermore, it also suffers from measurement error problems associated with the production function and index number approaches.

Figures 1-5 display the trends of these explanatory and dependent variables for each country over the sample period. Overall, they increased over the time span but the upward trend was neither uniform across countries nor uniform over time.

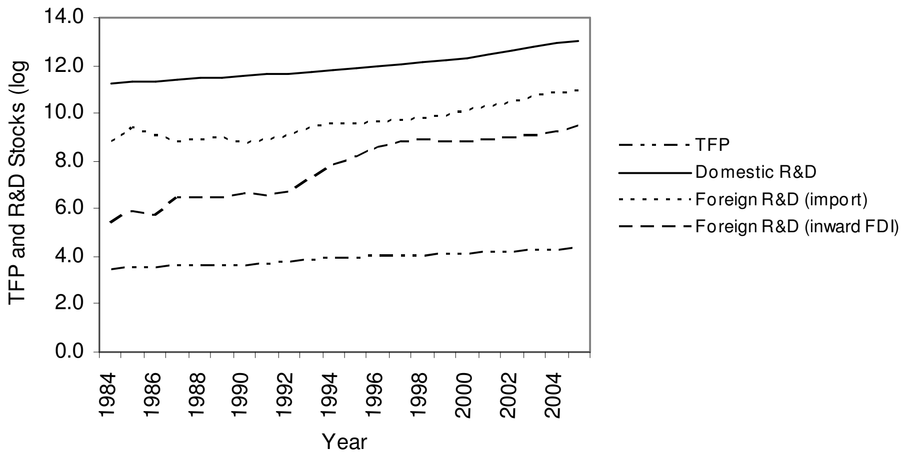


Figure 3.1: TFP and R&D capital stocks for China

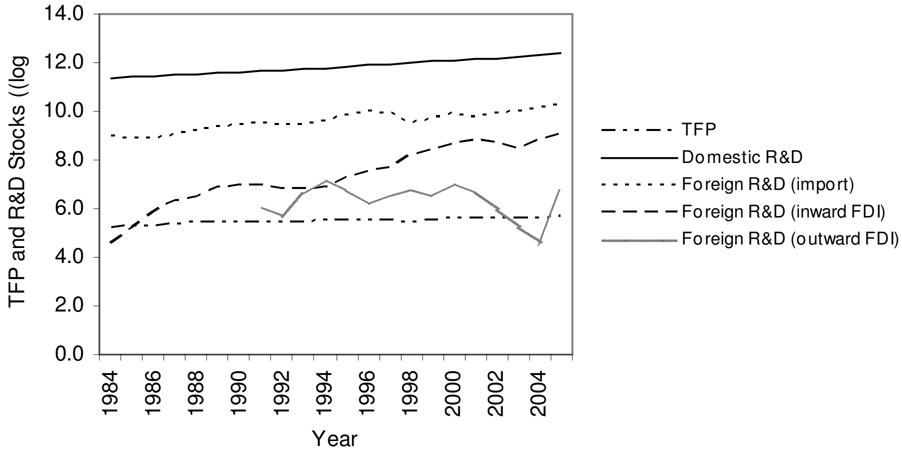


Figure 3.2: TFP and R&D capital stocks for Korea

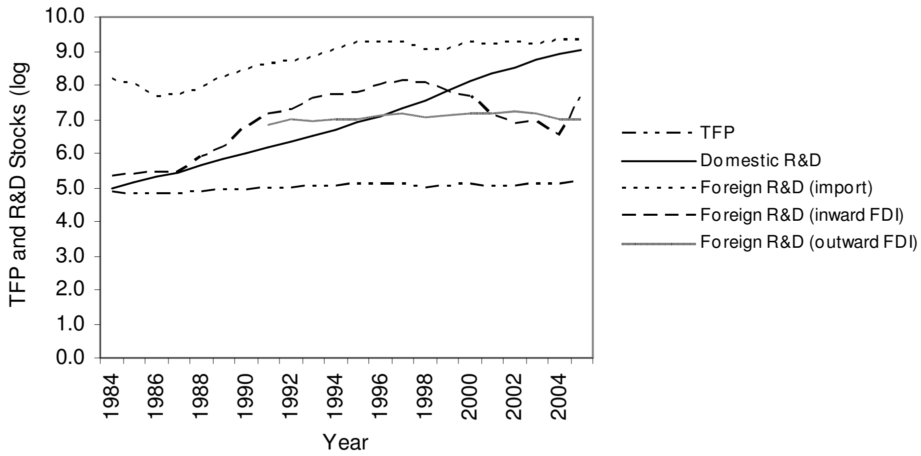


Figure 3.3: TFP and R&D capital stocks for Malaysia

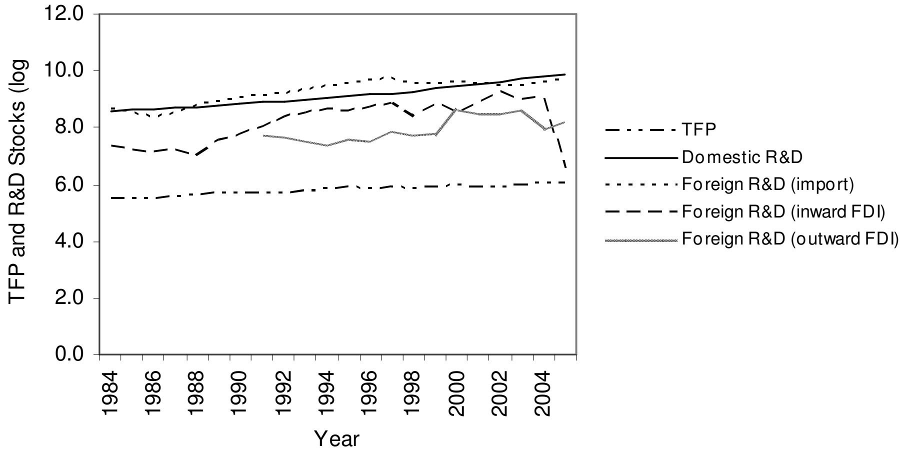


Figure 3.4: TFP and R&D capital stocks for Singapore

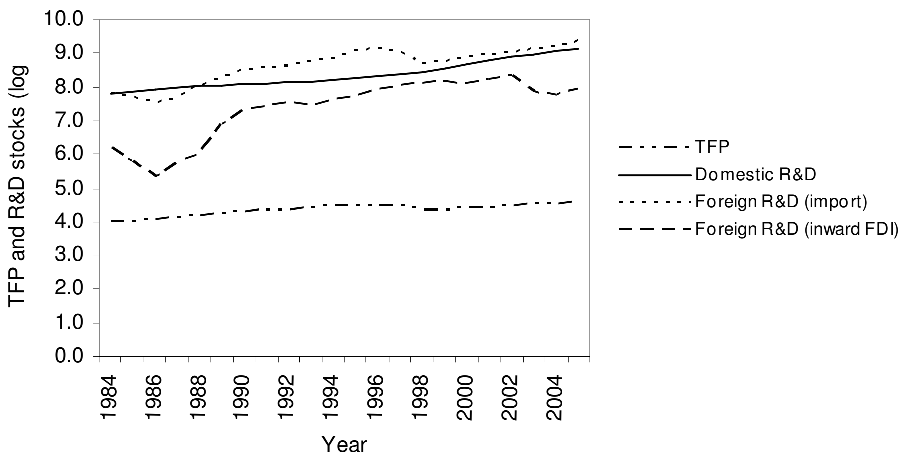


Figure 3.5: TFP and R&D capital stocks for Thailand

3.6 Empirical results

The discussion in Section 3.2 indicates that the assumption of cross-sectional dependence is likely to hold in the analysis of R&D spillovers. One way of testing the appropriateness of this assumption is to apply the *LM* test of Breusch and Pagan (1980) on our dataset. The test for the hypothesis that all correlation coefficients are jointly 0 is defined as:

$$LM = N\sum_{i=1}^{N}\sum_{j=1}^{i-1}\hat{c}_{ij} \tag{3.24}$$

where $\hat{c}_{ij}$ is the Pearson correlation coefficient. Breusch and Pagan show that the when N is fixed the test is distributed as χ^2 with $N(N\text{-}1)/2$ degree of freedom. When N is large, the normalised test $(LM-n)/\sqrt{2n}$ is asymptotically $N(0,1)$ as $T\to\infty$ and then $N\to\infty$. In our analysis, the hypothesis of cross sectional independence is tested on the residuals of individual series obtained by running OLS regression of each series on its own lag and deterministic components (intercept or intercept plus linear time trend). We also compute the *LM* statistic for two variants of model (3.1). Model I features both import and inward FDI channels for all countries over the 1984-2005 period. Model II features only outward FDI channel using data from Korea, Malaysia and Singapore for the 1991-2005 period. Table 3.1 report the results of no cross-sectional dependence tests. As shown in the table, the test statistics show strong evidence of cross-section dependence in most cases as the null of no cross-sectional dependence can be rejected at the 10% level of significance. Two exceptions are the tests on S^d where the correlation matrices are singular and S^{ft} where the null can not be rejected.

Table 3.1: Cross-sectional dependence tests

	intercept	Intercept + trend
TFP	82.989 (0.000)	79.196 (0.000)
S^d	n/s	n/s
S^{fm}	72.085 (0.000)	70.887 (0.000)
S^{ff}	16.590 (0.083)	16.879 (0.077)
S^{ft}	3.592 (0.309)	2.369 (0.499)
Model I: [TFP, S^d, S^{fm}, S^{ff}]	44.410 (0.000)	50.501 (0.000)
Model II: [TFP, S^d, S^{ft}]	12.788 (0.005)	14.877 (0.001)

Notes: n/s indicates that the test can not be computed because correlation matrix of residuals is singular.

3.6.1 Unit root tests

In Table 3.2 we report the results of the panel unit root tests. The IPS and CIPS tests for both model with- and without-trend are reported for $p \leq 3$. Generally, the results based on the IPS test show that the *t*-statistics are smaller that the critical values (in absolute term), regardless of the inclusion or exclusion of a linear time trend. The only minor exceptions are for S^d (p=1) in the model with intercept and TFP (p=2) in the model with intercept and trend where the null of a unit root can be rejected. However, the results of the CIPS test which control for cross-sectional dependence suggests that the null of unit root cannot be rejected in all cases. We also perform the standard ADF tests on our individual series which indicate that the null of a unit root can not be rejected in most cases (see Appendix 3.1). Overall, our findings are consistent with Coe and Helpman (1995) and others who also find that TFP and R&D series are non-stationary.

Table 3.2: Panel unit root tests

	IPS test			CIPS test		
	p=1	p =2	p =3	p=1	p =2	p =3
Intercept						
TFP	-1.414	-1.358	-1.320	-1.797	-2.071	-2.775
S^d	6.767*	1.200	1.584	0.837	0.704	0.840
S^{fm}	-2.057	-1.830	-1.676	-1.203	-1.219	-1.696
S^{ff}	-1.868	-1.583	-1.726	-1.380	-2.047	-2.752
S^{ft}	-1.879	-2.067	-1.720	-1.939	-3.388	-2.748
Intercept + trend						
TFP	-2.328	-2.871*	-2.296	-2.075	-2.686	-3.359
S^d	-0.092	-1.115	-1.004	-1.641	-1.102	0.008
S^{fm}	-2.398	-2.587	-2.097	-2.322	-1.837	-2.390
S^{ff}	-1.382	-1.582	-2.132	-1.423	-1.976	-2.500
S^{ft}	-1.891	-1.760	-1.268	-1.793	-1.629	-1.320

Notes: The 5% critical values for the IPS test are -2.19 (intercept) and -2.82 (intercept + trend) taken from Table 2 of IPS, while the ones for the CIPS test are -4.35 (intercept) and -4.97 (intercept + trend) taken from Table 1 of Pesaran (2007). * indicates statistical significance at the 5% level.

3.6.2 Cointegration test

In order to establish that our fitted regression model is not spurious, we carry out cointegration analysis on the series using both Pedroni (1999) and Westerlund (2007) test statistics. Both tests allow for heterogeneous cointegrating vectors but the one by Westerlund (2007) is flexible enough to accommodate for cross section correlation. The results of these tests are reported in Table 3.3. For Model I, six Pedroni's test statistics indicate that the model with intercept is cointegrated and all test statistics indicate that the model with intercept and trend is cointegrated using a 10% significance level. For Model II, in five cases the null of no-cointegration is rejected for both the model with intercept and model with intercept and trend. However, these results may be spurious if the cross sections are correlated. We therefore complement these results with the two test statistics of Westerlund (2007) which were shown to be robust under the cross-sectional dependence. We find that there is strong support for a cointegrating relationship for Model I as the null of no cointegration can be rejected at the 10% level. For Model II, we only find that the variables are cointegrated in model with intercept using the P_τ-statistic. In all other cases, the null cannot be rejected. Given that our sample size is small, these results may be unreliable. Therefore, we next employ the Johansen's (1991) maximum likelihood procedure to test for cointegration individually. Interestingly, both the λ_{trace} and $\lambda_{\max}$ statistics suggest that the variables of interest are cointegrated for all countries (see Appendix 3.2). Overall, our results strongly suggest that that TFP, domestic R&D, and foreign R&D are cointegrated. This finding is consistent with van Pottelsberghe and Lichtenberg (2001) and others who also find that these variables are cointegrated within a group of OECD countries.

Table 3.3: Panel cointegration tests

	Model I: [TFP, S^d, S^{fm}, S^{ff}]		Model II: [TFP, S^d, S^{ff}]	
	intercept	Intercept + trend	intercept	Intercept + trend
Panel A: Pedroni (1999)				
Z_ν	-1.076 (0.223)	-1.900 (0.065) [c]	-1.928 (0.062) [c]	-2.818 (0.007) [a]
Z_ρ	1.742 (0.087) [c]	2.703 (0.010) [b]	1.118 (0.213)	1.879 (0.068) [c]
Z_t	-2.225 (0.033) [b]	-4.330 (0.000) [a]	-1.441 (0.141)	-32.510 (0.000) [a]
Z_t^*	1.831 (0.074) [c]	2.332 (0.026) [b]	-2.595 (0.013) [b]	-1.484 (0.132)
$\tilde{Z}_\rho$	3.105 (0.003) [a]	3.651 (0.000) [a]	2.188 (0.036) [b]	2.745 (0.009) [a]
$\tilde{Z}_t$	-2.281 (0.029) [b]	-9.617 (0.000) [a]	-4.539 (0.000) [a]	-48.182 (0.000) [a]
$\tilde{Z}_t^*$	4.044 (0.000) [a]	4.361 (0.000) [a]	-2.458 (0.019) [b]	-0.5971 (0.333)
Panel B: Westerlund (2007)				
P_τ	-1.214 (0.080) [c]	-1.674 (0.040) [b]	-1.636 (0.074) [c]	2.173 (0.664)
G_τ	-2.449 (0.020) [b]	-1.362 (0.064) [c]	-0.312 (0.240)	1.310 (0.538)

Notes: Figures in parentheses are *p*-values and [a,b,c] indicates statistical significance at the 1%, 5%, and 10% level. Optimal lag lengths were selected based on AIC. Number of bootstraps for P_τ and G_τ tests are 500.

3.6.3 Analysis of R&D spillovers

Having established that the variables are cointegrated, we proceed to generate consistent estimates of β in Equation (3.1). To this end, the DSUR estimator outlined in Section 3.4 is used and results are reported in Tables 3.4 and 3.5. As shown in the Table 3.4, the TFP elasticities with respect to domestic R&D and both foreign R&D capital stocks have plausible magnitudes, lying in absolute value between zero and one. Domestic R&D is found to be important for Korea, Malaysia and Singapore but not for China and Thailand. Korea has the greatest benefit from domestic R&D. The estimated elasticity of 0.28 suggests that a 1% increase in domestic R&D will result in 0.28% higher productivity growth. This finding is consistent with Kim (2003) who points out that Korea depends on domestic firms for technology upgrading due to substantial restrictions on inward FDI. It is interesting to note that there is a clear positive relation between the magnitude of domestic R&D effects and the level of economic development. This suggests that as countries become more developed, domestic R&D becomes more important for domestic productivity growth. This is in line with Coe and Helpman (1995) who find that higher-income OECD countries benefit more from domestic R&D compared to other lower-income countries. With respect to international R&D spillovers, there is strong evidence suggesting that imports are a more important channel than inward FDI in transmitting the positive effect of foreign R&D. For all countries, the coefficients on the import-weighted foreign R&D stock are positive and significant. However, the R&D spillovers incorporated in inward FDI is ambiguous as only China and Malaysia benefit from having more FDI. In the case of Korea, Singapore, and Thailand, more FDI adversely affects their productivity growth. One possible explanation of this finding is that the benefit of FDI-related externalities is outweighed by the negative effect of increased competition from foreign firms. FDI inflows may force less productive domestic firms out of business (Aitken and Harrison, 1999). As presented in Table 3.5, evidence of spillover that passes through outward FDI is mixed as only Korea benefit from its investment abroad. Those results are in contrast with van Pottelsberghe and Lichtenberg (2001) who find that outward FDI is one of the important channels of R&D spillovers among the OECD countries. One explanation may lie in that the positive effects of investing in other countries are outweighed by the effect of lower domestic investment. This is consistent with Feldstein (1995) who finds that for each dollar of outward FDI, total domestic investment is reduced by approximately one dollar. Additionally, although FDI from Asian countries has been growing, a substantial amount of the flow goes to other developing countries for other reasons. At present, the amount invested in developed countries for the purpose of technology sourcing is relatively small (UNCTAD, 2006). In general, our results are consistent with the survey by Keller (2004) who concludes that trade (through imports) is a more effective channel than FDI in transmitting knowledge across borders.

