Three Essays on Information and Communication Technology and Financial Globalization

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Abstract

An advance in information and communication technology (ICT) is one of the most important forces in reshaping the world economy. So far, research on the role of ICT development in the financial globalization process is very limited. This dissertation is composed of three essays, which aim to fill part of this gap. The first essay explores transmission mechanism between Internet development and foreign direct investment (FDI) in developing economies. The second further investigates why developing economies cannot fully benefit from Internet development and provides policy recommendations. The third studies the relationship among financial integration, ICT and macroeconomic volatility in ten Asian economies.

The first essay examines three potential channels: inventory costs, market entry costs and payment of bribes, through which the Internet attracts FDI. It develops a model to explain the role of the Internet in determining inward FDI, and then empirically tests the hypotheses. The empirical findings show that the Internet development in developing economies attracts multinationals, since it reduces their costs of holding inventories and market entry costs. The Internet is found to reduce corruption, but evidence for their combined effects on FDI is mixed. In addition, this study performs Granger causality test and finds a causal relationship from the Internet to inward FDI stocks, rather than vice versa.

The second essay examines how the Internet—a communication network—which is characterized by the presence of positive and negative externalities affects the locational choice of FDI. A two-stage model is developed: at the first stage, multinational corporations do not cooperate and determine the degree of investment in Internet

technologies, whereas, at the second stage, these firms engage in a Cournot quantity competition for a homogenous product. This model predicts that positive Internet externalities stimulate FDI while negative Internet externalities discourage FDI. These hypotheses are tested by the panel data estimation and the system general method of moments (GMM) estimator. The empirical findings provide strong evidence that the presence of negative Internet spillovers in developing countries discourages inward FDI, and the presence of positive Internet externalities in developed economies attracts more FDI.

The third essay looks at ten Asian economies committed to ICT development and financial integration, and presents evidence on whether or not they have experienced greater output fluctuations from 1980 to 2003. A two-country dynamic general equilibrium model is used and ICT is assumed to increase the volume and speed of capital flows. This study's model predicts that economies with a high ICT development or/and a high degree of financial integration exhibit greater output fluctuations in the face of monetary policy shocks, but lower output fluctuations in the face of fiscal policy shocks. The empirical findings estimated by using the panel vector autoregresssion approach support these predictions.

Résumé

L'avancement des technologies de l'information et de la communication (TIC) est l'une des plus importantes forces en ce qui concerne la révolution de l'économie mondiale. Jusqu'à maintenant, la recherche sur le rôle du développement des TIC dans le processus de globalisation financière est très limitée. Cette dissertation est composée de trois essais, lesquels tenteront en partie de combler ce vide. Le premier essai porte sur les mécanismes de transmission entre le développement de l'Internet et l'investissement direct à l'étranger (IDE) dans les pays en voie de développement. Par la suite, le deuxième essai analyse pourquoi les pays en voie de développement ne peuvent pas complètement bénéficier du développement de l'Internet et offre des recommandations de politiques. Quant au troisième essai, il étudie le lien entre l'intégration financière, les TIC et la volatilité macroéconomique dans dix économies asiatiques.

Tout d'abord, le premier essai analyse trois voies potentielles, soit les coûts d'inventaire, les coûts d'entrée en marché et le paiement d'externalités, par lesquelles Internet attire l'IDE. Un modèle y est développé pour expliquer le rôle de l'Internet dans la détermination de l'IDE entrant, puis les hypothèses y sont testées de façon empirique. Les résultats obtenus empiriquement montrent que le développement de l'Internet dans les pays en voie de développement attire les multinationales, puisque cela leur permet de réduire les coûts de tenue d'inventaires et d'entrée en marché. Il a été démontré qu'Internet réduit la corruption, mais les preuves d'effets combinés sur l'IDE sont partagées. De plus, cette étude applique le test de causalité de Granger et démontre ainsi une relation de causalité de l'Internet vers les stocks d'IDE entrant, et non l'inverse.

Le deuxième essai examine quant à lui la façon dont l'Internet, un outil de

communication caractérisé par la présence d'externalités positives et négatives, affecte le choix de localisation de l'IDE. Un modèle à deux étapes est développé; lors de la première étape, les entreprises multinationales ne coopèrent pas et déterminent le degré d'investissement dans les technologies de l'Internet, alors que lors de la deuxième étape, ces compagnies prennent part àune compétition àla Cournot pour un produit homogène. Ce modèle prédit que des externalités Internet positives stimulent l'IDE, alors que des externalités Internet négatives découragent l'IDE. Ces hypothèses sont testées par l'estimateur de l'effet fixe et par l'estimateur du type méthode des moments généralisés (GMM). Les résultats obtenus empiriquement apportent des preuves importantes que la présence d'effets indirects négatifs d'Internet dans les pays en voie de développement découragent l'IDE entrant, alors que la présence d'externalités Internet positives attirent plus d'IDE.

Quant au troisième essai, il examine dix économies asiatiques vouées au développement des TIC et àl' intégration financière, et apporte des preuves permettant de démontrer si elles ont oui ou non effectivement subit de plus importantes fluctuations de productivité entre 1980 et 2003. Un modèle d'équilibre dynamique général à deux pays est utilisé, et les TIC sont considérées comme apportant une augmentation de volume et de vitesse de la circulation des capitaux. Le modèle de cette étude prédit que les économies avec un développement élevé des TIC et/ou un important degré d'intégration financière montrent une plus grande fluctuation de productivité lors de chocs monétaires, mais aussi une moindre fluctuation de productivité lors de chocs fiscaux. Les résultats, obtenus empiriquement et estimés en utilisant l'approche du modèle de vecteurs autorégressifs, supportent ces prédictions.

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Introduction

An advance in information and communication technology (ICT) is one of the most important forces in reshaping the world economy. So far, research on the role of ICT development in the financial globalization process is very limited. This dissertation is composed of three essays, which aim to fill part of this gap. The first two essays study the relationship between Internet development and foreign direct investment (FDI). The third essay examines the relationship between Internet development and capital flows from macroeconomic perspective.

The first essay attempts to answer two questions: Does Internet development stimulate FDI and how does the Internet attract FDI? Building on the studies by Freund and Weinhold (2004), and Choi (2003), this study highlights three potential channels through which the Internet attracts FDI to developing countries: lowering inventory costs, lowering entry costs, and reducing the payment of bribes. It develops a model to explain the role of the Internet in determining inward FDI, and then empirically tests the hypotheses. This study finds support that the first two roles of the Internet encourage inward FDI to developing countries, but ambiguous evidence for the third.

The purpose of the second essay is to examine whether, and how, Internet development affects the locational choice of FDI. This paper distinguishes itself from previous studies in two aspects. First, this study focuses on a communication network, such as the Internet, which is characterized by the presence of positive and negative network externalities. Second, it incorporates two determinants of FDI in relation to Internet development: geographical distance and agglomeration forces. Theoretically, a two-stage model—relating FDI, Internet externalities, and distance—is developed.

Empirically, two major types of formal statistical analyses—the panel data estimation and the system generalized method of moments (GMM) estimator—are performed to verify the predictions of the two-stage model, plus the effect of Internet spillovers on agglomeration countries. The empirical findings show that in developing countries, negative Internet spillovers dominate and strengthen the distance barrier; whereas in developed countries, positive Internet spillovers dominate and diminish the economic importance of the distance barrier. These findings also suggest that Internet spillovers, whether positive or negative, are able to divert the early concentration of FDI, but are unlikely to reverse the self-reinforcing process of FDI.

The objective of the third essay is to study the combined impact of ICT development and financial integration on output volatility in the sample of ten Asian economies from 1980 to 2003. This study contributes to recent studies on the linkage between financial integration and output volatility in two aspects. First, it highlights the role of ICT development in enhancing financial integration. This paper adopts Sutherland's (1996a)[1] theoretical model, in which an advance in ICT implies a decline in transaction costs for trading foreign bonds, and thus a greater degree of financial integration. Also, this paper is the only empirical study to have examined the combined effects of ICT development and financial integration on output volatility.

The second way this study contributes to recent studies on the linkage between financial integration and output volatility is to highlight the effects of policy shocks on output volatility, as in Buch, Dopke and Pierdzioch (2002). Unlike Buch, Döpke and Pierdzioch (2002) who use Granger causality test and panel regression, this study

[1] Sutherland (1996a) is a revised version of Sutherland (1996b).

employs panel vector autoregression (PVAR) approach and impulse response analysis.

In sum, at the theoretical level, ICT is assumed to promote the volume and speed of capital flows in this study's model. Further, this study extends Sutherland's (1996a) two-country dynamic general equilibrium model by introducing physical capital into the production function and budget constraint. However, these modifications do not affect Sutherland's (1996a) predictions that increasing financial market integration tends to increase output volatility in the case of a monetary shock, and decrease output volatility in the case of a government spending shock. Empirically, this study provides evidence that economies with high (low) ICT development exhibit higher (lower) output fluctuations in the face of a monetary shock and lower (higher) output fluctuations in the face of a fiscal shock.

Chapter 1 On the Link Between the Internet and Foreign Direct Investment

Abstract

This study aims to investigate three channels, inventory costs, market entry costs and payment of bribes, through which the Internet encourages foreign direct investment (FDI) to developing countries. Evidence exists that Internet development in developing countries lowers inventory costs, market entry costs and bribery payments of multinational corporations. In addition, this study performs Granger causality tests for a panel of 110 developing countries over the period 1995-2002 and finds a causal relationship from the Internet to inward FDI stocks, rather than vice versa. These estimation results provide strong support for the importance of the Internet in attracting FDI.

1.1 Introduction

The wide application of the Internet is one of the major forces reshaping the world economy. With the aid of the Internet, multinational corporations (MNCs) can electronically transfer text, imagery, and voice to facilitate the worldwide management of raw materials, parts, and skills from the manufacturing to sale processes. For instance, doing business in more than 100 countries, General Motors has links with thousands of its suppliers through an Internet-based system that allows it to draft and negotiate contracts, collaborate visually on auto-part development, and track sales. Using the panel data of 110 developing countries, Figure 1.1 shows that both the total number of Internet users and inward foreign direct investment (FDI) stocks have increased over the period of

1995 to 2002.

Two questions arise from this positive relationship: Does Internet development stimulate FDI and how does the Internet attract FDI? These questions are important for two reasons. First, from a policy perspective, FDI through multinational activity is widely believed to be a channel for transferring technology, management skills, and capital, all of which are driving forces of economic development, in particular for developing countries. Hence, this study's findings on the relationship between the Internet and FDI would help in formulating appropriate policies for attracting FDI.

Second, little is known about the transmission mechanism between Internet development and FDI. As examples of the limited literature on the correlation between the Internet and FDI or trade, Choi (2003) finds a positive relationship between Internet development and FDI, and Freund and Weinhold (2004) provide evidence of a positive relationship between the Internet and trade flows. Specifically, Choi acknowledges three ways by which the Internet stimulates FDI. First, the Internet lowers information search costs and hence market entry costs. Second, Internet usage cuts the costs of holding inventories by allowing large suppliers to bypass retailers and contact customers directly, thereby raising productivity. Third, the Internet improves the transparency of government policy and reduces corruption. However, neither Freund and Weinhold nor Choi directly test the channels through which the Internet stimulates FDI. This study attempts to fill this gap by investigating the link between the Internet and FDI.

Building on the studies by Freund and Weinhold (2004), and Choi (2003), this study highlights three potential channels through which the Internet attracts FDI to developing countries: lowering inventory costs, lowering entry costs, and reducing the payment of bribes. It develops a model to explain the role of the Internet in determining inward FDI, and then empirically tests the hypotheses. The present study finds support that the first two roles of the Internet encourage inward FDI to developing countries, but ambiguous evidence for the third.

The remainder of this paper is organized as follows. Section 2 briefly reviews previous studies. Section 3 lays out my model, which is the basis of the empirical analysis. Section 4 discusses data issues. Section 5 presents the baseline model specifications and the results. Section 6 offers the Granger causality test between the Internet and FDI. Section 7 presents the conclusions.

1.2 Literature Review

In addition to Choi (2003), this study's analysis of the relationship between the Internet and FDI relates to three strands of literature. The first studies the effects of the Internet on entry costs to foreign markets. The second examines the relationship between the Internet and inventory costs. The third considers the potential effects of the Internet on corruption.

1.2.1 The Internet and FDI

Choi (2003) suggests that Internet development improves productivity and hence stimulates the inward FDI. The production function of a country is given by:

$$Q_j = \theta(N_j)f(K_j) \tag{1.1}$$

where N_j is the level of Internet development in country j and K_j is the capital inflow to country j. A foreign subsidiary invests in foreign country j, and its profit is:

$$\pi_j = \theta\ (N_j)f(K_j) - rK_j \tag{1.2}$$

where r is the cost of capital. Profit maximization with respect to K_j gives:

$$r = \theta(N_j)\frac{\partial f(K_j)}{\partial K_j} \tag{1.3}$$

The optimal capital investment must satisfy this first-order condition. To examine the response of capital inflow to Internet development, differentiation of (1.3) with respect to Internet development, (N_j) gives:

$$\frac{\partial K_j}{\partial N_j} = \frac{\frac{-\partial\theta}{\partial N_j}\cdot\frac{\partial f}{\partial K_j}}{\theta(N_j)\cdot\frac{\partial^2 f}{\partial K_j^2}} > 0 \tag{1.4}$$

Given the assumptions that Internet improves productivity, i.e., $\partial\theta/\partial N_j > 0$ and marginal return to capital diminishes, i.e., $\partial f/\partial K_j > 0$ and $\partial^2 f/\partial K_j^2 < 0$, (1.4) implies $\partial K_j/\partial N_j > 0$. That is, the volume of inward FDI to country j is positively related with Internet development in country j.

Using the bilateral FDI data from 14 source countries and 53 host countries over the period 1994-1996, Choi estimates the following baseline gravity equation:

$$\begin{aligned} Ln(FDI_{i,j}) = \sum_k \alpha_k D_k + \beta_1 Ln(INTERNET_j) + \beta_2 Ln(DIST_{i,j}) \\ +\beta_3(LANG_{i,j}) + \beta_4 TradeBloc_{i,j} + \delta_1 Ln(GNP_j) \\ +\delta_1 Ln(Population_j) + X_j\zeta + e_{ij} \end{aligned} \tag{1.5}$$

where $FDI_{i,j}$ is the bilateral stocks of FDI from source country i to j; D_k is a source country dummy that takes the value one if the source country is i (i.e., if k = i), and zero otherwise; $INTERNET_j$ is the number of Internet hosts or users in host country j; $DIST_{i,j}$ is distance from country i to country j; $LANG_{i,j}$ is a dummy variable that takes the value one if the source country and host country share a common language, and zero otherwise; TradeBloc dummy takes the value one if two countries belong to the same trade bloc and zero otherwise; GNP_j is GNP of host country j and $Population_j$ is the population of host country j; X_j is a vector of characteristics specific to host country j other than GNP and population; $e_{i,j}$ is an independently and identically distributed (i.i.d.) error that follows a normal distribution; and α_k, β_i, δ_i, and ζ are parameters to be estimated. The coefficient of Internet hosts is 0.26, which implies that an increase of 10% in the number of Internet hosts leads to a 2.6% increase in inward FDI stocks.

1.2.2 The Internet, Entry Costs and FDI

Freund and Weinhold (2004) suggest that by using the e-marketplace (an organized exchange with numerous buyers and sellers through the Internet) and powerful search engines, firms' sunk entry costs for advertising their products and searching their trading partners are lower. Therefore, the trade in goods increases.

In their model, firms are engaged in Cournot quantity competition. Demand for the imperfectly competitive good in country j is:

$$P_j = K_j - Q_j \tag{1.6}$$

where P_j is the price in foreign market j, K_j is a constant and $Q_j = q_{ij} + q_j$. q_{ij} is the export quantity of a firm from country i to foreign market j, and q_j is the output for sale by other firms in j. The net profit is:

$$\pi_{ij} = (P_j - c - wd_{ij})q_j - F_{ij} \tag{1.7}$$

where c is the constant marginal cost for each firm, d is distance, wd_{ij} represents the shipment cost from i to j, and F_{ij} is the fixed cost of entering market j. The firm is to maximize net profits with respect to its exports:

$$\max_{q_{ij}} \; (K_j - q_j - q_{ij} - c - wd_{ij})q_{ij} - F_{ij} \tag{1.8}$$

The first-order condition gives

$$\frac{\partial \pi_{ij}}{\partial q_{ij}} = K_j - q_j - 2q_{ij} - c - wd_{ij} = 0 \tag{1.9}$$

If there are n firms in market j, (1.9) is rewritten as:

$$K_j - (n-1)q_{ij} - 2q_{ij} - c - nwd_{ij} + w\sum_{k\neq j} d_{kj} = 0 \tag{1.10}$$

Given all other firms' sales in j, rearranging (1.10) yields the optimal exports of the firm from i to j:

$$q_{ij} = \frac{\left(K_j - c - n_j wd_{ij} + w\sum_{k\neq j} d_{kj}\right)}{n_j + 1} = \frac{\left(K_j - c - w\bar{d}_j\right)}{n_j + 1} + \frac{n_j w\left(\bar{d}_j - d_{ij}\right)}{n_j + 1} \tag{1.11}$$

where n_j is the total number of firms competing in market, $\bar{d}_j$ is the average distance from i to j and $\Sigma_{i\neq k}\, d_{kj} \approx (n_j - 1)\bar{d}_j$. The above equation means that firm i's exports decrease in costs and in the number of firms in market j, and increase in market size (K_j). Moreover, the second term in (1.11) indicates that if firm i's distance to j (d_{kj}) is below (above) the average distance, its exports will be more (less) than the average exports.

Substitution of (1.11) into gross profit[1] gives:

$$\pi_{ij} = q_{ij}[(n+1)q_{ij} - nq_{ij}] = q_{ij}^2 \tag{1.12}$$

where π_{ij} is gross profit for each firm in country i exporting to j. Total exports from i to j, X_{ij}, will be:

$$X_{ij} = (\frac{\pi_{ij}}{F_{ij}^{\max}})q_{ij}m_i = (\frac{q_{ij}^3}{F_{ij}^{\max}})m_i, \tag{1.13}$$

where m_i is the total number of firms in country i. (1.13) predicts that the exports from i

[1] Gross profit is: $\pi_{ij} = q_{ij}\,[K_j - (n-1)q_{ij} - q_{ij} - c - nwd_{ij} + w\sum_{k\neq j} d_{kj}\,]$.

to j are larger than that of other countries if country i's economy size is larger (i.e., has higher m_i) and is closer to j (i.e., lower F_{ij}^{max} or higher π_{ij}).

With the Internet, total exports from i to j become:

$$X_{ij} = (\frac{q_{ij}^3}{x_{ij} \cdot F_{ij}^{max}}) m_i \qquad (1.14)$$

where x_{ij} represents the Internet connectedness between countries i and j. From (1.14), $(x_{ij} \cdot F_{ij}^{max})$ implies that the Internet reduces the fixed cost of entry into a new market. That is, the higher is the Internet connectedness (i.e., smaller x_{ij}), the lower will be $(x_{ij} \cdot F_{ij}^{max})$. As a result, the total exports from i to j increases. Taking the logarithm of (1.14) and then differentiating it with respect to time (holding m_i constant) gives:

$$\frac{\dot{X}_{ij}}{X} = 3\frac{\dot{q}_{ij}}{q} - \frac{\dot{x}_{ij}}{x} \qquad (1.15)$$

where $\dot{X}_{ij}$, $\dot{q}_{ij}$ and $\dot{x}_{ij}$ denote differentiation of X_{ij}, q_{ij} and x_{ij} with respect to time respectively. The first term in (1.15) implies that higher Internet growth leads to higher export growth from i to j. To understand more about the effects of the Internet on the quantity of export of each firm, total differentiation of (1.11) yields:

$$\partial q_{ij} = \frac{1}{n_j + 1}\partial K_j + \left(\frac{-(K - c - wd + w\bar{d}_j)}{(n_j + 1)^2} + \frac{w(\bar{d}_j - d_{ij})}{(n_j + 1)^2} \right) \partial n_j + \frac{\left(n_j - 1\right) w}{n_j + 1} \partial \bar{d}_j \qquad (1.16)$$

The first term in (1.16) represents the import market effect, indicating that an expansion of an import market is positively related to q_{ij}. The second term is the competition effect (greater n_j). An increase in the Internet connectedness allows more firms to enter market j and greater competition in market j, dampening each firm's export. As shown by the second term, the negative impact will be greater on the distant firms (i.e., those above the average distance) than on the proximate firms. The third term exhibits the average distance effect. An increase in average distance implies that more distant firms enter into market j but they export less because of the high transportation cost. Combining (1.15) and (1.16), the growth of exports from i to j is:

$$\frac{\dot{X}_{ij}}{X} = F\left(\overbrace{\frac{\dot{x}_{ij}}{x_{ij}}}^{-}, \overbrace{\frac{\dot{K}_j}{K_j}}^{+}, \overbrace{\frac{\dot{n}_j}{n_j}}^{-} . \overbrace{\frac{\dot{\bar{d}}}{\bar{d}}}^{+/-}, \overbrace{d_{ij}}^{?} \right) \tag{1.17}$$

(1.17) suggests that the main determinants of bilateral export growth are Internet growth, import-country GDP growth, change in the level of competition, and proximity of market. The sign of $\frac{\dot{\bar{d}}}{\bar{d}}$ can be positive or negative, because with the Internet, the import market expansion promotes export growth for distant firms on the one hand; and the competition effect reduces exports for distant firms on the other

The baseline panel regression equation for (1.17) is:

$$\begin{aligned} Growth(Exports_{12})_t = \beta_0 &+ \beta_1 Growth(GDP_2)_t + \beta_2 Ln(Exports_{12})_{1995} \\ &+ \beta_3 Ln(Distance_{12}) + \beta_4 Growth(Host_1)_{t-1} \\ &+ \beta_5 Growth(Host_2)_{t-1} + \beta_6 Ln(Host_1)_{1995} \\ &+ \beta_7 Ln(Host_2)_{1995} + \gamma_t + \varepsilon_{12} \end{aligned} \tag{1.18}$$

where γ_t is year-fixed effects to control for the changes in competitiveness, Host refers to domain names, Growth ($Exports_{12}$) is the growth rate of exports from country 1 to country 2, and Distance denotes geographical distance between countries. The data is collected for 56 countries over the period 1995-1999[2]. β_4, β_6 and β_7 are found to be statistically significant, suggesting that Internet growth facilitates bilateral trade growth. β_4 is approximately 0.02, implying that a 10-percentage-point increase in the growth of the Internet in the exporting country would lead to about a 0.2-percentage-point increase in export growth.

To examine the impact of the Internet on the overall trade growth, the specification of the equation is expressed as:

$$\begin{aligned} Log(AggregateTrade/GDP) = \beta_0 + \beta_1 Ln(ROWGDP) + \beta_2 Ln(Remote)_{1995} \\ + \beta_3 Ln(Population) + \beta_4 Ln(Host) + \varepsilon \end{aligned} \tag{1.19}$$

where ROWGDP is the rest-of-the world GDP and REMOTE is a distance-weighted measure of other countries' GDP. The coefficient of HOST is statistically significant in 1998 and 1999 but insignificant from 1995 to 1997. In 1999, an increase in the number of the Internet host by 10% increased the ratio of aggregate trade to GDP by 5%.

In sum, Freund and Weinhold (2004) find evidence that Internet development has a positive impact on bilateral trade growth and aggregate trade, but does not change the impact of the distance on trade.

It is likely that the above discussion—the effect of the Internet on exporters' entry costs to foreign markets—is also applicable to MNCs. According to the FDI survey done by the Multilateral Investment Guarantee Agency (2002), the worldwide web is an important source for MNCs to obtain investment information. Since information cost is an important determinant for entering a foreign market, emails, electronic data exchange,

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[2] The data spans the period from 1995 to 1999. After taking growth rates and introducing time lags, the estimation period is from 1997 to 1999.

and the medium of the worldwide web allow MNCs to access investment-related information at a lower cost. In this respect, host countries with a higher Internet penetration would lower entry costs and attract more MNCs.

1.2.3 The Internet, Inventory Costs and FDI

Information technology affects inventory behavior through at least two channels: improving the quality of information used by businesses and increasing the transmission speed of that information. An earlier theoretical and empirical study by Dudley and Lasserre (1989) examines the impact of falling telecommunications costs on inventory levels. An advance in telecommunications technology and the resulting decline in communication costs provide accurate and recent information on the demand for a firm's product, and thus allow better implementation of the just-in-time inventory system and lower inventory levels. In their model, Dudley and Lasserre develop a model with two equations for the demand for inventories and the demand for information. Using the data on Canadian inventories and on telecommunications between Canada and four European countries over the period 1975-1984, Dudley and Lasserre find that an increase in the volume of overseas communications permits firms to reduce their inventories, and that a decrease in the price of communication raises the demand for communication.

In addition, as discussed in Bruun and Mefford (2004), Dell Computer Corporation, a large direct seller of personal computers, implements just-in-time inventory (or lean production system) by using the Internet. Once the customer order is received, Dell transmits this information directly and immediately to manufacturing facilities and supplier companies all over the world. Dell's strategy is to build most of its computers at the time when they are ordered rather than building up a large stocks inventory ahead of time. According to Bruun and Mefford, Dell carries only an average of 10 days' inventory of components versus an industry average of 100 days.

1.2.4 The Internet, Corruption and FDI

The third strand of the literature considers the potential effect of the Internet on corruption. Although Vinod (1999) proposes that the Internet can be used to improve information exchange so as to combat corruption, he does not present any theoretical or empirical analysis. To address this problem, my empirical analysis examines whether the Internet variable has an impact on corruption.

1.3 Theoretical Analysis

The section above summarizes the findings of the existing literature on the impact of Internet development on inventory costs, entry costs, and corruption. This section develops a unified framework to explain the transmission mechanism through which the Internet affects the overall investment decisions of a MNC. Following Bajo-Rubio and Sosvilla-Rivero (1994), Barrel and Pain (1996), and Ryan and Tadesse (2004), my study solves the constrained profit maximization problem for a MNC that is allocating its production to both foreign and home countries. However, unlike their models, this study's model introduces the Internet, entry costs, inventory costs, and bribe payments into the cost function.

Consider the case of a MNC with the option of carrying out production from a domestic plant and from a foreign subsidiary. The total cost function faced by a MNC is:

$$C = c_d(Q_d)Q_d + c_f(Q_f)Q_f + E_f(N_f)Q_f + V_f(N_f)Q_f + B_f(N_f)Q_f \qquad (1.20)$$

where C represents the total cost, c the unit cost, Q the level of output, and the subscripts d and f the home country and the foreign country respectively. In particular, the present study's model introduces unit entry cost $E_f(N_f)$, unit inventory cost $V_f(N_f)$, and unit bribery cost $B_f(N_f)$, which are functions of the level of Internet development in the foreign country (N_f). In choosing the quantity of output produced in a foreign country, the MNC minimizes the total cost equation (1.20), subject to the constraint that the total output is equal to the total demand (D). That is,

$$Q_d + Q_f = D \tag{1.21}$$

The Lagrangian function can be written as:

$$\begin{aligned} L = {} & c_d(Q_d)Q_d + c_f(Q_f)Q_f + E_f(N_f)Q_f + V_f(N_f)Q_f + B_f(N_f)Q_f \\ & + \lambda(D - Q_d - Q_f) \end{aligned} \tag{1.22}$$

Differentiating (1.22) with respect to Q_d, Q_f and λ, respectively, yields the first-order conditions:

$$\frac{\partial L}{\partial Q_d} = \frac{\partial c_d}{\partial Q_d} Q_d + c_d(Q_d) - \lambda = 0 \tag{1.23}$$

$$\frac{\partial L}{\partial Q_f} = c_f(Q_f) + \frac{\partial c_f}{\partial Q_f} Q_f + E_f(N_f) + V_f(N_f) + B_f(N_f) - \lambda = 0 \tag{1.24}$$

$$\frac{\partial L}{\partial \lambda} = D - Q_d - Q_f = 0 \tag{1.25}$$

Solving for Q_f gives

$$Q_f = \gamma_1 D + \gamma_2[(c_d - c_f) - E_f(N_f) - V_f(N_f) - B_f(N_f)] \tag{1.26}$$

where $\gamma_1 = \dfrac{\frac{\partial c_d}{\partial Q_d}}{\frac{\partial c_d}{\partial Q_d} + \frac{\partial c_f}{\partial Q_f}}$ and $\gamma_2 = \dfrac{1}{\frac{\partial c_d}{\partial Q_d} + \frac{\partial c_f}{\partial Q_f}}$ are assumed to be positive[3]. From (1.26),

[3] Differentiation of (1.20) with respect to Qd gives $\partial c_d/\partial Q_d = (MC_d - c_d)/Q_d$ where MC_d denotes domestic

the output produced in a foreign plant depends positively on the total demand, negatively on the unit cost of the foreign plant relative to that of the home country plant, entry costs, inventory costs, and the payment of bribes.

Next, the firm must make a choice about the accumulation of capital and the labor to employ in the foreign plant. Assume that the foreign subsidiary employs two inputs, labor (L) and capital (K), each available respectively at a wage rate (w) and a real user cost of capital (r). Also, assume that the firm, using Cobb-Douglas production technology, minimizes its total cost of production (C_f):

$$C_f = w_f L_f + r_f K_f \tag{1.27}$$

subject to

$$Q_f = L_f^{\alpha} K_f^{\beta} \tag{1.28}$$

Solving for the desired foreign capital K_f gives:

$$K_f = \left(\frac{w_f}{r_f}\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} Q_f^{\left(\frac{1}{\alpha+\beta}\right)} \tag{1.29}$$

Substitution of Q_f from (1.26) into (1.29) yields

$$K_f = \left(\frac{w_f}{r_f}\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left[\gamma_1 D + \gamma_2 (c_d - c_f) - E_f(N_f) - V_f(N_f) - B_f(N_f)\right]^{\frac{1}{\alpha+\beta}} \tag{1.30}$$

To obtain the relationship between the desired capital stocks in the foreign country and Internet development, differentiation of (1.30) with respect to N_f gives

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marginal cost. Similarly, differentiation of (1.20) with respect to Qf yields $\partial c_f/\partial Q_f = [MC_f - c_f - E_f(N_f) - V_f(N_f) - B_f(N_f)]/Q_f$. Provided that there are no increasing returns to scale, i.e., $MC_d > c_d$ and $MC_f > [c_f + E_f(N_f) + V_f(N_f) + B_f(N_f)]$, so that $\gamma_1 > 0$ and $\gamma_2 > 0$.

$$\frac{\partial K_f}{\partial N_f}=\left[\gamma_1 D+\gamma_2(c_d-c_f)-E_f(N_f)-V_f(N_f)-B_f(N_f)\right]^{\frac{1-\alpha-\beta}{\alpha+\beta}}\times$$
$$-[\frac{1}{\alpha+\beta}(\frac{w_f}{r_f}\frac{\beta}{\alpha})^{\frac{\alpha}{\alpha+\beta}}(\frac{\partial E_f}{\partial N_f}+\frac{\partial V_f}{\partial N_f}+\frac{\partial B_f}{\partial N_f})] \quad (1.31)$$

Assuming that K_f—the desired foreign capital stocks—is positive in (1.30), it follows that the first term in (1.31) is positive. Therefore, the sign of $\frac{\partial K_f}{\partial N_f}$ in (1.31) depends on the sign of $(\frac{\partial E_f}{\partial N_f}+\frac{\partial V_f}{\partial N_f}+\frac{\partial B_f}{\partial N_f})$. As discussed in Section 1.2, Dudley and Lasserre (1989), and Brunn and Mefford (2004) provide evidence that an advance in communications technology lowers the required inventories for MNCs, and Freund and Weinhold (2004) show that the Internet reduces entry costs to foreign markets. As well, Vinod (1999) suggests that the Internet combats corruption. On the basis of these studies, the signs of $\frac{\partial E_f}{\partial N_f}$, $\frac{\partial V_f}{\partial N_f}$ *and* $\frac{\partial B_f}{\partial N_f}$ are expected to be negative. Since this study focuses on the transmission mechanism between Internet development and FDI, the reduced form of (1.31) is expressed as:

$$\frac{\partial K}{\partial N}=-f\left(\overbrace{\frac{\partial E}{\partial N}}^{-},\overbrace{\frac{\partial V}{\partial N}}^{-},\overbrace{\frac{\partial B}{\partial N}}^{-}\right)>0 \quad (1.32)$$

By omitting the subscript and aggregating across foreign subsidiaries, (1.32) indicates that the effect of the Internet on the desired stocks of foreign capital in the host country will be positive if $\frac{\partial E_f}{\partial N_f}$, $\frac{\partial V_f}{\partial N_f}$ *and* $\frac{\partial B_f}{\partial N_f}$ are negative. The empirical work below not only checks the expected signs of $\frac{\partial E_f}{\partial N_f}$, $\frac{\partial V_f}{\partial N_f}$ *and* $\frac{\partial B_f}{\partial N_f}$ but also the resulting positive relationship between the Internet and FDI.

1.4 Data Issues

This section discusses the choice of variables for (1.32). The sample countries included in the present study are developing economies, i.e., middle- and low-income groups based on the World Bank's income group classifications[4]. Unlike Choi who studies both developed and developing countries, this study focuses on developing countries. This distinction is important because the motivations for inward FDI to developed countries and developing countries are different. Blonigen and Wang (2004) and Alsan, Bloom and Canning (2004) show that the determinants of FDI vary systematically across countries at different stages of development, so that pooling data from developed and developing economies would yield misleading coefficient estimates. In addition, since information barriers and inventory costs are unlikely to be the determinants of FDI in OPEC countries, these countries are excluded from the present study, except for Indonesia whose economy is not dominated by oil exports.

At the macroeconomic level, the FDI statistic is the most popular measure of MNCs' activities. Inward FDI can be measured in terms of stocks and flows. According to the United Nations Conference on Trade and Development (UNCTAD), FDI stocks are estimated either by the accumulation of FDI flows over a period of time, or by adding or subtracting the flows to FDI stocks that has been obtained for a particular year from

[4] Using the World Bank's categorization, the low- and middle-income groups (all developing economies) include those countries in which the 2002 gross national income per capita was US $9,075 or less, as measured in the current US dollars. The high-income economies (OECD and non OECD countries) are those in which the 2002 gross national income per capita was US $9,075 or more.

national official sources of the IMF data series on assets and liabilities of direct investment. The FDI stocks always carry a non-negative sign, a reflection of the irreversibility characteristics of capital investment. In this paper, following (1.32) and Choi, inward FDI is measured in terms of stocks.

In this study, two popular proxies for Internet development—the number of web hosts obtained from counting top-level host domain names, and the number of Internet users—are used sequentially. The Internet data is not available (in particular for developing countries) until 1995, when it began to be widely used.[5]

Entry costs to a foreign market are information-related, such as information on the material costs, suppliers, distributors, investment partners, laws and regulations of the foreign country. As a proxy for entry costs, this study chooses the number of bilateral investment treaties. According to UNCTAD, bilateral investment treaties offer foreign investors additional and higher standards of legal protection and guarantees for foreign investments than those offered under national laws. Conceivably, the number of bilateral investment treaties reflects the efforts and willingness of the host government to promote foreign investment. In other words, if a country has signed more treaties, it will tend to provide more services or information to help foreign investors entering the market, resulting in lower entry costs.

Since this study does not employ bilateral FDI data, the source of inward FDI and the inventory change in the corresponding countries cannot be identified. Inventories to final sales in the United States are used to measure inventory costs. This measure can be

[5] The Internet originated in 1969 is a scheme launched by the US Defense Department Advanced Research Projects Agency to prevent a Soviet takeover or the destruction of American communications in case of nuclear war. However, it was not widely used in the private sector until the introduction of the first popular browser (i.e., Netscape) in 1994.

justified for two reasons. First, the United States is one of the major foreign investors and importers in the world. Second, economic indicators of the United States are commonly used in the empirical literature as proxy for global factors, such as the US yield curve and the US T-bill rate, as in Albuquerque, Loayza, and Servèn (2003).

The corruption measure compiled by the International Country Risk Group (ICRG) is calculated on a 0-6 scale, where lower scores indicate a higher level of corruption. The alternative measure of the corrupt government is the strength of democracy in a country. Rivera-Batiz (2002) finds that democracy is positively associated with improved governance, i.e., with less corrupt government. In this study, the measure of political freedom provided by the Freedom House (FH) and the Polity IV Project (Polity) are used. The former is scaled from 1 (the highest degree of political freedom) to 7 (the lowest degree of political freedom). The latter measures the openness of political institutions. Its highest rate of democracy is 10, while the lowest is 0. To avoid confusion in interpreting these three proxies of corruption, the ICRG index and the polity measure are recoded. For the ICRG index, 7 represent the highest level of corruption, while 1 represents the lowest. For the Polity measure, 11 represent the lowest level of democracy, while 1 represents the highest. Hence, a higher rating on a FH or Polity scale would indicate a lower level of democracy, which implies a lower quality of governance or a higher level of corruption. A summary of this study's data sources and definitions is provided in Appendix 1.1.

Annual data is used, and the sampling size is dictated by data availability. For each selected country, at least six years observations are available for each explanatory variable[6] for 1995-2002. Using the inward FDI stocks as a dependent variable and the number of Internet users, the ratio of US inventories to US sales, the cumulative number of bilateral investment treaties and the Freedom House's measure of political freedom as independent variables, 110 developing countries (listed in Appendix 1.1) are selected for the period 1995-2002. Appendix 1.2 provides the summary statistics.

1.5 Estimation and Results

1.5.1 Baseline Specifications

For empirical tests, (1.32) can be translated into two specification forms. First, from (1.32), inward FDI is a reduced-form estimation of Internet development, inventory costs, entry costs and bribe payments. Inward FDI is written in the following form known as the fixed effects model:

$$\begin{aligned} Ln(FDI)_{it} = \mu + \beta_1 Ln(INTERNET)_{it} + \beta_2 Ln(INVENTORY)_t \\ + \beta_3 Ln(EASE\ OF\ ENTRY)_{it} + \beta_4 Ln(CORRUPTION)_{it} \\ + \beta_5 (OTHER\ FACTORS)_{it} + c_i + u_{it} \\ i = 1, \ldots, N;\ and\ t = 1995, \ldots, 2002 \end{aligned} \quad (1.33)$$

where Ln represents a natural logarithm, i is the country, t is the time period, c_i is a time-invariant variable for unobserved country characteristics (such as culture, geographical location, and state of technology), and u_{it} is the error term. To establish the benchmark estimation, FDI is proxied by inward FDI stocks; INTERNET by the number of Internet users; INVENTORY by the US inventory/sales ratio; EASE OF ENTRY by the number of bilateral investment treaties; and CORRUPTION by the strength of political freedom. The inward FDI stocks and the number of Internet users are highly skewed, so that using

[6] Interpolation for the missing data is conducted before counting the missing observations.

the logarithm of this data not only reduces the skewness but also facilitates the comparison with Freund and Weinhold (2004) and Choi (2003). Since, in some cases, the number of Internet users is potentially zero, one unit is added to this variable before taking logarithms. Such a change is acceptable because those variables are not dominated by zeros[7], and one unit is small relative to thousands of Internet users. For other variables, the choice of the logarithm or the level form depends on which one gives a better statistical fit in terms of a higher absolute value of the t-statistic and higher 'within' R-square[8].

It is worth noting that the number of bilateral investment treaties is inversely related to entry costs: more investment treaties imply lower entry costs. More specifically, a positive β_3 implies that more bilateral investment treaties (i.e., lower entry costs) encourage inward FDI. A negative β_2 suggests that higher inventory costs discourage inward FDI, while a negative β_4 indicates that a higher level of corruption discourages inward FDI.

Second, an alternative specification of (1.32) is to look into the three channels through which the Internet affects FDI. (1.32) suggests that inventory costs, entry costs and bribe payments depend on the level of Internet development. The coefficients on US INVENTORY, EASE OF ENTRY and CORRUPTION can be expressed as:

$$\beta_k = \beta_{k0} + \beta_{k1} Ln(INTERNET) \tag{1.34}$$

where k = 2, 3, 4. Substitution of (1.34) into (1.33) gives

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[7] The countries with zero number of Internet users in a specific year—shown in parenthesis— include Burundi (1995), Comoros (1995, 1996, 1997), Sierra Leone (1995), Somalia (1995, 1996, 1997), Sudan (1995, 1996) and Togo (1995).

[8] The explanatory power of the regressors (excluding country fixed effects) within a given country is reported.

$$\begin{aligned} Ln(FDI)_{it} = \mu + \beta_1 Ln(INTERNET)_{it} + \beta_{20} Ln(INVENTORY)_t \\ +\beta_{30} Ln(EASE\ OF\ ENTRY)_{it} + \beta_{40} Ln(CORRUPTION)_{it} \\ +\beta_5 (OTHER\ FACTORS)_{it} \\ +\gamma_2 Ln(INTERNET)_{it} * Ln(INVENTORY)_t \\ +\gamma_3 Ln(INTERNET)_{it} * Ln(EASE\ OF\ ENTRY)_{it} \\ +\gamma_4 Ln(INTERNET)_{it} * Ln(CORRUPTION)_{it} \\ +c_i + u_{it} \qquad i = 1,\dots,N; and\ t = 1995,\dots,2002 \end{aligned} \tag{1.35}$$

where $\gamma_k = \beta_{k1}$, k = 2, 3, 4 and * indicates the multiplicative function (interaction). The sign of the interaction term between the Internet and inventory costs (γ_2) is expected to be positive, suggesting that the Internet reduces the negative impact of inventory costs on FDI. That is, the Internet lowers inventory costs and hence attracts FDI.[9] Similarly, the positive sign of the interaction term between the Internet and corruption (γ_4) indicates that the Internet reduces the negative impact of corruption on FDI.[10] The coefficient of the interaction term between the Internet and entry costs (γ_3) also is expected to be positive, implying that the Internet reinforces the positive effect of bilateral investment treaties on FDI.[11] For ease of reference, Table 1.1 summarizes the expected signs of the key variables.

1.5.2 Overall Internet Effect

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[9] The coefficient of INVENTORY (i.e., inventory costs) is expected to be negative. For instance, $\frac{\partial Ln(FDI)}{\partial Ln(INVENTORY)} = -\beta_{20} + \gamma_2 \times Ln(INTERNET)_{it}$

[10] The coefficient of CORRUPTION (i.e., payment of bribes) is expected to be negative. For instance, $\frac{\partial Ln(FDI)}{\partial Ln(CORRUPTION)} = -\beta_{40} + \gamma_4 \times Ln(INTERNET)_{it}$

[11] The coefficient of ENTRY (i.e., ease of entry or lower entry costs) is expected to be positive. For instance, $\frac{\partial Ln(FDI)}{\partial Ln(EASE\ OF\ ENTRY)} = \beta_{30} + \gamma_3 \times Ln(INTERNET)_{it}$

When applying the fixed effects estimator, heteroskedasticity and serial correlation in the error term u_{it} tend to give improper variance matrix estimator. All model specifications of Table 1.2 and Table 1.3 are tested for groupwise heteroskedasticity and serial correlation of the error terms within each panel. As a result, the null hypothesis of homoskedasticity across countries is rejected[12], and the null hypothesis for no first-order autocorrelation[13] in the error term is also rejected. The robust (clustered) variance matrix estimator is employed. According to Wooldridge (2002, p.277), it is valid in the presence of any heteroskedasticity or serial correlation in the error terms, provided that T is small relative to N. In this study, since the robust standard errors are larger than the usual one, the absolute value of the t statistic drops. Some key variables such as the Internet in column (1) of Table 1.2 and the interaction terms between the Internet and inventory costs in columns (1), (4), (5), and (6) of Table 1.3 become statistically insignificant. However, the robustnesses of the results reported in Table 1.2 and Table 1.3 are further examined by using the first difference estimator and the Hausman-Taylor model.

Table 1.2 reports the results for (1.33) using different proxies for measuring the Internet variable and the control of corruption. A positive relationship between Internet development and inward FDI stocks is found in all columns of Table 1.2, and they are statistically significant except in columns (1) and (7). It also can be noted that the coefficient of Internet hosts (column 5) is greater than Internet users (column 1). To investigate this result, this study re-runs the estimation for Internet users, using the same set of countries that are used to measure Internet hosts. After controlling the sample

[12] The test is based on Greene (2003, p.323).
[13] The test is based on Wooldridge (2002, p.283).

countries, both proxies—Internet users and Internet hosts—yield similar results. The coefficient of Internet users becomes 0.042, which is roughly similar to that of Internet hosts. Hence, the coefficient of Internet users in column (1) is smaller than in column (5) mainly due to the different choice of countries used for measurement. The number of sample countries for Internet hosts is smaller than that for Internet users, and those countries excluded from the Internet host measurement (due to missing data) also have less than the average number of Internet users.

As for the other variables, the coefficients of inventory costs and entry costs are statistically significant and possess the expected negative and positive signs respectively in all columns of Table 1.2. These findings suggest that lower inventory and lower entry costs attract more FDI. The coefficients of the corruption variable have the expected negative signs in columns (1) and (2) of Table 1.2, indicating that a higher level of corruption would discourage FDI. Conversely, in column (3), the coefficient of CORRUPTION is positive[14] when the ICRG's corruption score is used.

Market size and trade barriers usually are considered to be determinants of FDI, so two proxies are added—GDP/capita and trade/GDP—in column (4) of Table 1.2. The coefficient of Internet users is 0.039, which is statistically significant.

1.5.3 Three Channels

The regression results for (1.35) are reported in Table 1.3, in which the coefficients of the interaction terms are of particular interest. All columns of Table 1.3 (except column 3) display the expected signs—the negative signs of inventory costs and the positive signs of the interaction term between the Internet and inventory costs—which

[14] The efficient grease theory suggests that bribery would "grease the wheels of commerce"a nd does not necessarily discourage foreign investors.

suggest that the Internet lowers inventory costs and hence attracts more inward FDI stocks. However, only the interaction terms in columns (2) and (8) are statistically significant. In addition, the coefficients of entry costs and their interaction with the Internet are found to be positive in all columns of Table 1.3, indicating that the Internet lowers the costs of searching for information and facilitates MNCs entry into foreign markets. Most coefficients of these interaction terms are statistically significant except one in column (7). As for the impact of the Internet on corruption, the coefficients of the corruption and its interaction term with the Internet bear the expected negative and positive signs respectively in column (3), whereas they possess the positive and negative signs respectively in columns (1), (4), (5), (6) and (8) of Table 1.3. The latter suggests that fighting bribery does not attract more FDI, but they still support this study's hypothesis in the sense that the Internet helps combat corruption.

For robustness checks, the estimation use the benchmark specification: the number of Internet users, US inventories/US sales, the number of bilateral investment treaties, and the Freedom House's measure of political freedom.[15]

1.5.4 Robustness Checks

Since the above results may be influenced by one or several outlying observations, countries with the largest number of Internet users (the top 5%) or the least (the bottom 5%) are deleted from the sample. As shown in column (1) of Table 1.4, the coefficients of the overall Internet effect remain positive and statistically significant. The signs of the coefficients of the interaction terms in columns (2) and (4)—INTERNET*EASE OF ENTRY—remain positive and statistically significant.

[15] These variables of proxies (used in column 1 of Table 1.2) are chosen, since they give a relatively large number of sample countries and the expected signs for all variables.

In contrast to the fixed effect estimator which assumes that the error term u_{it} is serially uncorrelated, the first difference estimator implies that u_{it} follows a random walk. In columns (1)-(4) of Table 1.5, the key variables—INTERNET, INVENTORY, and EASE OF ENTRY—possess the expected positive, negative and positive signs respectively, and they all are statistically significant. Again, the signs of the corruption variables are ambiguous. Compared with the fixed effects in Table 1.3, all coefficients of the inventory variables and their interaction terms with the Internet variables bear expected negative and positive signs in Table 1.6. Their t-statistics of the interaction terms are also somewhat more significant with the first difference analysis. As shown in Table 1.6, the estimates on entry costs and their interaction terms with the Internet are fairly similar to the fixed effect estimates in terms of the statistical significance, signs[16] and magnitudes.

The model devised by Hausman and Taylor (1981) (the Hausman-Taylor model) is also employed. This model has two desirable properties which the fixed effects and random effects models are lacking. Unlike the random effects model, the Hausman-Taylor model allows some of the regressors to be correlated with individual effects. It also permits the estimation of time invariant variables, which are simply absorbed in a fixed effects model.

In addition to the explanatory variables—Internet Users, US Inventory/Sales, Ease of Entry and Political Freedom—discussed above, three time invariant variables are introduced as possible determinants of FDI: the level of inward FDI in 1994, the level of education in 1994, and the regional dummies. The first two variables attempt to capture

[16] In column (3) of Table 1.6, the coefficient of the entry costs has the wrong sign.

the differences between FDI and skilled labor among countries in an earlier year (i.e., 1994), while the third measures the regional effect. To decide whether the variables are exogenous or endogenous, an experiment is done with different groupings of explanatory variables[17]. In column (2) of Table 1.7, the Internet variable and its interaction term are treated as endogenous, whereas the sales to inventory and the number of bilateral treaties are treated as exogenous. The Hausman specification test based on chi-squared statistics is 0.18, which is far smaller than the critical value, so this result indicates that the fixed effects estimator used in column (1) is not preferred to the Hausman-Taylor estimator used in column (2). Again, the end results of this exercise support the above findings that the Internet attracts FDI by reducing inventory costs and entry costs.

1.6 Granger Causality Relationship Between the Internet and Inward FDI

All columns of Table 1.2 show a positive relationship between Internet development and FDI. However, the possibility cannot be ruled out that these findings merely are due to the reverse causality that FDI stimulates the usage of the Internet. For instance, MNCs are more likely to use the Internet or launch their websites to facilitate their operations in developing countries. So far, no study has examined the causal relationship between the Internet and FDI. To address this gap, this study employs two estimators—the Anderson and Hsiao (2003) estimator[18] (AH estimator) and the estimator proposed by Allerano and Bond (1991) (GMM estimator)—for testing the Granger-causal relationship between Internet development and inward FDI stocks. The differences between the AH and the GMM estimators in using the matrix of instruments are

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[17] Hausman and Taylor (1981) suggest that a necessary condition for sufficient instruments is that the number of time variant exogenous variables must be at least as large as the number of time invariant endogenous variables.

[18] See Hsiao (2003, p.85-86)

discussed in Appendix 1.3.

In this study's application, the short panel restricts the lag length to one. The Granger causality model is represented by a vector autoregressive representation (VAR) as:

$$(Ln\ FDI)_{it} = \mu + \delta(Ln\ FDI)_{it-1} + \beta(Ln\ INTERNET\ USER)_{it-1} + c_i + u_{it} \quad (1.36)$$

$$\begin{aligned}(Ln\ INTERNET\ \mathrm{USER})_{it} = \mu^* + \delta^*(Ln\ FDI)_{it-1} \\ +\beta^*(Ln\ INTERNET\ USER)_{it-1} \\ +c_i + u^*_{it}, \quad i = 1,\ \ldots,\ N;\ t = 1997,\ \ldots,\ 2002\end{aligned} \quad (1.37)$$

The Internet is said to Granger-cause inward FDI if β is statistically significant. Conversely, FDI is said to Granger-cause the Internet if δ* is statistically significant. The residuals of the two equations of the system are assumed to be independently distributed, and each equation is estimated separately. The estimation period for (1.36) and (1.37) is from 1997 to 2002, since one lag is introduced and both equations are required to take the first differencing.

Using the AH estimator, Table 1.8 reports the Granger-causality results running from the Internet to inward FDI stocks. Column (1) assumes that the Internet is strictly exogenous, while column (2) treats the Internet as predetermined. Other variables are also added in (1.36) to reduce the omitted variables bias. The resulting model specification becomes

$$\begin{aligned}(Ln\ FDI)_{it} = \mu + \delta(Ln\ FDI)_{it-1} + \beta(Ln\ INTERNET\ USER)_{it-1} \\ +\gamma(OTHER\ VARIABLES)_{it-1} + c_i + u_{it}\end{aligned} \quad (1.38)$$

Columns (3) and (4) report the results of (1.38), assuming that other variables are strictly exogenous.

The statistical significance of the lagged first-differenced INTERNET USERS in columns (1), (2), and (4) of Table 1.8 implies that the Internet does Granger-cause the inward FDI stocks. Conversely, none of the lagged first-differenced inward FDI stocks in Table 1.9 is found to be statistically significant, indicating that FDI does not Granger-cause the Internet.

The GMM estimation results are reported in Table 1.10 and Table 1.11. Of all the columns in Table 1.10, only (1) and (2) show the statistical significance of the lagged first-differenced INTERNET USERS. The consistency of GMM estimator relies on the assumption that no serial correlation exists in the error term u_{it}. The presence of first order autocorrelation in the differenced residuals does not imply that the estimates are inconsistent, whereas the presence of second-order autocorrelation would imply that the estimates are inconsistent. The Allerano-Bond m1 statistic (significant P-value at the 1% level, i.e., m1p < 0.01) displayed in columns (1) and (2) of Table 1.10 rejects the null hypothesis of no first-order autocorrelation in the differenced residuals. The Allerano-Bond m2 statistic (insignificant P-value at 1% level, i.e., m1p>0.01) indicates no second-order serial correlation in the first-differenced residuals. The significant m1 and insignificant m2 tests suggest that the error terms in levels are not serially correlated.

Moreover, the Hansen J statistic[19] is employed to check the overall validity of the moment conditions. The P-value of the Hansen J statistic reported in columns (1) and (2) of Table 1.10 does not reject the null hypothesis that the instruments satisfy the orthogonality conditions, i.e., that they are valid instruments at the 1% significance

[19] The Hansen J statistic is robust to heteroskedasticity.

level.[20] Hence, the statistical significance of the lagged first-differenced INTERNET USERS in columns (1) and (2) support the proposition that the Internet does Granger cause the inward FDI stocks.

In column (1) of Table 1.11, the Hansen J statistic rejects the null hypothesis that the overidentifying restrictions are valid, and the m2 statistic (m2p < 0.1) indicates the presence of second-order autocorrelation. Hence, column (1) is misspecified, and its estimates are inconsistent. The specification of column (2) passes the tests of the m2 statistic and the Hansen J statistic. The coefficient of the lagged first-differenced inward FDI stocks is positive and statistically significant, thus suggesting reverse causality from inward FDI stocks to Internet development. In columns (3), (4) and (5), the coefficients of the lagged first-differenced inward FDI stocks are found to be statistically insignificant.

Allerano and Bond (1991) compare the performance of the GMM estimator to the AH estimator, suggesting that the AH estimator is poorly determined and suffers from a massive loss in efficiency. However, in this study with short time period and wide panels, the use of the AH estimator is supported by Kiviet (1995) and Judson and Owen (1996) who argue that it could perform as well as other alternatives, such as the GMM, in terms of bias and efficiency. The AH estimator offers strong evidence for Granger causality running from the Internet to FDI (Table 1.8), but no evidence for reverse causation (Table 1.9). In addition, the GMM estimator confirms the Granger causality running from the Internet to inward FDI stocks [columns (1) and (2) of Table 1.10], but weakly supports

[20] The higher p-value of the Hansen J statistic in column (2) compared to column (1) render it more difficult to reject the null hypothesis that the instruments are valid, so that the Internet is better modeled as a predetermined variable, as in column (2).

the reverse causation [column (2) of Table 1.11].

1.7 Conclusions

Although this study's baseline specification differs from Choi (2003) in terms of explanatory variables, dataset, sample countries, time periods, and estimation procedure, the results in columns Table 1.2, Table 1.4 and Table 1.5 are complementary to Choi's conclusion that Internet development stimulates inward FDI stocks. Compared to Choi (2003) who finds that the coefficient of the number of Internet users is 0.184, this study reveals a relatively small impact of the Internet on FDI. Column (1) of Table 1.2 suggests that if the number of Internet users increases by 1%, FDI will increase by 0.029%. The average growth rate of Internet users (in log differences) over the period 1995-2002 is 9.69% (see Appendix 1.2), therefore, Internet development leads to about 0.28% annual increase in inward FDI stocks.

The findings on the causality direction running from the Internet to FDI are robust to the AH and the GMM estimators, whereas the evidence on the reverse direction is weak. These results further support the hypothesis that Internet development promotes inward FDI stocks.

This study also makes a contribution to literature on the Internet by explicitly capturing three channels through which the Internet affects FDI. Three hypotheses are proposed. First, using the Internet, MNCs can obtain accurate and timely information, thereby reducing the need for inventories and lowering inventory costs. Second, the Internet helps MNCs to search investment-related information, so that their entry costs to developing economies are lower. Third, the Internet acts as an effective channel for controlling corruption in developing countries, and thus reduces bribes paid by the

MNCs. The findings in Table 1.3, Table 1.6 and Table 1.7 strongly support the first two hypotheses. For the third, this study offers evidence that the Internet helps combat corruption (Table 1.3 and Table 1.6), but their combined impact on FDI is ambiguous due to the unclear effect of corruption on FDI.