Table 3.4: R&D spillovers via import and inward FDI channels

	China	Korea	Malaysia	Singapore	Thailand
Domestic RD:					
S^d	0.021	0.284*	0.052*	0.198*	0.010
	(0.034)	(0.031)	(0.004)	(0.013)	(0.007)
Foreign RD:					
S^{fm} (import channel)	0.202*	0.089*	0.047*	0.335*	0.323*
	(0.027)	(0.012)	(0.009)	(0.009)	(0.010)
S^{ff} (inward FDI channel)	0.068*	-0.029*	0.042*	-0.030*	-0.018*
	(0.009)	(0.010)	(0.003)	(0.007)	(0.004)

Notes: All variables are in logarithm. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

Table 3.5: R&D spillovers via outward FDI channel

	Korea	Malaysia	Singapore
Domestic RD:			
S^d	0.407*	0.146*	0.333*
	(0.129)	(0.048)	(0.154)
Foreign RD:			
S^{ft} (outward FDI channel)	0.028*	0.052	-0.103
	(0.011)	(0.068)	(0.055)

Notes: All variables are in logarithm. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

The next step of our analysis is to evaluate whether domestic R&D helps increase the incidence of R&D spillovers. To this end, Equation (3.5) is estimated focusing only on imports and inward FDI. To identify the most effective channel of spillovers, it would be desirable to estimate a model which includes both channels. However, our limited sample size impedes the implementation of this strategy. Therefore, two separate models are estimated for imports and inward FDI, and the results are presented in Table 3.6. As shown in panel A of Table 3.6, the coefficients on both domestic and foreign R&D capital stock are all positive and significant, except for domestic R&D of China. However, the interaction term is only positive and significant in the case of Malaysia, Singapore, and Thailand. This provides some support for the absorptive capacity hypothesis whereby domestic R&D activity helps local firms to improve their capacity to exploit outside knowledge. Investment in R&D improves the quality of human capital and results in better absorption of outside knowledge. Panel B of Table 3.6 presents the result of estimating Equation (3.5) using foreign R&D stock weighted by inward FDI. As shown in the table, the interaction term is only positive and significant for Malaysia and in all other cases the coefficients are negative. This finding provides further support to the ambiguous role of FDI in transmitting knowledge across borders. It is also interesting to note that the coefficients size on domestic R&D have increased significantly for China, Singapore, and Thailand. These coefficients may have reflected the effect of import channel which has been omitted (refer to results in Table 3.4).

Table 3.6: Absorptive capacity and R&D spillovers

	China	Korea	Malaysia	Singapore	Thailand
Panel A: Import channel					
Domestic RD:					
S^d	0.018	0.300*	0.051*	0.156*	0.047*
	(0.113)	(0.047)	(0.011)	(0.014)	(0.015)
Foreign RD:					
S^{fm}(import channel)	0.316*	0.075*	0.120*	0.275*	0.307*
	(0.049)	(0.019)	(0.010)	(0.005)	(0.007)
Interaction Effect:					
S^{fm} x S^d	0.017	-0.025	0.038*	0.101*	0.155*
	(0.027)	(0.019)	(0.009)	(0.017)	(0.021)
Panel B: inward FDI channel					
Domestic RD:					
S^d	0.325 *	0.320 *	0.110 *	0.865 *	0.841 *
	(0.019)	(0.155)	(0.010)	(0.077)	(0.045)
Foreign RD:					
S^{ff}(inward FDI channel)	0.112*	0.002	0.048 *	-0.107 *	-0.063 *
	(0.005)	(0.041)	(0.008)	(0.028)	(0.013)
Interaction Effect:					
S^d x S^{ff}	-0.095 *	-0.115 *	0.013 *	-0.299 *	-0.858 *
	(0.007)	(0.044)	(0.004)	(0.045)	(0.061)

Notes: All variables are in logarithm. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

A number of papers (e.g. van Pottelsberghe and Lichtenberg, 2001; Coe, *et al.*, 1997) show that the United States is the largest contributor to the productivity of developing countries while technology spillovers emanating from Japan are weak. In line with this literature, we examine the main source of spillovers for the East Asian countries. We estimate Equation (3.6) and report the results in Table 3.7. Panel A of Table 3.7 presents the estimation results of R&D spillovers from Japan while panel B reports the results for the United States. In the case of spillovers from Japan, in four cases (except Korea) the coefficients on import-weighted foreign R&D is found to be positive and significant, while three countries (China, Korea, and Malaysia) benefit from the inflows of Japanese FDI. In the case of spillovers from the United States, all countries benefit from its foreign R&D but only two countries (China and Thailand) gain by having more FDI from the United States. Although there is no clear pattern whether Japan or the United States is the strongest provider of spillovers, there is one important conclusion that emerges: imports are the main channel of spillover for East Asian countries regardless of their source.

Table 3.7: R&D spillovers: Japan vs. United States

	China	Korea	Malaysia	Singapore	Thailand
Panel A: R&D spillovers from Japan					
Domestic RD:					
S^d	0.159*	0.297*	0.041*	0.184*	-0.013
	(0.003)	(0.007)	(0.004)	(0.006)	(0.013)
Foreign RD:					
S^{fm}_{JPN} (import from Japan)	0.060*	-0.004	0.052*	0.280*	0.254*
	(0.001)	(0.004)	(0.007)	(0.007)	(0.011)
S^{ff}_{JPN} (inward FDI from Japan)	0.085*	0.018*	0.034*	-0.011	-0.015*
	(0.001)	(0.002)	(0.006)	(0.007)	(0.005)
Panel B: R&D spillovers from the United States					
Domestic RD:					
S^d	0.145 *	0.445 *	0.036 *	0.188 *	0.200 *
	(0.040)	(0.027)	(0.004)	(0.010)	(0.012)
Foreign RD:					
S^{fm}_{USA} (import from the U. S.)	0.180 *	0.021 *	0.118 *	0.337 *	0.175 *
	(0.029)	(0.010)	(0.006)	(0.007)	(0.008)
S^{ff}_{USA} (inward FDI from U. S.)	0.040 *	-0.025 *	-0.002 *	-0.066 *	0.039 *
	(0.005)	(0.008)	(0.000)	(0.005)	(0.002)

Notes: All variables are in logarithm. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

Since imports are found to be the main spillover channel, we analyze this aspect further by estimating a model that includes both Japanese and US import-weighted R&D capital stocks. This exercise allows us to identify the most effective channel of spillovers to the region. Results presented in Table 3.8 show that the overall findings point to the United States as a stronger provider of R&D spillover for China and Korea. This is consistent with van Pottelsberghe and Lichtenberg (2001) who find that the United States is an important R&D spillover generator while spillover from Japan is weak. However, it should be emphasized that Malaysia, Singapore, and Thailand, which are the members of the Association of Southeast Asian Nations (ASEAN), benefit more from the Japanese R&D. Although Malaysia and Thailand also benefit from the United States R&D (at the 10% significant level), the impact is smaller than the impact of the Japanese R&D. This finding could be due to close economic linkages between Japan and the ASEAN. ASEAN is Japan's second largest trade partner and private investments from Japan to ASEAN member countries have been substantial. Japan has also assisted the economic and social development of ASEAN member countries by providing bilateral Official Development Assistance (ODA), thereby strengthening the absorptive capacity of Southeast Asian countries for Japanese product.

Table 3.8: R&D spillovers via import channel: Japan vs. United States

	China	Korea	Malaysia	Singapore	Thailand
Domestic RD:					
S^d	0.261*	0.389 *	0.057 *	0.220 *	0.152 *
	(0.019)	(0.016)	(0.004)	(0.019)	(0.027)
Foreign RD:					
S^{fm}_{JPN} (imports from Japan)	-0.104 *	-0.048 *	0.080 *	0.995 *	0.151 *
	(0.006)	(0.007)	(0.007)	(0.031)	(0.017)
S^{fm}_{USA} (imports from the U.S.)	0.325 *	0.091 *	0.007	-0.648 *	0.090 *
	(0.018)	(0.008)	(0.004)	(0.032)	(0.008)

Notes: All variables are in logarithm. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

3.6.4 Robustness checks

In this paper we established that imports are the main channel of R&D spillovers to East Asian countries. In order to gauge the robustness of this finding, two sensitivity analyses are implemented. First, we assess the sensitivity of the findings to a different time period. For this purpose, the period 1990-2005 is chosen as these countries experienced massive inflows of FDI and also higher levels of imports. This may well capture the period during which these countries became more open to both trade and foreign investment. Due to the limitation of our sample size two models were estimated - separating imports and inward FDI channels. Our results generally indicate that imports are the main channel of technology spillovers (see Appendix 3.3). The coefficients on import-weighted foreign R&D are positive and significant except for China which is negative. As before, the role of FDI in transmitting knowledge across border is uncertain. It is also worth noting that domestic R&D is becoming more important during this period. In all cases, the coefficients on domestic R&D are positive and significant. Secondly, we evaluate the sensitivity of the estimation results to different rates of depreciation. We re-estimate the model using depreciation rates for capital stocks of 7% and 10% and find that imports remain as the main channel of R&D spillovers. Moreover, evidence of spillover effects via FDI is mixed (see Appendix 3.4). The only minor difference is that the coefficient on import-weighted foreign R&D for Malaysia lost its significance in model utilizing the 10% rate.

By and large, the results support that both foreign (import embodied) and domestic R&D are important for the productivity growth of the East Asian countries.

3.7 Conclusions

Economic theory predicts that innovative activity such as research and development (R&D) is a major source of productivity growth. It also predicts that the benefits of R&D may spill over across countries through economic interactions such as imports and FDI. It has been recognized that only a few developed countries are involved actively in R&D activities and this has invoked serious concerns among policymakers regarding the possibility of other countries benefiting from the R&D preformed by developed countries. A number of studies have addressed this issue by assessing the impact of foreign R&D on domestic productivity. These studies, which focused mainly on OECD countries, conclude that foreign R&D activity is an important source of domestic productivity growth. Unfortunately, little has been done to examine the impact of foreign R&D on the productivity of less developed countries. This study precisely assesses the extent of R&D spillovers from G-5 countries (France, Germany, Japan, United Kingdom, and United States) to a group of East Asian countries (China, Korea, Malaysia, Singapore, and Thailand). It exploits panel data over the 1984-2005 period and relies on the DSUR panel estimator due to Mark *et al*. (2005) to provide estimates of R&D effects on TFP.

There are several important conclusions that emerge. First, the overall findings confirm the importance of technology, be it developed locally or by foreign countries. Additionally, some of our TFP elasticity estimates suggest that the impact of domestic R&D on productivity is larger in higher income Asian countries, while in other lower income countries the elasticity is larger with respect to the foreign R&D capital stock. Thus, the strong contribution of domestic R&D to productivity does not occur until a country reaches a certain level of income. Until then, greater economic interactions with technology leaders are critical for technological progress. Secondly, imports are more important as a spillover channel than FDI. This is consistent with many studies that have been conducted using samples of developed countries. Thus, foreign R&D may have a stronger effect on domestic productivity the more open an economy is to international trade, highlighting the complementarity between trade and technology. Third, there is some evidence that domestic R&D enhances the incidence of international R&D spillovers. This finding corroborates other existing studies in the literature showing that the absorptive capacity of domestic R&D is an important factor determining economic performance, in the sense of being able to absorb and internalise knowledge generated by foreign firms. The impact of new knowledge on productivity also depends on its diffusion, which is determined by the effort of firms on R&D. This underlines the importance for governments to keep in mind the diffusion aspect of FDI in the formulation of technology policies. Finally, the U.S. is generally a strong provider of technology spillovers, but the strong spillover effects emanating from Japan are relatively weaker. However, the empirical evidence also suggests regional economic cooperation as important in promoting R&D spillovers. Recent stronger economic cooperation between Japan and ASEAN's countries has actually generated greater technological spillovers to these countries. Development aid and other kinds of assistance programs help also in increasing the absorptive capacity of Japanese products. It seems then that governments can foster the constant upgrading of technologies by promoting economic interactions through trade, investment and beyond, leading ultimately to higher standards of living of their citizens.

4. INSURANCE SECTOR DEVELOPMENT AND ECONOMIC GROWTH

4.1 Introduction

The important roles of financial markets in the development process can be traced back to Bagehot (1873). The author notes that the financial system performed an important function in channelling resources to promote the industrial revolution in England. This view was supported by Schumpeter (1934) who contends that the services provided by financial intermediaries are important for stimulating technological innovation and economic development. Banks are viewed as an important intermediating agent between surplus (i.e. lenders) and deficit units (i.e. borrowers). Hence, well-developed financial systems can channel financial resources to their most productive use, leading to the expansion of the economy.[37]

The link between financial development and economic growth has been tested using different procedures, data sets and time periods and there is overwhelming support for the critical role of financial development for economic growth. Financial markets are found to have a strong positive impact on output and productivity growth, as well as capital accumulation (Yang and Yi, 2008, Demetriades and Law, 2006, Beck and Levine, 2004, Rioja and Valev, 2004a, Beck *et al*., 2000).[38] Financial innovations help to reduce transaction and information costs while larger and more efficient financial markets help economic agents to hedge, trade and pool risk, thus raising investment and economic growth. While there is a plethora of research on the influence of banks and stock markets on economic growth, the role of other intermediaries such as insurance institutions has been largely ignored (Ang, 2008).

The importance of insurance sector for economic growth was first recognized by UNCTAD (1964), who acknowledged that "*a sound national insurance and reinsurance market is an essential characteristic of economic growth*". Ward and Zurburegg (2000) persuasively argue that insurance markets can have a positive impact on the economy by facilitating a myriad of economic transactions through risk transfer and indemnification. Additionally, insurance sector promotes financial intermediation similar to banking institutions. However, it is surprising that the impact of insurance on growth has not been analysed as rigorously as

[37] Robinson (1952) however argues that that financial development does not lead to higher economic growth but is driven by growth. Nevertheless, most empirical evidence is consistent with the Schumpeterian view of finance-led growth.

[38] Ang (2008) and Levine (2005) provide recent surveys of the related literature.

the role of banks. A review of the literature suggests only a few studies have examined this issue and they find that insurance sector development has a significant impact on economic growth (Outreville, 1990, Ward and Zurburegg, 2000, Webb at al., 2002, Kugler and Ofoghi, 2005, and Arena, 2008).

The main objective of this paper is to provide new empirical evidence on the insurance-growth nexus. This paper contributes to the literature in several important aspects. In particular, it provides panel evidence using data from 52 countries using a generalised method of moments (GMM) estimator that has a number of advantages compared to cross-section technique. In particular, this estimator controls for endogeneity of all explanatory variables, accounts for unobserved country-specific effects and allows the inclusion of lagged dependent variables as regressors, which are typical issues when estimating growth model. Most of the few studies on insurance-growth nexus have either used cross-section (e.g. Outreville, 1990; Webb *et al*., 2002) or time series approach (e.g. Ward and Zurburegg, 2000; Kugler and Ofoghi, 2005). One exception is Arena (2008) who uses the GMM panel estimator on data from 55 countries.[39] However, our study differs from Arena (2008) in two important dimensions. Firstly, in addition to examining the impact of insurance on output growth similar to Arena (2008), we also evaluate its impact on growth channels: capital accumulation and productivity growth. To our knowledge, none of the previous studies have examined the impact on insurance on the growth channels. Moreover, we quantify the relative importance of these channels for developed and developing countries. Secondly, unlike Arena (2008), we rigorously deal with the problem of instrument proliferations. This problem has been ignored not only by Arena (2008) but also by most of other studies in the past. However, ignoring these problems may lead to spurious conclusions because some of asymptotic results about the estimators and related specification test are misleading (Roodman, forthcoming).

Our findings suggest a strong, positive impact of insurance sector development on economic growth. In developing countries, the insurance sector is important for capital accumulation purposes while in developed countries it is important for productivity improvement. Moreover, we find that the proliferation of instruments appears to have a significant impact on the estimated long-run insurance effects. Ignoring these problems generally biases downward the estimates of insurance effects. Our findings are strongly consistent with models that predict that financial intermediation ease information and transaction costs and in so doing improve the allocation of resources and economic growth.

[39] After this paper was completed, we discovered the paper by Arena (2008).

The paper is structured as follows. Section 4.2 provides a review of the literature. Section 4.3 discusses the estimation procedures. Section 4.4 describes the data set. Section 4.5 contains the empirical results. The last section concludes.

4.2 Review of the literature

A financial system consists of banking institutions, financial markets, other financial intermediaries such as insurance companies and pension funds, and a regulatory body – the central bank - which oversees and supervises the operations of financial intermediaries. The financial system is the economic sector that utilizes productive resources to facilitate the process of capital formation through the provision of a wide range of financial tools to meet the different requirements of both borrowers and lenders. Thus, it plays a crucial role in mobilizing and intermediating saving, as well as enabling the efficient allocation of these resources to productive sectors.