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Tables

Table 1.1. Expected signs of key variables

Dependent Variable: FDI	Expected Signs
INTERNET	+
INVENTORY	-
EASE OF ENTRY	+
CORRUPTION	-
INTERNET*INVENTORY	+
INTERNET*EASE OF ENTRY	+
INTERNET*CORRUPTION	+

Table 1.2. Overall Internet effects (using the fixed effects regressions)

Dependent variable: Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(InternetUsers)	0.029	0.034*	0.041*	0.039**				
	(0.018)	(0.020)	(0.020)	(0.019)				
	[0.011]	[0.012]	[0.012]	[0.012]				
Ln(InternetHosts)					0.041**	0.043**	0.034	0.038*
					(0.020)	(0.021)	(0.020)	(0.020)
					[0.014]	[0.014]	[0.014]	[0.013]
Inventory/Sales	-2.053***	-2.197***	-1.331***	-1.539***	-2.370***	-2.386***	-1.845***	-1.873***
	(0.418)	(0.418)	(0.439)	(0.343)	(0.331)	(0.331)	(0.341)	(0.323)
	[0.232]	[0.243]	[0.253]	[0.251]	[0.221]	[0.225]	[0.233]	[0.221]
Ln(EaseOfEntry)	0.517***	0.388***	0.488***	0.415***	0.436***	0.406***	0.438***	0.388***
	(0.120)	(0.103)	(0.096)	(0.110)	(0.103)	(0.110)	(0.117)	(0.112)
	[0.047]	[0.052]	[0.054]	[0.053]	[0.056]	[0.059]	[0.061]	[0.054]
Corruption[1]	-0.002			0.012	0.014			0.013
	(0.035)			(0.035)	(0.040)			(0.037)
	[0.020]			[0.021]	[0.022]			[0.021]
Corruption[2]		-0.032				-0.024		
		(0.026)				(0.032)		
		[0.011]				[0.012]		
Corruption[3]			0.033				0.032	
			(0.041)				(0.046)	
			[0.023]				[0.025]	
Ln(GDP/Capita)				1.597***				1.524***
				(0.391)				(0.396)
				[0.180]				[0.183]
Trade/GDP				0.285				0.345
				(0.210)				(0.223)
				[0.120]				[0.124]
Observations	879	792	584	731	733	703	520	708
Number of countries	110	99	73	92	95	91	67	92
Within R-square	0.62	0.61	0.64	0.69	0.63	0.62	0.64	0.68

Robust (clustered) standard errors are in parentheses and the usual standard errors are in brackets. The significance of the t-statistic is based on the robust standard errors. *, ** and *** denote statistical significance at the 10% level, the 5% level, and the 1% level respectively.

Table 1.3. Three channels through which the Internet affects FDI (using the fixed effects regressions)

Dependent variable: Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(InternetUsers)	-0.238	-0.331*	0.017	-0.202				
	(0.157)	(0.174)	(0.198)	(0.197)				
	[0.110]	[0.119]	[0.127]	[0.128]				
Ln(InternetHosts)					-0.315	-0.351	-0.051	-0.342
					(0.243)	(0.254)	(0.324)	(0.230)
					[0.133]	[0.137]	[0.162]	[0.129]
Inventory/Sales	-2.719***	-3.239***	-1.072	-2.320**	-2.784***	-2.942***	-1.735**	-2.534***
	(0.813)	(0.901)	(0.748)	(0.920)	(0.755)	(0.774)	(0.850)	(0.706)
	[0.518]	[0.561]	[0.589]	[0.618]	[0.424]	[0.436]	[0.486]	[0.410]
Ln(EaseOfEntry)	0.164	0.016	0.306*	0.149	0.094	0.081	0.273	0.105
	(0.179)	(0.153)	(0.156)	(0.186)	(0.164)	(0.179)	(0.199)	(0.165)
	[0.068]	[0.073]	[0.075]	[0.079]	[0.077]	[0.082]	[0.087]	[0.074]
Corruption[1]	0.040			0.095	0.070			0.074
	(0.057)			(0.079)	(0.060)			(0.059)
	[0.032]			[0.039]	[0.034]			[0.034]
Corruption[2]		-0.005				0.006		
		(0.040)				(0.045)		
		[0.020]				[0.021]		
Corruption[3]			-0.012				0.013	
			(0.126)				(0.121)	
			[0.055]				[0.058]	
Ln(GDP/Capita)				1.408***				1.351***
				(0.404)				(0.392)
				[0.184]				[0.182]
Trade/GDP				0.251				0.354*
				(0.212)				(0.210)
				[0.119]				[0.121]
Internet*Inventory	0.102	0.136*	-0.009	0.101	0.127	0.141	0.012	0.148*
	(0.062)	(0.070)	(0.071)	(0.077)	(0.092)	(0.095)	(0.117)	(0.087)
	[0.046]	[0.050]	[0.049]	[0.052]	[0.054]	[0.056]	[0.061]	[0.052]
Internet*EaseOfEntry	0.036***	0.041***	0.018*	0.028**	0.056***	0.054**	0.027	0.047**
	(0.011)	(0.012)	(0.011)	(0.014)	(0.019)	(0.021)	(0.021)	(0.018)
	[0.005]	[0.006]	[0.005]	[0.007]	[0.009]	[0.010]	[0.009]	[0.009]
Internet*Corruption	-0.004	-0.002	0.003	-0.008	-0.008	-0.004	0.001	-0.009
	(0.005)	(0.003)	(0.011)	(0.007)	(0.007)	(0.005)	(0.013)	(0.007)
	[0.003]	[0.002]	[0.005]	[0.003]	[0.004]	[0.002]	[0.007]	[0.004]
Observations	879	792	584	731	733	703	520	708
Number of countries	110	99	73	92	95	91	67	92
Within R-square	0.64	0.64	0.66	0.70	0.66	0.65	0.65	0.70

Robust (clustered) standard errors are in parentheses and the usual standard errors are in brackets. The significance of the t-statistic is based on the robust standard errors. *, ** and *** denote statistical significance at the 10%, the 5% and the 1% levels respectively. 1. The FH's measure of political freedom. 2. The Polity's democracy indicator. 3. The ICRG's corruption measure.

Table 1.4. Removal of outlier effects

Dependent variable: Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)
	Remove Internet Outliers[1]	Remove Internet Outliers[1]	Remove FDI Outliers[2]	Remove FDI Outliers[2]
Ln(InternetUsers)	0.041**	-0.211	0.041**	-0.197
	(0.018)	(0.187)	(0.019)	(0.190)
Inventory/Sales	-1.202***	-1.774**	-1.281***	-1.807**
	(0.328)	(0.851)	(0.325)	(0.869)
Ln(EaseOfEntry)	0.497***	0.138	0.477***	0.106
	(0.108)	(0.183)	(0.106)	(0.186)
Corruption(1)	0.001	0.063	-0.013	0.055
	(0.036)	(0.068)	(0.037)	(0.069)
Ln(GDP/Capita)	1.658***	1.558***	1.679***	1.560***
	(0.332)	(0.293)	(0.336)	(0.294)
Trade/GDP	0.129	0.009	0.112	-0.004
	(0.234)	(0.230)	(0.234)	(0.231)
Ln(Internet*InventoryCost		0.092		0.089
		(0.072)		(0.073)
Internet*EaseOfEntry		0.041***		0.041***
		(0.014)		(0.014)
Internet*Corruption[3]		-0.006		-0.008
		(0.006)		(0.006)
Observations	732	732	730	730
Number of countries	92	92	92	92
Within R-square	0.68	0.71	0.69	0.72
Adjusted R-square	0.97	0.97	0.96	0.97

Robust (clustered) standard errors are in parentheses. *, ** and *** denote statistical significance at the 10%, the 5% and the 1% levels respectively. 1. The countries that have the least number of Internet users (the bottom 5%) are Central African Republic, Comoros, Guinea-Bissau, Sierra Leone, St. Vincent and the Grenadines and Tajikistan. The countries that have the highest number of Internet users (the top 5%) are Brazil, China, India, Malaysia, Mexico and Poland.

2. The countries that receive the least amount of inward FDI stocks (the bottom 5%) are Burundi, Central African Republic, Comoros, Guinea-Bissau, Nepal and Sierra Leone. The countries that receive the largest amount of inward FDI stocks (the top 5%) are Argentina, Brazil, China, Indonesia, Malaysia and Mexico.

3. The FH's measure of political freedom.

Table 1.5. Overall Internet effects (using the first difference estimator)

Dependent variable: Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D.Ln(InternetUsers)	0.051***	0.054***	0.049***	0.054***				
	(0.009)	(0.010)	(0.010)	(0.011)				
D.Ln(InternetHosts)					0.046***	0.046***	0.037***	0.045***
					(0.012)	(0.013)	(0.013)	(0.012)
D.Inventory/Sales	-1.147***	-1.189***	-0.802***	-1.015***	-1.281***	-1.315***	-1.086***	-1.146***
	(0.145)	(0.153)	(0.158)	(0.148)	(0.156)	(0.159)	(0.175)	(0.160)
D.Ln(EaseOfEntry)	0.294***	0.262***	0.262***	0.269***	0.325***	0.315***	0.272***	0.280***
	(0.063)	(0.067)	(0.058)	(0.066)	(0.065)	(0.069)	(0.068)	(0.065)
D.Corruption[1]	0.010			-0.014	-0.017			-0.018
	(0.026)			(0.014)	(0.015)			(0.015)
D.Corruption[2]		-0.010				-0.018		
		(0.011)				(0.015)		
D.Corruption[3]			0.025				-0.017	
			(0.019)				(0.013)	
D.Ln(GDP/Capita)				1.050***				1.142***
				(0.256)				(0.266)
D.Trade/GDP				0.115*				0.194**
				(0.066)				(0.079)
Observations	769	693	511	639	638	612	453	616
Adj R-square	0.33	0.33	0.31	0.39	0.34	0.34	0.30	0.39

Robust (clustered) standard errors are in parentheses. *, ** and *** denote statistical significance at the 10%, the 5% and the 1% levels respectively. D denotes the first-differenced parameter. 1. The FH's measure of political freedom. 2. The Polity's democracy indicator. 3. The ICRG's corruption measure.

Table 1.6. Three channels through which the Internet affects FDI (using the first difference estimator)

Dependent variable: Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D.Ln(Internet Users)	-0.100	-0.148*	-0.056	-0.134				
	(0.074)	(0.086)	(0.092)	(0.095)				
D.Ln(Internet Hosts)					-0.077	-0.119	-0.030	-0.050
					(0.110)	(0.116)	(0.095)	(0.105)
D.Inventory/Sales	-1.589***	-1.796***	-0.957***	-1.664***	-1.437***	-1.552***	-0.979***	-1.293***
	(0.376)	(0.425)	(0.357)	(0.449)	(0.358)	(0.376)	(0.281)	(0.338)
D.Ln(EaseOfEntry)	0.003	-0.025	0.021	0.007	0.108	0.104	0.142	0.102
	(0.085)	(0.094)	(0.084)	(0.112)	(0.093)	(0.100)	(0.096)	(0.095)
D.Corruption[1]	0.069			0.042	0.046			0.053*
	(0.042)			(0.035)	(0.032)			(0.031)
D.Corruption[2]		0.006				-0.004		
		(0.021)				(0.015)		
D.Corruption[3]			0.001				-0.018	
			(0.069)				(0.013)	
D.Ln(GDP/Capita)				0.940***				1.049***
				(0.243)				(0.252)
D.Trade/GDP				0.098				0.186**
				(0.065)				(0.080)
D.Internet* InventoryCost	0.057*	0.068**	0.022	0.068*	0.041	0.049	0.005	0.037
	(0.031)	(0.034)	(0.031)	(0.037)	(0.043)	(0.045)	(0.035)	(0.040)
D.Internet* EaseOfEntry	0.031***	0.031***	0.025***	0.028***	0.035***	0.034***	0.021*	0.029***
	(0.006)	(0.007)	(0.007)	(0.009)	(0.010)	(0.011)	(0.011)	(0.010)
D.Internet* Corruption	-0.007**	-0.002	0.002	-0.006*	-0.009**	-0.002	0.003	-0.010**
	(0.003)	(0.002)	(0.006)	(0.003)	(0.004)	(0.002)	(0.002)	(0.004)
Observations	769	693	511	639	638	612	453	616
Adj R-square	0.36	0.35	0.33	0.41	0.37	0.36	0.31	0.41

Robust (clustered) standard errors are in parentheses. *, ** and *** denote statistical significance at the 10%, the 5% and the 1% levels respectively. D denotes the first-differenced parameter. 1. The FH's measure of political freedom. 2. The Polity's democracy indicator. 3. The ICRG's corruption measure.

Table 1.7. The Hausman-Taylor model

Dependent variable: Ln (Inward FDI stocks)

	Variables	(1) Fixed Effects	(2) Hausman Taylor
Time-varying exogenous	Ln (Internet Users)	-0.213**	
		(0.107)	
	Inventory/ Sales	-2.520***	-2.522***
		(0.512)	(0.513)
	Ln (Ease of Entry)	0.060	0.057
		(0.068)	(0.067)
	Corruption[1]	0.057*	0.054*
		(0.032)	(0.031)
	Ln (Internet Users)* Inventory/ Sales	0.093**	
		(0.045)	
	Ln (Internet Users)* Ln (Ease of Entry)	0.040***	
		(0.005)	
	Ln (Internet Users)* Corruption[1]	-0.006**	
		(0.003)	
Time-varying endogenous	Ln (Internet Users)		-0.214**
			(0.107)
	Ln (Internet Users)* Inventory/ Sales		0.093**
			(0.045)
	Ln (Internet Users)* Ln (Ease of Entry)		0.040***
			(0.005)
	Ln (Internet Users)* Corruption[1]		-0.006**
			(0.003)
Time-invariant exogenous	Regional Dummy		0.062
			(0.069)
	(Primary School Enrollment)$_{1994}$ (%)		0.006*
			(0.003)
	Ln (FDI)1994		0.597***
			(0.097)
Observations		832	832
Number of countries		104	104
Hausman Test $\chi 2$			0.18
Degrees of freedom			7.00
p-value			1.00

Standard errors are in parentheses. * denotes statistical significance at the 10% level. ** denote statistical significance at the 5% level. *** denote statistical significance at the 1% level.

1. It is proxied by the FH's measure of political freedom.

Table 1.8. Granger causality running from the Internet to inward FDI stocks (using the AH estimator)

Dependent variable: Lag1d. Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)
Lag1d. Ln (Inward FDI Stocks)	0.891***	0.863***	0.850***	0.968***
	(0.149)	(0.128)	(0.141)	(0.125)
Lag1d. Ln (Internet Users)	0.024*	0.033*	0.027	0.042***
	(0.013)	(0.019)	(0.019)	(0.015)
Lag1d. Inventory/ Sales			-0.174	-0.292*
			(0.170)	(0.172)
Lag1d. Ln (Ease of Entry)			0.031	0.000
			(0.057)	(0.065)
Lag1d. Corruption[1]			-0.049	-0.053
			(0.044)	(0.046)
Lag1d. Ln (GDP/Capita)				0.359
				(0.218)
Lag1d. Trade/GDP				0.186*
				(0.103)
Predetermined variables	Lagged first differences of Inward FDI stocks	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users
Observations	660	660	660	621
Number of countries	110	110	110	104

'Lag1d' represents lagged first difference. Robust standard errors are in parentheses. * denotes statistical significance at the 10% level. ** denote significance at the 5% level. *** denote statistical significance at the 1% level.

1. It is proxied by the FH's measure of political freedom.

Table 1.9. Granger causality running from inward FDI stocks to the Internet (using the AH estimator)

Dependent variable: Lag1d. Ln (Internet Users)

	(1)	(2)	(3)	(4)
Lag1d. Ln (Internet Users)	0.782***	0.782***	0.714***	0.592***
	(0.123)	(0.125)	(0.116)	(0.101)
Lag1d. Ln (Inward FDI Stocks)	0.014	0.410	0.375	-0.176
	(0.127)	(0.796)	(0.897)	(0.408)
Lag1d. Inventory/ Sales			-1.804***	-1.664***
			(0.619)	(0.508)
Lag1d. Ln (Ease of entry)			0.032	0.238
			(0.221)	(0.151)
Lag1d. Corruption[1]			0.079*	0.076
			(0.043)	(0.048)
Lag1d. Ln (GDP/Capita)				0.111
				(0.563)
Lag1d. Trade/GDP				-0.154
				(0.280)
Predetermined variables	Lagged first differences of Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users
Observations	659	659	659	620
Number of countries	110	110	110	104

'Lag1d' represents lagged first difference. Robust standard errors are in parentheses. * denotes statistical significance at the 10% level. ** denote significance at the 5% level. *** denote statistical significance at the 1% level.

1. It is proxied by the FH's measure of political freedom.

Table 1.10. Granger causality results running from the Internet to inward FDI stocks (using the GMM estimator)

Dependent variable: Lag1d. Ln (Inward FDI stocks)

	(1)	(2)	(3)	(4)	(5)
Lag1d. Ln (Inward FDI Stocks)	0.743*** (0.048)	0.790*** (0.039)	0.731*** (0.047)	0.690*** (0.047)	0.625*** (0.048)
Lag1d. Ln (Internet Users)	0.027** (0.010)	0.016* (0.008)	0.003 (0.009)	0.005 (0.010)	0.004 (0.009)
Lag1d. Inventory/ Sales			-0.402** (0.200)	-0.304* (0.178)	-0.365* (0.185)
Lag1d. Ln (Entry)			0.050 (0.045)	0.138 (0.094)	0.158** (0.079)
Lag1d. Corruption[1]			-0.045 (0.040)	-0.029 (0.044)	-0.035 (0.049)
Lag1d. Ln (GDP/Capita)					0.424*** (0.138)
Lag1d. Trade/GDP					0.154* (0.081)
Predetermined Variables	Lagged first differences of Inward FDI stocks	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks, Internet Users, Political Freedom and Bilateral Investment Treaty	Lagged first differences of Inward FDI stocks, Internet Users, Political Freedom and Bilateral Investment Treaty
Observations	660	660	660	660	621
Number of countries	110	110	110	110	104
Hansen	0.13	0.24	0.25	0.22	0.45
m1	-3.27	-3.27	-3.57	-3.67	-3.90
m1p	0.00	0.00	0.00	0.00	0.00
m2	-0.03	-0.04	-0.12	-0.05	0.24
m2p	0.98	0.97	0.90	0.96	0.81

'Lag1d' represents lagged first difference. Robust standard errors are in parentheses. * denotes statistical significance at the 10% level. ** denote statistical significance at the 5% level. *** denote statistical significance at the 1% level.

Table 1.11. Granger causality results running from Inward FDI stocks to the Internet (using the GMM estimator)

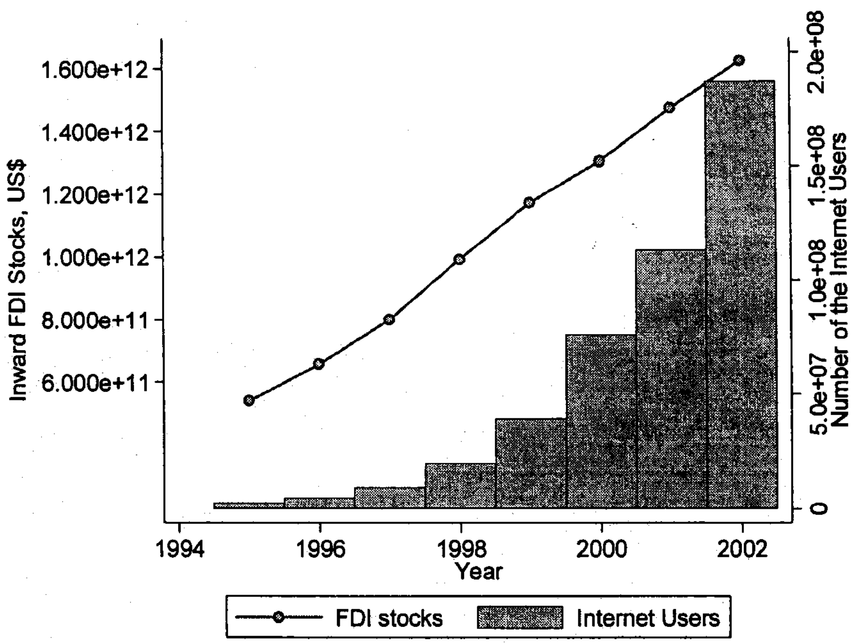
Dependent variable: Lag1d. Ln (Internet Users)

	(1)	(2)	(3)	(4)	(5)
Lag1d. Ln (Inward FDI Stocks)	2.140***	0.478***	0.265	0.145	0.197
	(0.287)	(0.166)	(0.173)	(0.179)	(0.170)
Lag1d. Ln (Internet Users)	0.380***	0.776***	0.726***	0.711***	0.676***
	(0.054)	(0.050)	(0.042)	(0.040)	(0.057)
Lag1d. Inventory/ Sales			-2.049***	-2.130***	-2.112***
			(0.657)	(0.738)	(0.673)
Lag1d. Ln (Ease of Entry)			0.051	0.224	0.241
			(0.136)	(0.296)	(0.233)
Lag1d. Corruption[1]			0.077*	-0.203*	-0.211*
			(0.045)	(0.119)	(0.119)
Lag1d. Ln (GDP/Capita)					0.307
					(0.528)
Lag1d. Trade/GDP					-0.140
					(0.292)
Endogenous Variables	Lagged first differences of Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks and Internet Users	Lagged first differences of Inward FDI stocks, Internet Users, Political Freedom and Bilateral Investment Treaty	Lagged first differences of Inward FDI stocks, Internet Users, Political Freedom and Bilateral Investment Treaty
Observations	659	659	659	659	620
Number of countries	110	110	110	110	104
Hansen	0.00	0.20	0.19	0.36	0.34
M1	-2.24	-3.71	-3.81	-3.98	-4.06
M1p	0.03	0.00	0.00	0.00	0.00
M2	1.78	0.36	0.39	1.22	0.84
M2p	0.08	0.72	0.70	0.22	0.40

'Lag1d' represents lagged first difference. Robust standard errors are in parentheses. * denotes statistical significance at the 10% level. ** denote statistical significance at the 5% level. *** denote statistical significance at the 1% level.

Figures

Figure 1.1. Relationship between the total number of Internet users and total inward FDI stocks over time



Appendices

Appendix 1.1. Data issues

List of sample countries

Albania
Algeria
Argentina
Armenia
Azerbaijan
Bangladesh
Belarus
Belize
Benin
Bolivia
Bosnia and Herzegovina
Brazil
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Cape Verde
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo, Dem. Rep.
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Czech Republic
Dominica
Dominican Republic
Ecuador
Egypt, Arab Rep.
El Salvador
Equatorial Guinea
Estonia
Ethiopia
Gambia, The
Georgia
Ghana
Grenada
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
India
Indonesia
Jamaica
Jordan
Kazakhstan
Kenya
Kyrgyz Republic
Lao PDR
Latvia
Lebanon
Lesotho
Liberia
Lithuania
Macedonia, FYR
Madagascar
Malawi
Malaysia
Mali
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Morocco
Namibia
Nepal
Nicaragua
Niger
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Romania
Russian Federation
Rwanda
Senegal
Sierra Leone
Slovak Republic
Somalia
South Africa
Sri Lanka
St. Lucia
St. Vincent and the Grenadines
Sudan
Swaziland
Tajikistan
Tanzania
Thailand
Togo
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
Uruguay
Uzbekistan
Vietnam
Zambia
Zimbabwe

Sources of data

Variables	Description	Sources
Bilateral Investment Treaties	BITs, under the auspices of the International Monetary Fund and the Bank for Reconstruction and Development (World Bank), have been enacted in order to provide protection for foreign direct investors. BITs generally offer foreign investors additional and higher standards of legal protection and guarantees fore foreign investments than those offered under national laws.	United Nations Conference on Trade and Development (UNCTAD)
Corruption indicator	It is recoded: a score of 1 indicates the lowest level of corruption and 7 the highest level of corruption.	International Country Risk Group
Freedom House measure	Political rights enable people to participate freely in the political process, including through the right to vote, compete for public office, and elect representatives who have a decisive impact on public policies and are accountable to the electorate. A rating of 7 indicates the lowest degree of political freedom and 1 the highest degree of political freedom.	Freedom House Survey
Internet hosts	Internet hosts refer to the number of computers that are directly connected to the worldwide Internet network.	Global Market Information. (Original Source: International Telecommunication Union/World Bank).
Internet users	Internet users are people with access to the worldwide network.	Global Market Information. (Original Source: International Telecommunication Union/World Bank) and United Nations.
Inward FDI stocks	Inward direction presents a non-resident direct investment in the reporting economy. FDI stocks are the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise, plus the net indebtedness of affiliates to the parent enterprises.	United Nations Conference on Trade and Development (UNCTAD).
Polity measure	Democracy score measures general openness of political institutions. It is recoded: a score of 1 indicates the highest level of democracy and 11 the lowest.	Polity IV Project
US Inventory/Sales	Private Inventories and Domestic Final Sales	Bureau of Economic Analysis

Appendix 1.2. Summary statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
FDI Stocks	9.73E+09	3.47E+10	2000000	4.48E+11	N = 880
Ln (FDI Stocks)	20.87531	2.077356	14.50866	26.82782	N = 880
Internet Users	513704.5	2725681	0	5.91E+07	N = 879
Ln (Internet Users)	9.688264	3.106291	0	17.89474	N = 879
Inventory/Sales	2.170938	0.099508	2.0025	2.355	N = 880
Bilateral Investment Treaties	18.87841	19.17977	1	107	N = 880
Ln (Bilateral Investment Treaties)	2.358202	1.183147	0	4.672829	N = 880
Freedom House measure	3.853409	2.041127	1	7	N = 880

Correlation matrix

	FDI stocks	Internet Users	Inventory/ Sales	Bilateral Investment Treaties	Freedom House measure	Ln (FDI stocks)	Ln (Internet Users)	Ln (Bilateral Investment Treaties)
FDI stocks	1							
Internet Users	0.7775*	1						
Inventory/Sales	-0.0892*	-0.1737*	1					
Bilateral Investment Treaties	0.4451*	0.3794*	-0.1875*	1				
Freedom House measure	0.0402	0.0088	0.0347	-0.0472	1			
Ln (FDI stocks)	0.5286*	0.3566*	-0.1798*	0.6188*	-0.1870*	1		
Ln (Internet Users)	0.4021*	0.3514*	-0.5448*	0.6266*	-0.2992*	0.7338*	1	
Ln (Bilateral Investment Treaties)	0.2860*	0.2310*	-0.1979*	0.8580*	-0.0774*	0.6283*	0.6572*	1

* denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Appendix 1.3. The AH and the GMM estimators

The Granger causality model is usually represented by a vector autoregressive representation (VAR) in which y depends on its own lags and lags of x. For the panel analysis, fixed effects are included and the VAR model[21] becomes

$$y_{it} = \alpha_0 + \sum_{j=1}^{q} \alpha_j^y y_{i,t-j} + \sum_{j=1}^{q} \beta_j^y x_{i,t-j} + c_i^y + u_{it}^y \qquad (1.39)$$

$$x_{it} = \beta_0 + \sum_{j=1}^{q} \alpha_j^x y_{i,t-j} + \sum_{j=1}^{q} \beta_j^x x_{i,t-j} + c_i^x + u_{it}^x \qquad (1.40)$$

where α and β are parameters and q is the lag period. The residuals of the two equations of the system are assumed to be independently distributed and each equation is estimated separately. x does not Granger-cause y if all lags of β_j^y are jointly insignificant, i.e., $\beta_1^y = \beta_2^y = \ldots = \beta_p^y = 0$. Similarly, y does not Granger-cause x if all lags of α_j^x are jointly insignificant, i.e., $\alpha_1^x = \alpha_2^x = \ldots = \alpha_m^x = 0$.

(1.39) is chosen for illustration. Anderson and Hsiao (1981) suggest first differencing of the model to eliminate the bias caused by the fixed effects. (1.39) becomes

$$y_{it} - y_{it-1} = \alpha(y_{i,t-1} - y_{i,t-2}) + \beta(x_{i,t-1} - x_{i,t-2}) + (u_{it} - u_{it-1}) \qquad (1.41)$$

Since the regressor $(y_{i,t-1} - y_{i,t-2})$ is potentially correlated with the error term $(u_{it} - u_{i,t-1})$, the problem of simultaneity remains. Then the method of instrumental variables estimation is applied to solve this problem. As Hsiao (2003, p.85-86) suggests, $(y_{i,t-2} - y_{i,t-3})$ or $y_{i,t-2}$ is correlated with $(y_{i,t-1} - y_{i,t-2})$ but uncorrelated with $(u_i - u_{i,t-1})$, so that it can be used as an instrument for $(y_{i,t-1} - y_{i,t-2})$. Regarding the choice between the lagged level (i.e., $y_{i,t-2}$) and

[21] The parameters (α and β) are assumed to be constant across countries and over time.

the lagged difference (i.e., $y_{i,t-2} - y_{i,t-3}$) as an instrument, the simulation results in Arellano and Bond (1991) and Kiviet (1995) show that the former is preferred. Therefore, the lagged level will be used as an instrument in the following discussion.

Further, there are two possible assumptions for the regressor, x_{it}. First, x_{it} is strictly exogenous, i.e., $E(x_{it}u_{it}) = 0$ for all t, s = 1, 2, …, T. Therefore, the lagged difference $(x_{i,t-1} - x_{i,t-2})$ can serve as its own instrument. The matrix of instruments for $(y_{i,t-1} - y_{i,t-2})$ and $(x_{i,t-1} - x_{i,t-2})$ in (1.41) for each period (t = 3, …, T) is given by:

$$Z_i^{AH1} = \begin{bmatrix} y_{i,1} & \Delta x_{i,2} \\ \cdot & \cdot \\ \cdot & \cdot \\ y_{i,T-2} & \Delta x_{i,T-1} \end{bmatrix} \qquad (1.42)$$

Second, if x_{it} is predetermined with $E(x_{it}u_{is}) \neq 0$ for s < t, $(y_{i,t-1} - y_{i,t-2})$ as well as $(x_{i,t-1} - x_{i,t-2})$ require instrumental variables. Likewise, the instrumental variable for $(x_{i,t-1} - x_{i,t-2})$ is $x_{i,t-2}$. Therefore, the matrix of instruments in (1.40) for each period (t = 3, …, T) is:

$$Z_i^{AH2} = \begin{bmatrix} y_{i,1} & x_{i,1} \\ \cdot & \cdot \\ \cdot & \cdot \\ y_{i,T-2} & x_{i,T-2} \end{bmatrix} \qquad (1.43)$$

With instruments Z_i^{AH1} or Z_i^{AH2}, the estimated coefficients for (1.41) can be obtained from a two-stage least-squares regression (Hsiao, 2003, p.83-84).

Next, turn to instrumental variables suggested by Holtz-Eaken et al. Unlike the matrix, Z^{AH1} and Z^{AH2}, in which the dimension of the instrumental variables is constant across time, Holtz-Eaken et al. use all available lagged values of the dependent variables as instruments in each time period. For instance, if x_{it} is strictly exogenous, at t = 4, $[y_1, \Delta x_3]$ are valid instruments for $[(y_{i,3} - y_{i,2}), (x_{i,3} - x_{i,2})]$, in addition to $[y_2, (x_{i,3} - x_{i,2})]$. The matrix of instruments proposed by Holtz-Eaken et al., Z^{NHR1} satisfies the condition that $E(Z_i^{NHR1'}\Delta u_i) = 0$, for each period (t = 3, ..., T). It is defined as:

$$z_i^{NHR1} = \begin{pmatrix} y_{i1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \Delta x_{i2} \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 & 0 & 0 & \Delta x_{i3} \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & \vdots \\ 0 & 0 & 0 & 0 & y_{i1} & y_{i2} & \cdots & y_{iT-2} & \Delta x_{iT-1} \end{pmatrix} \quad (1.44)$$

If x_{it} is predetermined, the matrix of instruments, Z^{NHR2} satisfies the condition that $E(Z_i^{NHR2'}\Delta u_i) = 0$[22], for each period (t = 3, ..., T). It is defined as:

$$Z_i^{NHR2} = \begin{bmatrix} y_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \vdots \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 & 0 & 0 & \vdots \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & \vdots \\ 0 & 0 & 0 & 0 & y_{i1} & y_{i2} & \cdots & y_{iT-2} & \vdots \end{bmatrix} \quad (1.45)$$
$$\begin{matrix} x_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & x_1 & x_2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_1 & x_2 & \cdots & x_{T-2} \end{matrix}\Bigg]$$

Premultiplying the differenced equation (1.41) by $Z_i^{NHR1'}$ or $Z_i^{NHR2'}$ gives

$$Z^{NHRi'}\Delta y = Z^{NHRi'}(\Delta y_{-1})\alpha + Z^{NHRi'}(\Delta x_{-1})\beta + Z^{NHRi'}(\Delta u) \qquad i=1,2 \qquad (1.46)$$

Performing GLS on Eq (1.46) gives the Arellano and Bond (1991) one-step GMM estimator.

[22] NHR2′ denotes the transpose of the matrix NHR2.

Chapter 2 Internet Externalities and Location of Foreign Direct Investment: A Comparison Between Developed and Developing Countries

Abstract

The widespread use of the Internet in developing countries since the mid-1990s has created high expectations of attracting inflows of foreign direct investment (FDI). In recent years however, even though the Internet traverses every single country in the world, disparities in the quality of its infrastructure in developing and developed countries have become apparent. As such, developing countries face a dilemma of increasing Internet usage: it gives rise both to positive externalities (i.e., lower connectivity charges) and negative externalities (i.e., congestion). The purpose of the present study is to examine how the Internet—a communication network—which is characterized by the presence of positive and negative externalities affects the locational choice of FDI.

This paper presents a two-stage game, which demonstrates that positive Internet spillovers stimulate FDI while negative Internet spillovers discourage FDI. These hypotheses are tested by two major empirical methodologies—the panel data estimation and the system general method of moments estimator. The empirical findings provide strong evidence that the presence of negative Internet spillovers in developing countries discourages inward FDI, and the presence of positive Internet spillovers in developed countries attracts more FDI. In addition, positive Internet spillovers are found to be more

effective than negative Internet spillovers in reducing the distance barrier[1] to FDI. As well, the evidence suggests that Internet development is likely to divert the early concentration of FDI, but is unlikely to reverse the self-reinforcing process of FDI.

2.1 Introduction

The widespread use of the Internet since the mid-1990s has created high expectations in developing countries[2] for attracting foreign direct investment (FDI). With Internet development, multinational corporations (MNCs) can expand geographically and even become "placeless". Cairncross (2001) further argues that to allow communications to work their magic, poor countries will be able to join a world club of traders, electronically linked, and begin to operate as though geography has no meaning (i.e., "the death of distance"). Therefore, the purpose of this paper is to examine whether, and how, Internet development affects the locational choice of FDI.

This paper distinguishes itself from previous studies in two aspects. First, this study focuses on a communication network, such as the Internet, which is characterized by the presence of positive and negative network externalities. An unintended "spillover" of any good is called an externality. If the spillover is positive, then it is a positive externality, a benefit; if the spillover is negative, then it is a negative externality (Hallgren and McAdams, 1999). In the present study, positive (negative) spillovers and positive (negative) externalities are used interchangeably. Positive Internet spillovers mean that new Internet users can add value to the value of all other users. For instance, as

[1] By "distance barrier", I mean that the distance between the host country and investing country is a barrier to FDI.

[2] Following the World Bank's classification, the term 'developing countries' is used to denote the set of low and middle income countries. The term 'developed countries' refers to the group of high income countries.

more users share the communication network costs, the cost per user of the network decreases. Also, as more users get connected, a larger base for prospective customers and suppliers is created. On the other hand, negative Internet spillovers mean that the growing number of users increase the strain on the existing connections, causing Internet congestion.

It is worth noting that developing countries have experienced a severe Internet congestion problem. For example, a writer recalls a personally frustrating experience while trying to surf the Internet in Lagos in 2000: "It took upward of one hour to gain access to the Internet" (Jansen, 2000). The lack of bandwidth[3] in developing countries is one of the major causes of Internet congestion. According to Sarrocco (2002, p.23)[4], "the availability of adequate and reliable bandwidth on international links, together with the quality of the local network, is one of the primary obstacles to universal connectivity[5] of and within the less developed countries." The report also points out that until a few years ago, few developing countries had more than 64 Kbit/s, which means that an entire country had, on average, the same amount of bandwidth that a single user could have in Europe or the United States. As shown in Figure 2.1, the digital divide between the high income group (developed countries) and low- and middle- income groups (developing countries) in terms of bandwidth per capita[6] is much larger than in the number of Internet

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[3] The width of the "digital route" is the bandwidth, for example, the maximum amount of information (bits/second) that can be transmitted along a channel (data transmission rate). This definition is taken from Sarrocco (2002).

[4] This is a background paper for the workshop "Improving IP Connectivity in the Least Developing Countries" organized by the International Telecommunication Union. IP is an acronym for Internet protocols.

[5] "Connectivity" is the possibility for a user of an electronic network to communicate with other networks. If access to other networks is non-existent or too narrow, it will be impossible to communicate with other countries regardless of the content.

[6] The data on the bandwidth per capita is only available for 2002.

users per 100 population.

The second way that the present study is distinguishable from previous studies is that it incorporates two determinants of FDI in relation to Internet development: geographical distance and agglomeration forces. Recent empirical studies, such as Breton, Di Mauro and Lucke (1999) and Buch, Kleinert, Lipponer and Toubal (2005) find that the geographical distance—a proxy for traveling costs, monitoring costs, and information costs—is negatively associated with inward FDI. To describe this negative relationship, the term "distance barrier"—the distance between the host country and investing country as a barrier to FDI—is used in the present study. In Harris (1995), organizing production over space requires communication with all the providers of factor services, and coordination cost (or communication costs) are modeled as a function of communication network costs and the size of the market covered. The present study, building on these theoretical and empirical studies, models coordination cost as a function of the geographical distance and Internet expenditure, and empirically tests the impact of Internet spillovers on the distance barrier.

In the present study, agglomeration effects are included as another determinant of FDI. They emerge from the clustering of other firms, the process which gives rise to positive externalities such as knowledge spillovers, specialized labor, and markets for inputs and outputs. Hence, agglomeration effects imply that the presence of past FDI attracts more FDI. The World Development Report (2001) acknowledges that although the Internet increases the mobility of MNCs, they tend to concentrate geographically because of agglomeration forces. The present study provides empirical evidence on whether the Internet has reinforced or diversified agglomeration forces.

In sum, this paper aims to identify the type of Internet externalities (positive or negative) and their impact on the distance barrier and agglomeration forces in both developed and developing countries.

Theoretically, a two-stage model—relating FDI, Internet externalities, and distance—is developed. Empirically, two major types of formal statistical analyses—the panel data estimation and the system generalized method of moments (GMM) estimator—are performed to verify the predictions of the two-stage model, plus the effect of Internet spillovers on agglomeration countries. The empirical findings show that in developing countries, negative Internet spillovers dominate and strengthen the distance barrier; whereas in developed countries, positive Internet spillovers dominate and diminish the economic importance of the distance barrier. These findings also suggest that Internet spillovers, whether positive or negative, are able to divert the early concentration of FDI, but are unlikely to reverse the self-reinforcing process of FDI.

The remainder of the present study is structured as follows. Section 2 reviews the related theoretical and empirical studies. Section 3 provides a two-stage model. Section 4 discusses the data issues. Section 5 reports the results using different econometric analyses. Section 6 concludes with a summary of the results and the policy implications.

2.2 Literature Review

This section reviews Harris (1995), Freund and Weinhold (2003, 2004), and Choi (2003), all of which examine the relationship between Internet development and international trade or FDI. Selected empirical studies concerning the effects of distance and agglomeration forces on FDI are also discussed.

2.2.1 Theoretical study on Communication Costs and Trade

Harris (1995)[7] develops a general equilibrium model, which consists of three main sectors in an open economy: the goods market, the labor market and the telecommunications market. In his model, the advanced communication technology facilitates coordination within the firm and between the firm and suppliers of factor services. The firm's total cost function depends not only on its production costs but also on its communication costs.

The communication network is provided by a monopoly that uses average cost pricing. The network cost per user (N) is a function of the size of the market served and the number of firms (or users) (d) of the network. If the network is subject to no congestion, more users can share the common costs of constructing the network. That is, N decreases in d. If the network is subject to congestion, more users raise the cost of providing a network of a given communication quality, so that N increases in d.

The goods market size (s) is determined by the KK locus and the technological locus (TT). The former is derived from the labor market equilibrium while the latter represents the set of points at which cost reduction gained from an extended network coverage equals costs of provision. As shown in Figure 2.2, the KK locus is upward sloping. The TT locus is downward sloping if there are no congestion effects. The TT locus is upward sloping if congestion effects dominate. Suppose that income growth leads to a rightward shift in the KK locus (i.e., from KK to KK'), the new equilibrium market size (s) increases given the negative slope of TT while s decreases given the positive slope of TT. Hence, the network externalities—a determinant of the slope of the TT locus—have impact on the extent of market expansion.

[7] Harris (1995) contains two models, one of which better serves the purpose of this paper and is chosen for presentation here.

2.2.2 Empirical Studies

2.2.2.1 The Relationship between the Internet and Distance

Freund and Weinhold (2004) use the Cournot competition model, in which the cost function includes fixed entry costs and variable transportation costs that increase with the distance between exporters and the foreign market. The Internet reduces the fixed entry costs to foreign markets, thereby increasing export opportunities to remote foreign markets and reducing the impact of distance on trade. This is the market expansion effect of the Internet. However, the Internet also intensifies competition by allowing more firms to enter the market. As the number of firms increases, total exports increase but each firm's exports decline. The exports of distant firms with higher transport costs fall by a greater extent than of proximate firms, which the Internet enhances the effect of distance on trade. This is the competition effect of the Internet.

In sum, the effect of the Internet on distance depends on whether the market expansion effect outweighs the competition effect. If the market expansion effect is stronger than the competition effect, the Internet will dilute the impact of distance on trade. But, if the competition effect is dominant, the Internet does not overcome the negative impact of distance on trade. The findings in Freund and Weinhold (2003, 2004) offer little evidence that, on a net basis, the Internet penetration tends to reduce the distance barrier to trade.

The specification of the gravity equation in Freund and Weinhold (2003) is:

$$tot_{ij} = \beta_0 + \beta_1(gdp_i gdp_j) + \beta_2(pop_i pop_j) + \beta_3(dist_{ij}) + + \beta_1(ADG_i) \\ + \beta_5(LANG) + \beta_6(LINK) + \beta_7(FTA) + \beta_8(cmass_i cmass_j) + \varepsilon_{ij}, \quad (2.1)$$

where tot_{ij} denotes the natural logarithm of the total bilateral trading volume between countries i and j, $gdp_i gdp_j$ the log of the product of the GNP's of country i and j, $cmass_i cmass_j$ the log of the product of Internet Hosts of countries i and j, and $dist_{ij}$ the log of the direct line distances between country i and j. ADJ, LANG, LINK and FTA are dummy variables which take the value 1 for adjacent countries, country pairs which share a common language, countries which share some colonial linkages, and country pairs which are both members of a free trade area, respectively. The dataset covers 56 developed and developing countries from the period 1995-1999. Freund and Weinhold (2003) find that the coefficient of distance is negative and does not consistently drop over time: the elasticity of the total trade volume with respect to distance drops from |-0.893| in 1995 to |-0.856| in 1998, but rises to |-0.9| in 1999.

Using the same dataset, Freund and Weinhold (2004) employ a different specification of the gravity equation, which is:

$$\begin{aligned} Growth(Exports_{12})_t = {} & \beta_0 + \beta_1 Growth(Host_1)_{t-1} + \beta_2 Growth(Host_2)_{t-1} \\ & + \beta_3 ln(Host_1)_{1995} + \beta_4 ln(Host_2)_{1995} \\ & + \beta_5 ln(Distance_{12}) + \beta_6 LONGDIST_{12} \\ & + \beta_7 Growth(Host_1)_{t-1} * LONGDIST_{12} \\ & + \beta_8 Growth(Host_2)_{t-1} * LONGDIST_{12} + \gamma_t + \varepsilon_{12}, \end{aligned} \tag{2.2}$$

where γ_t is year-fixed effects, Growth ($Host_1$) is the growth rate of domain names in country 1, and $LONGDIST_{12}$ is a dummy variable, which equals one if the distance between countries 1 and 2 exceeds the average distance between all countries. They find that the coefficient of distance is negative and the coefficient of the interaction term between the growth of Host and $LONGDIST_{12}$ is positive but statistically insignificant. These results do not provide clear evidence that increased Internet penetration has altered the negative effect of distance on trade.

Choi (2003)[8] reports that the coefficient of distance is –0.52 and is statistically significant. When the distance barrier between two countries decreases by 10%, FDI increases by 5.2%. If the distance variable decreases by 5%, FDI increases by 2.6%, which is same as the result of a 10% increase in number of the Internet hosts. He, therefore, suggests that increasing the Internet measure by 10% is roughly equivalent to reducing the geographical distance by 5%. Strictly speaking, Choi (2003) does not explain fully the effect of the Internet on distance, because his analysis neither compares the coefficients of distance with and without the Internet nor includes any interaction term between distance and the Internet variable.

2.2.2.2 The Relationship between Distance and FDI

Recent empirical studies on FDI have indicated that longer distance involves greater cultural differences, greater traveling costs and higher communication costs, so that distance would have a negative effect on multinational activities. Using the aggregate level data of FDI for 11 major OECD investing countries in the mid-1990s, Brenton, Di Mauro and Lűcke (1999) find that the coefficient of distance is negative and statistically significant, ranging from -0.01 to -1.26. Ekholm (1998) provides similar evidence on the industry level data of Swedish multinationals in 1994. They find that the coefficient of geographical distance is negative and statistically significant. Buch, Kleinert, Lipponer, and Toubal (2005) employ a firm-level data set on the FDI stocks of German firms from 1995 to 2001. On average, the foreign activities of German firms decrease by about 0.4% if distance increases by 1%.

In Portes and Rey (1999), information costs are proxied by geographical distance,

[8] Choi (2003) is reviewed in section 1.2.1 of Chapter 1.

which is found to be an important determinant of cross-border portfolio investment flows. Using the data set on bilateral gross cross-border equity flows between 14 countries over the period 1989-1996, Portes and Rey find that the information costs of asset trading are negatively associated with distance. After controlling for the characteristics of the countries, the elasticity of asset flows, with respect to distance is -0.85.

Buch (2004) examines the importance of information costs and regulations for banks' foreign activities. In her model of international banking, banks' monitoring costs are a function of distance between banks and customers. Buch (2004) examines the data for five countries—France, Germany, Italy, United Kingdom and United States—over the period 1983-1999. The geographical distance between the borrowers and foreign banks are found to be negatively associated with banks' international asset holdings. Buch (2004) further argues that if technological progress reduces information costs, the importance of distance for international banking would decrease over time. Hence, the coefficient of the distance variable is not only negative but should also become smaller over time. For the United States, a declining importance of distance is found. However, for European countries (France, Germany, Italy and Untied Kingdom), distance retained the same importance as it used to have.

2.2.2.3 Agglomeration Effects and FDI

Multinational firms benefit from positive externalities—knowledge spillovers, specialized labor, and the markets for inputs and outputs—in the presence of other firms, so that the existing MNCs attract more MNCs. On the other hand, the presence of other firms leads to greater competition in foreign markets, thereby discouraging FDI. Hence, the clustering of MNCs generates two opposing forces: agglomeration and diversification of FDI. Empirically, these two forces are difficult to be distinguished, so that the net effect is estimated, as in Cheng and Kwan (2000), and Campos and Kinoshita (2003).

Cheng and Kwan study agglomeration effects of FDI stocks in 29 Chinese regions from 1985 to 1995. Employing the system generalized method of moments, they estimate the equation:

$$Ln(y_{it}) = \alpha Ln(y_{it-1}) + \beta' x_{it} + \theta' z_i + \lambda_i + \gamma_t + \varepsilon_{it} \tag{2.3}$$

where $Ln(y_{it})$ is the natural logarithm of FDI stock per capita, x_{it} is a vector of explanatory variables including labor wage and density of roads; z_i is a vector of time invariant variables, λ_i are unobserved regional-specific effects, γ_t are time-specific effects, and ε_{it} is a random error term. Their results indicate that the coefficient of the lagged value of FDI stock per capita is between 0.45 and 0.6, which suggests a strong but not overwhelming agglomeration effects.

Similar to Kwan and Cheng, Kinoshita and Campos (2003) investigate whether the agglomeration effects play a crucial role in the locational choice of FDI in 25 transitional countries between 1990 and 1998. The dependent variable is per capita FDI stock, and the explanatory variables include institutional factors (i.e., rule of law and quality of bureaucracy), traditional factors (i.e., market size and labor costs), initial level of development (i.e., trade dependence and natural resource endowment) and other factors, such as distance from Brussels to the host capital city. Using the system generalized method of moments estimator, Kinoshita and Campos find that the coefficient of lagged FDI is 0.79, which is statistically significant.

2.3 A Two-Stage Game

This study's two-stage model, incorporating the Internet spillover effects and the determinants of the location of FDI, is developed on the basis of D'Aspremont and Jacquemin (1988). In their model, firms act non-cooperatively[9] in investing in R&D. At the first stage, firms determine how much to invest in R&D technologies, and, at the second stage, they engage in a Cournot quantity competition for the production of a homogenous product. The present study's model takes the two-stage game as its basic framework and modifies D'Aspremont's and Jacquemin's (1988) model by introducing coordination cost function in terms of geographical distance.

The present study's two-stage model also incorporates and extends previous related studies such as Harris (1995), Choi (2003), and Freund and Weinhold (2004). It has three properties. First, firms not only compete with each other in terms of quantity (as in Freund and Weinhold (2004)) but also compete to reduce coordination cost by using the Internet. Second, the present study's model highlights the role of information and communication technology in improving the firms' coordination abilities across space, as in Harris (1995). Third, unlike Choi (2003) and Freund and Weinhold (2004), the present study's model allows for the positive and negative spillovers of Internet usage.

First, consider the case without the impact of the Internet. Suppose that Cournot competition takes place, and two MNCs (MNC 1 and MNC 2) choose production quantities simultaneously in the host country k. The unit coordination cost of MNC τ (τ = 1, 2) required for foreign production increases proportionally with the distance between MNC τ's headquarter in the home country and its subsidiary in the host country k, so that:

$$c_\tau = Ad_{\tau k} \qquad \tau = 1,2;\ A > 0;\ 0 < d_{\tau k} \leq 1 \tag{2.4}$$

[9] Their paper also discusses how firms cooperate in investing in R&D.

where A is a constant, and $d_{\tau k}$ denotes the geographical distance between MNC τ and the host country k. $d_{\tau k}$, normalized at one[10], represents the longest distance from MNC τ to the host country k. The two MNCs are assumed to be located the same distance from the host country k, so that the subscripts for $d_{\tau k}$ are suppressed in the following analysis. The market demand function of the standard Cournot market structure is given by:

$$p(Q_{no\ internet}) = a - Q_{no\ internet}, \quad a > 0,\ Q_{no\ internet} = q_1 + q_2 \tag{2.5}$$

where the subscript—no internet—refers to the case without the impact of the Internet, and Q denotes the aggregate foreign output in country k. In the present study, Q also reflects the aggregate inward FDI to country k. That is, the greater the output of the MNCs in country k, the more FDI will be received by country k. MNC τ chooses its foreign production to maximize its net profits:

$$\max_{q_\tau} \pi_\tau = (p - c_\tau)q_\tau, \quad \tau=1,2 \tag{2.6}$$

The first-order conditions of MNC 1 and MNC 2 (i.e., $\frac{\partial \pi_\tau}{\partial q_\tau} = 0$) give respectively:

$$q_1(q_2) = \frac{a - q_2 - Ad}{3}$$
$$q_2(q_1) = \frac{a - q_1 - Ad}{3} \tag{2.7}$$

where a > Ad. Solving the system of equations (2.7) yields the Cournot equilibrium output:

$$q_\tau^c = \frac{a - Ad}{3} \tag{2.8}$$

The total output is:

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[10] If $d_{\tau k} = 0$, firm τ is a domestic firm and it is not the objective of the present study. Therefore, $d_{\tau k}$ is restricted to be greater than zero and less or equal to one.

$$Q^{*}_{no\ internet} = q_1^c + q_2^c = \frac{2(a - Ad)}{3} \tag{2.9}$$

Differentiation of (2.9) with respect to d gives:

$$\frac{\partial Q^{*}_{no\ internet}}{\partial d} = \frac{-2A}{3} < 0. \tag{2.10}$$

(2.10) indicates that total foreign production is negatively related to distance. This unambiguous negative sign will no longer hold as the analysis below takes account of Internet effects.

Next, the present study turns to the case of Internet spending. In the present study, MNCs do not cooperate on Internet investment and foreign production. In the first stage, each MNC chooses its Internet spending for data storage systems, secure networks, hardware and software to reduce its own coordination cost. In the second stage, each MNC acts as a Cournot competitor in choosing its foreign production in the host country k.

With positive Internet spillovers, the unit coordination cost function of MNC i[11] is:

$$c_i = (A - n_i - \beta n_j)d \quad j \neq i;\ i = 1,2;\ A > 0;\ 0 \leq d < 1;\ 0 < \beta < 1 \tag{2.11}$$

where β measures the effect of MNC i's Internet investment on the unit coordination cost of MNC j, and n_i denotes MNC i's Internet spending. With negative Internet spillovers, MNC i's coordination cost function is:

$$c_i = (A - n_i + \beta n_j)d \quad j \neq i;\ i = 1,2;\ A > 0;\ 0 < d \leq 1;\ 0 < \beta < 1 \tag{2.12}$$

The coordination cost functions (2.11) and (2.12) imply that MNC i's coordination cost

[11] In this case, MNC τ is renamed as MNC i.

are decreasing in its own Internet spending n_i. Its cost reduction effort can be enhanced by positive Internet spillovers, or offset by negative Internet spillovers.

As an illustration of a two-stage game, the coordination cost function with positive Internet spillovers (2.11) is chosen. Given the inverse demand function (2.5), the profit with positive Internet spillovers is:

$$\pi_i = [a - q_i - q_j - (A - n_i - \beta n_j)d]q_i - \frac{(n_i)^2}{2} \quad j \neq i;\ i=1,2;\ 0<\beta<1 \qquad (2.13)$$

The cost of Internet investment function is assumed to be quadratic, reflecting decreasing returns to Internet investment. That is, the cost per unit of Internet investment increases with the advancement of the Internet network. To obtain the final equilibrium output, the present study first solves for the Nash equilibrium output in the second stage, and then works backwards to solve for the first-stage Internet investment.

MNC i chooses its foreign production to maximize the profit (2.13). The first-order conditions of MNC i and MNC j give:

$$q_i = \frac{a - q_j - Ad + n_i d + n_j \beta d}{2}$$
$$q_j = \frac{a - q_i - Ad + n_j d + n_i \beta d}{2} \qquad (2.14)$$

Second-order conditions are satisfied for the existence of a unique and symmetric solution, for which:

$$q_i^c = q_j^c = \frac{a - Ad + n_i(2d - \beta d) + n_j(2\beta d - d)}{3} \qquad (2.15)$$

(2.15) indicates that the output of each MNC is an increasing function of its own Internet spending. An increase in MNC i's Internet spending reduces its coordination cost, thereby making higher foreign production more profitable. However, the effect of its rival's Internet spending (i.e., n_j) on MNC i's foreign production is ambiguous, depending on the degree of Internet spillovers. By substituting q_i^c and q_j^c into the profit (2.13), firm i chooses Internet investment to maximize its profit. The first-order condition gives:

$$\frac{\partial \pi_i}{\partial n_i} = \frac{2[a - Ad + n_i(2d - \beta d) + n_j(2\beta d - d)]}{9}(2-\beta)d - n_i = 0 \qquad (2.16)$$

A unique and symmetric Nash equilibrium[12] exists, i.e., $n_i = n_j = n^{nc}$, for which:

$$n^{nc} = \frac{d(2-\beta)(a-dA)}{4.5 - d^2(2-\beta)(1+\beta)} \qquad (2.17)$$

(2.17) indicates that each MNC's Internet spending is decreasing in β.[13] Substitution of n^{nc} into (2.15) gives the equilibrium output of firm i:

$$q_i^* = \frac{1.5(a-dA)}{4.5 - d^2(1+\beta)(2-\beta)} \qquad (2.18)$$

The aggregate quantity of output is:

$$Q_{ps}^* = q_i^* + q_j^* = \frac{3(a-dA)}{4.5 - d^2(1+\beta)(2-\beta)} \qquad (2.19)$$

where the subscript ps denotes positive Internet spillovers.