According to Levine (2005), financial systems influence savings and investment decisions and hence long-run output growth via two primary financial functions: resource allocation and risk management. These functions can be further separated into five basic functions. In particular, financial system (i) produces information about possible investment opportunities; (ii) facilitates the trading, hedging, diversification and pooling of real (and financial) risks; (iii) exerts corporate control and monitor managers; (iv) mobilise saving; and (v) facilitates the exchange of goods and services. By fulfilling these functions, financial system improves both the quantity and quality of real investments and thus promoting GDP growth. Financial innovation reduce transaction and information costs while larger and more efficient financial markets help economic agents hedge, trade and pool risk, thereby raising investment and output growth.

With regard to insurance sector, it may generate a positive impact on the economy by improving the financial systems, both as a provider of risk transfer and indemnification services and as an institutional investor (Ward and Zurburegg, 2000). CEA (2006) highlights six channels via which insurance sector development may have positive impact on the economy. First, by providing insurance coverage directly to firms, insurance companies improve the financial soundness of the firms. The absence of insurance protection tends to be harmful particularly for small firms that have limited capital and access to external financing. Insurance allow firms to expand and take on risks without the need to set aside capital in liquid contingency funds. Second, insurance foster entrepreneurial attitude, encourage innovation and competition. Being innovative presupposes the willingness to take risks. Insurance decreases the risks supported by entrepreneur through mitigating and pooling procedures and thus allow them to take additional risks. By protecting entrepreneur against risks, insurance companies stimulate innovation which is critical for growth of the economy. Therefore, the more willingness to take risk is available, the more will be produced. Third, insurance offer social protection and thus releasing the pressure on the public sector finance. In most countries (especially developed countries), the population structure is changing with a longer life expectancy and low-birth rate. At the same time, people expect to receive a high level of healthcare, pensions, unemployment and other social benefits. This situation adds pressure to the public sector finance. Innovations in insurance products such as private unemployment insurance and funded private pensions can release some of this pressure. Fourth, insurance promote sensible risk management by firms and households. Price and policy conditions of insurance are based on risk assessment. This will provide the policyholders an indication of their risk level. This may encourage them to take action to reduce the risk profile or to reduce potential damage, leading to responsible and sustainable use of resources. Fifth, insurance fosters stable consumption. Consumption represents almost 80% of GDP and constitutes one of the main drivers of economic growth. By offering lifelong insurance protection, insurance serve as a security net allowing stable consumption throughout individual's life. Finally, insurance activity may also have indirect impacts on growth via its positive effect on the development of other financial institutions and markets such as banks and capital markets. The development of these institutions and markets has been shown to be important for long-run output growth (see Levine, 2005, for a survey). Insurance companies protect banks and their customers against a range of risk, underpinning bank lending by protecting customers against risks that might otherwise leave them unable to repay their debts (Rule, 2001). This protection services encourages bank borrowing by reducing companies' cost of capital (Grace and Rebello, 1993). For instance, property insurance may facilitate bank lending via credit collateralization, which would reduce bank's credit risk exposure (Zou and Adams, 2006). However, the development of insurance markets may also have a negative implication on banking development because of 'saving substitution effects'. In market for intermediated saving, insurance companies compete and could reduce bank's market share. In the case of capital markets, insurance activity could promote stock and bond markets by investing funds (savings) in stock and bond markets (Catalan *et al*., 2000). This process would not only develop capital markets but also promote efficient allocation of funds in the economy because insurance companies would gather all relevant information to evaluate projects and firms before allocating their capital (Skipper, 1997). Moreover, increased level of monitoring by insurance companies in projects or firms that they have invested will improve the potential of the funded projects (Conyon and Leech, 1994).

At the theoretical level, several models emphasize the importance of financial intermediaries for economic growth. These models underlines that well-functioning financial intermediaries ameliorate information and transactions costs and therefore promote efficient allocation of resources, leading to the expansion of the economy. For instance, using the simplest endogenous growth setting, i.e., the *AK* model, Pagano (1993) demonstrates that financial intermediaries can affect growth through savings (i.e., the proportion of savings channelled to productive investment) and by increasing the marginal productivity of capital. The model by King and Levine (1993b) emphasizes on risk diversification as a channel via which financial intermediaries can accelerate technological change and economic growth. Economic agents are continuously trying to gain market niche through risky innovative activity. With access to external finance, they are able to hold a diversified portfolio of innovative projects. This leads to reduced cross-sectional risk and thus promotes investments in growth-enhancing innovative activities. The model presented in Greenwood and Jovanovic (1990) is particularly novel because it formally models the dynamic interaction between financial intermediaries and growth. Their model postulates that financial intermediaries produce better information about potential investments and therefore improve resources allocation and foster economic growth. However, higher output growth means that more individuals are able to join financial intermediaries, which improves the ability of financial intermediaries to produce better information with positive implications on growth. The model by Bencivenga and Smith (1991) show that efficient financial intermediation can boost growth by economizing on monitoring costs. On the role of insurance sector, the model by Webb *et al.*(2002) predicts that insurance activity promotes the productivity of physical capital, resulting in higher level of output.

There are two channels via which financial system can spur growth: the capital accumulation channel and the productivity channel. The capital accumulation channel relies on the "debt-accumulation" hypothesis of Gurley and Shaw (1955) which focuses on the financial sector's ability to overcome indivisibility problems through saving mobilization. By channelling saving to the productive sector, it boosts capital accumulation and output growth. On the other hand, the productivity channel is based upon recent endogenous growth models (Greenwood and Jovanovic, 1990, King and Levine, 1993b) which emphasize on the role of financial sector ability in financing innovative activities. In particular, the model by King and Levine (1993b) emphasise on the ability of financial markets to finance entrepreneurial activity, leading to greater productivity growth. Also, financial markets can facilitate the adoption of technologies developed by others. For instance, Alfaro *et al*. (2004) empirically show that the acquisition of new technology linked to FDI inflows requires the presence of well-developed financial institutions in the host country. Moreover, Alfaro *et al.*(forthcoming) show technology spillovers from FDI contribute to productivity growth and not the accumulation of capital.

Several models indicate that there may be differences in the relative important of growth channels for countries at different stages of economic developments. For instance, the model by Acemoglu and Zilibotti (1997) predict that risky (but productive) projects with higher rates of return are indivisible and have minimum size requirements. As a result, poorer countries with limited available funds are not able diversify across all available productive projects. Since diversification opportunities are limited, these countries will typically pursue primitive capital accumulation strategy where some funds are invested in safe but less productive assets, which eventually reduce their productivity. Further theoretical support is provided by Acemoglu *et al.* (2006) who predict that a developing country that is behind the technological frontier will typically pursue a capital accumulation growth strategy (i.e. investment-based growth). At this stage of development, there is less incentive to be selective of firms and managers because this is highly costly. Hence, there exist a long-term relationship between financial agents and firms, which result in funds flowing to those established firms for capital accumulation purpose. In contrast, industrial countries that are at the technological frontier have a strong incentive for innovation. At this stage, financial agents are very selective of firms and managers that can achieve this goal. Therefore, funds are expected to flows to activities with larger productivity gains (i.e. innovation-based growth).

Empirical evidence on the impact of financial developments on economy growth has largely focused on the roles of banks and stock markets. Ang (2008) and Levine (2005) provide excellent surveys of the related literature which suggest that a well-functioning financial system has a positive impact on long-run economic growth. The findings are supported by cross-country regressions (Levine and Zervos, 1998, King and Levine, 1993a, King and Levine, 1993b), panel studies (Demetriades and Law, 2006, Rioja and Valev, 2004a, Levine *et al.*, 2000), time series analyses (Yang and Yi, 2008, Abu-Bader and Abu-Qarn, 2008, Luintel and Khan, 1999), firm-level (Demirguc-Kunt and Maksimovic, 1998), and industry-level estimations (Rajan and Zingales, 1998). Although banking institutions and stock markets perform different functions, both boost output growth, capital accumulation, and productivity (Rioja and Valev, 2004b, Levine and Zervos, 1998, Beck *et al.*, 2000). Furthermore, Rioja and Valev (2004b) find that banking sector development has a greater impact on capital accumulation in developing countries than in industrial countries, although the effect on productivity growth is stronger in the latter.

Despite the importance of the insurance activity for economic growth, relatively little research has been carried out on this issue. This topic has not been studied as extensively as the role of banks and stock markets. However, ignoring the rapid development of insurance markets may lead to a significant underestimation of the overall impact of financial development on economic growth. A review of the literature reveals only a handful of empirical studies. For instance, using a cross-sectional analysis Outreville (1990) finds a positive relationship between property-liability insurance and GDP per capita in 55 developing countries. Ward and Zurbruegg (2000) analyse nine OECD countries and find that the insurance industry (represented by total insurance premia) *Granger*-causes real GDP in Canada and Japan. Causality is bi-directional in Italy, but no causal relation can be established for other countries.[40] Browne *et al.*(2000) find that non-life insurance consumption is associated positively with the income level for a sample of OECD countries over the 1986–1993 period. Using a sample of 55 countries and an iterated three-stage least squares simultaneous estimation technique, Webb *et al.* (2002) find that the life insurance penetration robustly predicts productivity increases. Kugler and Ofoghi (2005) examined the relationship between insurance and GDP growth in the UK under the lens of cointegration analysis. They find an overwhelming support for a long run relationship between different insurance sectors and economic growth.[41] Moreover, insurance activity is found to *Granger-cause* economic growth in most of the sectors. Recently, Arena (2008) examines the influence of life and non-life insurance on economic growth. Using data from 55 countries and the GMM panel estimator, the author finds that both life and non-life insurance activity have a positive and significant causal effect on output growth of high-income countries. In the case of developing countries, output growth is driven by the development of non-life insurance market. Although the aforementioned studies has made important contributions to the literature, empirical evidence on insurance-growth nexus remains limited in two aspects (i) panel evidence on causal effect of insurance on growth, and (ii) the impact of insurance on the growth channels namely, capital accumulation and productivity growth. Therefore, this issue deserves further examination.

With this backdrop, we contribute to the literature by examining the causal effect of insurance sector developments on growth, using a panel of 52 developed and developing countries over 25 years (1981-2005). Also, we assess the impact of insurance on capital accumulation and productivity growth across developed and developing countries

[40] Other countries are Austria, Australia, Switzerland, France, United Kingdom, and the United States.
[41] Eight insurance sectors were analyzed: life; motor insurance; accident and health insurance; property; liability; pecuniary loss; reinsurance; and marine, aviation, and transport.

4.3 Estimation Procedures

In this paper, we follow the standard econometric specification of the finance and growth literature (e.g., Beck *et al*., 2000, Levine *et al*., 2000).[42] This section explains our econometric procedures. The first sub-section explains the cross country estimation technique and instrumental variables used to alleviate the endogeneity problems. The second sub-section explains the dynamic panel estimator.

4.3.1 Cross-section regressions with instrumental variables

Following earlier literature (e.g. King and Levine, 1993a; Levine and Zervos, 1998), the first step of our analysis involves a cross-sectional estimation. Although the cross-country estimator does not deal as rigorously as the panel estimators with simultaneity issues, omitted variables, and unobserved country-specific effects, it is useful in verifying the consistency of panel data findings. Following La Porta *et al*. (1997, 1998) – henceforth LLSV, we use legal origins to control for simultaneity bias. LLSV (1997) argue that a country's legal and regulatory system will fundamentally influence the ability of the financial system to provide high-quality financial services. Specifically, it will determine the ability of financial intermediaries to identify worthy firms, exert corporate control, manage risk, mobilize savings, and ease exchange. According to Reynolds and Flores (1996), legal systems with European origins can be classified into four major legal families: the English common law countries, and the French, German and Scandinavian civil law countries. This classification excludes countries with socialist and Islamic based legal systems. All four legal families descend from the Roman law as compiled by the Byzantine Emperor Justinian in the sixth century. In the last four centuries, the four legal families have evolved differently. The Scandinavian countries formed their own legal codes in the 17th and 18th centuries. The French Civil Code was written in 1804 and later spread to other countries (especially Latin American and African countries) through occupation and colonization. The German Civil Code was completed almost a century later in 1896. It has had a great influence on Austria and Switzerland. It also heavily influenced Japanese Civil Code which later spread to Korea. Unlike the civil law countries, the English legal system was developed based on common law, where the main source of law was jurisprudence, i.e. judges sentences in particular cases. Through colonialism, it was spread to many Asian and African countries, North America, Australia, and New Zealand.

[42] The cross-section and panel studies on finance-growth nexus typically use Barro (1991) regression model and augment it with some financial development indicators.

There are two conditions under which the legal origins can be appropriate instruments for insurance sector development. First, legal origins must be exogenous to economic growth during the chosen sample period. Second, they must be correlated with insurance sector development. Regarding the exogeneity, we take the legal origins as exogenous because they were spread through colonialism and occupation. Moreover, we provide the specification test for checking the validity of these instruments. In terms of the link between legal origins and insurance sector development, a growing body of literature has shown that legal origins help shaping the development of the financial system. LLSV (1998) show that the legal origins materially influence the legal treatment of shareholders, the efficiency of contract enforcement, the law governing creditor rights, and accounting standards. Statistically, several studies have shown that these legal and regulatory characteristics influence financial sector developments (Levine *et al*., 2000, Beck *et al*., 2000). Although the literature on the legal system and insurance markets development is less developed, Browne *et al*.(2000) show that a country's legal system is a significant determinant of demand for automobile and general liability insurance.

The cross-sectional regression exploits data averaged over the 1981-2005 period, such that there is one observation per country. The basic model can be expressed as follows:

$$GROWTH_i = \phi + \delta INS_i + \gamma M_i + e_i, \quad (4.1)$$

where *i* is the country index, *GROWTH* is growth rate of real GDP per capita, *INS* denotes insurance variable (i.e. life penetration ratio), *M* is a vector of other variables hypothesized to affect growth, and e is the error term. In order to examine whether cross-country variations in the exogenous component of insurance sector development explain cross-country variations in economic growth rates, the legal origins are used as instrumental variables for insurance. We use a two-stage least-squares (2SLS) estimator to generate consistent estimate of δ in Equation (4.1). In the first stage, the insurance variable is regressed on all of the variables in vector *M* plus the excluded instruments (i.e. legal origins which are assumed in vector *Z*). In the second stage, Equation (4.1) is estimated as usual, except that the insurance variable is replaced with its predicted values from the regression in the first stage. This estimation requires that the variables in vector *Z* are appropriate instruments which amount to the set of orthogonality conditions E(*Z*e)=0. We test this condition using the Sargan overidentifying test. Under the null that the instruments are not correlated with the error terms, the test has a χ^2 distribution with (*J*-*K*) degree of freedom, where *J* is the number of instruments and *K* is number of regressors.

4.3.2 GMM panel estimator

For panel data analysis, we use a generalized method of moments (GMM) dynamic panel estimator which was first proposed by Holtz-Eakin *et al.*(1988) and subsequently extended by Arellano and Bond (1991), Arellano and Bover (1995),and Blundell and Bond (1998). Consider the following growth equation:

$$y_{it} - y_{i,t-1} = (\alpha - 1)y_{i,t-1} + \beta_1 INS_{it} + \beta_2 X_{i,t} + \eta_i + \varepsilon_{i,t} \tag{4.2}$$

where y is real GDP per capita (in log), X represents a set of explanatory variables which affect growth , η is an unobserved country-specific effects, and ε is the error term. Equivalently, Equation (4.2) may be written as:

$$y_{it} = \alpha y_{i,t-1} + \beta_1 INS_{it} + \beta_2 X_{i,t} + \eta_i + \varepsilon_{i,t} \tag{4.3}$$

Several studies show that the country-specific effects play an important role in shaping the development of insurance markets and should be controlled for in the analysis of insurance-growth relationship. For instance, Fukuyama (1995) highlights the importance of culture in demand for insurance.[43] Moreover, Angeer (1993) points out that a country's regulation can facilitate as well as constrain insurance activities. In order to eliminate country-specific fixed effects in Equation (4.3), Arellano and Bond (1991) suggest a first-difference transformation as follows:

$$y_{i,t} - y_{i,t-1} = \alpha(y_{i,t-1} - y_{t,t-2}) + \beta_1(INS_{it} - INS_{i,t-1}) + \beta_2(X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \tag{4.4}$$

To address the possible simultaneity bias of explanatory variables and the correlation between $(y_{i,t-1} - y_{i,t-2})$ and $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$, Arellano and Bond (1991) propose that the lagged levels of the regressors are used as instruments. This is valid under the assumptions (i) the error term is not serially correlated, and (ii) the lag of the explanatory variables are weakly exogenous. Following Arellano and Bond (1991), we set the following moment conditions:

$$E\left[y_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \quad for\ s \geq 2; t = 3,....,T \tag{4.5}$$

$$E\left[INS_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \quad for\ s \geq 2; t = 3,....,T \tag{4.6}$$

[43] In the high-trust countries such as U.K., U.S., and Japan, insurance markets play important role in transferring risk, while in low-trust countries like France and Italy the potential role of insurance is greatly reduced.

$$E[X_{i,t-s}\cdot(\varepsilon_{i,t}-\varepsilon_{i,t-1})]=0 \text{ for } s\geq 2; t=3,....,T \quad (4.7)$$

Although the difference estimator above is able to alleviate some of the problems encountered in estimating dynamic growth model, it nevertheless has one major shortcoming. Alonso-Borrego and Arellano (1999) and Blundell and Bond (1998) show that when the explanatory variables are persistent the lagged levels of the variables become weak instruments. They show that weak instruments may lead to biased parameter estimates in small samples and larger variance asymptotically. Before, Arellano and Bover (1995) propose an alternative system estimator that combines the difference Equation (4.4) and the level Equation (4.3). Blundell and Bond (1998) show that this estimator is able to reduce biases and imprecision associated with difference estimator. Following Arellano and Bover (1995), the instruments for the regression in differences are the same as above. The regression in levels uses lagged differences of the corresponding variables as instruments. This is valid under the assumption that there is no correlation between the differences in explanatory variables and the country-specific fixed effect. The additional moment conditions for the second part of the system (the regression in levels) are given by:

$$E[(y_{i,t-s}-y_{i,t-s-1})\cdot(\eta_i+\varepsilon_{i,t})]=0 \text{ for } s=1 \quad (4.8)$$

$$E[(INS_{i,t-s}-INS_{i,t-s-1})\cdot(\eta_i+\varepsilon_{i,t})]=0 \text{ for } s=1 \quad (4.9)$$

$$E[(X_{i,t-s}-X_{i,t-s-1})\cdot(\eta_i+\varepsilon_{i,t})]=0 \text{ for } s=1 \quad (4.10)$$

The consistency of the GMM estimator depends on two specification tests. The first is the Hansen (1982) *J* test of over-identifying restrictions. Under the null of joint validity of all instruments, the empirical moments have zero expectation, so the *J* statistic is distributed as a χ^2 with degrees of freedom equal to the degree of overidentification (i.e. number of instruments minus the number of independent variables). If the errors are believed to be homoskedastic, the *J*-test is the classic Sargan (1958) statistic. The second test examines the hypothesis of no second-order serial correlation in the error term of the difference Equation (4.4) (Arellano and Bond, 1991). Failure to reject the null of both tests provides support to the estimated model.