Using the coordination cost function (2.12) and applying the above procedures (2.13)-(2.19), the aggregate quantity of output with negative Internet spillovers is:

$$Q_{ns}^* = q_i^* + q_j^* = \frac{3(a-dA)}{4.5 - d^2(1-\beta)(2+\beta)} \qquad (2.20)$$

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[12] The second-order conditions for a maximum are satisfied.

[13] Differentiation of n^{nc} with respect to β gives

$$\frac{\partial n^{nc}}{\partial \beta} = \frac{-d(a-Ad)\{4.5 + d^2(2-\beta)(\beta-2)\}}{[4.5 - d^2(1+\beta)(2-\beta)]^2}$$

Given $0 < \beta < 1$ and $0 < d \leq 1$, $[4.5 + d^2(2-\beta)(\beta-2)] > 0$. Therefore, $\partial n^{nc}/\partial \beta < 0$.

where the subscript ns denotes negative Internet spillovers.

To examine how Internet externalities affect total foreign production, the total output Q^*_{ps} is differentiated with respect to β:

$$\frac{\partial Q^*_{ps}}{\partial \beta} = \frac{3d^2(a-dA)(1-2\beta)}{[4.5-d^2(1+\beta)(2-\beta)]^2} \lesseqgtr 0 \qquad (2.21)$$

where a > Ad. The sign of $\partial Q^*_{ps}/\partial\beta$ depends on the magnitude of β. Three possibilities exist. First, if β > 0.5, then $\partial Q^*_{ps}/\partial\beta < 0$. The intuition behind this result is as follows. When positive Internet spillovers are strong, MNC i's Internet investment benefits rival j substantially. Therefore, MNC i is unlikely to strengthen its competitive position and MNC j tends to free ride on MNC i's Internet investment. As a result, each MNC reduces its individual Internet spending and hence foreign production [see Eq (2.15)]. Second, if 0 < β < 0.5, then $\partial Q^*_{ps}/\partial\beta > 0$. When positive Internet spillovers are small, each MNC does not gain much from the other's Internet investment. Each MNC improves its cost advantage with its own Internet investment, leading to an increase in its foreign production as well as in total foreign production. Third, if β = 0.5, then $\partial Q^*_{ps}/\partial\beta = 0$. That is, if positive Internet spillovers reach 0.5, neither firm i nor j increases its foreign production.

Differentiation of Q^*_{ns} with respect to β gives:

$$\frac{\partial Q^*_{ns}}{\partial \beta} = \frac{-3d^2(a-dA)(1+2\beta)}{[4.5-d^2(1-\beta)(2+\beta)]^2} < 0 \qquad (2.22)$$

(2.22) suggests that negative Internet spillovers reduce total foreign production. The intuition is that MNC i's cost reduction effort is offset by its rival's Internet activity[14], so that it has no incentive to increase its own Internet investment and foreign production

To examine the impact of physical distance on foreign production, differentiation of (2.19) and (2.20) with respect to d yields respectively,

$$\frac{\partial Q^*_{ps}}{\partial d} = \frac{-13.5A + [3Ad^2 + 6(a - Ad)d][(1+\beta)(2-\beta)]}{[4.5 - d^2(1+\beta)(2-\beta)]^2} \tag{2.23}$$

$$\frac{\partial Q^*_{ns}}{\partial d} = \frac{-13.5A + [3Ad^2 + 6(a - Ad)d][(1-\beta)(2+\beta)]}{[4.5 - d^2(1-\beta)(2+\beta)]^2} \tag{2.24}$$

The only difference between (2.23) and (2.24) is the sign of β. Without Internet investment, $\frac{\partial Q^*_{no\ internet}}{\partial d}$ in (2.10) is always negative. With Internet investment, the sign of $\partial Q^* / \partial d$ in (2.23) and (2.24) could be positive or negative depending on whether the first negative term (-13.5A) is larger or smaller than the remaining positive terms of the numerator. The remaining terms are positive given the assumption that (a - dA) > 0 and 0 < β < 1. Since (1 + β)(2 - β) > (1-β)(2+β), the positive term $[3Ad^2 + 6(a\text{-}Ad)d][(1+\beta)(2\text{-}\beta)]$ in (2.23) is larger than $[3Ad^2 + 6(a\text{-}Ad)d][(1\text{-}\beta)(2+\beta)]$ in (2.24). Therefore, $\partial Q^*_{ps} / \partial d$ is more likely than $\partial Q^*_{ns} / \partial d$ to be positive, implying that positive spillovers tend to be more effective than negative spillovers in dampening the negative effects of distance on foreign production. The explanation is that given positive Internet spillovers, distant firms located far away from the host country k benefit from their own and other MNCs'

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[14] With negative Internet spillovers, (2.15) becomes:

$$q_i^c = q_j^c = \frac{a - Ad + n_i(2d + \beta d) + n_j(-2\beta d - d)}{3}$$

Unlike (2.15) which suggests that the effect of n_j on q_i^c can be positive or negative, this equation indicates that the effect of the rival's Internet spending on a MNC's output is always negative.

Internet spending, so that they are able to increase foreign production in the host country k.

In sum, on the basis of (2.21)-(2.24), the reduced form of foreign production (also defined as FDI) can be written as:

$$Q^* = F(\underbrace{\text{Positive Internet Spillovers}}_{+/-}, \underbrace{\text{Negative Internet Spillovers}}_{-}, \underbrace{\text{Distance}}_{+/-}) \tag{2.25}$$

Specifically, three hypotheses for empirical analysis are proposed:

1. For developed countries, positive Internet spillovers stimulate more inward FDI. However, strong positive spillovers ($\beta > 0.5$) or negative spillovers could reduce inward FDI.
2. For developing countries, positive Internet spillovers attract more inward FDI, while negative spillovers discourage inward FDI. It is worth noting that the existence of strong positive Internet spillovers (i.e., $\beta > 0.5$) is ruled out due to the fact that the Internet infrastructure is relatively poor in developing countries.
3. Due to the influence of the Internet, the impact of distance on foreign investment can be positive or negative. However, positive Internet spillovers are more likely than negative Internet spillovers to reduce the distance barrier.

2.4 Data Description and Variable Measurements

Annual data is used, and the sampling size is dictated by data availability. Each selected country possesses at least six annual observations for each explanatory variable[15] over the sample period 1995-2002. The United States, the United Kingdom and Japan

[15] Interpolation for the missing data is conducted before counting the missing observations.

represent the investing countries. The sample countries listed in Appendix 2.1 represent the recipient countries of FDI[16], and are classified into developing countries (middle and low income groups) and developed countries (high income group) based on the World Bank's criteria[17]. The dependent variable—inward FDI stocks—is obtained from the United Nations Conference on Trade and Development.

The unavailability of an extensive dataset on bilateral FDI flows has impeded measuring the distance between the source and the host countries, as done in the gravity equation. Instead, the distance variable is measured in the manner of Gallup, Sachs and Mellinger (2000). They capture the closeness of the country to the factor market by using the minimum great circle distance[18] from the country's capital city to the respective capital city in one of the three capital-goods-supplying regions: the United States, Western Europe, and Japan. Similarly, the present study uses the minimum great circle distance from the host country's capital city to one of the capital cities of the three respective major FDI source countries: the Untied States, the United Kingdom, and Japan. These three countries are the leading FDI source countries in North America, Europe, and Asia[19] respectively. They account for 40% of the outward FDI stocks in the

[16] The United States, the United Kingdom, and Japan are excluded.

[17] Using the World Bank's categorization, the low- and middle-income groups (developing countries) include those countries in which the 2002 gross national income per capita was US $9,075 or less, as measured in current US dollars. The high-income countries (OECD and non-OECD countries) are those in which the 2002 gross national income per capita was US$9,075 or more. Member countries of OPEC are excluded except for Indonesia, whose economy is not dominated by oil exports.

[18] The "great circle distance" is the shortest distance between two points on the surface of a sphere. Long-distance air traffic uses great circle routes routinely, saving time and fuel. Navigational radio signals also follow great circle paths. This definition is taken from Encyclopedia Britannica Online.

[19] The value of outward FDI stocks of Hong Kong (China) is higher than that of Japan over the period 1995-2002. Hong Kong (China) plays an important role as a funding hub, with a considerable amount of the investment flowing in and out, so that the present study does not consider Hong Kong's "transit FDI" as a major foreign investor in the region.

world each year from 1995 to 2002,[20] with the USA taking the lead in FDI abroad and the UK coming second.[21]

In order to minimize the possibility that geographical distance may capture the impact of the omitted transportation cost, the present study includes trade flows (exports plus imports) from the host countries to one of their major foreign investors—the United States, the United Kingdom, or Japan. For a host country, say China, communication costs are proxied by the minimum great circle distance between China and her major foreign investor (i.e., Japan), whereas transportation costs are measured by the trade flows between these two countries.

As explained in Lee and Sharma (1998), the economic cause of Internet congestion is the excess of demand relative to the capacity of the Internet infrastructure. In the present study, the ratio of the number of Internet users to the number of mainline telephone subscribers is used to proxy for Internet spillovers. Whereas the numerator measures the demand for the Internet, the denominator reflects the capacity of Internet infrastructure. As suggested by Giacomello and Picci (2003), if a person has a telephone subscription, then the cable is also there for a potential Internet dial-up, so that using telephone subscribers is a reasonable measure of the transmission capacity of the Internet infrastructure. However, for developed countries, the number of mainline telephone subscribers may underestimate the capacity of the Internet infrastructure, since it cannot reflect high-speed dial-up service and excludes broadband transmission.

Alternatively, the measure of Internet spillovers is the ratio of the number of

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[20] The calculation is based on the data obtained from the United Nations Conference on Trade and Development.
[21] Japan ranks number 7 after the US, UK, Germany, France, Netherlands, and Hong Kong (China) over the same period.

Internet users to the total population. Its denominator assumes that the overall capacity of the Internet network is to accommodate the whole country's population. This measure may overestimate the capacity of the Internet infrastructure because queues still exist for the connection of telephone mainlines in some developing countries.

Both measures—the ratio of the number of Internet users to fixed line subscribers, and the ratio of the number of Internet users to the total population—are taken alternatively to measure Internet spillovers in the subsequent empirical analysis.

GNI per capita is also included in all empirical equations to help control for the omitted variables that reflect market size and the stage of economic development. Since this study focuses on income—GNI per capita—which measures the income of the residents of the country regardless of the location of production, it is a better proxy than GDP per capita.

Definitions of all variables and sources, and summary statistics are provided in Appendix 2.1. It is interesting to note that the mean geographical distance from a major foreign investor to developed countries is 2,437 km, approximately one-half less than for developing countries. This difference highlights the importance of the present study's examination of whether Internet spillovers reduce the distance barrier in developing countries.

2.5 Empirical Methodology

To examine the relationships proposed in (2.25) and the combined effects of Internet spillovers and agglomeration forces on FDI, this study performs several types of formal statistical tests, each of which has some advantages over the others. First, following Freund and Weinhold (2003), the present study performs the panel data regression with year fixed effects. This part of the analysis mainly serves as a benchmark.

Second, the random effects model and Zellner's (1962) seemingly unrelated regressions (SUR) are employed to check for robustness. Unlike the fixed effects model, the random effects model allows for time invariant explanatory variables such as distance. However, its assumption that the fixed effects are uncorrelated with the other regressors is not easily justified.[22] Since both the fixed effects and random effects models hold all slope coefficients constant, their results concerning average behavior may cover up different behavior over time. Thus, the SUR model is employed to capture different slope coefficients over time. This type of model also allows the correlation of the error terms across equations.

In the third part of the analysis, the present study uses the system generalized method of moments (SYS-GMM) estimator, which has two advantages in the present context. First, the SYS-GMM model can take account of country specific effects (i.e., country size, technology level) and use the lagged dependent variable as a proxy for agglomeration. The introduction of country fixed effects not only helps control for the omitted variables but also reduces the possibility that the heterogeneity between countries is captured by distance. Furthermore, Blundell and Bond (1998a) find that in the presence of fixed effects, the OLS estimation on the lagged dependent variable is upward-biased, while the within group estimator is downward-biased. Using the SYS-GMM estimator, they report that the coefficient of the lagged dependent variable appears to be reasonable, since it is higher than the within group estimate and well below the OLS levels. Second, the present study opts for the SYS-GMM rather than the first-differenced GMM estimator

[22] See Greene (2003, p. 241)

because the former keeps the time-invariant distance variable, which is the parameter of interest. Blundell and Bond (1998b) also find that with short sample periods and persistent series, the SYS-GMM estimator exploiting additional moment condition improves the performance of the first-differenced estimator. Using the data on 140 manufacturing companies in the United Kingdom over the fairly short period of 1979-1984, Blundell and Bond (1998b) show that the coefficients exhibit large finite sample biases and very low precision for the first-differenced GMM estimator. On the other hand, the SYS-GMM estimator not only improves the precision but also reduces the small sample bias. When the period extends from 1976 to 1984, the differences between the first-differenced estimator and the SYS-GMM estimator become smaller. In the present study, the relatively short sampling period is another reason for choosing the SYS-GMM estimator instead of the first-differenced estimator.

2.5.1 Panel data estimation

(2.26) and (2.27) are used to estimate the reduced form equation (2.25) and the relationship between Internet spillovers and agglomeration effects. The panel data regression (2.26) examines the types of Internet spillovers (positive or negative), and the distance effect on FDI for developed and developing countries. It takes the following form:

$$\begin{aligned} Ln(FDI)_{it} = \beta_0 &+ \beta_1 Ln(FDI/CAPITA)_{i,1994} + \beta_2 Ln(DISTANCE)_i \\ &+ \beta_3 Ln(INTERNET)_{it} + \beta_4 Ln(TRADE\ FLOWS)_{it} \\ &+ \beta_5 Ln(GNI/CAPITA)_{it} + \gamma_t + \varepsilon_{it}, \\ &i = 1, \ldots, n;\ t = 1995, \ldots, 2002 \end{aligned} \quad (2.26)$$

where Ln represents natural logarithm, i the i th country, t the time period, and ε_{it} the error term. γ_i are year-fixed effects reflecting common shocks to all countries. For the benchmark estimation, FDI denotes inward FDI stocks; DISTANCE denotes the minimum great circle distance between the host country i and one of the foreign major investors (the US, the UK, or Japan). As explained earlier, the process by which the presence of past FDI attracts more FDI is referred to as "agglomeration effects". However, including a lagged dependent variable $(FDI)_{it-1}$ on the right hand side of (2.26) may induce the endogeneity problem and hence render the ordinary least squares (OLS) estimator biased and inconsistent. Instead, the inward FDI stocks per capital in 1994 ($FDI/CAPITA_{1994}$) is used as a proxy for agglomeration forces to reflect the past locational decision of FDI. TRADE FLOWS and GNI/CAPITA are control variables for transportation costs and market size respectively. INTERNET denotes the number of Internet users per 100 telephone mainlines (INTERNET/100PHONELINE) or the number of Internet users per 100 population (INTERNET/100POPULATION).[23] A positive sign of the coefficient of the INTERNET is interpreted as an indicator of the existence of positive Internet spillover. That is, high Internet usage in the host country allows MNCs to benefit from lower connectivity charges and larger potential suppliers or consumers, and therefore, promotes more inward FDI. Conversely, a negative coefficient of the INTERNET implies that an increase in Internet usage would increase costs for MNCs, including slower transmission of messages and an ever-increasing difficulty in getting connected, thereby discouraging inward FDI.

To examine the combined effects—Internet spillovers and the distance effect or Internet spillovers and agglomeration forces—on FDI, the panel data regression (2.26) is

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[23] An alternative interpretation of these variables is the Internet usage as a percentage of the capacity of Internet Infrastructure, the latter of which is measured in terms of total population or total telephone mainlines.

modified as follows:

$$\begin{aligned} Ln(FDI)_{it} = \beta_0 + \beta_1 Ln(FDI/CAPITA)_{i,1994} + \beta_2 Ln(DISTANCE)_i \\ +\beta_3 Ln(INTERNET)_{it} + \beta_4 (INTERACTION)_{k,it} \\ +\beta_5 Ln(TRADE\ FLOWS)_{it} + \beta_6 Ln(GNI/CAPITA)_{it} \\ +\gamma_t + \varepsilon_{it}, \qquad i = 1, ..., n;\ t = 1995, ..., 2002;\ k=1, 2 \end{aligned} \tag{2.27}$$

where $(INTERACTION)_{1,it}$ = $Ln(INTERNET)_{it}$ x $Ln(DISTANCE)_i$ and $(INTERACTION)_{2,it}$ = $Ln(INTERNET)_{it}$ x $Ln(FDI/CAPITA)_{i,1994}$. The former captures the effects of the Internet on distance, while the latter measures the impact of the Internet on agglomeration forces.

Table 2.1, Table 2.2, and Table 2.3 report the results of estimating (2.26) and (2.27) for developing countries, developed countries, and the full sample (all income groups) respectively. From columns (1) and (4) of Table 2.1, the coefficients of the INTERNET/100PHONELINE and INTERNET/100POPULATION are negative and statistically significant, indicating that negative Internet spillovers exist in developing countries.

As for other variables, the negative coefficients of distance and the positive coefficients of past FDI shown in columns (1) and (4) of Table 2.1 have expected signs and are statistically significant. From columns (2) and (5), the negative coefficients of the distance variable and the negative coefficients of Internet*Distance suggest that negative Internet spillovers amplify the negative impact of distance on FDI. Of these two results, only the one in column (5) is statistically significant. As shown in columns (3) and (6) of Table 2.1, the coefficients of past FDI are positive, and their interaction terms with Internet spillovers are negative and statistically significant. These findings suggest that increasing Internet usage reduces agglomeration effects of FDI.

As shown in columns (1) and (4) of Table 2.2, the signs of the Internet variables in developed countries are opposite from those in developing countries. That is, Internet spillovers are found to be positive and statistically significant for developed countries. It is also worth noting that the coefficients of INTERNET/100POPULATION and INTERNET/100PHONELINE have similar magnitudes, but the former is statistically significant at the 5% level, while the latter is statistically significant at the 10% level. These different results justify the concern (raised in section 3) that for developed countries, the use of INTERNET/100PHONELINE may underestimate the transmission capacity of the communication network, and hence underestimate the effect of positive Internet spillovers. In Table 2.3, the income group dummy is introduced by defining the developed countries to be one and the developing countries to be zero. The interaction term between Internet density and the income group in columns (1) and (4) provide further evidence that Internet spillovers for developed countries are statistically significantly higher than for developing countries.

In contrast to the findings of developing countries [columns (2) and (5) of Table 2.1], the coefficients of Internet*Distance in developed countries [columns (2) and (5) of Table 2.2] are statistically significant and positive. It is also worth noting the coefficients of the Internet variable are negative in columns (2) and (5) of Table 2.1[24], and positive in

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[24]From column (2) of Table 2.1, $\frac{\partial Ln(FDI)}{\partial(Ln(INTERNET/100PHONELINE))} = -0.173 - 0.007Ln(DISTANCE)$. As shown in Appendix 2.1, the mean of Ln(DISTANCE) for developing countries is 8.3, so that $\frac{\partial Ln(FDI)}{\partial(Ln(INTERNET/100PHONELINE))} = -0.23$. This implies that at the average distance, the impact of Internet usage on FDI is negative. Similar calculation is done for column (5) of Table 2.1 and the effect of Internet usage on FDI is -0.196.

columns (2) and (5) of Table 2.2[25]. All these findings not only suggest that increasing Internet usage in developed countries helps attract more distant MNCs, but also support the hypothesis that positive Internet spillovers are more likely than negative Internet spillovers to reduce the distance barrier. The coefficients of the interaction term, IncomeGroup*Internet*Distance in columns (2) and (5) of Table 2.3 are found to be positive and statistically significant[26], confirming that the distance barrier is more effectively reduced by Internet development in developed countries than in developing countries.

For both developed and developing countries, the coefficients of past FDI and its interaction term with Internet spillovers are found to be positive and negative respectively, as shown in columns (3) and (6) of Table 2.1 and Table 2.2. These results suggest that Internet development reduces the impact of past FDI on the locational choice of present FDI. However, the interaction term IncomeGroup*Internet*FDI/Capita1994 in columns (3) and (6) of Table 2.3 has negative signs and is statistically significant, indicating that Internet development in developed countries is stronger than that in developing countries to reduce agglomeration effects.

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[25]From column 2 of Table 2.1, $\frac{\partial Ln(FDI)}{\partial(Ln(INTERNET/100PHONELINE))} = -0.769 + 0.106Ln(DISTANCE)$.
As shown in Appendix 2.1, the mean of Ln(DISTANCE) for developed countries is 7.46, so that $\frac{\partial Ln(FDI)}{\partial(Ln(INTERNET/100PHONELINE))} = 0.022$. This implies that at the average distance, the impact of Internet usage on FDI is positive. Similar calculation is done for column (5) of Table 2.2, and the effect of Internet usage on FDI is also positive.

[26] Column (2) is chosen for illustration. $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet)*Ln(Distance))} = 0.024IncomeGroup + 0.039$. For developed countries, the income group dummy is 1, so that $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet)*Ln(Distance))} = 0.063$. For developed countries, the income group dummy is 0, so that $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet)*Ln(Distance))} = 0.024$.

2.5.2 Robustness Checks

The random effect estimator and the seemingly unrelated regressions (SUR) are used for robustness checks.

2.5.2.1 Random Effects Estimator

(2.27) is reformulated in the following form of the random effects model by including the unobserved country effects (α_i):

$$
\begin{aligned}
Ln(FDI)_{it} = \beta_0 &+ \beta_1 Ln(FDI/CAPITA)_{i,1994} + \beta_2 Ln(DISTANCE)_i \\
&+ \beta_3 Ln(INTERNET)_{it} + \beta_4 (INTERACTION)_{k,it} \\
&+ \beta_5 Ln(TRADE\ FLOWS)_{it} + \beta_6 Ln(GNI/CAPITA)_{it} \\
&+ \alpha_i + \gamma_t + \varepsilon_{it}, \\
&i = 1,\ldots,n;\ t = 1995,\ldots,2002,\ k = 1,2
\end{aligned}
\tag{2.28}
$$

Table 2.4 reports robust findings for developing countries. The coefficients of Internet spillovers [columns (1) and (4)], Internet*Distance [columns (2) and (5)] and Internet*FDI/Capita [columns (3) and (6)] are negative and most of them are statistically significant (except the coefficient of INTERNET/100PHONELINE in column 1). However, for developed countries, the signs of Internet spillovers and its interaction term with distance are not robust. As shown in Table 2.5, the former is negative in columns (1) and (4) while the latter is negative in columns (2) and (6).

2.5.2.2 Seemingly Unrelated Regressions

Using seemingly unrelated regressions, the present study examines the effects of the Internet over two periods: 1995-1998 and 1999-2002. The system of two equations for estimation is:

$$
\begin{aligned}
Ln(FDI)_{ih} &= \beta_0 + \beta_{1h} Ln(FDI/CAPITA)_{i,1994} + \beta_{2h} Ln(DISTANCE)_i \\
&\quad + \beta_{3h} Ln(INTERNET)_{ih} + \beta_{4h} (INTERACTION)_{k,ih} \\
&\quad + \beta_{5h} Ln(TRADE\ FLOWS)_{it} + \beta_{5h} Ln(GNI/CAPITA)_{ih} + \varepsilon_{ih}, \\
&\quad i = 1,\ldots,n;\ h = 1995\text{-}1998, k = 1,2 \\
Ln(FDI)_{ij} &= \beta_0 + \beta_{1j} Ln(FDI/CAPITA)_{i,1998} + \beta_{2j} Ln(DISTANCE)_i \\
&\quad + \beta_{3j} Ln(INTERNET)_{ij} + \beta_{4j} (INTEACTION)_{k,ij} \\
&\quad + \beta_{5j} Ln(TRADE\ FLOWS)_{it} + \beta_{5j} Ln(GNI/CAPITA)_{ij} + \varepsilon_{ij}, \\
&\quad i = 1,\ldots,n;\ j = 1999\text{-}2002;\ k = 1,2
\end{aligned}
\tag{2.29}
$$

All variables (except FDI/CAPITA) are based on four-year period averages. The present study includes past FDI per capita—FDI per capita in 1994 for the period 1995-1998 and FDI per capita in 1998 for the period 1999-2002—to capture agglomeration effects.

The coefficients of (2.29) can be estimated by SUR[27] or OLS on each equation separately. The former has higher efficiency gain relative to the latter when the error terms corresponding to different equations are highly correlated (Greene 2003, p. 343). Therefore, the Breusch-Pagan Lagrange multiplier test for the diagonality of the variance-covariance matrix[28] is employed for justifying the use of SUR estimation methods. All specifications of the regression equations reported in Table 2.6 and Table 2.7 pass the Breusch-Pagan Lagrange multiplier test, rejecting the null hypothesis that the residuals in the corresponding equations are uncorrelated.

Negative Internet spillovers are found in the first period (1995-1998) and the second period (1999-2002), as shown in columns (1A) and (1B) of Table 2.6. Although the impact of negative Internet spillovers drops from 0.085 to 0.035, the null

[27] Since the variance-covariance matrix (Σ) is unknown, the feasible generalized least squares (FGLS) estimator is used rather than GLS estimator.
[28] When the variance-covariance matrix is diagonal, the OLS estimator is fully efficient.

hypothesis—the equality of these two coefficients—is not rejected by the F-test, suggesting that this change is not statistically significant. By using INTERNET/100POPULATION, columns (4A) and (4B) of Table 2.6 show negative Internet spillovers. The null hypothesis that the coefficients are equal across two periods is not rejected.

Table 2.7 reports the results for developed countries, which are similar to the baseline findings. With positive spillover effects, the Internet shrinks the distance barrier and reduces the agglomeration of FDI.

2.5.3 The System GMM Estimator

The empirical relationship of (2.30) takes the form of the dynamic panel model:

$$\begin{aligned} Log(FDI)_{it} = \beta_0 + \beta_1 Ln(FDI)_{i,t-1} + \beta_2 Ln(INTERNET)_{it} \\ +\beta_3(INTERACTION)_{k,it} + \beta_4(OTHER\ FACTORS)_{it} \\ +\beta_5(TIME\ DUMMY)_t + \theta_1 Ln(DISTANCE)_i + u_{it}, \\ i = 1,\ \ldots,\ n;\ t = 3,\ \ldots,\ 8;\ k = 1,2 \end{aligned} \tag{2.30}$$

where the error term u_{it} is the sum of fixed country effects (μ_i) and disturbance (v_{it}), i.e., $u_{it} = \mu_i + v_{it}$, and t denotes the years[29] from 1997 to 2002. Time dummies are included to control for the specific time effects common to all countries. In addition, the major difference between (2.30) and (2.27) is the measue of agglomeration effects. The former employs a lagged dependent variable while the latter uses FDI/cpatia in 1994. The technical discussion of the system GMM estimator is provided in Appendix 2.2.

Instrumental variables have to be chosen for (2.30). The distance variable and the time dummies are assumed to be exogenous and uncorrelated with unobserved individual

[29]The data covers from 1995 to 2002. Since the equation needs to introduce one lag and take the first difference, the estimation period starts from 1997 to 2002.

country effects (μ_i). The lagged dependent variable (FDI_{it-1}) is considered to be predetermined. The remaining explanatory variables—the Internet, GNI/capita, and trade flows—can be correlated with μ_i, and they can be exogenous, predetermined or endogenous with respect to the disturbance (ν_{it}).

If the explanatory variables, Internet, GNI/capita, and trade flows, are treated as exogenous, the model passes the correlation tests m1 and m2 statistic but fails the Hansen's J statistic[30] for the full sample countries.[31] The m1 and m2 statistic test the first-order and second-order serial correlations in the first-differenced residuals respectively. The presence of the former does not imply that the estimates are inconsistent. The presence of the latter implies that the errors in levels are serially correlated, thus violating a key assumption of the first-differenced GMM estimator, and leading to inconsistent estimates. The null hypothesis of the Hansen's J statistic—that the over-identifying restrictions are valid—is rejected, implying that some of the independent variables may not be truly exogenous. Therefore, the present study experiments with these variables—the Internet, GNI/capita, and trade flows—as if exogenous or predetermined.

Suppose that the trade flows are predetermined, and the Internet and GNI/capita are exogenous. The significant m1 test and insignificant m2 test show that no serial correlation exists in the level residuals. In addition, the Hansen's J test does not reject the over-identification test, confirming the validity of instruments chosen for the level

[30] The Sargan test is a special case of the Hansen's J statistic under the assumption of conditional homoskedasticity. Since the Sargan test is not robust to heteroskedasticity, the Hansen J statistic, which is robust to intra-cluster correlation, is reported in the present study.
[31] These results are not reported.

equations and the first-differenced equations. Table 2.8 provides a list of instrumental variables.

Columns (1) and (4) of Table 2.9 confirm the finding of the existence of negative Internet spillovers in developing countries. As discussed in Section 3, for developing countries, the use of INTERNET/100POPULATION may overestimate the transmission capacity of the communication network. This, in turn, may reflect a less serious Internet congestion problem, as evidenced by a statistically significant INTERNET/100PHONELINE in column (1) and statistically insignificant INTERNET/100POPULATION in column (4).

The coefficients of the interaction term between Internet spillovers and distance are found to be positive and negative in columns (2) and (4) of Table 2.9 respectively. However, they are statistically insignificant, suggesting that the impact of the Internet on the distance barrier is very limited in developing countries.

The interaction term between the Internet and the lagged FDI shown in column (3) and (6) has a positive coefficient, different in sign from that of the baseline result. These different results suggest that the Internet is able to change the historical location of FDI $(FDI/Capita)_{1994}$, but is unlikely to divert the short run self-reinforcing process (FDI_{t-1}).

The above estimation cannot be repeated for developed countries because the full set of instruments for the predetermined variables is too large relative to the number of countries. Using the specification in column (1) or (4) of Table 2.9, the number of instruments is greater than the number of developed countries, so that the estimated covariance matrix is not defined. To reduce the instrumental matrix, the columns of the instrument matrix are combined by addition. However, the number of instruments is relatively large and is almost equal to the number of countries. Consequently, the instruments tend to overfit the predetermined variables and bias the results. The coefficients on lagged FDI in the estimations for the developed countries prove to be unreasonably high, so that these results are not reported.

The full sample is used to compare the effects of the Internet spillovers between developed and developing countries. Columns (1)-(3) of Table 2.10 present the results using INTERENET/100PHONELINE as the Internet variable, while columns (4)-(6) report the results using INTERNET/100POPULATION. In columns (1) and (4), the positive coefficients of the interaction term between the income group dummy and Internet spillovers are statistically significant, showing that Internet spillovers for developed countries are positive and significantly higher than that for developing countries.[32] In columns (2) and (5) Table 2.10, the coefficients of (IncomeGroup)*Ln(Internet)*Ln(Distance) are positive, indicating that Internet development has a greater impact on reducing the distance barrier for developed compared to developing countries[33], but only the one in column (5) is statistically

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[32]Column (1) is chosen for illustration. $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet))} = 0.103 IncomeGroup - 0.022$. For developed countries, the income group dummy is 1, so that $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet))} = 0.081$. For developing countries, the income group dummy is 0 so that the coefficient of the Internet spillovers is $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet))} = -0.022$..

[33]Column (2) is chosen for illustration. $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet)*Ln(Distance))} = 0.04 IncomeGroup + 0.009$. For developed countries, the income group dummy is 1, so that $\frac{\partial(Inward\ FDI\ stocks)}{\partial(Ln(Internet)*Ln(Distance))} = 0.05$..For

significant. The coefficients of IncomeGroup*Ln(Internet)*Ln(Inward FDI stocks) in columns (3) and (6) are negative and positive respectively, and both are statistically significant. Therefore, this study offers no clear evidence on whether Internet development promotes statistically significantly stronger agglomeration effects of FDI for developed countries than for developing countries.

It is worth noting that the above SYS-GMM analysis employs the one-step estimator rather than the two-step estimator. As the simulation studies in Blundell and Bond (1998b) suggest, using the two-step GMM estimator yields very modest efficiency gains even in the presence of high heteroskedasticity, but its estimate is less reliable and its asymptotic standard errors tend to be seriously downward biased.

2.6 Conclusions

A two-stage model is developed to study the relationship among FDI, Internet spillovers, and coordination cost (in terms of distance). If increasing Internet usage leads to positive Internet spillovers, such as lower connectivity charges and the expansion of potential e-markets, MNCs can reduce coordination cost through their own Internet investment and so increase foreign production. On the other hand, if the wide use of the Internet leads to negative Internet spillovers, such as network congestion, MNCs cannot benefit form their own Internet investment and so reduces foreign production. In sum, this study's model predicts that positive Internet spillovers encourage FDI, while negative Internet spillovers discourage FDI.

Using the data on 106 developing countries and 30 developed countries during

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developing countries, the income group dummy is 0, so that $\frac{\partial(\textit{Inward FDI stocks})}{\partial(Ln(Internet) * Ln(Distance))} = 0.01$.

1995 to 2002, two major empirical tests—the ordinary least squares (OLS) regressions with year fixed effects and the systems GMM estimator—are performed. This study extends Choi (2003) and Freund and Weinhold (2003, 2004) by stressing the importance of Internet infrastructure and Internet spillovers. This study reveals the presence of negative Internet spillovers in developing countries [columns (1) and (4) of Table 2.1, and columns (1) and (4) of Table 2.9] and positive Internet spillovers in developed countries [columns (1) and (4) of Table 2.2, and columns (1) and (4) of Table 2.10].

The empirical evidence indicates that in the presence of positive Internet spillovers, increasing Internet usage in developed countries considerably reduces the distance barrier so as to attract more FDI [columns (2) and (5) of Table 2.2]. On the other hand, in the presence of negative Internet spillovers, increasing Internet usage in developing countries does not statistically significantly reduce the distance barrier to FDI [columns (2) and (5) of Table 2.9]. It even amplifies the negative impact of distance on FDI, as shown in columns (2) and (5) of Table 2.1. These findings are consistent with the present study's model prediction that positive Internet spillovers are more likely than negative Internet spillovers to reduce the distance barrier to FDI. In addition, although this paper adopts different theoretical and empirical approaches from Freund and Weinhold (2004), its findings about developing countries are complementary to their finding[34]: increased Internet penetration does not significantly alter the negative effect of distance on trade.

With regard to the impact of the Internet on agglomeration effects of FDI, the World Development Report (2001) suggests that even with the Internet, the

[34] Their sample includes developed and developing countries.

agglomeration forces are strong enough to encourage the concentration of FDI. The present study provides support to the qualitative discussion of the World Development Report. As shown in columns (3) and (6) of Table 2.9, the results of the SYS-GMM estimator indicate that the Internet favors the self-reinforcing process of FDI (proxied by lagged FDI). However, the present study also shows that the Internet tends to reduce the effect of past FDI [proxied by $(FDI/CAPITA)_{1994}$] on present FDI, suggesting that Internet development can help developing countries to catch up with leading countries in receiving FDI [columns (3) and (6) of Table 2.1 and Table 2.2].

All in all, to fully realize the benefits of the Internet, developing countries need not only to increase the popularity of Internet usage, but also to improve their telecommunication infrastructure such as bandwidth per capita. Two benefits exist for using the Internet to attract FDI. First, the distance barrier is no longer beyond the control of policy makers. In the presence of a high quality telecommunication infrastructure, the Internet can reduce the distance barrier to MNCs, creating new opportunities for poor countries that are located far away from the major foreign investors. Second, the results concerning agglomeration forces indicate that an opportunity exists for developing countries to attract FDI. Since the Internet is able to change the effect of past FDI, poor countries that improve their investment environment could bring in new FDI. Then the self-reinforcing process is in force and the comparative advantage starts to accumulate, thereby attracting more FDI in the long term.

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Tables

Table 2.1. OLS regression model for developing countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)			Ln(InternetUser/100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(FDI/Capita)$_{1994}$	0.263***	0.263***	0.339***	0.220***	0.218***	0.184***
	(0.044)	*(0.044)*	*(0.027)*	*(0.05)*	*(0.05)*	*(0.03)*
	(0.030)	(0.030)	(0.036)	(0.03)	(0.03)	(0.03)
Ln(Distance)	-0.271***	-0.258***	-0.255***	-0.396***	-0.444***	-0.372***
	(0.026)	*(0.043)*	*(0.026)*	*(0.01)*	*(0.05)*	*(0.01)*
	(0.080)	(0.110)	(0.080)	(0.08)	(0.08)	(0.08)
Ln(Internet)	-0.235***	-0.173	-0.091	-0.197***	0.510***	-0.090*
	(0.046)	*(0.228)*	*(0.060)*	*(0.023)*	*(0.087)*	*(0.039)*
	(0.038)	(0.339)	(0.054)	(0.035)	(0.249)	(0.047)
Ln(TradeFlows)	0.684***	0.684***	0.683***	0.682***	0.683***	0.680***
	(0.008)	*(0.008)*	*(0.009)*	*(0.007)*	*(0.008)*	*(0.008)*
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Ln(GNI/Capita)	-0.298***	-0.298***	-0.273***	-0.02	0.01	0.01
	(0.030)	*(0.030)*	*(0.023)*	*(0.054)*	*(0.058)*	*(0.049)*
	(0.057)	(0.057)	(0.057)	(0.078)	(0.078)	(0.078)
Ln(Internet)*Ln(Distance)		-0.007			-0.085***	
		(0.025)			*(0.012)*	
		(0.041)			(0.030)	
Ln(Internet)*Ln(FDI/Capita)$_{1994}$			-0.043***			-0.029***
			(0.006)			*(0.005)*
			(0.012)			(0.008)
Observations	842	842	842	842	842	842
Number of countries	106	106	106	106	106	106
Number of years	8	8	8	8	8	8
Within R-square	0.720	0.720	0.720	0.72	0.72	0.72
Adjusted R-square	0.730	0.730	0.730	0.72	0.73	0.73

Standard errors are in parentheses. *Robust (clustered) standard errors are in parentheses and in italics.* Significance is measured using the robust standard errors. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Table 2.2 OLS regression model for developed countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Ln(FDI/Capita)_{1994}$	0.450***	0.435***	0.690***	0.449***	0.430***	0.613***
	(0.021)	*(0.021)*	*(0.058)*	*(0.02)*	*(0.02)*	*(0.03)*
	(0.050)	(0.051)	(0.131)	(0.05)	(0.05)	(0.10)
Ln(Distance)	-0.042	-0.367***	0	-0.04	-0.308***	0.00
	(0.023)	*(0.079)*	*(0.032)*	*(0.02)*	*(0.08)*	*(0.03)*
	(0.072)	(0.174)	(0.075)	(0.07)	(0.13)	(0.07)
Ln(Internet)	0.089*	-0.769**	0.627***	0.086**	-0.843***	0.564***
	(0.042)	*(0.238)*	*(0.120)*	*(0.035)*	*(0.225)*	*(0.096)*
	(0.068)	(0.426)	(0.279)	(0.063)	(0.395)	(0.258)
Ln(TradeFlows)	0.874***	0.867***	0.890***	0.874***	0.864***	0.889***
	(0.010)	*(0.009)*	*(0.014)*	*(0.009)*	*(0.008)*	*(0.012)*
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Ln(GNI/Capita)	0.033	0.100*	0.077**	0.02	0.131**	0.075*
	(0.021)	*(0.046)*	*(0.030)*	*(0.025)*	*(0.054)*	*(0.038)*
	(0.150)	(0.153)	(0.151)	(0.154)	(0.160)	(0.157)
Ln(Internet)*Ln(Distance)		0.106***			0.114***	
		(0.029)			*(0.029)*	
		(0.052)			(0.048)	
$Ln(Internet)*Ln(FDI/Capita)_{1994}$			-0.080***			-0.071***
			(0.022)			*(0.018)*
			(0.040)			(0.037)
Observations	234	234	234	234	234	234
Number of countries	30	30	30	30	30	30
Number of years	8	8	8	8	8	8
Within R-square	0.880	0.880	0.880	0.88	0.88	0.88
Adjusted R-square	0.880	0.880	0.880	0.88	0.88	0.88

Standard errors are in parentheses. *Robust (clustered) standard errors are in parentheses and in italics.* Significance is measured using the robust standard errors. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Table 2.3. OLS regression model for the full sample of countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)	Ln(InternetUser/100Phoneline			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Ln(FDI/Capita)_{1994}$	0.278***	0.275***	0.289***	0.251***	0.246***	0.162***
	(0.041)	*(0.04)*	*(0.03)*	*(0.05)*	*(0.04)*	*(0.03)*
	(0.027)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Ln(Distance)	-0.286***	-0.274***	-0.256***	-0.325***	-0.428***	-0.293***
	(0.018)	*(0.05)*	*(0.02)*	*(0.01)*	*(0.05)*	*(0.01)*
	(0.059)	(0.11)	(0.06)	(0.06)	(0.08)	(0.06)
Ln(Internet)	-0.162**	-0.19	-0.03	-0.151***	0.579***	-0.05
	(0.047)	*(0.22)*	*(0.06)*	*(0.029)*	*(0.10)*	*(0.04)*
	(0.033)	(0.33)	(0.05)	(0.031)	(0.24)	(0.04)
Ln(TradeFlows)	0.722***	0.719***	0.717***	0.717***	0.716***	0.713***
	(0.004)	*(0.01)*	*(0.01)*	*(0.004)*	*(0.01)*	*(0.00)*
	(0.016)	(0.02)	(0.02)	(0.016)	(0.02)	(0.02)
Ln(GNI/Capita)	-0.338***	-0.324***	-0.259***	-0.122*	-0.07	-0.04
	(0.032)	*(0.03)*	*(0.03)*	*(0.061)*	*(0.06)*	*(0.05)*
	(0.051)	(0.05)	(0.05)	(0.069)	(0.07)	(0.07)
Ln(Internet)* Ln(Distance)		0.00			-0.090***	
		(0.02)			*(0.01)*	
		(0.04)			(0.03)	
Ln(Internet)* $Ln(FDI/Capita)_{1994}$			-0.038***			-0.028***
			(0.01)			*(0.01)*
			(0.01)			(0.01)
IncomeGroup	-0.075	5.369***	-4.240***	-0.11	2.390*	-4.154***
	(0.175)	*(0.92)*	*(0.22)*	*(0.146)*	*(1.06)*	*(0.16)*
	(0.201)	(1.94)	(1.23)	(0.168)	(1.44)	(0.95)
IncomeGroup* Ln(Internet)	0.165**	-1.529***	0.508***	0.147**	-2.229***	0.452***
	(0.058)	*(0.26)*	*(0.09)*	*(0.047)*	*(0.33)*	*(0.08)*
	(0.056)	(0.61)	(0.37)	(0.051)	(0.53)	(0.34)
IncomeGroup* Ln(Distance)		-0.698***			-0.327*	
		(0.15)			*(0.15)*	
		(0.25)			(0.18)	

Table 2.3 (Cont'd) OLS regression model for the full sample of countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)	Ln(InternetUser/100Phoneline			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
IncomeGroup* Ln(Internet)* Ln(Distance)		0.218***			0.300***	
		(0.04)			*(0.05)*	
		(0.08)			(0.07)	
IncomeGroup* Ln(FDI/Capita)$_{1994}$			0.531***			0.554***
			(0.04)			*(0.03)*
			(0.17)			(0.13)
IncomeGroup* Ln(Internet)* Ln(FDI/Capita)$_{1994}$			-0.035*			-0.035**
			(0.02)			*(0.01)*
			(0.05)			(0.05)
Observations	1070	1070	1070	1070	1070	1070
Number of countries	136	136	136	136	136	136
Number of years	8	8	8	8	8	8
Within R-square	0.80	0.80	0.81	0.80	0.81	0.81
Adjusted R-square	0.80	0.80	0.81	0.80	0.81	0.81

Standard errors are in parentheses. *Robust (clustered) standard errors are in italics.* Significance is measured using the robust standard errors. *, ** and *** denote significance at the 10%, 5% and 1% levels respectively.

Table 2.4. Random effect model for developing countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Ln(FDI/Capita)_{1994}$	0.174***	0.202***	0.270***	0.184***	0.214***	0.160**
	(0.065)	(0.066)	(0.065)	(0.066)	(0.066)	(0.065)
Ln(Distance)	-0.328	-0.249	-0.336	-0.360*	-0.446**	-0.374*
	(0.208)	(0.210)	(0.208)	(0.210)	(0.211)	(0.210)
Ln(Internet)	-0.019	0.567***	0.128***	-0.030*	0.483***	0.106***
	(0.016)	(0.114)	(0.018)	(0.016)	(0.105)	(0.017)
Ln(TradeFlows)	0.269***	0.240***	0.250***	0.268***	0.243***	0.251***
	(0.024)	(0.024)	(0.022)	(0.024)	(0.024)	(0.022)
Ln(GNI/Capita)	0.296***	0.254***	0.301***	0.309***	0.265***	0.324***
	(0.079)	(0.078)	(0.071)	(0.079)	(0.078)	(0.071)
Ln(Internet)*Ln(Distance)		-0.070***			-0.061***	
		(0.013)			(0.012)	
$Ln(Internet)*Ln(FDI/Capita)_{1994}$			-0.045***			-0.042***
			(0.003)			(0.003)
Observations	842	842	842	842	842	842
Number of countries	106	106	106	106	106	106
Number of years	8	8	8	8	8	8

Standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Table 2.5. Random effect model for developed countries over the period 1995-2002

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(FDI/Capita)$_{1994}$	0.539***	0.556***	0.684***	0.538***	0.556***	0.648***
	(0.137)	(0.138)	(0.146)	(0.137)	(0.138)	(0.144)
Ln(Distance)	-0.232	-0.164	-0.253	-0.231	-0.192	-0.253
	(0.195)	(0.199)	(0.199)	(0.195)	(0.197)	(0.199)
Ln(Internet)	-0.002	0.282*	0.264***	-0.001	0.271*	0.250***
	(0.029)	(0.148)	(0.083)	(0.029)	(0.142)	(0.080)
Ln(TradeFlows)	0.721***	0.686***	0.696***	0.722***	0.684***	0.699***
	(0.075)	(0.076)	(0.075)	(0.075)	(0.077)	(0.075)
Ln(GNI/Capita)	0.126	0.144	0.139	0.127	0.136	0.153
	(0.212)	(0.211)	(0.209)	(0.211)	(0.210)	(0.208)
Ln(Internet)*Ln(Distance)		-0.034**			-0.032*	
		(0.017)			(0.017)	
Ln(Internet)*Ln(FDI/Capita)$_{1994}$			-0.042***			-0.040***
			(0.012)			(0.012)
Observations	234	234	234	234	234	234
Number of countries	30	30	30	30	30	30
Number of years	8	8	8	8	8	8

Standard errors are in parentheses. Significance is measured using the robust standard errors. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Table 2.6. Seemingly unrelated regressions for developing countries

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)					
	1995-1998	1999-2002	1995-1998	1999-2002	1995-1998	1999-2002
	(1A)	(1B)	(2A)	(2B)	(3A)	(3B)
Ln(FDI/Capita)[1]	0.286***	0.187***	0.295***	0.206***	0.294***	0.118
	(0.053)	(0.067)	(0.057)	(0.071)	(0.056)	(0.157)
Ln(Distance)	-0.339*	-0.312	-0.448*	-0.787	-0.329	-0.31
	(0.201)	(0.203)	(0.229)	(0.543)	(0.201)	(0.202)
Ln(Internet)	-0.085	-0.035	-0.983	-1.29	-0.048	-0.131
	(0.054)	(0.071)	(0.862)	(1.317)	(0.114)	(0.203)
Ln(TradeFlows)	0.637***	0.628***	0.651***	0.647***	0.648***	0.639***
	(0.045)	(0.045)	(0.046)	(0.045)	(0.045)	(0.045)
Ln(GNI/Capita)	-0.285**	-0.205	-0.314**	-0.246*	-0.282**	-0.218
	(0.121)	(0.132)	(0.126)	(0.135)	(0.128)	(0.137)
Ln(Internet)*Ln(Distance)			0.108	0.149		
			(0.105)	(0.157)		
Ln(Internet)*Ln(FDI/Capita)[1]					-0.012	0.021
					(0.028)	(0.043)
Observations	106	106	106	106	106	106

	Ln(InternetUser/ 100Population)					
	1995-1998	1999-2002	1995-1998	1999-2002	1995-1998	1999-2002
	(4A)	(4B)	(5A)	(5B)	(6A)	(6B)
Ln(FDI/Capita)[1]	0.278***	0.192***	0.283***	0.195***	0.289***	0.199***
	(0.052)	(0.069)	(0.053)	(0.071)	(0.076)	(0.070)
Ln(Distance)	-0.408**	-0.355*	-0.451*	-0.213	-0.414**	-0.368*
	(0.201)	(0.201)	(0.232)	(0.226)	(0.202)	(0.201)
Ln(Internet)	-0.085*	-0.102	0.148	1.066	-0.088	-0.221
	(0.051)	(0.073)	(0.644)	(0.887)	(0.096)	(0.154)
Ln(TradeFlows)	0.638***	0.636***	0.650***	0.649***	0.644***	0.644***
	(0.045)	(0.045)	(0.045)	(0.045)	(0.046)	(0.045)
Ln(GNI/Capita)	-0.189	-0.106	-0.217	-0.098	-0.207	-0.132
	(0.144)	(0.145)	(0.150)	(0.149)	(0.146)	(0.147)
Ln(Internet)*Ln(Distance)			-0.027	-0.14		
			(0.078)	(0.106)		
Ln(Internet)*Ln(FDI/Capita)[1]					0.00	0.024
					(0.020)	(0.027)
Observations	106	106	106	106	106	106

Standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level. 1. For the period 1995-1998, Ln(FDI/Capita) represents Ln(FDI/Capita) in 1994. For the period 1999-2002, Ln(FDI/Capita) represents Ln(FDI/Capita) in 1998.

Table 2.7. Seemingly unrelated regressions for developed countries

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)					
	1995-1998	1999-2002	1995-1998	1999-2002	1995-1998	1999-2002
	(1A)	(1B)	(2A)	(2B)	(3A)	(3B)
Ln(FDI/Capita)[1]	0.519***	0.573***	0.519***	0.594***	0.667*	1.215*
	(0.121)	(0.143)	(0.117)	(0.147)	(0.341)	(0.658)
Ln(Distance)	-0.058	-0.083	-0.561	-0.375	-0.016	-0.014
	(0.191)	(0.193)	(0.493)	(1.268)	(0.196)	(0.203)
Ln(Internet)	0.168	0.235	-1.325	-0.321	0.614	1.493
	(0.119)	(0.184)	(1.353)	(2.384)	(0.938)	(1.254)
Ln(TradeFlows)	0.856***	0.851***	0.833***	0.851***	0.881***	0.876***
	(0.086)	(0.085)	(0.085)	(0.085)	(0.088)	(0.088)
Ln(GNI/Capita)	-0.028	0.012	0.014	-0.034	-0.022	0.061
	(0.334)	(0.361)	(0.329)	(0.365)	(0.342)	(0.384)
Ln(Internet)*Ln(Distance)			0.193	0.072		
			(0.175)	(0.310)		
Ln(Internet)*Ln(FDI/Capita)[1]					-0.066	-0.169
					(0.129)	(0.164)
Observations	30	30	30	30	30	30

	Ln(InternetUser/ 100Population)					
	1995-1998	1999-2002	1995-1998	1999-2002	1995-1998	1999-2002
	(4A)	(4B)	(5A)	(5B)	(6A)	(6B)
Ln(FDI/Capita)[1]	0.504***	0.556***	0.480***	0.533***	0.607***	0.951*
	(0.123)	(0.143)	(0.119)	(0.148)	(0.228)	(0.518)
Ln(Distance)	-0.048	-0.069	-0.594	-1.283	-0.011	-0.017
	(0.190)	(0.192)	(0.377)	(1.023)	(0.195)	(0.200)
Ln(Internet)	0.179	0.27	-2.077	-2.448	0.633	1.216
	(0.119)	(0.193)	(1.355)	(2.247)	(0.812)	(1.201)
Ln(TradeFlows)	0.854***	0.845***	0.811***	0.823***	0.876***	0.862***
	(0.086)	(0.085)	(0.086)	(0.085)	(0.088)	(0.087)
Ln(GNI/Capita)	-0.067	-0.046	0.075	-0.036	-0.05	0.045
	(0.331)	(0.361)	(0.328)	(0.361)	(0.338)	(0.390)
Ln(Internet)*Ln(Distance)			0.293*	0.359		
			(0.177)	(0.298)		
Ln(Internet)*Ln(FDI/Capita)[1]					-0.066	-0.129
					(0.112)	(0.158)
Observations	30	30	30	30	30	30

Standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

1. For the period 1995-1998, Ln(FDI/Capita) represents Ln(FDI/Capita) in 1994. For the period 1999-2002, Ln(FDI/Capita) represents Ln(FDI/Capita) in 1998

Table 2.8. Instrumental variables for the system GMM estimator

Variables	Exogenous/ Predetermined	Instruments in the level equations	Instruments in the first-differenced equations
$Ln(Internet)_t$; $Ln(GNI/capita)_t$; $Ln(Internet)_t$ x Ln(Distance); IncomeGroup x $Ln(Internet)_t$; IncomeGroup x $Ln(Internet)_t$ x Ln(Distance)	Exogenous	Variables in levels, i.e., $Ln(Internet)_t$	Variables in their own first differences, $\Delta Ln(Internet)_t$
Ln(Inward FDI $stocks)_{t-1}$,; $Ln(TradeFlows)_t$; $Ln(Internet)_t$ x Ln(Inward FDI $stocks)_{t-1}$[1]; IncomeGroup x Ln Ln(Inward FDI $stocks)_{t-1}$; IncomeGroup x $Ln(Internet)_t$ x Ln(Inward FDI $stocks)_{t-1}$	Predetermined	One lag of their own first differences, i.e., [ΔLn(Inward FDI $stocks)_{T-1-s}$] for period T and s=1.	All available lags of their own levels, i.e., [Ln(Inward FDI $stocks)_1$, ..., Ln(Inward FDI $stocks)_{T-1}$] for period T.
Ln(Distance) ; IncomeGroup; IncomeGroup x Ln(Distance) ; $(Year\ Dummines)_t$	Exogenous	Variables in levels	The time invariant variables are eliminated in the first-differenced equations.

1. The Internet variable is treated as exogenous. Its interaction term with the lagged FDI is considered to be predetermined because the lagged FDI is predetermined.

Table 2.9. The system GMM estimator for developing countries

Dependent variable: Ln(Inward FDI stocks)

	Ln(InternetUser/100Phoneline)			Ln(InternetUser/ 100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Inward FDI stocks)$_{t-1}$	0.822***	0.825***	0.853***	0.827***	0.822***	0.921***
	(0.042)	(0.041)	(0.031)	(0.045)	(0.049)	(0.025)
Ln(Distance)	-0.111**	-0.128**	-0.100***	-0.130**	-0.133**	-0.104***
	(0.053)	(0.054)	(0.027)	(0.052)	(0.053)	(0.028)
Ln(Internet)	-0.031**	-0.099	-0.577***	-0.016	0.064	-0.045
	(0.016)	(0.099)	(0.191)	(0.015)	(0.107)	(0.086)
Ln(TradeFlows)	0.052*	0.051*	0.040*	0.045*	0.046*	0.03
	(0.027)	(0.027)	(0.024)	(0.027)	(0.027)	(0.022)
Ln(GNI/Capita)	0.074*	0.072*	0.011	0.094*	0.099*	0.015
	(0.042)	(0.042)	(0.024)	(0.053)	(0.055)	(0.026)
Ln(Internet)*Ln(Distance)		0.008			-0.01	
		(0.012)			(0.013)	
Ln(Internet)*Ln(Inward FDI stocks)$_{t-1}$			0.027***			0.002
			(0.009)			(0.004)
Hansen	0.20	0.17	0.38	0.290	0.290	0.420
m1	-4.12	-4.13	-4.03	-4.140	-4.110	-4.270
m1p	0.00	0.00	0.00	0.000	0.000	0.000
m2	-1.22	-1.22	-0.38	-1.100	-1.100	-0.880
m2p	0.22	0.22	0.70	0.270	0.270	0.380
Observations	737	737	737	737	737	737
Number of countries	106	106	106	106	106	106

Time dummies are included in all equations.

Robust standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level. Time dummies are not displayed to save space.