The GMM estimators are typically applied in one- and two-step variants (Arellano and Bond, 1991). The one-step estimators use weighting matrices that are independent of estimated parameters, whereas the efficient two-step GMM estimator uses the so-called optimal weighting matrices where the moment conditions are weighted by a consistent estimate of their covariance matrix. This makes the two-step estimator asymptotically more efficient than the one-step estimator. However, the use of the two-step estimator in small samples, such as our study, has several problems. These problems result from the proliferation of instruments that makes some of asymptotic results about the estimators and related specification test misleading (Roodman, forthcoming). The first problem relates to standard errors of the two-step estimators. When instruments are numerous, the asymptotic standard errors of the parameter estimates are severely downward biased because of imprecise estimate of the optimal weighting matrices (Windmeijer, 2005). As a result, the efficiency gain over the one-step estimator may be small and this makes the two-step estimator a poor guide for hypothesis testing. Windmeijer (2005) devises a correction procedure for the covariance matrix and consequently makes the two-step estimator more efficient than the one-step estimator, particularly for the system GMM. Before this correction procedure became available, researchers routinely relied on the one-step result in making inferences. The second problem is that the instrument proliferations can generate results that are invalid yet appear valid because of weakened *Hansen* overidentification test.[44] In Monte Carlo simulations of difference GMM on $N = 100$ panels, Bowsher (2002) show that the test is clearly undersized once T reaches 13 (66 instrument). At $T = 15$ (91 instruments), it never rejects the null of joint validity at 0.05 or 0.10, rather than rejecting it 5% or 10% of the time as a well-sized test would. The final problem is that numerous instruments can overfit the instrumented variables and consequently failing to filter out the endogenous component. This will result in biased coefficient estimates.[45] In a simulation of difference GMM estimator on an 8 x 100 panel, Windmeijer (2005) shows that the average bias in the two-step estimates of parameter drops by 40% when the instruments count is reduced from 28 to 13. Recently, Calderon *et al*. (2002) propose a novel approach that reduces the dimensionality of the instrumental variables matrix to alleviates problems induced by the proliferation of instruments.[46] However, one problem faced by empirical economists when applying the GMM estimator is that the theory is not explicit enough about how many instruments are considered 'too many'. Arellano and Bond (1998) show that the approximation of the optimal weighting matrix with limited data can be singular when J approaches N. This has contributed to the idea that N is a key threshold for safe estimation.

In this paper we use several variants of the GMM estimator to highlight potential problems induced by the proliferation of instruments. This is particularly important for the present study given a small size of our sample.

[44] The Sargan test is not affected by the problem of instrument proliferation because it does not depend on the optimal weighting matrix. However, the test is only consistent when the errors are homoskedastic, which is rarely practical.
[45] This problem is not unique to the two-step estimator. It also affects the consistency of the one-step estimate.
[46] Roodman (forthcoming) provide a useful technical explanation of the Calderon *et al.*'s, (2002) procedure.

4.4 Data set

The data set consists of panel observations from 52 countries for the period 1981 – 2005.[47] The life insurance penetration ratio, measured by the volume of life insurance premia as a share of GDP, is used to proxy for the development of insurance markets. The data was taken from the *Financial Structure Database* of the World Bank.

In this paper, there are three dependent variables of interest namely, output growth defined as the growth rate of real per capita GDP, capital growth defined as the growth rate of per capita physical capital stock, and productivity growth defined as the rate of growth rate of the "residuals" (i.e. Solow residual). The real GDP per capita is PPP-adjusted and taken from Heston *et al.* (2006). GDP adjusted by PPP has the advantage of expressing income in comparable units in terms of living standards across countries. Capital stock is generated from the aggregate real investment series following the perpetual inventory method. It is estimated by taking into account the continual additions to and subtractions from the stock of capital as new investment and retirement of old capital occurs. Capital stock at time *t* is given by:

$$K_t = (1-\delta)K_{t-1} + I_t, \tag{4.11}$$

where K is the capital stock, δ is the rate of physical depreciation and I is gross fixed capital formation. Assuming that capital and output grow at the same rate, the initial level of the capital stock is determined using the following formula $K_{t-1} = I_t/(g+\delta)$, where δ is assumed to be 7% and g is average growth rate of output measured over 10 years (Beck *et al.*, 2000). Per capita capital stock is calculated as the ratio of capital stock to total population.

The productivity growth is obtained from the following neo-classical production function:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{4.12}$$

We divide Equation (4.12) by L and take log-time derivatives. Following Beck *et al.* (2000), we set the share of capital in GDP, α, to 0.3 yielding the productivity growth rate as follows:

$$\text{Productivity Growth} = \text{Output Growth} - 0.3 * \text{Capital Growth} \tag{4.13}$$

[47] Refer to Appendix 2.1 for a list of countries.

Our approach of calculating TFP has been criticised for conceptual and measurement errors. Several problems that have been highlighted are incorrect concept of capital, measurement errors in input and output variables, missing or appropriate data, incorrect weight for indices, theoretical specifications, and aggregation over heterogeneity (see Griliches, 1987). Several alternatives have been proposed in the literature such as the index number and econometric model approaches (see Lipsey and Carlaw (2004), for a discussion). Although the index number approach is more flexible in the sense that it does require production function, it suffers from other similar problems linked to the production function approach. Moreover, the DEA approach, which makes a strong claim to be superior, suffers from an incredible assumption that all countries in the sample have the same production function. The econometrics approach to TFP measurement which is based on econometric models is able to avoid many problems associated with the production function or index number approach. It may also allow for adjustment cost, variations in capacity utilisation and investigation of different form of technical change other than Hicks-neutral formulation implied by the other approaches. An example can be found in Nadiri and Pruncha (2001). However, a full-fledged econometric model raises complex econometrics issues and sometimes put a question mark on the robustness of results. Moreover, limited data availability may have negative implication on the degrees of freedom. Furthermore, it also suffers from measurement error problems associated with the production function and index number approaches. In light of these arguments and for the reason to be consistent with the finance-growth literature [Beck *et al.* (2000), Rioja and Valev (2004)], we calculate TFP using the production approach.

Following Levine *et al*. (2000) and Beck *et al*. (2000), the remaining conditioning variables are initial income, life expectancy, government size (government spending/GDP), openness to trade ((exports + imports)/GDP), inflation rate, and the black market exchange rate premium. We include initial income to account for the "convergence effect" while life expectancy is used as a proxy for human capital. [48] Government size, the inflation rate, trade openness and black market exchange rate premium account for country-specific government policies. The inflation rate and life expectancy were taken from the *World Development Indicators* database. The index of black market exchange rate premium from Gwartney and Lawson (2006) is scaled from 0 to 10, in which 10 means zero premium. The remaining data were taken from the Penn World Tables of Heston *et al*. (2006). All data, except for initial income which the logged value of GPD per capita the beginning of each five-year period, are averaged over non-overlapping five-year period (i.e. 1981-1985, 1986-1990,……, 2001-2005)

[48] Secondary school enrollment in the Barro-Lee dataset is a common proxy for human capital in the literature. Due to its unavailability for recent years, we use life expectancy instead.

to factor out the business cycle effect. Data for legal origins are from La Porta *et al*. (1999) who also provide a list of countries with a socialist and Islamic legal system. Table 1 provides the summary of data sources.

Table 4.1: Sources of data

Variable	Source	Unit of Measurement
Life insurance penetration ratio	Financial Structure Database	% of GDP
Real GDP per capita	Penn World Table	PPP price
Life expectancy	World Development Indicators	Years
Inflation	World Development Indicators	rate
Openness	Penn World Table	% of GDP
Government expenditure	Penn World Table	% of GDP
Black market premium	Fraser Institute	Index (0 – 10 scale)
Private credit	Financial Structure Database	% of GDP
Total share traded	Financial Structure Database	% of GDP
Legal origins	La Porta *et al*. (1999)	Dummy variable

Figure 4.1 displays output growth and the insurance penetration ratio for the sampled countries, averaged over the whole period (1981-2005). It shows that there is a positive relationship between the variables, although China (CHN) and South Africa (ZAF) fall relatively far from the rest. China has the highest output growth rates (8.14%) but the level of insurance sector development is very low (0.8%). In contrast, South Africa has a relatively low rate of output growth (0.8%) but the insurance penetration ratio is very high (9.28%). Figure 2.2 illustrates a clear positive relationship between insurance sector development and output growth. It displays two samples. One that includes all 52 countries and another that excludes the two potential outliers, China and South Africa. The figure shows that countries with higher level of insurance penetration ratio tend to enjoy faster growth over the 1980-2005 period. This relationship becomes more apparent when China and South Africa are excluded.

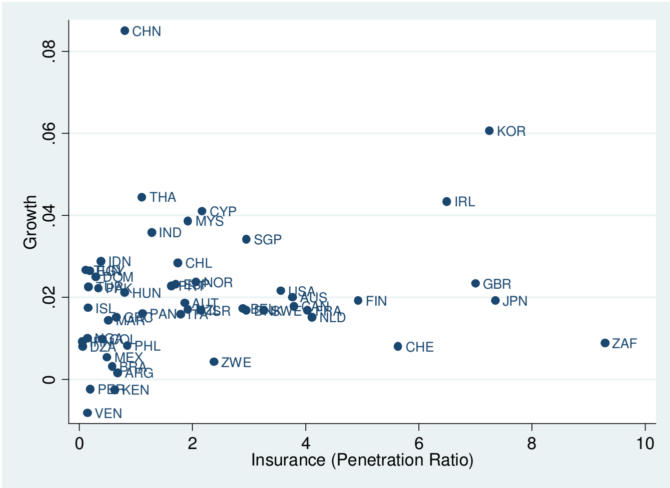


Figure 4.1 Scatter plot of growth vs. insurance penetration ratio

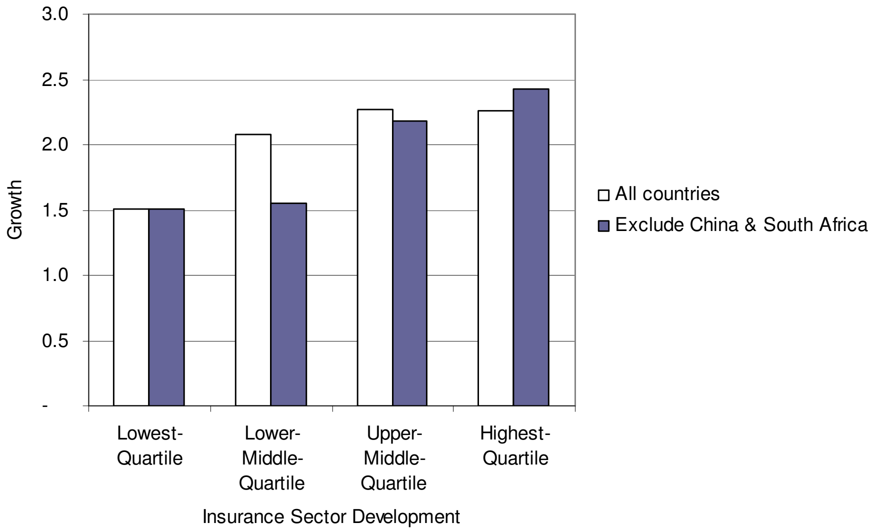


Figure 4.2 Economic growth and insurance sector development

Table 4.2 provides informative descriptive statistics on three growth variables and an insurance proxy (i.e. life insurance penetration ratio). Statistics are reported for the whole sample and separating developed from developing countries (income groups). Two features of the data are worth mentioning. First, there is substantial variance among the countries in the growth and insurance indicators. For example, output growth ranges from -0.92% (Venezuela) to 8.14% (China) and insurance ranges from 0.04% (Iran) to 9.28% (South Africa). Similar variation is also observed within the two income groups. Second, the mean values of the growth rates of output and capital and of the insurance indicator are higher in developed countries than in developing countries. However, the productivity growth is slightly larger in developing countries (1.6%) than in developed countries (1.58%), in contrast to theoretical prediction. The reason stems in the abnormally high productivity growth in China. Excluding China means productivity growth for developing countries is much lower than in developed countries.

Table 4.2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
A: Full sample					
Output growth	52	0.0194	0.0152	-0.0092	0.0814
Capital growth	52	0.0103	0.0239	-0.0364	0.0862
Productivity growth	52	0.0159	0.0099	-0.0008	0.0552
Insurance/GDP	52	0.0216	0.0224	0.0472	0.0928
B: Developed Countries					
Output growth	25	0.0219	0.0106	0.0078	0.0574
Capital growth	25	0.0202	0.0120	0.0058	0.0626
Productivity growth	25	0.0158	0.0083	0.0062	0.0390
Insurance/GDP	25	0.0344	0.0202	0.0015	0.0735
C: Developing Countries					
Output growth	27	0.0171	0.0184	-0.0092	0.0814
Capital growth	27	0.0012	0.0283	-0.0364	0.0862
Productivity growth	27	0.0160	0.0114	-0.0008	0.0552
Insurance/GDP	27	0.0098	0.0176	0.0004	0.0928

Table 4.3 presents the correlations between the growth and insurance indicator, computed by using panel data (i.e. data averaged over 5-year interval). Two observations emerge. First, the correlation between insurance and output growth are relatively small. They are 0.19, 0.12 and 0.17 for the full sample, developed and developing countries, respectively. Second, the correlation between insurance and capital growth is larger than between insurance and productivity growth. The same pattern appears for the two income groups. However, correlation does not imply causation which is precisely the type of relation that we are interested in this study.

Table 4.3: Correlation analysis

Variable	Output	Capital	Productivity	Insurance
A: Full sample				
Output growth	1			
Capital growth	0.68	1		
Productivity growth	0.93	0.39	1	
Insurance/GDP	0.19	0.39	0.06	1
B: Developed Countries				
Output growth	1			
Capital growth	0.62	1		
Productivity growth	0.96	0.4	1	
Insurance/GDP	0.12	0.32	0.03	1
C: Developing Countries				
Output growth	1			
Capital growth	0.71	1		
Productivity growth	0.93	0.43	1	
Insurance/GDP	0.17	0.21	0.09	1

4.5 Empirical results

In this section, we present and discuss the empirical results of the effect of insurance sector developments on growth (Tables 4.4 – 4.9). Table 4.4 and 4.5 reports the results from cross-section regression, when insurance is instrumented by legal origins and estimation by 2SLS are used, respectively. The rest of the tables report the results for the GMM estimator when examining (i) the effect of insurance markets on output growth (Table 4.6), (ii) effect of insurance development on capital accumulation and productivity growth (Table 4.7), (iii) the growth-effect of insurance across developed and developing countries (Table 4.8), and (iv) the robustness of findings, controlling for banking sector and stock market developments (Table 4.9).

4.5.1 Cross-section estimation

The first part of our analysis is to estimate a cross-country growth equation using country averages over the full 25-year period. The legal origins are used as instruments for insurance indicator and the 2SLS estimation technique is applied to generate consistent estimates of coefficients. We consider legal origins as an exogenous ‘endowment’ since they were spread through conquest and imperialism. However, it is important to note that exogeneity is not a sufficient condition for economically meaningful instrumental variables. The legal origins must also be strongly correlated with insurance indicator during our chosen sample period. Therefore, the first step of our cross-country analysis involves a regression of the insurance indicator (i.e. life insurance penetration ratio) on the dummy variables for English, French, German, and Socialist legal origins relative to Scandinavian legal origin (reference group). The results which are summarized in Table 4.4 show that the countries with a German legal origin have better developed insurance sector while countries with socialist legal system tend to have less developed markets than the rest. More importantly, the *p*-value and *F*-test suggest that legal origins explain a significant fraction of cross-country differences in insurance activity. Thus, there is strong connection between legal origins and insurance sector developments.

Table 4.4: Legal origins and insurance sector development

	Coefficient	S.e	*p*-value
Constant	2.671	0.736	0.001
ENGLISH	0.321	0.963	0.740
FRENCH	-1.642	0.776	0.040
GERMAN	2.853	1.381	0.044
SOCIALIST	-1.871	0.736	0.014
Observations	52		
Prob(*F*-test)	0.000		
R-square	0.36		

Notes: The dependent variable is the life insurance penetration ratio. S.e. are robust standard errors. ENGLISH = English legal origin. FRENCH = French legal origin. GERMAN =German legal origin. SOCIALIST = Socialist legal system. Scandinavian legal origin is the reference group.

We next use legal origins as instruments and proceed to examine the impact of insurance on growth using 2SLS technique. Table 4.5 presents our results. As shown in the table, the estimated coefficient for insurance is positive and statistically significant at the 5% level. An improvement in insurance sector by 1 percentage-point would lead to 0.012 percentage-point higher output. This suggests that there is a strong connection between the exogenous component of insurance sector development and long-run output growth. Furthermore, the Hansen test suggests that the instruments are not correlated with the error term as the null cannot be rejected at the usual level. This finding together with instruments being highly correlated with insurance indicator (Table 4.4) provides evidence in favour of the validity of instruments. Therefore, the strong positive effect on insurance development on output growth is not due to simultaneity bias. The estimated coefficient can be interpreted as the effect of the exogenous component of insurance sector development on output growth.[49]

With respect to other conditioning variables, we find that only initial GDP per capita, life expectancy and openness are statistically significant and enter the regression equations with the signs as predicted by theories. All other variables are insignificant. Our finding of no significant impact of government size on output growth is consistent Ram (1986) who argues that the government size can have both positive and negative impacts on the economy. A larger government size can be detrimental if government operations are inefficient, regulatory process impose excessive burdens on the economy and fiscal and monetary policies distort the incentives and lower the productivity of the economy. Meanwhile, government size can be beneficial through its roles in harmonizing conflicts between private and social interests. Also, it can secure an increase in productive investment and provide a socially optimal direction for growth and development. In the case of inflation rate, we find no negative relationship as reported by some studies (Levine *et al.*, 2000). Our results however are consistent with Bekaert *et al.* (2005) who find that in three of four regressions, the coefficients on inflation rate are not statistically different from zero. Only in the case of Argentina and Brazil which experienced hyper-inflation the coefficients are significant. Before, Barro (1997) find that the significant negative relationship between inflation and growth is primarily driven by a strong negative relation between very high inflation rate (over 15%) and economic growth. Finally, the coefficient on black market premium is insignificant, in contrast to the results reported by Bekaert *et al.* (2005). However, it should be noted that our proxy of black premium is different from Bekaert *et al.* (2005) and the results may not be completely comparable. Another explanation may be due to a strong correlation between inflation rate and black market premium as suggested by Pinto (1989). The author argues that when a dual exchange rate system (i.e. official and black market) works as a tool for taxation, the increase in the deficit resulting from unification of black and official exchange rates will lead to higher inflation. Increased inflation results from the government's need to print more money to cover the gap between spending and revenues.

[49] We have also estimated OLS regression and find that the impact of insurance on output growth is significant but with a smaller magnitude. Specifically, we find the estimated coefficient on insurance is 0.003 (s.e. 0.0008).

Table 4.5: Two-stage least square estimation

	Coefficient	S.e	*p*-value
Insurance †	0.012	0.005	0.011
Initial GDP per capita †	-0.090	0.025	0.000
Life expectancy †	0.547	0.204	0.007
Government size †	0.001	0.024	0.959
Inflation rate ††	0.024	0.017	0.180
Openness †	0.028	0.016	0.087
Black market premium †	-0.012	0.008	0.131
Observations	52		
Hansen test (*p*-value)	0.817(0.664)		

Notes: All data averaged over 1981-2005 (except initial income which is GDP per capita at the start of 1976) and the legal origins from LLSV (1999) are used as instruments for insurance variable † and †† indicate variables are included as log(variable) and log(1+variable), respectively.

An array of sensitivity analyses is carried out to gauge the robustness of our findings. Firstly, estimation results excluding China and South Africa show that the identified effect remains intact (see Appendix 4.2). Secondly, to formally check on the potential impact of outliers, we compute the Cook's D statistic[50] to identify countries with high combination of residuals and leverage. The test suggests that China, Japan, Kenya, Nigeria, South Korea, and the United States are potential outliers. Interestingly, the exclusion of these outliers did not alter the estimation results (see Appendix 4.4). Finally, the model is re-estimated using the cross-section GMM estimator. The moments are set such that the instruments (i.e. legal origin) are uncorrelated with the error term. The results show that the exogenous component of insurance development exerts a strong positive impact on output growth (see Appendix 4.5).

4.5.2 Panel estimation

The second step of our analysis is to evaluate the impact of insurance sector development on output growth using the GMM panel estimator. The results are reported in Table 4.6. For comparison purposes with the earlier literature, the first panel analysis is to employ the difference-GMM estimator and results are reported in column (i). The results show that the coefficient on the insurance indicator is statistically insignificant at the usual level. This is not a surprise because the difference-GMM estimator can be poorly behaved when the series are persistent, which is common in a short panel like our study.

[50] Refer to Appendix 4.3 for further details about the Cook's D statistic.

The next step of our analysis is to utilize the one-step system-GMM estimator which is commonly used in the literature. The results presented in column (ii) show that the coefficient on insurance is positive and statistically significant at the 5% level. Moreover, all other conditioning variables enter the regression equation with the expected sign and statistically significant, except for government size and inflation. However, the number of instruments (which is greater than *N*) suggests possible problems. Although this does not affect the efficiency of the one-step estimates, it nevertheless affects the consistency of the parameter estimates. Moreover, the over-identification test suggests that the null of joint validity of all instruments can be rejected at the 5 percent. Thus, these results are driven by simultaneity bias.

We next apply the two-step system GMM estimator and correct the standard errors following Windmeijer (2005). Results reported in column (iii) show that the estimated coefficient on insurance is positive and statistically significant at the 5 percent level. Interestingly, the magnitude of insurance effect is similar to the one-step estimate. The *p*-values of both serial correlation and overindentification tests suggest that the model is correctly specified and the instruments are valid. However, the number of instruments of larger than *N* suggests possible biased parameter estimates and weakened Hansen test. Thus, the finding of a significant impact of insurance on growth obtained from the corrected two-step estimator could be spurious.

Finally, we reduce the number of instrumental variables following a novel procedure suggested by Calderon *et al*. (2002). This is done by collapsing the instrumental variables matrix and results are tabulated in column (iv). We find that the coefficient estimate on insurance remains positive and significant but with a larger magnitude. We cannot reject the model on the basis of either Hansen's test or of second-order serial correlation. More importantly, there is no evidence of instrument proliferation as the number of instruments appears to be substantially smaller than *N*. Specifically, we find that a 1 percentage-point improvement in insurance sector will increase output growth by 0.010 percentage-points. The magnitude of the impact is close to the cross-country estimates but two times bigger that the one-step and corrected two-step estimates.

Table 4.6: Panel estimation: Insurance and economic growth

	(i) One-step Difference GMM			(ii) One-step System GMM			(iii) Corrected Two-step System GMM			(iv) Alternative two-step System GMM		
	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value	Coeff.	S.e*	*p*-value	Coeff.	S.e*	*p*-value
Insurance[†]	-0.004	0.010	0.642	0.005	0.002	0.006	0.005	0.001	0.004	0.010	0.003	0.001
Initial GDP per capita[†]	-0.088	0.020	0.000	-0.021	0.003	0.000	-0.020	0.007	0.005	-0.033	0.010	0.001
Life expectancy[†]	0.156	0.200	0.435	0.236	0.058	0.000	0.239	0.092	0.010	0.323	0.127	0.011
Government size[†]	-0.191	0.077	0.014	-0.148	0.048	0.002	-0.155	0.061	0.012	-0.155	0.069	0.027
Inflation rate[††]	0.002	0.008	0.781	-0.009	0.004	0.046	-0.006	0.006	0.275	0.004	0.009	0.647
Openness[†]	0.002	0.035	0.944	0.003	0.009	0.727	0.003	0.012	0.813	0.023	0.038	0.543
Black market premium[†]	0.001	0.005	0.754	0.004	0.004	0.273	0.004	0.003	0.191	-0.005	0.010	0.579
Instruments	42			68			68			32		
Arrelano-Bond test for AR(2) (*p*-value)	0.950			0.770			0.607			0.514		
Sargan/Hansen test (*p*-value)	0.894			0.004			0.836			0.187		

Notes: s.e. is robust standard error. * indicates standard errors corrected for finite samples following Windmeijer (2005). Alternative two-step GMM is performed by collapsing the instrumental variable matrix following Calderon *et al*. (2002. [†] and [††] indicate transformations of the variables as log(variable) and log(1+variable), respectively.

Several studies have assessed the impact of banks and stock markets development on the channels of growth: capital accumulation and productivity growth (e.g. Levine and Zervos, 1998; Beck *et al*, 2000; Rioja and Valev, 2004). They generally find that the developments of both banking institutions and stock markets exert a positive impact on both capital accumulation and productivity growth. In line with this literature, Table 4.7 presents our empirical results of the impact of insurance on capital accumulation and productivity growth.[51] We find that insurance sector development has a significant positive effect on both capital accumulation and productivity improvement. This is consistent with the above-mentioned studies that use bank and stock market indicators.

Table 4.7: Panel estimation: Insurance and economic growth channels

	Capital Accumulation			Total factor Productivity		
	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value
Insurance †	0.018	0.007	0.016	0.004	0.002	0.097
Initial value †	-0.028	0.020	0.162	-0.031	0.013	0.021
Life expectancy †	0.403	0.212	0.057	0.220	0.094	0.020
Government size †	-0.021	0.066	0.744	-0.141	0.075	0.061
Inflation rate ††	0.019	0.014	0.194	-0.001	0.009	0.943
Openness †	0.102	0.052	0.052	0.005	0.046	0.906
Black market premium †	0.002	0.007	0.760	-0.011	0.009	0.249
Instruments	33			33		
Arrelano-Bond test for AR(2) (*p*-value)	0.091			0.349		
Hansen test of (*p*-value)	0.109			0.175		

Notes: S.e. indicates robust standard errors and corrected for finite samples following Windmeijer (2005). The estimation is performed by collapsing the instrumental variable matrix following Calderon *et al.* (2002). † and †† indicate transformations of the variables as log(variable) and log(1+variable), respectively.

Our next analysis is to examine possible differential effects of insurance on growth across developed and developing countries. For this purpose, we classify countries into two groups: developed and developing countries.[52] We do not estimate a separate regression for each group because this will exacerbate biases induced by the proliferation of instruments. Instead, a dummy variable is created for developed countries (HIGH) with developing countries

[51] For this purpose and subsequent analysis, we only use the alternative two-step system GMM estimator.
[52] Countries are divided according to 2005 GNI per capita, calculated using the World Bank Atlas method. The groups are developing (i.e. middle- and low income) if GNI per capita is $10,725 or less and developed (i.e. high-income) if the GNI per capita is more than $10,725.

serving as the reference group. HIGH is assigned a value of 1 for developed countries and zero otherwise. We then interact the HIGH dummy with insurance variable (INS) as follows: β_1INS + β_2INSxHIGH. With this specification, $\beta_1+\beta_2$ captures the effect of insurance sector development on growth for the developed countries while β_1 measures the impact for the developing countries. In column (i) of Table 4.8, the reported results show that the coefficient estimates for insurance are positive and statistically significant at the 10 percent level for both developed and developing countries. However, the coefficient estimates for developed countries is larger (0.053) than the estimate for developing countries (0.011). The economic interpretation of these coefficients is that 1-percentage-point increase in insurance development (in logs) would lead to 0.011 percentage-point increase in the growth rates of developing countries. For developed countries, the impact is 0.064 (i.e. = 0.053 + 0.011). Since the *p*-values of testing for serial correlation (0.313) and of the Hansen overidentification tests (0.457) are high, the null of both tests not be rejected. Therefore, serial correlation and simultaneity bias should be of no statistical concern. The results of estimating the capital stock equation can be found in column (ii). The estimated coefficient for the developing countries insurance indicator is positive statistically significant though not significant for developed countries. The coefficient estimate for the developing countries is 0.014 which suggests that a 1-percentage-point improvement in insurance sector development increases the per capita capital stock by 0.014-percentage-points. Since the impact on capital stock for developed countries is measured by $\beta_1+\beta_2$, it also increases by the same magnitude. The specification tests suggest that there are no problems of serial correlation and simultaneity bias. Finally, the results of estimating TFP equation are reported in the last column, revealing that the TFP-effect of insurance sector development is only positive and statistically significant for developed countries. There, productivity growth is estimated to increase by 0.016-percentage-points if an insurance sector development improves by 1-percentage-point. Furthermore, the estimated model passes both serial correlation and simultaneity bias specification tests. By and large, these findings suggest that the richer the country the higher the effect of insurance sector development on productivity growth, consistent with the theoretical results advanced by Acemoglu *et al.* (2006).

Table 4.8: Panel estimation: Insurance and growth across developed and developing countries

	(i) Output Growth			(ii) Capital Accumulation			(iii) Total factor Productivity		
	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value
Insurance - developing[†]	0.011	0.004	0.005	0.014	0.006	0.016	0.003	0.007	0.607
Insurance - developed[†]	0.053	0.028	0.061	0.003	0.010	0.765	0.016	0.009	0.074
Initial value[†]	-0.047	0.011	0.000	-0.020	0.010	0.060	-0.046	0.014	0.001
Life expectancy[†]	0.347	0.183	0.058	0.318	0.134	0.018	0.111	0.144	0.437
Government size[†]	-0.140	0.078	0.074	-0.138	0.081	0.090	-0.060	0.095	0.525
Inflation rate[††]	-0.015	0.012	0.215	0.010	0.012	0.423	-0.015	0.008	0.080
Openness[†]	0.021	0.030	0.480	0.104	0.050	0.037	0.016	0.039	0.673
Black market premium[†]	-0.020	0.009	0.032	0.005	0.007	0.460	-0.008	0.007	0.251
Instruments	37			37			37		
Arrelano-Bond test for AR(2) (*p*-value)	0.313			0.312			0.541		
Hansen test of (*p*-value)	0.457			0.354			0.283		

Notes: S.e. indicates robust standard errors and corrected for finite samples following Windmeijer (2005). The estimation is performed by collapsing the instrumental variable matrix following Calderon *et al.* (2002). [†] and [††] indicate transformations of the variables as log(variable) and log(1+variable), respectively.

Several papers (Levine and Zervos, 1998, Beck and Levine, 2004) have assessed the growth effects of bank-based measures of financial development along with stock markets (i.e. market-based). Although these studies find that the overall financial development, captured by the joint significance of banks and stock markets indicators, has a positive and significant impact on growth, there is no clear evidence as to whether a bank-based or a market-based financial system exerts stronger effects on growth. In line with this literature, we include the both bank and stock market indicators in the econometric specifications to disentangle the contribution of insurance sector development from bank or stock market development.

Following the literature (e.g. Beck *et al*., 2000 and Levine *et al*., 2000), we use private sector (henceforth PRC) as a proxy variable of banking sector developments. PRC measures the value of credit issued by financial intermediaries to the private sector, expressed as a ratio to GDP. PRC isolates credit issued to the private sector, as opposed to credit issued to governments, government agencies, and public enterprises. Furthermore, it excludes credit issued by the central bank. Beck *et al.* (2000) convincingly argues why this measure reflects more accurately the efficiency of banks institutions in providing credit.

We proxy the degree of stock market development by a broadly used measure of stock market liquidity: the total volume of shares traded divided by domestic GDP (henceforth TST). Since the number of available stock market indicators is limited among developing countries, we follow Rioja and Valev's (2004) approach by using a dummy variable for the TST.[53] The dummy variable which equals 1 if the country's TST is larger than the observed median value of the sample and 0 otherwise. In so doing, we manage to pick up countries and time periods where stock markets are an "important" part of the financial system. Although this approach entails loss of information, it is still preferable to assuming that the countries excluded from the sample do not have a stock market at all or to only use the very restricted sample. The estimation results of adding PRC and TST are reported in Table 4.9. As shown in the table, the coefficients on PRC are positive and statistically significant in both the output and capital stock equations, while TST is positive and significant only in the productivity equation. More importantly, the inclusions of PRC and TST did not affect the signs and statistical significance of the coefficients for insurance. This implies that insurance sector developments exert independent influences on output growth, capital accumulation, and productivity improvement.