Table 2.10. The system GMM estimator for the full sample of countries

Dependent variable: Ln(Inward FDI stocks)

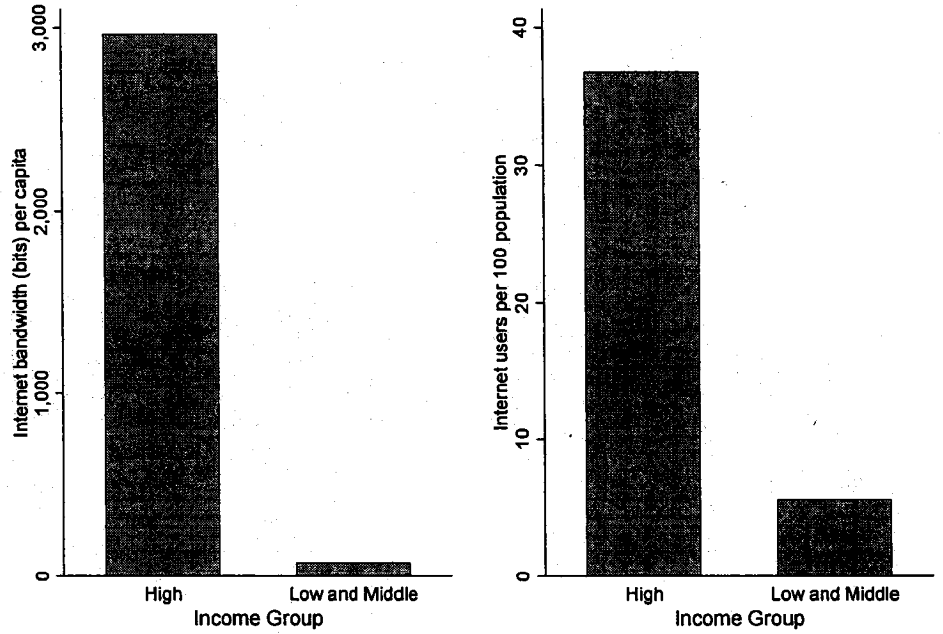
	Ln(InternetUser/100Phoneline)			Ln(InternetUser/100Population)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Inward FDI stocks)$_{t-1}$	0.806***	0.817***	0.860***	0.804***	0.803***	0.920***
	(0.043)	(0.041)	(0.028)	(0.046)	(0.051)	(0.022)
Ln(Distance)	-0.126***	-0.128**	-0.083***	-0.133***	-0.133**	-0.075***
	(0.041)	(0.056)	(0.022)	(0.041)	(0.057)	(0.023)
Ln(Internet)	-0.022	-0.096	-0.579***	-0.018	0.083	(0.052)
	(0.016)	(0.100)	(0.186)	(0.014)	(0.114)	(0.087)
Ln(TradeFlows)	0.056**	0.054**	0.045**	0.052*	0.054**	0.037*
	(0.027)	(0.026)	(0.023)	(0.027)	(0.027)	(0.020)
Ln(GNI/Capita)	0.086**	0.081*	0.007	0.112**	0.116**	0.020
	(0.042)	(0.044)	(0.023)	(0.051)	(0.056)	(0.024)
Ln(Internet)*Ln(Distance)		0.009			-0.012	
		(0.012)			(0.014)	
Ln(Internet)*Ln(Inward FDI stocks)$_{t-1}$			0.027***			0.002
			(0.009)			(0.004)
IncomeGroup	-0.357**	0.946	0.347	-0.300**	0.854	0.656
	(0.145)	(1.107)	(0.499)	(0.123)	(1.049)	(0.549)
IncomeGroup*Ln(Internet)	0.103***	-0.204	0.233	0.099***	-0.431	0.001
	(0.033)	(0.224)	(0.177)	(0.035)	(0.279)	(0.160)
IncomeGroup*Ln(Distance)		-0.170			-0.150	
		(0.149)			(0.141)	
IncomeGroup*Ln(Internet)*Ln(Distance)		0.040			0.068*	
		(0.029)			(0.036)	
IncomeGroup* Ln(Inward FDI stocks)$_{t-1}$			-0.065			-0.116
			(0.064)			(0.072)
IncomeGroup*Ln(Internet)*Ln(Inward FDI stocks)$_{t-1}$			-0.010			0.003
			(0.008)			(0.007)
Hansen	0.150	0.130	0.430	0.160	0.140	0.680
m1	-4.770	-4.740	-4.910	-4.740	-4.580	-5.120
m1p	0.000	0.000	0.000	0.000	0.000	0.000
m2	-0.500	-0.490	0.140	-0.480	-0.430	-0.350
m2p	0.610	0.620	0.890	0.630	0.670	0.730
Observations	941	941	941	941	941	941
Number of countries	136	136	136	136	136	136

Time dummies are included in all equations.

Robust standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

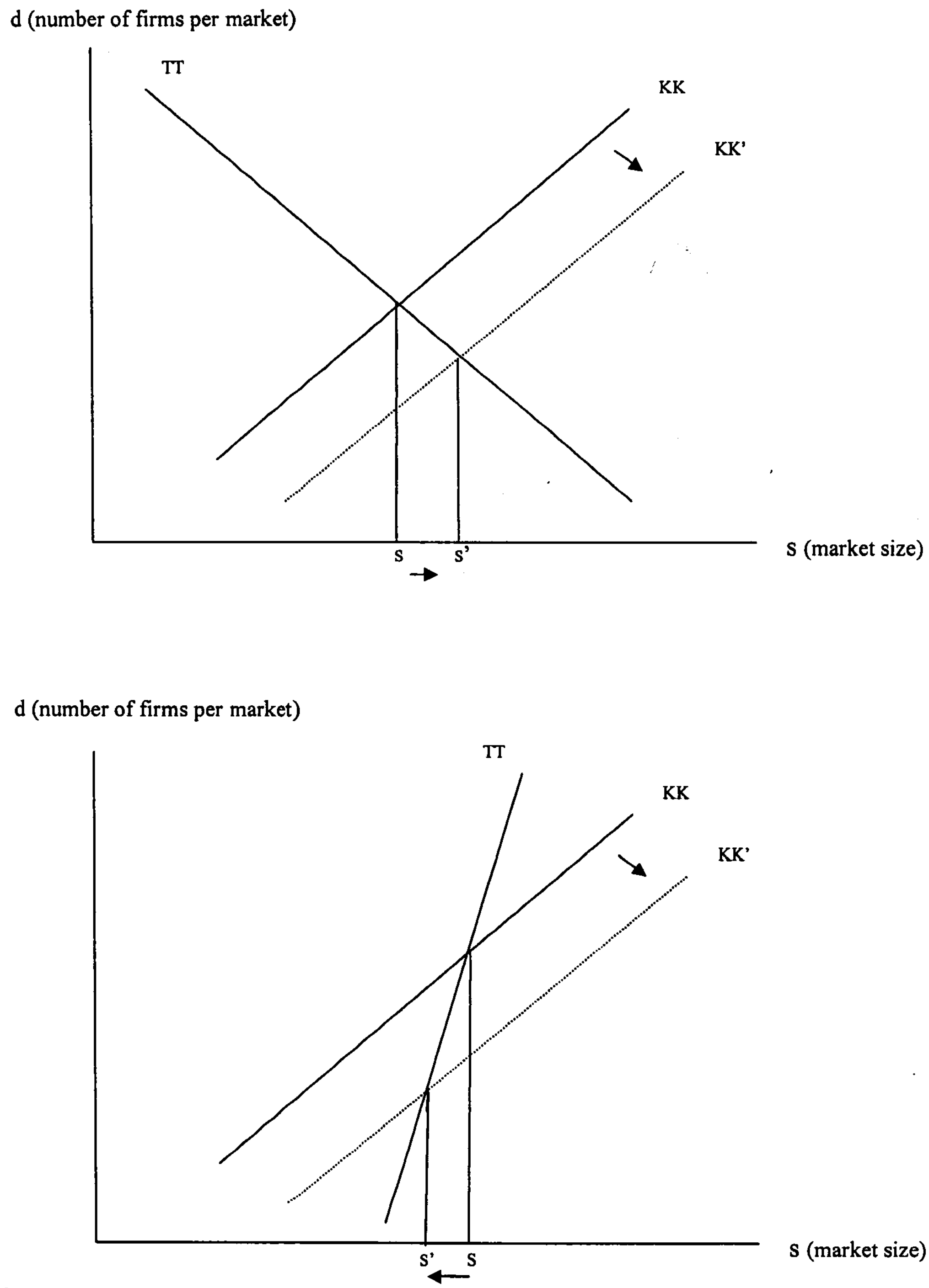
Figures

Figure 2.1. Digital Divide between developed and developing countries (in 2002)



Data Source: International Telecommunication Union's Digital Access Index, 2002

Figure 2.2. S-d plane – market equilibrium



Source: Based on Harris (1995)

Appendices

Appendix 2.1. Data

List of sample countries

Country	Income Group	Country	Income Group
Antigua and Barbuda	High	Panama	Upper middle
Australia	High	Seychelles	Upper middle
Austria	High	Slovak Republic	Upper middle
Bahamas, The	High	St. Kitts and Nevis	Upper middle
Barbados	High	Uruguay	Upper middle
Canada	High	Albania	Lower middle
Cyprus	High	Algeria	Lower middle
Denmark	High	Armenia	Lower middle
Finland	High	Belarus	Lower middle
France	High	Bolivia	Lower middle
Germany	High	Brazil	Lower middle
Greece	High	Bulgaria	Lower middle
Hong Kong, China	High	Cape Verde	Lower middle
Iceland	High	China	Lower middle
Ireland	High	Colombia	Lower middle
Israel	High	Djibouti	Lower middle
Italy	High	Dominican Republic	Lower middle
Korea, Rep.	High	Ecuador	Lower middle
Macao, China	High	Egypt, Arab Rep.	Lower middle
Malta	High	El Salvador	Lower middle
Netherlands	High	Fiji	Lower middle
New Caledonia	High	Guatemala	Lower middle
New Zealand	High	Guyana	Lower middle
Norway	High	Honduras	Lower middle
Portugal	High	Jamaica	Lower middle
Singapore	High	Jordan	Lower middle
Slovenia	High	Kazakhstan	Lower middle
Spain	High	Kiribati	Lower middle
Sweden	High	Macedonia, FYR	Lower middle
Switzerland	High	Morocco	Lower middle
Argentina	Upper middle	Paraguay	Lower middle
Belize	Upper middle	Peru	Lower middle
Chile	Upper middle	Philippines	Lower middle
Costa Rica	Upper middle	Romania	Lower middle
Croatia	Upper middle	Russian Federation	Lower middle
Czech Republic	Upper middle	Samoa	Lower middle
Dominica	Upper middle	Sri Lanka	Lower middle
Estonia	Upper middle	St. Vincent and the Grenadines	Lower middle
Hungary	Upper middle	Thailand	Lower middle
Latvia	Upper middle	Tonga	Lower middle
Lebanon	Upper middle	Tunisia	Lower middle

Country	Income Group	Country	Income Group
Lithuania	Upper middle	Turkey	Lower middle
Malaysia	Upper middle	Turkmenistan	Lower middle
Mauritius	Upper middle	Ukraine	Lower middle
Mexico	Upper middle	Vanuatu	Lower middle
Angola	Low	Lao PDR	Low
Azerbaijan	Low	Madagascar	Low
Bangladesh	Low	Malawi	Low
Benin	Low	Mali	Low
Burkina Faso	Low	Mauritania	Low
Cambodia	Low	Moldova	Low
Cameroon	Low	Mongolia	Low
Central African Republic	Low	Mozambique	Low
Chad	Low	Nepal	Low
Congo, Dem. Rep.	Low	Nicaragua	Low
Cote d'Ivoire	Low	Niger	Low
Equatorial Guinea	Low	Pakistan	Low
Ethiopia	Low	Papua New Guinea	Low
Gambia, The	Low	Rwanda	Low
Georgia	Low	Senegal	Low
Ghana	Low	Solomon Islands	Low
Guinea	Low	Tajikistan	Low
Guinea-Bissau	Low	Tanzania	Low
Haiti	Low	Uganda	Low
India	Low	Uzbekistan	Low
Indonesia	Low	Vietnam	Low
Kenya	Low	Zambia	Low
Kyrgyz Republic	Low	Zimbabwe	Low

Data Sources and Description

Variables	Description	Sources
Trade flows (in current US dollars)	Sum of imports to and exports from the United States, or the Kingdom or Japan	Direction of Trade Statistics, International Monetary Fund
Total Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin.	World Development Indicators
GNI per capita, Atlas method (current US$)	GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. To smooth fluctuations in prices and exchange rates, a special Atlas method of conversion is used by the World Bank.	World Development Indicators
Internet users	Internet users are people with access to the worldwide network.	Obtained from Global Market Information, World Bank and United Nations World Development Indicators. (Original Source: International Telecommunication Union)
Main telephone lines	A main line is a telephone line connecting the subscriber's terminal equipment to the public switched network and which has a dedicated port in the telephone exchange equipment.	International Telecommunication Union
Inward FDI stock (current US$)	Inward direction presents a non-resident direct investment in the reporting economy. FDI stock is the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise, plus the net indebtedness of affiliates to the parent enterprises.	United Nations Conference on Trade and Development (UNCTAD).
Distance (km)	Great circle distance from capital city of the host country to Washington D.C, or London or Tokyo.	Downloaded from: http://www.wcrl.ars.usda.gov/cec/java/lat-long.htm

Summary Statistics (1995-2002)

Variables	Countries	Mean	Std. Dev.	Min	Max
Full Sample					
Inward FDI stocks	136	23,400,000,000	58,200,000,000	3,625,000	332,000,000,000
Ln (Inward FDI stocks)	136	21.47	2.32	14.98	26.48
InternetUser/ 100Population	136	5.46	8.52	0.01	41.34
Ln(InternetUser/100Population)	136	-0.62	-2.28	-6.67	3.55
InternetUser/100Phoneline	136	22.00	14.64	0.96	74.93
Ln(InternetUser/100Phoneline)	136	2.07	0.94	-0.40	4.00
Distance	136	4,084.51	2,300.49	342.40	9,728.66
Ln(Distance)	136	8.12	0.69	5.84	9.18
(FDI/Capita)1994	136	1,249.69	3,756.88	1.51	36,898.63
Ln(FDI/Capita)1994	136	5.03	2.24	0.41	10.52
Trade Flows	136	9,410,000,000	36,300,000,000	2,445,084	344,000,000,000
Ln(Trade Flows)	136	19.96	2.65	14.67	26.56
GNI/Capita	136	5,576.09	8,611.82	100.00	40,221.25
Ln(GNI/Capita)	136	7.49	1.56	4.58	10.60
Low and Middle Income Group					
Inward FDI stocks	106	9,590,000,000	32,800,000,000	3,625,000	288,000,000,000
Ln (Inward FDI stocks)	106	20.88	1.99	14.98	26.32
InternetUser/100Population	106	1.88	2.72	0.01	16.27
Ln(InternetUser/100Population)	106	-1.44	-1.86	-6.67	2.42
InternetUser/100Phoneline	106	18.79	12.91	0.96	74.93
Ln(InternetUser/100Phoneline)	106	1.82	0.84	-0.40	3.49
Distance	106	4,550.75	2,105.85	1,035.78	9,728.66
Ln(Distance)	106	8.30	0.52	6.94	9.18
(FDI/Capita)1994	106	299.77	705.16	1.51	5,439.02
Ln(FDI/Capita)1994	106	4.24	1.82	0.41	8.60
Trade Flows	106	4,580,000,000	22,300,000,000	2,445,084	215,000,000,000
Ln(Trade Flows)	106	19.27	2.38	14.67	26.06
GNI/Capita	106	1,576.80	1,608.64	100.00	7,360.00
Ln(GNI/Capita)	106	6.84	1.06	4.58	8.89

Variables	Countries	Mean	Std. Dev.	Min	Max
High Income Group					
Inward FDI stocks	30	72,000,000,000	93,500,000,000	127,000,000	332,000,000,000
Ln (Inward FDI stocks)	30	23.56	2.23	18.65	26.48
InternetUser/100Population	30	18.12	9.92	3.22	41.34
Ln(InternetUser/100Population)	30	2.26	0.85	0.10	3.55
InternetUser/100Phoneline	30	33.36	14.95	6.85	62.90
Ln(InternetUser/100Phoneline)	30	2.96	0.71	0.95	4.00
Distance	30	2,437.10	2,231.10	342.40	9,265.14
Ln(Distance)	30	7.46	0.84	5.84	9.13
(FDI/Capita)1994	30	4,606.07	6,996.52	184.51	36,898.63
Ln(FDI/Capita)1994	30	7.80	1.12	5.22	10.52
Trade Flows	30	26,500,000,000	62,900,000,000	109,000,000	344,000,000,000
Ln(Trade Flows)	30	22.39	2.09	18.50	26.56
GNI/Capita	30	19,706.95	8,416.98	8,206.25	40,221.25
Ln(GNI/Capita)	30	9.79	0.45	9.01	10.60

Partial correlation between variables (full sample)

	Ln (Inward FDI stocks)	Ln Internet User/ 100Population	Ln(InternetUser/ 100Phoneline)	Ln(Distance)	Ln(FDI/ Capita)$_{1994}$	Ln(Trade Flows)	Ln(GNI/ Capita)
Ln (Inward FDI stocks)	1						
Ln(InternetUser/ 100Population)	0.5041*	1					
Ln(Internet User/100Phoneline)	0.2861*	0.7781*	1				
Ln(Distance)	-0.4499*	-0.4271*	-0.1028*	1			
Ln(FDI/Capita) 1994	0.5671*	0.6265*	0.3237*	-0.3713*	1		
Ln(Trade Flows)	0.8694*	0.5018*	0.2209*	-0.4509*	0.5542*	1	
Ln(GNI/ Capita)	0.6004*	0.7570*	0.3042*	-0.5635*	0.8323*	0.6567*	1

*denotes statistically significant at the one percent level.

Appendix 2.2. System GMM Estimator

The dynamic panel model (2.30) can be expressed in the following general form

$$y_{it} = \delta y_{it-1} + x'_{it}\beta + \theta Z_i + u_{it}, \quad i = 1, \ldots, N; \; t = 2, \ldots, 8 \qquad (2.31)$$

where δ is a scalar, x'_{it} is a vector of independent variables, Z_i is a time invariant variable (i.e., distance), t = 2, …, 8 denotes the years from 1996 to 2002, and the error term, u_{it} is the sum of fixed country effects (μ_i) and disturbance (v_{it}), i.e., $u_{it} = \mu_i + v_{it}$. Since y_{it} is a function of μ_i, the lagged dependent variable y_{it-1} on the right hand side of (2.31) is also a function of μ_i. Therefore, y_{it-1} is correlated with the error term u_{it}.

Instrumental variables in the first differenced equations

Following Arellano and Bond (1991), the first differencing of (2.31) yields:

$$\Delta y_{it} = \delta \Delta y_{it-1} + \Delta x'_{it}\beta + \Delta v_{it}, \quad i = 1, \ldots, N; \; t = 3, \ldots, 8 \qquad (2.32)$$

where t = 3, …, 8 denotes the years from 1997 to 2002. (2.32) not only removes μ_i, but also the time-invariant distance variable. However, the regressors ($\Delta y_{it-1} = y_{it-1} - y_{it-2}$) in the transformed equation are potentially correlated with the error terms (Δv_{it}), so that instrumental variables for Δy_{it-1} have to be used. The error terms are assumed to be independent across countries and serially uncorrelated:

$$E(v_{it}v_{is}) = 0 \quad for \; s \neq t \qquad (2.33)$$

Further, the initial condition y_{i1} is assumed to be predetermined. That is, y_{i1} is uncorrelated with the subsequent error term:

$$E(y_{i1}v_{it}) = 0 \quad for \; t \geq 2 \qquad (2.34)$$

In addition, y_{it} lagged by two periods (y_{it-2}) or more satisfying the condition:

$$E(y_{it-s}\Delta v_{it}) = 0 \quad for \; t = 3, \ldots, T \; and \; s \geq 2 \qquad (2.35)$$

would be valid instruments for Δy_{it-1}.

The choice of instrumental variables for the explanatory variables Δx_{it} in (2.32) depends on the assumptions of the correlations between x_{it} and the two components of the error term (μ_i and v_{it}) in (2.31).

x_{it} is assumed to be correlated with μ_i, but have different correlation relationships between x_{it} and v_{it}. If x_{it} is strictly exogenous in the sense that x_{it} is uncorrelated with all past, present and future realizations of v_{it}. In this case,

$$E(x_{it}v_{is}) = 0 \quad \textit{for all } s,t = 1,2,\ \ldots,\ T \tag{2.36}$$

Therefore, all the x_{it} are valid instruments. Also, Δx_{it} can serve as its own instrument in the differenced equation, as suggested in Arellano and Bond (1991). That is,

$$E(\Delta x_{it-s}v_{it}) = 0 \quad \textit{for all } t = 3,\ \ldots,\ T \textit{ and all } s \tag{2.37}$$

If x_{it} is predetermined in the sense that x_{it} is uncorrelated with v_{it}, but x_{it} is correlated with v_{it-1} and earlier shocks. In this case,

$$E(x_{it}v_{is}) \neq 0 \ \textit{for all } s < t \textit{ and zero otherwise,} \tag{2.38}$$

so x_{it} lagged by one period (x_{it-1}) or more can be valid instruments in the first-differenced equation. If x_{it} is strictly endogenous, x_{it} is correlated with v_{it} and earlier shocks. In this case,

$$E(x_{it}v_{is}) \neq 0 \quad \textit{for all } s \leq t \textit{ and zero otherwise} \tag{2.39}$$

so x_{it} lagged by two periods (x_{it-2}) or more would be valid instruments in the first-differenced equation.

The first-differenced GMM estimator is obtained by using the above moment conditions. However, the first-differenced estimator eliminates the distance variable, which is the parameter of interest. In addition, Arellano and Bond (1998b) suggest that the SYS-GMM estimator, which combines the additional moment conditions in the levels equations, and the set of moment conditions specified in the first-differenced equations, would be more efficient than the first-differenced GMM estimator.

Instrumental variables in the level equations

In what follows, the moment conditions in the untransformed levels equation (2.31) are discussed. x_{it} is assumed to be uncorrelated with the unobserved individual effects (μ_i), but has different correlation relationships with v_{it}. If x_{it} is either predetermined or strictly exogenous with respect to v_{it}, x_{it} becomes its own instrument for all periods in the level equations, since,

$$\begin{aligned} &E(x_{it}(\mu_i + v_{it})] = 0 \quad \textit{for } i = 1, \ldots, N \textit{ and } t = 2, \ldots, T, \\ &\textit{and } E(x_{i1}(\mu_i + v_{i2})] = 0 \quad \textit{for } i = 1, \ldots, N \end{aligned} \tag{2.40}$$

If x_{it} is endogenous with respect to v_{it}, x_{it-1} would be a valid instrument in the level equations. That is,

$$E(x_{it-1}(\mu_i + v_{it})] = 0 \quad \textit{for } i = 1, \ldots, N \textit{ and } t = 2, \ldots, T \tag{2.41}$$

Now, x_{it} is assumed to be correlated with μ_i, but Δx_{it} is assumed to be uncorrelated with μ_i. If x_{it} is endogenous with respect to v_{it}, Δx_{it-1} would be a valid instrument in the level equations, since,

$$E(\Delta x_{it-1} v_{it}) = 0 \quad t = 2, \ldots, T \tag{2.42}$$

If x_{it} is exogenous or predetermined with respect to v_{it}, Δx_{it} would be a valid instrument in the level equations, i.e.,

$$E(\Delta x_{it} v_{it}) = 0 \quad t = 2, \ldots, T \tag{2.43}$$

If x_{it} is endogenous, then Δx_{it-1} can be used as an instrument in the level equations.

Furthermore, the lagged differences of y_{it}, Δy_{it-1} (for t = 3,...,T), can be a valid instrument for the lagged dependent variable y_{it-1} in the levels equations provided that the initial condition satisfies

$$E(\Delta y_{i2}\mu_i) = 0 \quad i = 1, \ldots, N \tag{2.44}$$

Bond (2002) highlights the significance of the moment condition (2.44) because the lagged levels of the series are poor instruments for the first-differenced equations when the time series of y_{it} are highly persistent or close to a random walk.

The system GMM estimator is calculated using the above moment conditions for the first-differenced equations as well as the level equations based on a stacked system comprising all (T-2) equations in first differences and the (T-2) equations in levels corresponding to periods t = 3,...T.

Chapter 3 Financial Integration, Information and Communication Technology, and Macroeconomic Volatility: Evidence from Ten Asian Economies

Abstract

Developments in information and communication technology (ICT) are one of the main forces underlying the expansion and integration of international financial markets. However, the huge increase in the turnover of capital flows also has raised concerns about macroeconomic stability. This paper looks at ten Asian economies—China, Hong Kong, India, Korea, Malaysia, Pakistan, the Philippines, Singapore, Taiwan, and Thailand—committed to ICT development and financial integration and presents evidence on whether or not they have experienced greater output fluctuations from 1980 to 2003.

The relationship among financial integration, ICT, and output volatility are studied using a two-country dynamic general equilibrium model. An advance in ICT lowers the transaction costs of trading foreign bonds and so enhances finance integration. This model predicts that high (low) financial market integration led by high (low) ICT development tends to increase (reduce) output volatility in the face of a monetary shock, but to reduce (increase) output volatility in the face of a fiscal shock.

Empirically, an ICT index is constructed to measure the level of the availability and quality of the ICT infrastructure within a country. Based on this index, ten Asian economies are split into two groups—high ICT development and low ICT development. Using the panel vector autoregression approach and the impulse response analysis, this

study finds that, for the high (low) ICT group, the output responses to a monetary shock are higher (lower) while the output responses to a fiscal shock are lower (higher).

3.1 Introduction

During the last two decades, the financial markets of Asian economies have become increasingly integrated with international financial markets through capital flows. The surge in capital flows to Asian economies is due not only to changes in their policies, such as the liberalization of these flows and opening up of stock markets, but also to the developments in information and communication technology (ICT). In the present study, financial integration refers to cross-border capital flows, and output volatility refers to short term output fluctuations.

As shown in Figure 3.1[1], gross foreign direct investment (FDI) flows increase for ten Asian economies—China, Hong Kong, India, Korea, Malaysia, Pakistan, the Philippines, Singapore, Taiwan, and Thailand—from 1980 to 2000. This trend is accompanied by an increase in trade in telecommunication equipment or telecommunication investment, both of which reflect an advance in ICT. Within the same period, the average annual growth rate of gross FDI flows, trade in telecommunication equipment and telecommunication investment are 19%, 17% and 16% respectively.

Table 3.1 reports the overall mean value of output volatility, as measured by the standard deviation of real GDP[2], for the sample countries. It decreased slightly from 3.88% in the first period (1980-1985) to 3.67% in the second one (1986-1991) and then increased to 4.40% in the third one (1992-1997). It further increased to 5.63% in the fourth period (1998-2003), and this large rise probably is due to the Asian currency crisis

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[1] The definitions of these variables are discussed in Section 3.4.1.2 and Appendix 3.3.
[2] They are logged and then detrended using a band-pass (2,8) filter.

of 1997. Even if the fourth period is excluded, all individual economies except Hong Kong, Taiwan, and the Philippines still display higher output volatilities in the third period than in the first one. The increase in volatility prompts a question: are these output fluctuations associated with an advance in ICT and financial integration?

This question is important for three reasons. First, financial liberalization is widely believed to be an underlying source of the banking and currency crises in the 1990s (i.e., Stiglitz (2002, p.99)). It follows that financial integration is expected to increase short term output fluctuations. Recent empirical studies, such as Easterly, Islam and Stiglitz (2001), Buch, Döpke and Pierdzioch (2002), and Bakaert, Harvey and Lundblad (2004), do not find a statistically significant link of this relationship, whereas O'Donnell (as cited in Kose, Prasad, Rogoff and Wei, 2003) finds that a higher degree of financial integration is associated with lower (higher) output volatility in OECD (non-OECD) countries. However, the empirical evidence of the impact of financial integration on macroeconomic volatility is rather sparse and inconclusive, as noted in Kose, Prasad, Rogoff and Wei (2003).