[53] Data from the *Financial Structure Database* are only available for about 40 countries with limited time dimension.

Table 4.9: Panel estimation: Adding bank and stock market indicators

	(i) Output Growth			(ii) Capital Accumulation			(iii) Total Factor Productivity		
	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value	Coeff.	S.e	*p*-value
Insurance [†]	0.015	0.006	0.022	0.015	0.007	0.047	0.012	0.006	0.071
Initial value [†]	-0.044	0.016	0.007	-0.026	0.021	0.208	-0.046	0.027	0.090
Life expectancy [†]	0.248	0.128	0.053	0.412	0.213	0.053	0.094	0.137	0.494
Government size [†]	-0.174	0.086	0.044	-0.020	0.083	0.803	-0.169	0.091	0.062
Inflation rate [††]	-0.008	0.007	0.252	0.018	0.017	0.306	-0.014	0.007	0.050
Openness [†]	-0.026	0.028	0.350	0.035	0.038	0.359	-0.017	0.032	0.588
Black market premium [†]	0.006	0.006	0.354	0.001	0.004	0.805	-0.006	0.010	0.511
PRC [†]	0.020	0.011	0.061	0.021	0.008	0.014	0.011	0.012	0.352
TST	0.009	0.007	0.210	0.004	0.008	0.604	0.026	0.011	0.023
Instruments		40			40			40	
Observations									
Arrelano-Bond test for AR(2) (*p*-value)		0.300			0.123			0.438	
Hansen test (*p*-value)		0.175			0.184			0.448	

Notes: S.e. indicates robust standard errors and corrected for finite samples following Windmeijer (2005). The estimation is performed by collapsing the instrumental variable matrix following Calderon *et al.* (2002). [†] and [††] indicate transformations of the variables as log(variable) and log(1+variable), respectively. PRC denotes private credits expressed as ratios to GDP. TST is a dummy variable which equals 1 if the number of shares traded is greater than the sample median and 0 otherwise.

4.6 Conclusions

Although the finance-growth nexus has been heavily researched at both theoretical and empirical levels, the impact of insurance development on growth has so far received much less attention. This paper provides empirical evidence in support of a robust positive effect of insurance sector development on growth, exploiting data from a panel of 52 developed and developing countries over the 1981-2005 period. Importantly, its impact on growth is independent of bank and stock market development indicators. In addition, we quantify the relative importance of the different transmission channels (capital accumulation versus TFP growth) and discover that their relative importance in promoting growth varies with the degree of development of the countries in the sample. Consistent with the theoretical work by Acemoglu *et al*. (2006), we observe that in developed countries, insurance sector development enhances GDP growth through TFP, while in developing ones, insurance has a positive effect on GDP growth by facilitating capital accumulation. It thus appears that the strong contribution of insurance development to productivity growth does not occur until a country has reached a certain income level, roughly in the range that defines developed countries. Until then, most of effect occurs through capital accumulation.

Methodologically, we use several variants of the GMM estimator to highlight the danger of ignoring the proliferation of instruments, which appears to have an impact on the size of estimated coefficient. Should one ignore these problems, the impact of insurance on growth is underestimated approximately by half.

These findings are strongly consistent with models that predict that well-functioning financial systems ease information and transaction costs, thereby improving the allocation of resources and economic growth. It is our hope that they also offer a new perspective on the finance and growth debate.

5. CONCLUSIONS

Understanding what explains the wealth of nations is one of the oldest and most important economic quests in the entire discipline. As a result, empirical studies of economic growth have received lots of attention in the economic literature. Economists agree that economic growth and improvements in productivity are crucial for all countries. The process is however not yet fully understood, as there are many factors that can influence whether a country is able to enter a period of rapid and sustained growth. One major (and difficult) problem when dealing with the empirics of economic growth is to identify its most salient determinants. Departing from this base, this thesis has examined and conducted an empirical inquiry regarding the influence of FDI, R&D, and insurance markets on economic growth. The findings of this thesis shed new light on these important issues.

Chapter 2 has examined the role of economic freedom on the impact of FDI on economic growth. Here we argued that the positive impact of FDI on growth is contingent on the level of economic freedom in the host countries and only countries whose level of economic freedom is sufficiently high can benefit from FDI inflows. The proposed hypothesis is tested exploiting longitudinal data for 84 countries over the 1976-2005 period. Methodologically, we adopt a regression specification characterized by threshold effects, that allows FDI to have a nonlinear effect on growth, We can therefore accommodate the economically appealing possibility that the positive impact of FDI on growth 'kicks in' only after host countries have reached a given threshold level of economic freedom.

The estimation results show that FDI has no direct (linear) effect on output growth. However, there exists a non-linear pattern characterised by threshold effects, in which FDI contributes to output growth only after the level of economic freedom in the host countries has exceeded a certain threshold level. Below that threshold level, FDI has no real economic benefits for the recipient countries. Several sensitivity analyses were implemented to measure the robustness of the findings. We are able to reproduce the results of the analysis for a different sample (1981-2005) and when we control for a potential endogeneity bias. This finding is consistent with the growing view that countries with better absorptive capacity are more likely to benefit from the presence of foreign capital. And more freedom seems to foster a healthy economic environment that facilitates the adoption and diffusion of new technologies fostered by FDI inflows, thereby nurturing the economic ingredients necessary to economic development.

Accordingly, policy makers should formulate policies to promote long-term economic freedom. For instance, the security of property rights and legal structure can be improved by promoting judicial independence, establishing a trusted legal framework for private businesses to challenge the legality of government actions and reducing military interference in the rule of law and of the political process. Also, the participation of foreign banks in local markets is expected to improve the access to financial services and enhance the competition in the local banking sector, leading to a lower cost of financing. Reducing interest rate controls and directing more credit to the private sector are also likely to facilitate technology spillovers. Promoting freedom of exchange across borders through reductions in tariff and non-tariff barriers, or through reductions in foreign capital ownership controls, is also expected to enhance spillover effects. Yet another instance would be improving the regulations governing business activity by easing the process of business creation, enhancing labour market flexibility, reducing the levels of bureaucracy, price controls and other rent-seeking activities. However, it is worth noting that the adoption of such policies may be politically unpopular in the short run. The long-run economic benefits are nevertheless expected to outweigh the short-run costs.

Chapter 3 has tested empirically R&D spillovers from industrial countries to East Asian countries. Although innovative activities, such as R&D, are key drivers of productivity growth, only a few industrialised countries appear to be significantly spending in R&D. This observation has raised serious concerns regarding the extent to which developing countries are benefiting from their R&D activity. We therefore examine the impact of G-5 countries' (France, Germany, Japan, United Kingdom, and United States) R&D on the productivity of East Asian countries (China, Korea, Malaysia, Singapore, and Thailand). East Asian countries were chosen because they experienced spectacular an exceptional growth performance over the last three decades, and are relatively open to both trade and FDI. Using panel data over the 1984-2005 period, we analyse three potential channels through which foreign R&D may have spilled over, namely imports, inward FDI, and outward FDI. Our analysis involves three important exercises. First, pre-testing of a unit root was conducted for all series using both panel and univariate tests. We find that the series are generally non-stationary. Second, we examine whether the variables are cointegrated and we find strong support for cointegrating relationships between the variables. Finally and more importantly, we evaluate the impact of R&D (both domestic and foreign) on the productivity of East Asian countries using the DSUR estimator.

Four important conclusions emerge. First, technology appears to be crucial for productivity growth regardless of where it is developed, be it by a domestic or a foreign firm. Furthermore, domestic R&D activity becomes more important the further a country develops, suggesting that the strong productivity impact of domestic R&D does not occur until a certain level of average income is reached. Up to then, economic interactions with R&D leaders seem to matter for technology upgrading purposes.

Second, imports are the most important spillover channel. In general, FDI does not seem to directly contribute to improve the technological base of the recipient countries. Inward FDI can crowd domestic firms out of markets and reduce the productivity of domestic firms. Moreover, technology sourcing via outward FDI is less efficient because the amount of FDI invested in industrial countries is relatively small. Up to now, a substantial fraction of East Asian countries' FDI goes to other developing countries (for other reasons). This underlines the importance for the government of promoting trade liberalization, because the more open an economy to trade, the higher is the impact of foreign R&D on domestic productivity. One possible option is to sign a free trade agreement (FTA) or an economic partnership (EP) with R&D leaders. Several East Asian countries have recently signed FTAs or EFs with industrial countries, like the United States or Japan. These efforts should be made extant to other R&D leaders, such as the European countries, because further reductions in tariff and no-tariff barriers to trade are expected to further boost R&D spillovers in the region.

Third, sufficient absorptive capacity of foreign technology must be available in the host countries. The ability to absorb and internalise technology developed by others has been highlighted in the literature as an important pre-condition for benefiting from technological spillovers. Given that the impact of foreign knowledge on productivity complements the R&D efforts of domestic firms, it is also crucial for governments to promote domestic R&D activity, e.g., through grants, project funding or tax incentives, but also through the provision of public education targeted at the development of science, technology, and engineering skills.

Finally, our results suggest that the United States is, in general, a stronger provider of technology spillovers than Japan, emphasizing the strategic importance for the region in nurturing economic relations with the United States, the world's biggest R&D spender. Economic cooperation in the forms of FTAs and EPs can help to improve trade relations. For instance, Singapore has concluded an FTA with the United States in 2003 and there are ongoing discussions between the United States and other countries in the region to sign a similar agreement. Nevertheless the impact of economic cooperation beyond trade on technology spillovers should not be underestimated. Development aid and other kinds of assistance programs are also critical for the formation of a country's absorptive capacity. For instance, Japanese government has offered Official Development Aids (ODA) to the ASEAN member over the last few decades which focus on the training of skilled workers and technicians as well as on the promotion of human resources development in high value-added industries. These programs not only lead to greater acceptance of Japanese products but also promote the absorptive capacity for Japanese technology. Therefore, promoting interactions with other R&D leaders that go beyond trade and investment appears to be beneficial.

Chapter 4 examines the role of insurance sector development on economic growth. There are two opposing views on the role of financial markets on economic growth. One group argues that well-functioning financial markets alleviate information and transactions costs, leading to more efficient resource allocations and higher output growth. Another group views financial development as a result of economic growth: it is the expansion of economic activity that boosts the demand for financial products/services and therefore deepens financial markets and institutions. This debate has received much research interest, generating a sizeable empirical literature on the direction of causality between financial development and economic growth. The findings are essentially based on the role of banks, and are consistent with financial development leading economic growth. The literature is however almost silent on the role of other financial intermediaries such as insurance institutions. On this basis, this chapter examines the influence of insurance sector developments on output growth, capital accumulation, and productivity growth. Exploiting a panel of 52 countries over the 1981-2005 period, we implement a recent GMM estimator to tackle pervasive problems in estimating growth regressions (country-specific effects and simultaneity bias). It also deals with the issue of instruments proliferation due to the small sample size available to conduct the study.

The analysis is undertaken in two steps. First, we examine the influence of insurance sector development on growth using a cross-section of countries, in the spirit of the earlier finance-growth literature. This serves as a benchmark for the subsequent panel data analysis. Following an insight from LLSV (1997, 1998), we use legal origins as instrumental variables for insurance sector development to expunge the endogeneity bias. We find that a country's legal origin explains a significant fraction of the cross-country differences in insurance sector development. More importantly, the exogenous component of insurance sector development is found to explain cross-country differences in growth performance.

Second, we implement a dynamic panel GMM estimator that deals rigorously with endogeneity issues while tackling other issues in estimating growth models, such as country-specific effects and weak instruments. The main findings are that insurance sector development (i) influences output growth, capital accumulation, and productivity growth, and (ii) affects growth predominantly through capital accumulation in developing countries, while in developed countries it enhances productivity growth. Importantly, these findings are not driven by biases introduced by unobserved country-specific effects, simultaneity, or potential problems associated with weak and numerous instruments. They remain valid even after controlling for bank and stock market development.

These findings suggest that insurance sector development facilitates and enhances economic growth. Policy makers should not neglect the role of viable insurance markets and institutions in delivering long-run economic benefits. Insurance services have a productive impact within an economy through the risk transfer and indemnification services they offer, helping risk-averse individuals to engage in new (though risky) productive activities. With insurance coverage, these activities will generate positive externalities in terms of increased purchases, profits, employment, etc., ultimately leading towards higher growth.

Appendix 2.1: List of countries

Country	Code	EF Group	Country	Code	EF Group
Algeria	DZA	Low	Japan	JPN	High
Argentina	ARG	Low	Kenya	KEN	High
Australia	AUS	High	Madagascar	MAC	Low
Austria	AUT	High	Malawi	MWI	Low
Bahamas	BHS	High	Malaysia	MYS	High
Bangladesh	BGD	Low	Mali	MLI	Low
Benin	BEN	Low	Mexico	MEX	High
Bolivia	BOL	Low	Morocco	MAR	Low
Brazil	BRA	Low	Nepal	NPL	Low
Burundi	BDI	Low	Netherlands	NLD	High
Cameroon	CMR	Low	New Zealand	NZL	High
Canada	CAN	High	Nicaragua	NIC	Low
Central African Rep.	CAF	Low	Niger	NER	Low
Chile	CHL	High	Nigeria	NGA	Low
Colombia	COL	Low	Norway	NOR	High
Congo, Dem. Rep.	ZAR	Low	Pakistan	PAK	Low
Costa Rica	CRI	High	Panama	PAN	High
Cote d`Ivoire	CIV	Low	Papua New Guinea	PNG	High
Cyprus	CYP	High	Paraguay	PRY	High
Denmark	DNK	High	Peru	PER	Low
Dominican Republic	DOM	High	Philippines	PHL	High
Ecuador	ECU	Low	Portugal	PRT	High
Egypt	EGY	Low	Rwanda	RWA	Low
El Salvador	SLV	High	Senegal	SEN	Low
Finland	FIN	High	Sierra Leone	SLE	Low
France	FRA	High	South Africa	ZAF	High
Gabon	GAB	Low	Spain	ESP	High
Germany	GER	High	Sri Lanka	LKA	Low
Ghana	GHA	Low	Sweden	SWE	High
Greece	GRC	High	Switzerland	CHE	High
Guatemala	GTM	High	Syria	SYR	Low
Haiti	HTI	High	Thailand	THA	High
Honduras	HND	High	Togo	TGO	Low
Hungary	HUN	High	Trinidad &Tobago	TTO	High
Iceland	ISL	High	Tunisia	TUN	Low
India	IND	Low	Turkey	TUR	Low
Indonesia	IDN	High	United Kingdom	GBR	High
Iran	IRN	Low	United States	USA	High
Ireland	IRL	High	Uruguay	URY	High
Israel	ISR	Low	Venezuela	VEN	Low
Italy	ITA	High	Zambia	ZMB	Low
Jamaica	JAM	High	Zimbabwe	ZWE	Low

Notes: High and Low are countries with EF index above and below 5.6517, respectively.

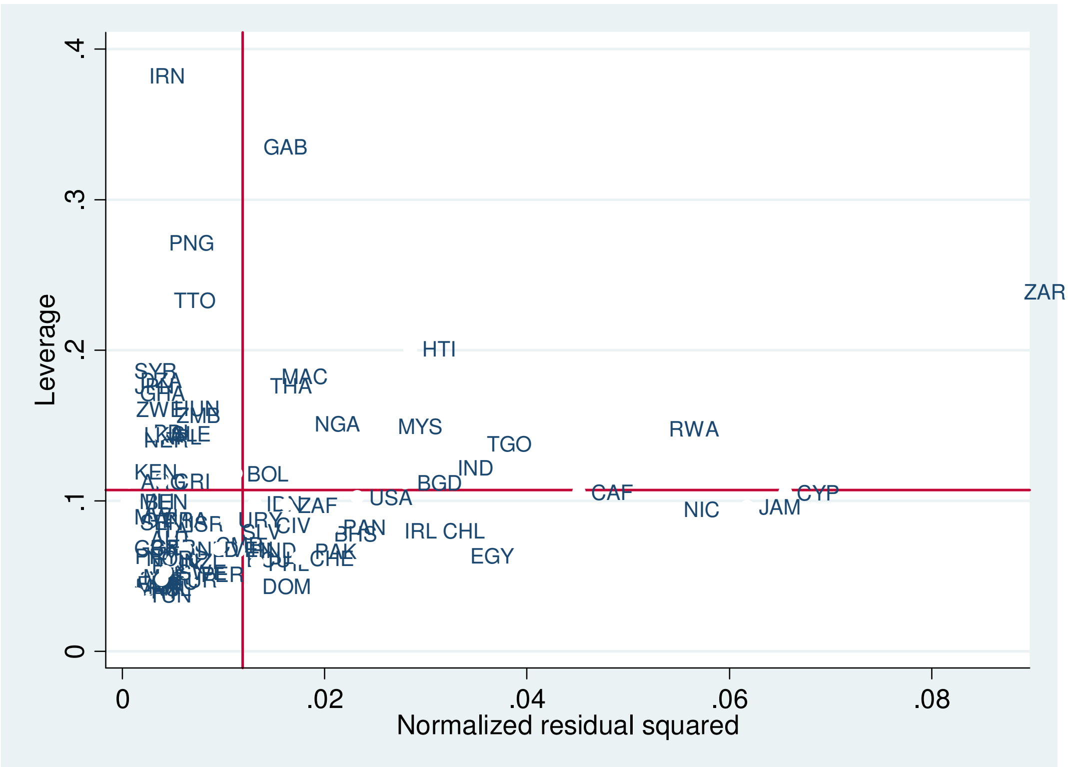
Appendix 2.2: Robustness checks for the interaction specification

	(i) excluding outliers			(ii) Adding FDI x PRC			(iii) Adding FDI x LIFE		
	Coeff	S.e.	*p*-value	Coeff	S.e.	*p*-value	Coeff	S.e.	*p*-value
Initial Income	-0.013	0.002	0.000	-0.014	0.002	0.000	-0.014	0.002	0.000
Population growth	0.426	0.151	0.006	0.416	0.160	0.012	0.400	0.161	0.016
Investment ratio	0.040	0.022	0.073	0.023	0.021	0.292	0.020	0.022	0.352
FDI	0.053	0.093	0.571	0.047	0.093	0.615	0.039	0.097	0.683
Life expectancy (LIFE)	0.062	0.008	0.000	0.060	0.008	0.000	0.060	0.008	0.000
FDI x LIFE							-0.444	0.823	0.591
Economic Freedom (EF)	0.004	0.001	0.005	0.002	0.001	0.087	0.002	0.001	.090
FDI x EF	0.186	0.100	0.067	0.309	0.161	0.060	0.320	0.162	0.053
Private Credit (PRC)				0.004	0.001	0.035	0.004	0.001	0.033
FDI x PRC				-0.180	0.169	0.290	-0.114	0.225	0.613
Constant	-0.149	0.029	0.000	-0.139	0.027	0.000	-0.139	0.028	0.000
R^2	0.60			0.63			0.63		
Number of observations	78			78			78		

Notes: All regression are carried out using a sample that exclude outliers countries - Dem. Rep. of Congo, Cyprus, Gabon, Haiti, Jamaica, and Rwanda – as identified by the DFIT statistic. All interaction terms are orthogonalised to remove multicollinearity effects. Private credit is the log of average value over 1976-2005 period. See notes to Table 3 for the definition of remaining variables.

Appendix 2.3: Identification of outliers – DFITS statistic

The DFITS statistic identifies observation with high combination of leverage and residual. The statistic is given by $DFITS_j = r_j\sqrt{h_j/(1-h_j)}$, where r_j is studentized residual given by $r_j = e_j/(s_{(j)}\sqrt{1-h_j})$ with $s_{(j)}$ refer to the root mean squared error (s) of the regression equation with *j*th observation removed, and *h* is leverage statistic. Following Belsley *et al.*(1980), an observation is considered as outlier if the absolute DFITS statistic is greater than $2\sqrt{k/n}$, where *k* denotes the number of explanatory variables and *n* the number of countries. The test suggests Dem. Rep of Congo (ZAR), Cyprus (CYP), Gabon (GAB), Haiti (HTI), Jamaica (Levin et al.), and Rwanda (Osterwald-Lenum) are potential outliers. The following figure shows the scatter plot of residuals vs. leverage statistic.



Appendix 2.4: Model selection

	Regressors					Unadjusted		Adjusted#	
Model with 5 regressors	RYPC76	I/Y	GPOP	LIFE	FDI	AIC	SBC	AIC	SBC
1	*					-8.9493	-8.7178	-8.8492	-8.6177
2		*				-8.9711	-8.7395	-8.8710	-8.6395
3			*			-9.0104	-8.7789	-8.9103	-8.6788
4				*		-8.9661	-8.7346	-8.8660	-8.6345
5					*	-9.0258	-8.7943	-8.9258	-8.6943
6	*	*				-8.9765	-8.7161	-8.8632	-8.6027
7	*		*			-9.0628	-8.8024	-8.9495	-8.6891
8	*			*		-9.0538	-8.7934	-8.9405	-8.6801
9	*				*	-9.0247	-8.7642	-8.9114	-8.6509
10		*	*			-9.0515	-8.7910	-8.9382	-8.6777
11		*		*		-8.9627	-8.7023	-8.8494	-8.5890
12		*			*	-9.0537	-8.7933	-8.9404	-8.6800
13			*	*		-9.0554	-8.7949	-8.9420	-8.6816
14			*		*	-9.0577	-8.7973	-8.9444	-8.6840
15				*	*	-9.0408	-8.7804	-8.9275	-8.6671
16			*	*	*	-9.0898	-8.8004	-8.9631	-8.6737
17		*		*	*	-9.0470	-8.7576	-8.9202	-8.6308
18		*	*		*	-9.0562	-8.7668	-8.9294	-8.6400
19		*	*	*		-9.0402	-8.7508	-8.9134	-8.6241
20	*			*	*	-9.0794	-8.7900	-8.9526	-8.6632
21	*		*		*	-9.0936	-8.8042	-8.9668	-8.6774
22	*		*	*		-9.0420	-8.7526	-8.9152	-8.6258
23	*	*			*	-9.0521	-8.7627	-8.9254	-8.6360
24	*	*		*		-9.0869	-8.7975	-8.9602	-8.6708
25	*	*	*			-9.0559	-8.7665	-8.9292	-8.6398
26		*	*	*	*	-9.0713	-8.7530	-8.9310	-8.6127
27	*		*	*	*	-9.0720	-8.7537	-8.9316	-8.6133
28	*	*		*	*	-9.0711	-8.7528	-8.9307	-8.6124
29	*	*	*		*	-9.0713	-8.7530	-8.9310	-8.6127
30	*	*	*	*		-9.0748	-8.7564	-8.9344	-8.6161
31	*	*	*	*	*	-9.1643	-8.8170	-9.0101	-8.6629
32						-9.0093	-8.8357	-8.9352	-8.7616
Model with 4 regressors									
33	*					-8.7398	-8.5372	-8.6528	-8.4502
34		*				-8.7010	-8.4984	-8.6140	-8.4114
35			*			-8.7470	-8.5444	-8.6599	-8.4574
36					*	-8.6943	-8.4917	-8.6073	-8.4047
37	*	*				-8.7378	-8.5063	-8.6378	-8.4063
38	*		*			-8.7312	-8.4997	-8.6311	-8.3996
39	*				*	-8.7394	-8.5079	-8.6393	-8.4078
40		*	*			-8.7238	-8.4923	-8.6237	-8.3922
41		*			*	-8.7237	-8.4922	-8.6236	-8.3921

Appendix 2.4: Model selection (continued)

	Regressors					Unadjusted		Adjusted[#]	
	RYPC76	I/Y	GPOP	LIFE	FDI	AIC	SBC	AIC	SBC
42			*		*	-8.7502	-8.5187	-8.6501	-8.4186
43		*	*		*	-8.7369	-8.4765	-8.6236	-8.3631
44	*		*		*	-8.7334	-8.4729	-8.6200	-8.3596
45	*	*			*	-8.7471	-8.4866	-8.6337	-8.3733
46	*	*	*			-8.7279	-8.4674	-8.6145	-8.3541
47	*	*	*		*	-8.9228	-8.6334	-8.7961	-8.5067
48						-8.7260	-8.5814	-8.6647	-8.5200
49	*					-9.0183	-8.8157	-8.9313	-8.7287
50		*				-8.9564	-8.7539	-8.8694	-8.6668
51				*		-8.9996	-8.7971	-8.9126	-8.7101
52					*	-9.0107	-8.8081	-8.9237	-8.7211
53	*	*				-8.9993	-8.7678	-8.8993	-8.6677
54	*			*		-9.0375	-8.8060	-8.9375	-8.7060
55	*				*	-9.0535	-8.8220	-8.9534	-8.7219
56		*		*		-8.9876	-8.7561	-8.8875	-8.6560
57		*			*	-9.0338	-8.8023	-8.9337	-8.7022
58				*	*	-9.0437	-8.8122	-8.9437	-8.7121
59		*		*	*	-9.0564	-8.7960	-8.9431	-8.6827
60	*			*	*	-9.0578	-8.7973	-8.9444	-8.6840
61	*	*			*	-9.0563	-8.7959	-8.9430	-8.6825
62	*	*		*		-9.0606	-8.8002	-8.9473	-8.6869
63	*	*		*	*	-9.1069	-8.8175	-8.9801	-8.6907
64						-9.0028	-8.8581	-8.9415	-8.7968
65	*					-8.8508	-8.6483	-8.7638	-8.5612
66			*			-8.8837	-8.6811	-8.7967	-8.5941
67				*		-8.8532	-8.6506	-8.7662	-8.5636
68					*	-8.8958	-8.6932	-8.8088	-8.6062
69	*		*			-8.8833	-8.6518	-8.7832	-8.5517
70	*			*		-8.8944	-8.6629	-8.7943	-8.5628
71	*				*	-8.8868	-8.6553	-8.7867	-8.5552
72			*	*		-8.8716	-8.6401	-8.7716	-8.5401
73			*		*	-8.8905	-8.6589	-8.7904	-8.5589
74				*	*	-8.8875	-8.6560	-8.7874	-8.5559
75			*	*	*	-8.9012	-8.6407	-8.7878	-8.5274
76	*			*	*	-8.8992	-8.6388	-8.7859	-8.5254
77	*		*		*	-8.9010	-8.6405	-8.7876	-8.5272
78	*		*	*		-8.9080	-8.6475	-8.7947	-8.5342
79	*		*	*	*	-9.1427‡	-8.8533	-9.0159‡	-8.7265
80						-9.0063	-8.8616	-8.9449	-8.8002
81		*				-8.6851	-8.4825	-8.5980	-8.3955
82			*			-8.7951	-8.5926	-8.7081	-8.5055
83				*		-8.7686	-8.5660	-8.6815	-8.4790

Appendix 2.4: Model selection (continued)

	Regressors					Unadjusted		Adjusted[#]	
	RYPC76	I/Y	GPOP	LIFE	FDI	AIC	SBC	AIC	SBC
84	■				*	-8.7091	-8.5065	-8.6220	-8.4195
85	■	*	*			-8.8081	-8.5766	-8.7080	-8.4765
86	■	*		*		-8.8268	-8.5953	-8.7267	-8.4952
87	■	*			*	-8.7372	-8.5057	-8.6371	-8.4056
88	■		*	*		-8.7766	-8.5451	-8.6766	-8.4451
89	■		*		*	-8.8217	-8.5902	-8.7216	-8.4901
90	■			*	*	-8.7853	-8.5538	-8.6852	-8.4537
91	■		*	*	*	-8.8087	-8.5483	-8.6954	-8.4350
92	■	*		*	*	-8.8128	-8.5524	-8.6995	-8.4390
93	■	*	*		*	-8.8097	-8.5493	-8.6964	-8.4360
94	■	*	*	*		-8.8114	-8.5509	-8.6981	-8.4376
95	■	*	*	*	*	-8.8302	-8.5408	-8.7034	-8.4140
96	■					-8.6592	-8.5145	-8.5978	-8.4532
Model with 3 regessors									
97	*		■	■		-8.4490	-8.2754	-8.3749	-8.2013
98		*	■	■		-8.4397	-8.2661	-8.3656	-8.1920
99			■	■	*	-8.4782	-8.3045	-8.4041	-8.2304
100	*	*	■	■		-8.4711	-8.2685	-8.3841	-8.1815
101	*		■	■	*	-8.4769	-8.2744	-8.3899	-8.1874
102		*	■	■	*	-8.4710	-8.2685	-8.3840	-8.1815
103	*	*	■	■	*	-8.9110	-8.6795	-8.8109	-8.5794
104			■	■		-8.7382	-8.6224	-8.6894	-8.5736
105	*	■		■		-8.5594	-8.3857	-8.4853	-8.3116
106		■	*	■		-8.5586	-8.3850	-8.4845	-8.3109
107		■		■	*	-8.5463	-8.3727	-8.4722	-8.2986
108	*	■	*	■		-8.5600	-8.3574	-8.4730	-8.2704
109	*	■		■	*	-8.5772	-8.3747	-8.4902	-8.2876
110		■	*	■	*	-8.5713	-8.3687	-8.4843	-8.2817
111	*	■	*	■	*	-8.6930	-8.4615	-8.5929	-8.3614
112		■		■		-8.5674	-8.4517	-8.5186	-8.4029
113	*	■	■			-8.8871	-8.7135	-8.8130	-8.6394
114		■	■	*		-8.8906	-8.7170	-8.8165	-8.6429
115		■	■		*	-8.9180	-8.7443	-8.8439	-8.6702
116	*	■	■	*		-8.9444	-8.7418	-8.8574	-8.6548
117	*	■	■		*	-8.9362	-8.7336	-8.8492	-8.6466
118		■	■	*	*	-8.9366	-8.7341	-8.8496	-8.6471
119	*	■	■	*	*	-9.1026	-8.8711	-9.0026	-8.7711
120		■	■			-9.0131	-8.8974[‡]	-8.9643	-8.8486[‡]
121	■	*		■		-8.6658	-8.4922	-8.5917	-8.4181
122	■		*	■		-8.6961	-8.5224	-8.6220	-8.4483
123	■			■	*	-8.6686	-8.4949	-8.5945	-8.4208
124	■	*	*	■		-8.6795	-8.4769	-8.5925	-8.3899

Appendix 2.4: Model selection (continued)

	Regressors					Unadjusted		Adjusted[#]	
	RYPC76	I/Y	GPOP	LIFE	FDI	AIC	SBC	AIC	SBC
125		*			*	-8.7161	-8.5136	-8.6291	-8.4265
126			*		*	-8.6915	-8.4890	-8.6045	-8.4020
127		*	*		*	-8.7988	-8.5673	-8.6987	-8.4672
128						-8.6173	-8.5015	-8.5685	-8.4528
129		*				-8.7785	-8.6049	-8.7044	-8.5308
130				*		-8.5867	-8.4131	-8.5126	-8.3390
131					*	-8.6320	-8.4584	-8.5579	-8.3843
132		*		*		-8.6164	-8.4138	-8.5293	-8.3268
133		*			*	-8.7161	-8.5136	-8.6291	-8.4265
134				*	*	-8.6148	-8.4122	-8.5278	-8.3252
135		*		*	*	-8.7309	-8.4994	-8.6308	-8.3993
136						-8.8261	-8.7104	-8.7773	-8.6616
137			*			-8.7089	-8.5353	-8.6348	-8.4612
138				*		-8.7187	-8.5451	-8.6446	-8.4710
139					*	-8.6676	-8.4940	-8.5935	-8.4199
140			*	*		-8.7197	-8.5171	-8.6327	-8.4301
141			*		*	-8.7171	-8.5145	-8.6301	-8.4275
142				*	*	-8.7173	-8.5148	-8.6303	-8.4278
143			*	*	*	-8.7661	-8.5346	-8.6660	-8.4345
144						-8.6710	-8.5552	-8.6222	-8.5064
Model with 2 regressors									
145	*					-8.4607	-8.3160	-8.3993	-8.2546
146					*	-8.4607	-8.3160	-8.3993	-8.2546
147	*				*	-8.7340	-8.5603	-8.6598	-8.4862
148						-8.5873	-8.5005	-8.5509	-8.4641
149		*				-8.4235	-8.2788	-8.3621	-8.2174
150					*	-8.4474	-8.3027	-8.3861	-8.2414
151		*			*	-8.6213	-8.4476	-8.5471	-8.3735
152						-8.5639	-8.4771	-8.5275	-8.4407
153			*			-8.4561	-8.3114	-8.3947	-8.2500
154					*	-8.5418	-8.3972	-8.4805	-8.3358
155			*		*	-8.6916	-8.5180	-8.6175	-8.4439
156						-8.5488	-8.4620	-8.5124	-8.4256
157				*		-8.6413	-8.4966	-8.5799	-8.4352
158					*	-8.6436	-8.4989	-8.5822	-8.4375
159				*	*	-8.7467	-8.5731	-8.6726	-8.4990
160						-8.5866	-8.4998	-8.5503	-8.4634
Model with 1 regressor									
161					*	-8.6491	-8.5334	-8.6003	-8.4846
162						-8.5623	-8.5044	-8.5382	-8.4803

Notes: # indicates adjustment for degree of freedom. * indicates that the variables are allowed to switch across regimes. Shaded boxes indicate that the variables are omitted. For instance, Model 5 includes all five regressors and only FDI is allowed to switch across regimes while all other variables are constrained to be linear. In Model 96, four regressors (i.e. investment ratio, population growth, life expectancy and FDI) are included as regressors and all of them are constrained to be linear. ‡ indicates the optimal models.

Appendix 2.5: Further split

	Low-EF group	High-EF group
Threshold estimate	4.651	6.993
LM-test for no threshold	25.248	15.242
p-value	0.162	0.573
Number of countries	40	44

Notes: The bootstrap *p*-values for the threshold estimates were calculated with 1000 replications and 10% trimming percentage.

Appendix 2.6: Bootstrapped *p*-values

Threshold estimate: 5.651	*Trimming percentage*				
LM-test for no threshold: 29.145	10	15	20	25	30
Bootstrap Replications:					
1,000	0.024	0.022	0.019	0.016	0.011
5,000	0.022	0.019	0.017	0.015	0.012
10,000	0.021	0.018	0.016	0.014	0.011

Appendix 2.7: Threshold regression (1981-2005)

	Low-EF (EF≤5.674)			High-EF (EF>5.674)		
	Coeff.	s.e	t-stat	Coeff.	s.e	t-stat
Initial income	-0.010	0.002	-4.852	-0.010	0.003	-2.952
Population Growth	-0.486	0.374	-1.301	0.859	0.187	4.602
Investment ratio	-0.021	0.027	-0.769	0.127	0.024	5.300
Life Expectancy	0.065	0.011	5.746	0.045	0.023	1.959
FDI	-0.381	0.192	-1.983	0.329	0.092	3.568
Threshold estimate	5.6740					
LM-test for no threshold	33.212					
(*p*-value)	(0.0030)					
Number of countries	37			47		
R^2	0.56			0.61		

Notes: The dependent variable is average real GDP growth (1981–2005). Initial income is the logarithm of per capita income in 1981. All other regressors are the average values over 1981-2005 period. Life expectancy is in the logarithmic form. EF is the index of economic freedom used as a threshold variable. *p*-value was bootstrapped with 1000 replications and 10% trimming percentage. Standard errors (s.e) are corrected for heteroskedasticity. There are 37 and 47 countries in the Low-EF and High-EF group, respectively.

Appendix 2.8: Threshold regression (1976-2005) – EF growth as a threshold variable

	Low-EF growth (EF ≤ 0.0117)			High-EF growth (EF>0.0117)		
	Coeff.	s.e	t-stat	Coeff.	s.e	t-stat
Initial income	-0.010	0.002	-5.030	-0.034	0.002	-14.433
Population Growth	0.335	0.172	1.949	0.419	0.247	1.699
Investment ratio	0.051	0.026	1.991	0.192	0.030	6.361
Life Expectancy	0.049	0.007	6.841	0.151	0.016	9.423
FDI	0.304	0.134	2.269	0.197	0.110	1.785
Threshold estimate	0.0117					
LM-test for no threshold	32.9350					
(*p*-value)	(0.011)					
Number of countries	61			23		
R^2	0.54			0.84		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the logarithm of per capita income in 1976. All other regressors are the average values over 1976-2005 period. Life expectancy is in the logarithmic form. The growth rate of the EF index is used as a threshold variable. *p*-value was bootstrapped with 1000 replications and 10% trimming percentage. Standard errors (s.e) are corrected for heteroskedasticity. There are 61 and 23 countries in the Low-EF growth and High-EF growth groups, respectively.

Appendix 2.9: Threshold regression using EF index from the Heritage Foundation (1976-2006)

	Low-EF (EF≤64.60)			High-EF (EF>64.60)		
	Coeff.	s.e.	t-stat	Coeff.	s.e.	t-stat
Initial income	-0.011	0.002	-5.492	-0.010	0.005	-1.965
Population Growth	0.096	0.221	0.434	1.191	0.410	2.907
Investment ratio	-0.020	0.034	-0.583	0.136	0.041	3.324
Life Expectancy	0.071	0.012	5.746	0.047	0.058	0.808
FDI	-0.245	0.163	-1.503	0.385	0.162	2.370
Threshold estimate	64.60					
LM-test for no threshold	23.206					
(*p*-value)	(0.086)					
Number of countries	55			29		
R^2	0.48			0.66		

Notes: The dependent variable is average real GDP growth (1976–2005). Initial income is the logarithm of per capita income at the beginning of 1976. All other regressors are the average values over the 1976-2005 period except for the EF index which is averaged over the 1996-2005 period. Life expectancy is in the logarithmic form. *p*-value was bootstrapped with 1000 replications and 10% trimming percentage. Standard errors (s.e) are corrected for heteroskedasticity.

Appendix 3.1: ADF tests

	China	Korea	Malaysia	Singapore	Thailand
Panel A: Model with intercepts					
TFP	-0.4207	-1.6737	-0.6848	-0.4814	-1.8334
	(-3.0521)	(-3.0123)	(-3.0123)	(-3.0123)	(-3.0206)
S^d	3.2134 *	3.3237 *	-0.4724	2.4583	1.1247
	(-3.0206)	(-3.0299)	(-3.0206)	(-3.0299)	(-3.0206)
S^{fm}	0.5296	-0.9107	-0.6244	-1.0201	-0.7595
	(-3.0123)	(-3.0123)	(-3.0123)	(-3.0123)	(-3.0123)
S^{ff}	-1.2739	-2.6011	-1.5575	-1.4907	-1.1481
	(-3.0206)	(-3.0123)	(-3.0521)	(-3.0123)	(-3.0123)
S^{ft}		-3.5447 *	-1.7192	-1.5093	
	n/a	(-3.1199)	(-3.1199)	(-3.1753)	n/a
Panel B: Model with intercepts and linear trends					
TFP	-3.6269	-2.4304	-1.6913	-1.8762	-2.3319
	(-3.6908)	(-3.6449)	(-3.6449)	(-3.6449)	(-3.6584)
S^d	0.5994	-0.0673	-2.9505	-2.4338	-0.9416
	(-3.6584)	(-3.6736)	(-3.6908)	(-3.6736)	(-3.6584)
S^{fm}	-4.1522 *	-3.1290	-1.5270	-1.0767	-2.5577
	(-3.6584)	(-3.6584)	(-3.6449)	(-3.6449)	(-3.6584)
S^{ff}	-1.4375	-4.1908 *	-3.7873 *	1.7885	-0.9503
	(-3.6584)	(-3.7104)	(-3.6908)	(-3.7104)	(-3.6449)
S^{ft}		-3.6664	-1.3401	-2.6035	
	n/a	(-3.8289)	(-3.7911)	(-3.9333)	n/a

Notes: Figures in parentheses are the 5% critical values, following MacKinnon's (1996) simulation procedure. * indicates statistical significance at the 5% level. n/a indicates data unavailability. Optimal lags were chosen based on the AIC.

Appendix 3.2: Johansen cointegration tests

	Null	Alternative	λ_{max}	λ_{trace}
Panel A: [TFP, S^d, S^{fm}, S^{ff}]				
China	r=0	r=1	68.29 *	131.59 *
	r≤2	r=2	44.83 *	63.29 *
	r≤3	r=3	12.31	18.46
	r≤4	r=4	6.15	6.15
Korea	r=0	r=1	51.85 *	102.78 *
	r≤2	r=2	23.69 *	50.92 *
	r≤3	r=3	19.71 *	27.22 *
	r≤4	r=4	7.51	7.51
Malaysia	r=0	r=1	38.90 *	89.31 *
	r≤2	r=2	23.61 *	50.41 *
	r≤3	r=3	18.37 *	26.80 *
	r≤4	r=4	8.42	8.42
Singapore	r=0	r=1	35.24 *	69.44 *
	r≤2	r=2	18.07	34.20
	r≤3	r=3	9.67	16.12
	r≤4	r=4	6.45	6.45
Thailand	r=0	r=1	58.58 *	111.33 *
	r≤2	r=2	28.90 *	52.75 *
	r≤3	r=3	14.71	23.84 *
	r≤4	r=4	9.13	9.13
95% Critical values	r=0	r=1	28.58	54.07
	r≤2	r=2	22.29	35.19
	r≤3	r=3	15.89	20.26
	r≤4	r=4	9.16	9.16
Panel B: [TFP, S^d, S^{ft}]				
Korea	r=0	r=1	29.26 *	55.14 *
	r≤2	r=2	15.43	25.88 *
	r≤3	r=3	10.44	10.44
Malaysia	r=0	r=1	27.55 *	45.80 *
	r≤2	r=2	12.74	18.25
	r≤3	r=3	5.51	5.51
Singapore	r=0	r=1	36.04 *	52.27 *
	r≤2	r=2	12.04	16.23
	r≤3	r=3	4.18	4.18
95% critical values	r=0	r=1	22.29	35.19
	r≤2	r=2	15.89	20.26
	r≤3	r=3	9.16	9.16

Notes: r is the number of cointegrating vector. Critical values were taken from Osterwald-Lenum (1992). * indicates significant at 95% level.

Appendix 3.3: R&D spillovers (1990-2005)

	China	Korea	Malaysia	Singapore	Thailand
Panel A: R&D spillovers via import channel					
Domestic RD:					
S^d	0.353*	0.433*	0.024*	0.202*	0.103*
	(0.006)	(0.012)	(0.008)	(0.003)	(0.015)
Foreign RD:					
S^{fm} (import channel)	-0.028*	0.046*	0.510*	0.424*	0.393*
	(0.007)	(0.015)	(0.007)	(0.003)	(0.014)
Panel B: R&D spillovers via inward FDI channel					
Domestic RD:					
S^d	0.307*	0.758*	0.137*	0.594*	0.722*
	(0.017)	(0.042)	(0.011)	(0.067)	(0.093)
Foreign RD:					
S^{ff} (inward FDI channel)	0.078*	-0.084*	0.082*	-0.166*	-0.233*
	(0.004)	(0.004)	(0.003)	(0.032)	(0.030)

Notes: All variables are in logarithmic form. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

Appendix 3.4: R&D spillovers (1984-2005): sensitivity to different rates of depreciation

	China	Korea	Malaysia	Singapore	Thailand
Panel A: 7 percent					
Domestic RD					
S^d	-0.174*	0.336 *	0.062 *	0.236 *	0.079 *
	(0.044)	(0.038)	(0.004)	(0.010)	(0.011)
Foreign RD					
S^{fm} (import channel)	0.365 *	0.098 *	0.011	0.344 *	0.226 *
	(0.027)	(0.010)	(0.008)	(0.006)	(0.016)
S^{ff} (inward FDI channel)	0.094 *	-0.038 *	0.046 *	-0.067 *	0.021 *
	(0.010)	(0.009)	(0.003)	(0.004)	(0.007)
Panel B: 10 percent					
Domestic RD					
S^d	0.116 *	0.304 *	0.058 *	0.239 *	0.073 *
	(0.033)	(0.013)	(0.004)	(0.006)	(0.004)
Foreign RD					
S^{fm} (import channel)	0.055 *	0.071 *	0.032 *	0.293 *	0.320 *
	(0.035)	(0.007)	(0.010)	(0.008)	(0.007)
S^{ff} (inward FDI channel)	0.113 *	-0.021 *	0.035 *	-0.026 *	-0.044 *
	(0.011)	(0.004)	(0.004)	(0.006)	(0.004)

Notes: All variables are in logarithmic form. Figures in parentheses are robust standard errors. * indicates significant at the 5% level.

Appendix 4.1: List of countries

Developed Countries:

Country	code	Legal Origin
Australia	AUS	English
Austria	AUT	German
Belgium	BEL	French
Canada	CAN	English
Cyprus	CYP	English
Denmark	DNK	Scandinavian
Finland	FIN	Scandinavian
France	FRA	French
Greece	GRC	French
Israel	ISR	English
Italy	ITA	French
Japan	JPN	German
Korea, Rep.	KOR	German
Netherlands	NLD	French
New Zealand	NZL	English
Iceland	ISL	Scandinavian
Ireland	IRL	English
Norway	NOR	Scandinavian
Portugal	PRT	French
Singapore	SGP	English
Spain	ESP	French
Sweden	SWE	Scandinavian
Switzerland	CHE	French
United Kingdom	GBR	English
United States	USA	English

Developing Countries:

Country	code	Legal Origin
Algeria	DZA	French
Argentina	ARG	French
Brazil	BRA	French
Chile	CHL	French
China	CHN	Socialist
Colombia	COL	French
Dominican, Rep.	DOM	French
Egypt	EGY	French
Hungary	HUN	Socialist
India	IND	English
Indonesia	IDN	French
Iran	IRN	French
Kenya	KEN	English
Malaysia	MYS	English
Mexico	MEX	French
Morocco	MAR	French
Nigeria	NGA	English
Pakistan	PAK	English
Panama	PAN	French
Peru	PER	French
Philippines	PHL	French
South Africa	ZAF	English
Thailand	THA	English
Tunisia	TUN	French
Turkey	TUR	French
Venezuela	VEN	French
Zimbabwe	ZWE	English

Appendix 4.2: Two-stage least square estimation - excluding China and South Africa

	Coefficient	S.e	*p*-value
Insurance†	0.009	0.003	0.003
Initial GDP per capita †	-0.054	0.012	0.000
Life expectancy†	0.263	0.089	0.003
Government size†	0.014	0.014	0.319
Inflation rate††	0.012	0.010	0.207
Openness†	0.023	0.011	0.037
Black market premium†	-0.002	0.004	0.650
Observations	50		
Hansen test (*p*-value)	1.074 (0.584)		

Notes: The cross-country regression uses data averaged over 1981-2005 and the legal origins of countries from LLSV (1999) are used as instrumental variables for insurance activity. † and †† indicate variables are included as log(variable) and log(1+variable), respectively.

Appendix 4.3: Identification of outliers – Cook's Distance statistic

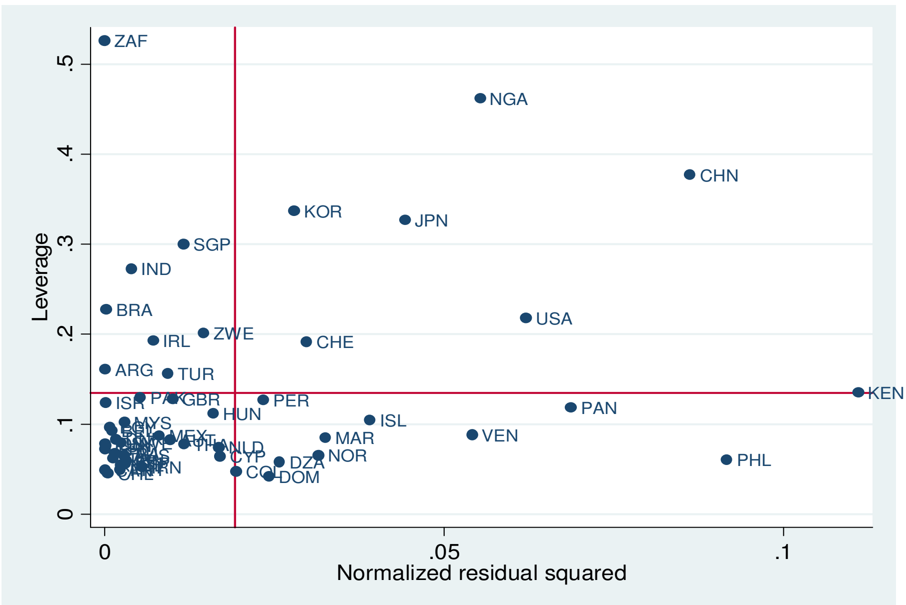
Cook's distance statistic (Cook's D) is used to identify observation with high combination of residual and leverage. Data points with large residuals and/or high leverage may distort the outcome and accuracy of a regression. The statistic tells how much influence the i^{th} data has upon the model. The statistic is calculated as follows:

$$D_i = \frac{\sum(\hat{Y}_j - \hat{Y}_{j(i)})^2}{p \cdot MSE}$$

Algebraically, the above formula can be expressed as follows:

$$D_i = \frac{e_i^2}{p \cdot MSE}\left[\frac{h_{ii}}{(1-h_{ii})^2}\right]$$

where h_{ii} is the i^{th} diagonal element of the Hat matrix $\mathbf{X}(\mathbf{X}^T\mathbf{X})^{-1}\mathbf{X}^T$, e_i is the residual (i.e. the difference between the observed value and the value of fitted by the proposed model), p is the number of parameters in the model and MSE is the Mean Square Error. The convention cut-off point is 4/n, where n is number of countries. According to this rule, the potential outlier countries are China, Japan, Kenya, Nigeria, South Korea and the United States. The following figure presents the scatter plot of residuals vs. leverage.



Appendix 4.4: Two-stage least square estimation – excluding outliers

	Coefficient	S.e	*p*-value
Insurance[ΐ]	0.004	0.002	0.036
Initial GDP per capita[ΐ]	-0.057	0.015	0.000
Life expectancy[ΐ]	0.338	0.112	0.003
Government size[ΐ]	0.013	0.009	0.172
Inflation rate[ΐΐ]	-0.000	0.005	0.952
Openness[ΐ]	0.017	0.005	0.002
Black market premium[ΐ]	0.001	0.005	0.833
Observations	46		
Hansen test (*p*-value)	5.384 (0.067)		

Notes: The cross-country regression uses data averaged over 1981-2005 and the legal origins of countries from LLSV (1999) are used as instrumental variables for insurance activity. [ΐ] and [ΐΐ] indicate variables are included as log(variable) and log(1+variable), respectively. The outlier countries are China, Japan, Kenya, Nigeria, South Korea, and the United States.

Appendix 4.5: Cross-section GMM estimation

	Coefficient	S.e	*p*-value
Insurance†	0.014	0.004	0.002
Initial GDP per capita†	-0.101	0.021	0.000
Life expectancy†	0.640	0.169	0.000
Government size†	-0.002	0.023	0.924
Inflation rate††	0.029	0.016	0.072
Openness†	0.032	0.015	0.041
Black market premium†	-0.014	0.007	0.060
Observations	52		
Hansen test (*p*-value)	0.817 (0.664)		

Notes: The cross-country regression uses data averaged over 1981-2005 and the legal origins of countries from LLSV (1999) are used as instrumental variables for insurance activity. † and †† indicate variables are included as log(variable) and log(1+variable), respectively.

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