Second, many authors, such as Eichengreen, Mussa and et al. (1998) and Dailami and ul Haque (1999) acknowledge the extraordinary effect of ICT on the volume of international financial transactions. With ICT, financial institutions not only expand their financial services worldwide, but also provide them at low costs. Claessens, Glaessner and Klingebiel (2002) point out that many new trading systems and electronic communication networks have been set up in industrial and emerging markets, allowing global securities trading. For instance, Phillip's On-line Electronic Mart System (POEMS), a Singapore based non-bank online broker, offers online trading on other regional exchanges, such as Singapore, Kuala Lumpur, and Hong Kong. According to Claessens, Glaessner and Klingebiel (2002), the marginal costs for banking transactions are much lower than those of traditional delivery channels—US$1 at bank branches compared to US$0.5 at automated teller machines. The costs of delivering bank services are further reduced through the use of online transactions, and the costs of online brokerage are just 25 percent of traditional costs. Despite the important role of ICT development in financial integration, studies related to this topic are limited.

Third, policymakers are concerned with the benefits and the risks of financial integration, since it brings potentially large gains such as portfolio risk diversification, consumption smoothing through borrowing, and economic growth through improving the efficiency of financial intermediaries. Potentially significant costs exist as well, in particular, macroeconomic instability, which is detrimental to economic growth (Ramey and Ramey, 1995) and human capital accumulation (Easterly, Islam and Stiglitz, 2001).

The objective of this paper is to study the combined impact of ICT development and financial integration on output volatility in the sample of ten Asian economies from 1980 to 2003. This study contributes to recent studies on the linkage between financial integration and output volatility in two aspects. First, it highlights the role of ICT development in enhancing financial integration. This paper adopts Sutherland's (1996a)[3] theoretical model, in which an advance in ICT implies a decline in transaction costs for trading foreign bonds, and thus a greater degree of financial integration. Also, this paper is the only empirical study to have examined the combined effects of ICT development and financial integration on output volatility.

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[3] Sutherland (1996a) is a revised version of Sutherland (1996b).

The second way this study contributes to recent studies on the linkage between financial integration and output volatility is to highlight the effects of policy shocks on output volatility, as in Buch, Dopke and Pierdzioch (2002). Unlike Buch, Döpke and Pierdzioch (2002) who use Granger causality test and panel regression, this study employs panel vector autoregression (PVAR) approach and impulse response analysis.

In sum, at the theoretical level, this study extends Sutherland's (1996a) two-country dynamic general equilibrium model by introducing physical capital into the production function and budget constraint. However, these modifications do not affect Sutherland's (1996a) predictions that increasing financial market integration tends to increase output volatility in the case of a monetary shock, and decrease output volatility in the case of a government spending shock. Further, ICT is assumed to promote the volume and speed of capital flows in this study's model. Empirically, this study provides evidence that economies with high (low) ICT development exhibit higher (lower) output fluctuations in the face of a monetary shock and lower (higher) output fluctuations in the face of a fiscal shock.

This paper is organized as follows. Section 2 reviews selected theoretical and empirical studies that are related to this study. Section 3 presents the two-country dynamic general equilibrium model and the simulation results. Section 4 discusses the data and the estimation results. Section 5 concludes.

3.2 Selective Review of Theoretical and Empirical Literature

3.2.1 Theory

This study's theoretical framework is closely related to the works of Obstfeld and Rogoff (1995), Sutherland (1996a, 1996b) and Buch, Dopke, and Pierdzioch (2002, 2003). The model developed by Obstfeld and Rogoff (1995) is often considered to be a workhorse model, which stimulates further generalizations and refinements in subsequent work for new open economy macroeconomics analysis. Lane (2001) and Sarno (2001) provide extensive reviews of the new open economy macroeconomics literature. This class of theories is characterized by introducing nominal rigidities and market imperfections into a dynamic general dynamic equilibrium model with well specified microfoundations (Lane, 2001, and Mark, 2001).

Obstfeld and Rogoff (1995) develop a two-country general equilibrium model, which involves the microfoundations for intertemporal choice, a monopolistic supply sector and price rigidities. Prices are predetermined; that is, they are set a period in advance but can be adjusted fully after one period. The only internationally traded asset is a riskless real bond, denominated in the consumption good. Each agent decides her optimal choices of consumption, money holdings, bond holdings and output. Their model shows that in the presence of nominal rigidities, a monetary shock has real effects. A permanent increase in the money supply, for instance, would lead to a permanent increase in consumption.

In order to study whether financial market integration leads to a greater volatility of economic variables, Sutherland (1996a, 1996b) makes two modifications to the model of Obstfeld and Rogoff (1995). First, unlike the Obstfeld and Rogoff model, which assumes a fully integrated world financial market (i.e., domestic and foreign bonds are perfect substitutes), Sutherland allows imperfect financial market integration. The convex adjustment costs involved in the purchase of foreign bonds is considered to be a form of trading friction across international financial markets. Second, goods prices are subject to multi-period adjustment. In Sutherland (1996a, 1996b), the simulation results show that in the event of a domestic monetary policy shock, financial market integration increases output volatility. Conversely, in the case of a fiscal policy shock, financial market integration reduces output volatility. These finding will be discussed at full length in Section 3.3.

Buch, Döpke and Pierdzioch (2002) modify the model of Sutherland (1996a) by incorporating habit formation into the consumption function, adding a stochastic risk premium shock in financial markets, and using a richer specification of the policy functions. As in Sutherland (1996a, 1996b), the simulation results reported in Buch, Döpke and Pierdzioch (2002) show that high capital mobility tends to magnify the effects of a domestic monetary shock on output volatility, but tends to cushion the effects of a domestic government spending shock on output volatility.

Buch and Pierdzioch (2003) further extend the Sutherland (1996a, 1996b) model by introducing the domestic credit market and a financial accelerator mechanism. Their model has three new features. First, agents hold deposits in addition to bonds. Second, production is made up of three types of firms: entrepreneurs using physical capital and labor to produce wholesale goods; capital producers using a production technology to produce capital goods; and retailers buying the wholesale goods and then selling it as differentiated goods. Third, financial intermediaries collect deposits from agents and make loans to entrepreneurs. Entrepreneurs have to pay an external finance premium (i.e., the costs of external funds minus the opportunity costs of internal funds) when taking loans from financial intermediaries. The financial accelerator mechanism works in the following manner. In the event of a monetary shock, i.e., higher real interest rate, investment declines and the price of capital decreases, the latter of which worsens the entrepreneur's balance sheets and increases the external finance premium for loans. Therefore, the demand for investment goods and the net worth of entrepreneurs decrease. In Buch and Pierdzioch (2003), the simulation results show that in the presence of credit markets and the financial accelerator mechanism, business cycle volatility is only slightly higher in the case of high capital mobility than in the case of low capital mobility. Their empirical findings also suggest that financial openness has a small impact on output volatility.

3.2.2 Empirical Studies

So far, no empirical research has been done on the role of ICT in financial integration. The studies reviewed below discuss three issues on the complex relationship between financial integration and output volatility.

First, the link between financial openness and macroeconomic volatility depends upon the nature of the shocks. Buch, Döpke and Pierdzioch (2002) use data for 24 OECD countries over the years from 1960 to 2000. Using the Anderson-Hsiao estimator, the Granger causality tests do not indicate any statistical significant relationship running from the volatility of short term interest rate to output volatility, or from government spending volatility to output volatility. However, the panel regressions provide evidence that in financially more open economies, monetary policy shocks increase output volatility, while government spending shocks diminish output fluctuations. The former is statistically significant but the latter is statistically insignificant.

Second, the relationship between financial openness and macroeconomic volatility is nonlinear. Kose, Prasad and Terrones (2003) study 21 industrial and 55 developing countries over the period 1960-1999, and find that the relationship between financial openness and consumption volatility is nonlinear. That is, increasing financial openness is associated with rising volatility of consumption, but only up to a certain threshold. However, the nonlinear relationship between volatility of output growth and financial openness is statistically insignificant.

Third, well-established financial markets and financial institutions help reduce output volatility. Easterly, Islam and Stiglitz (2001) find that a higher level of financial development, which efficiently matches savers and investors, is associated with lower volatility in growth of GDP per capita. Deinzer, Iyigun and Owen (2002) show that countries with more developed financial sectors experience smaller fluctuations in output, consumption, and investment growth. Buch and Pierdzioch (2003) find that larger credit markets are associated with lower volatility of growth of real GNP, but this result is statistically significant only in developed countries.

3.3 A Two-Country Dynamic General Equilibrium Model

This study introduces physical capital into Sutherland's (1996a) model. On the demand side, agents have an additional source of income from renting physical capital. On the supply side, by including physical capital, the production function becomes more realistic.

3.3.1 The Model Setup

The world is comprised of two countries—Home and Foreign—which are populated by a continuum of agents. In each country, there exists a government, firms and consumers. Agents consume goods, supply labor, and rent physical capital to firms. Each firm uses labor and capital to produce a single differentiated good, which is indexed by z on the unit interval, i.e., $z \in [0, 1]$. The Home country consists of producers on the interval [0, n] and the remaining (n, 1] reside in the Foreign country. It is assumed that the population size of each country is constant and both countries are of equal population size, i.e., n = ½.

Mainly, this study's discussion focuses on the model for the Home country. The conditions for the Foreign country are analogously defined in all cases, except those that are explicitly derived. The Foreign variables are indicated by a star.

Households

All agents are identical and the population size of each country is normalized to one, so that national aggregates and per capita quantity variables are the same.[4] The Home representative agent's intertemporal utility function is additively separable over time. It is given by[5]:

$$U_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma - 1} C_s^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{1}{2} N_s^2 \right] \tag{3.1}$$

where E denotes expectation conditional on all the available information in period t, C a basket of differentiated goods, N the labor supply, M nominal money holdings, and P the general price index. The agent derives utility from holding real money balances (M/P)[6] for their liquidity services. The work effort ($\frac{1}{2}N^2$) generates disutility. The parameter β (0 < β < 1) denotes the Home agent's subjective discount rate which measures the value of

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[4] As noted in Obstfeld and Rogoff (1996, p. 3), this assumed demographics simplify the notation by making the representative individual's first-order conditions describe aggregate dynamic behavior.
[5] All agents are assumed to have the same utility preferences and the same budget constraints, so that the indices to distinguish different agents are dropped for simplicity of notation.
[6] It is assumed that the Home agent does not receive any liquidity benefit from holding Foreign currency, i.e., no currency substitution. The same assumption is applied to the Foreign agent holding Home currency.

future consumption in terms of present consumption.[7] The intertemporal elasticity of substitution is denoted by σ (σ > 0), which measures the willingness of an agent to substitute the consumption across time in response to a change in the real interest rate.[8] The positive parameter χ governs the relative importance of real money balances in the utility function, and the positive parameter ε determines the elasticity of money demand. The utility function is identical for the Foreign representative agent.

C—the real consumption index—is a constant elasticity of substitution function that aggregates across different varieties of consumption goods (both domestic and foreign produced). It is defined as follows:

$$C_t = \left[\int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} \partial z \right]^{\frac{\theta}{\theta-1}}, \tag{3.2}$$

where c(z) is the Home agent's consumption of good z. The parameter θ (θ > 1) denotes the elasticity of substitution between different goods and also governs the monopolistic power of the price markup.[9]

This study assumes that the law of one price holds for each individual good,

$$p_t(z) = S_t p_t^*(z), \tag{3.3}$$

where p(z) is the Home price of good z, p*(z) is the foreign currency price of good z, and S is the nominal exchange rate (defined as the price of the Foreign currency in terms of the Home currency). This study also assumes that Home and Foreign goods markets are perfectly integrated, and firms set a single price for both markets. Goods indexed

[7] If the value of β is lower, an agent is more impatient and prefers to today's consumption.
[8] The lower is σ, the less an agent is willing to change consumption path in response to the change in real interest rate. In other words, she prefers to smooth consumption over time.
[9] Higher θ implies a higher elasticity of substitution betweena differentiated goods and lower monopolistic power of the price markup.

between 0 and 1/2 are made at Home, and goods indexed 1/2 and above are produced abroad. The general price index P for the Home country is:

$$P_t = \left[\int_0^1 p_t(z)^{1-\theta} \partial z \right]^{\frac{1}{1-\theta}} = \left[\int_0^{1/2} p_t(z)^{1-\theta} \partial z + \int_{1/2}^1 S_t p_t *(z)^{1-\theta} \partial z \right]^{\frac{1}{1-\theta}} \tag{3.4}$$

The price index P* for the Foreign country is written as:

$$P_t^* = \left[\int_0^1 p_t^*(z)^{1-\theta} \partial z \right]^{\frac{1}{1-\theta}} = \left[\int_0^{1/2} \frac{1}{S_t} p_t(z)^{1-\theta} \partial z + \int_{1/2}^1 p_t^*(z)^{1-\theta} \partial z \right]^{\frac{1}{1-\theta}} \tag{3.5}$$

Since preferences are identical across countries and the law of one price holds, purchasing power parity (PPP) holds:

$$P_t = S_t P_t^* \tag{3.6}$$

Financial Market Integration

The Home agent holds three forms of financial assets: domestic money, Home and Foreign bonds. The Home agent incurs no costs of trading Home bonds in the Home financial market, but needs to pay transaction costs for trading Foreign bonds in the Foreign financial market. The transaction costs of the purchase and sale of Foreign bonds are given by:

$$X_{F,t} = \frac{\psi_F}{2} I_{F,t}^2 \tag{3.7}$$

where ψ_F is a positive parameter and I_F is the level of funds transferred from the Home to the Foreign bond market in period t. Both $X_{F,t}$ and $I_{F,t}$ are denominated in terms of the composite consumption good. The convex form of transaction costs in (3.7) suggests that the transaction costs in foreign financial markets incur decreasing returns to scale. That is, the transaction costs of trading Foreign bonds increase by more than the increase in the size of the transactions.

Developments in ICT improve access to information on financial markets, enhance the speed of placing orders across countries, reduce the trading costs of financial assets, and increase the capacity of transferring information. For instance, DFNN.com is a Philippine-based financial e-commerce solutions provider. It provides free access to updated stock quotes, research reports, technical analysis charts, news headlines, market commentaries, and product information on various financial products and services, all of which promotes online trading and online banking (Claessens, Glaessner and Klingebiel, 2002). All these benefits of an advance in ICT are modeled as a reduction in the transaction costs of trading foreign financial assets by setting ψ_F at a low value. Similarly, financial liberalization measures imply a low value of ψ_F. The lower the transaction costs are, the higher the degree of financial market integration.

The evolution of Foreign bond holdings (F_t) is given by:

$$F_t = (1 + i^*_{t-1})F_{t-1} + P^*_t I_{F,t} \tag{3.8}$$

The Household's Maximization Problem

Physical capital is introduced into Sutherland's (1996a) model. All domestic physical capital is owned and accumulated by domestic individuals. A unit of capital (K) is created from a unit of the composite consumption good (C) and is constructed in the same manner as C. Therefore, the price of physical capital good is also measured in terms of the general price index (P_t).

The law of motion for physical capital is specified by:

$$K_{t+1} = (1 - \delta)K_t + I_{K,t} \tag{3.9}$$

where K_{t+1} is the stock of capital accumulated through the end of period t and $I_{k,t}$ is the gross capital investment. In each period, the agent invests in physical capital and rents the existing capital stock to the firms at $r_{K,t}$—the real rental rate per unit of capital[10]. Physical capital depreciates at the constant rate δ. The adjustment costs $X_{K,t}$ associated with physical capital accumulation is nonlinear:

$$X_{K,t} = \frac{\psi_K}{2} I_{K,t}^2 \tag{3.10}$$

where ψ_K is a positive parameter and X_K is denominated in terms of the composite consumption good.

The intertemporal budget constraint for each Home agent is written as:

$$\begin{aligned} &P_t C_t + P_t[K_{t+1} - (1-\delta)K_t] + P_t X_{K,t} + M_t + D_t + S_t F_t + P_t X_{F,t} + P_t T_t \\ &= (1+i_{t-1})D_{t-1} + S_t(1+i_{t-1}^*)F_{t-1} + P_t r_{K,t} K_t + W_t N_t + \pi_t + M_{t-1} \end{aligned} \tag{3.11}$$

where T stands for taxation, W is nominal wages, π is profits from the ownership of domestic firms[11], i_{t-1} is nominal Home interests for Home bonds (D_t) between t-1 and t, i_{t-1}* is nominal Foreign interests for Foreign bonds (F_{t-1}) (denominated in foreign currency) between t and t-1. M_{t-1} is the quantity of nominal balances that is accumulated in t-1. In this model, the Home nominal interest rate is given by the Fisher equation:

$$1 + i_t = E_t \frac{P_{t+1}}{P_t}(1 + r_t) \tag{3.12}$$

Maximizing (3.1) subject to the budget constraint (3.11) yields the following first-order conditions for C_t, M_t N_t, F_t, and K_{t+1} repsectively

[10] As in Hairault and Portier (1993), the real interest rate is given by $r_t = r_{K,t} - \delta$, where δ is the depreciation rate.

[11] All the firms are owned by the consumers within the country. The Home representative agent receives the share of the profits from all the firms. That is, $\pi = \int_0^{1/2} \pi(z)\partial z$.

$$C_{t+1} = \left[\beta E_t (1+i_t) \frac{P_t}{P_{t+1}} \right]^{\sigma} C_t \tag{3.13}$$

$$\chi \left(\frac{M_t}{P_t} \right)^{-\varepsilon} = C_t^{-1/\sigma} \frac{i_t}{1+i_t} \tag{3.14}$$

$$N_t = C_t^{-1/\sigma} \frac{W_t}{P_t} \tag{3.15}$$

$$(1+\psi_F I_{F,t})(1+i_t) = E_t \frac{S_{t+1}}{S_t}(1+i_t^*)(1+\psi_F I_{F,t+1}) \tag{3.16}$$

$$\frac{1}{\beta}\left[1+\psi_K \frac{(K_{t+1}-K_t)}{K_t}\right] C_t^{-\sigma} = E_t C_{t+1}^{-\sigma}\left[r_{K,t+1} + (1-\delta) + \frac{1}{2}\psi_k \frac{K_{t+2}^2 - K_{t+1}^2}{K_{t+1}^2}\right] \tag{3.17}$$

An analogous set of conditions hold for the Foreign country. (3.13) is the Euler consumption equation which determines the optimal intertemporal consumption path. A higher real interest rate r_t implies higher opportunity costs of current consumption, so that an agent tends to postpone consumption to the next period. (3.14) shows that the demand for real money balances is positively related to real consumption expenditures and negatively related to the nominal interest rate (i.e., the opportunity costs of holding money). (3.15) is the labor supply rule which equates the marginal disutility of labor to the marginal utility of the real wage. The labor supply function (3.15) also implies a unitary labor supply elasticity.[12] (3.16) describes the optimal allocation of Home and Foreign bonds. If Home and Foreign capital markets are perfectly integrated, Ψ_F will be zero, and (3.16) implies the uncovered interest parity condition. (3.17) determines the agent's investment in physical capital for which the consumption forgone today (left-

[12] Using (3.15), $\frac{\partial N_t}{\partial (W_t / P_t)} \frac{W_t / P_t}{N_t} = 1$. The value for this elasticity follows Christiano, Eichenbaum and Evans (1997) and Bergin and Tchakarov (2003).

hand side) must be equal to the gains in future consumption in terms of the increase in physical capital stocks and the receipt of real rental rate (right-hand side).

The individual demand for product z is:[13]

$$c_t(z) = \left(\frac{p_t(z)}{P_t}\right)^{-\theta} C_t \tag{3.18}$$

The Government

The real Home government consumption expenditure, G, is a composite of government consumptions of individual goods, g(z). It is constructed in the same manner as the composite consumption good (C):

$$G_t = \left[\int_0^1 g_t(z)^{\frac{\theta-1}{\theta}} \partial z\right]^{\frac{\theta}{\theta-1}} \tag{3.19}$$

The government runs balanced budget each period and its expenditure is financed by lump sum taxes and increases in the monetary supply:

$$P_t G_t = P_t T_t + M_t - M_{t-1} \tag{3.20}$$

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[13]It is obtained by minimizing the Home agent's expenditure. That is,

$$\min_{c_t(z)} \int_0^1 p_t(z) c_t(z) \partial z \text{ subject to } \left[\int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} \partial z\right]^{\frac{\theta-1}{\theta}} = C_t$$

The Lagrangian expression is:

$$L = \int_0^1 p_t(z) c_t(z) \partial z + \lambda_t \left\{\left[\int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} \partial z\right]^{\frac{\theta-1}{\theta}} - C_t\right\}$$

where λ is a multiplier. The resulting conditions are:

$$c_t(z) = C_t \left(\frac{p_t(z)}{\lambda}\right)^{-\theta}$$

Substitution of the above relation into the definition of composite good (3.2) gives:

$$\lambda_t = \left[\int_0^1 p_t(z)^{1-\theta} \partial z\right]^{\frac{1}{1-\theta}} = P_t$$

Therefore, $c_t(z) = C_t \left(\frac{p_t(z)}{P_t}\right)^{-\theta}$

An analogous budget constraint holds for the Foreign government.

Firms

Firms in the Home country rent physical capital (K) at the real rental rate (r_K) and hire labor (N) at the nominal wage rate (W). Each firm has the same production function, which is given by:

$$y_t^s(z) = A_t K_t(z)^{\alpha} N_t(z)^{1-\alpha} \tag{3.21}$$

where $y^s(z)$ denotes production of good z, A represents a technology shock common to all Home firms, and K(z) and N(z) are capital and labor input in the production of product z. Firms rent capital and hire labor in perfectly competitive factor markets. The labor markets in each country are assumed to be perfectly competitive and labor migration across countries is not allowed. The agent takes the real wage as given. All firms are assumed to face the same real wage for labor and real rental rate for capital. Firm z chooses capital and labor to minimize costs so that:

$$\begin{aligned} &Min \frac{W_t}{P_t} N_t(z) + r_{K,t} K_t(z) \\ &s.t.\ y_t^s(z) = A_t K_t(z)^{\alpha} N_t(z)^{1-\alpha} \end{aligned} \tag{3.22}$$

Setting up the Lagrangian and taking derivatives with respect to K_t and N_t, respectively, give:

$$\frac{1}{MC_t(z)} \frac{W_t}{P_t} = (1-\alpha) \frac{y_t^s(z)}{N_t(z)} \tag{3.23}$$

$$\frac{1}{MC_t(z)} r_{K,t} = \alpha \frac{y_t^s(z)}{K_t(z)} \tag{3.24}$$

where MC(z)[14] is the real marginal costs of production evaluated on the Home currency and is equal for all firms within the Home country.

Next, turning to price-setting behavior, this study follows Sutherland's (1996a) assumptions. First, firms set a unified price for Home and Foreign markets. In other words, the price for goods sold in the Foreign market is the price for goods sold in the Home market multiplied by the exchange rate. Second, firms adjust the price in the way of Calvo's (1983) random price staggering. In each period, a firm has probability γ of maintaining the current price level inherited from the previous period and probability $(1 - \gamma)$ of resetting its price to the new optimal level. These probabilities are the same for all firms in the country.

The Home firm z faces a downward sloping demand curve:

$$y_t^d(z) = \left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t \tag{3.25}$$

where Q is the world per capita consumption of Home goods. It is defined as:

$$\begin{aligned} Q_t &= n\{C_t + G_t + [K_{t+1} - (1-\delta)K_t] + X_{K,t} + X_{F,t}\} \\ &\quad + (1-n)\{C_t^* + G_t^* + [K_{t+1}^* - (1-\delta)K_t^*] + X_{K,t}^* + X_{F,t}^*\} \end{aligned} \tag{3.26}$$

Firm z's real profit is given by

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[14]Define $C_t = \frac{W_t}{P_t} N_t(z) + r_{K,t} K_t(z)$

The Lagrangian for this problem is :

$L = \frac{W_t}{P_t} N_t(z) + r_{K,t} K_t(z) + \lambda_t [y_t^s(z) - A_t K_t(z)^{\alpha} N_t(z)^{1-\alpha}]$

By applying the envelope theorem, we obtain

$\frac{\partial C_t^o}{\partial y_t^s} = \frac{\partial L}{\partial y_t^s} = \lambda_t$

where C_t^o is the indirect cost function. As seen from the above equation, the Lagrange multiplier (λ) can be interpreted as the marginal costs of production.

$$\frac{\pi_t(z)}{P_t} = \frac{p_t(z)}{P_t}\left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t - \frac{MC_t(z)}{P_t}\left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t \qquad (3.27)$$

In the presence of the price inertia, the price set in the current period has an impact on profits in future periods. The objective function of the firm is to choose the price level in period t so as to maximize the discounted value of current and future profits. Firm z's maximand is:

$$V_t(z) = E_t \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} \frac{\pi_s(z)}{P_s} \qquad (3.28)$$

where $R_{t,s}$ is the discount factor[15] between time t and time s. The first-order condition for firm z is

$$p_t(z)(\theta-1)\sum_{s=t}^{\infty}\gamma^{s-t}R_{t,s}\frac{Q_s}{P_s}\left(\frac{1}{P_s}\right)^{-\theta} = \theta\sum_{s=t}^{\infty}\gamma^{s-t}R_{t,s}\frac{Q_s}{P_s}\left(\frac{1}{P_s}\right)^{-\theta} MC_s \qquad (3.29)$$

The structure of the pricing setting behavior is that all Home firms which are allowed to change their prices in period t will all set their prices at p_t. More specifically, in period t, a proportion 1 - γ of Home firms is able to set domestic prices at p_t, a proportion (1-γ)γ has to keep prices unchanged at p_{t-1} as set in period t-1, a proportion $(1 - \gamma)^s\gamma$ keeps prices unchanged at p_{t-s} as set in period t-s, and so on. As a result, the sub-price index for Home goods in period t is defined as follows:

$$\begin{aligned} q_t &= \left[(1-\gamma)p_t^{1-\theta} + (1-\gamma)\gamma p_{t-1}^{1-\theta} + (1-\gamma)\gamma^2 p_{t-2}^{1-\theta} + \dots\right]^{\frac{1}{1-\theta}} \\ &= \left[(1-\gamma)\sum_{s=0}^{\infty}\gamma^s p_{t-s}^{1-\theta}\right]^{\frac{1}{1-\theta}} \end{aligned} \qquad (3.30)$$

[15] $R_{t,s} = \left(\frac{1}{1+r_t}\right)\left(\frac{1}{1+r_{t+1}}\right)\left(\frac{1}{1+r_{t+2}}\right) + \dots + \left(\frac{1}{1+r_{t+s}}\right)$

where $s \leq t$ and p_t denotes the price level set by all Home firms. From (3.30), the sub-price index in the current period t is the weighted average of the past price (p_{t-s}) and the newly set price (p_t). The sub-price index for the Foreign goods is:

$$q_t^* = \left[(1-\gamma)\sum_{s=0}^{\infty} \gamma^s p_{t-s}^{*\,1-\theta} \right]^{\frac{1}{1-\theta}} \tag{3.31}$$

Using (3.30) and (3.31), the general price index (3.4) is rewritten as:

$$P_t = [nq_t^{1-\theta} + (1-n)S_t q_t^{*1-\theta}]^{\frac{1}{1-\theta}} \tag{3.32}$$

Market Clearing and Consolidated Budget Constraint

In equilibrium, all goods and factor markets have to clear. To aggregate the production function (3.21) across firms, the aggregate output in the Home country becomes:

$$Y_t^s = \int_0^{1/2} y_t^s(z)\partial z = \int_0^{1/2} A_t K_t(z)^\alpha N_t(z)^{1-\alpha} \partial z \tag{3.33}$$

Since the capital-labor ratio is the same for all firms[16], it must be equal to the capital-ratio for the whole country. That is, $\frac{K_t(z)}{N_t(z)} = \frac{\int_0^{1/2} K_t(z)\partial z}{\int_0^{1/2} N_t(z)\partial z}$. (3.33) can be rearranged as:

$$\frac{Y_t^s}{\int_0^{1/2} N_t(z)\partial z} = \int_0^{1/2} A_t \left(\frac{K_t(z)}{N_t(z)} \right)^\alpha \partial z = A_t \left(\frac{K_t}{N_t} \right)^\alpha \tag{3.34}$$

---

[16] From (3.23) and (3.24), $\frac{K_t}{N_t} = \frac{\frac{W_t}{P_t}(\alpha)}{r_{K,t}(1-\alpha)}$.
Therefore, all firms have to produce with this capital-labor ratio.

where

$$\int_0^{1/2} N_t(z)\partial z = N_t \tag{3.35}$$

$$\int_0^{1/2} K_t(z)\partial z = K_t \tag{3.36}$$

Hence, (3.34) becomes:

$$Y_t^s = A_t K_t^{\alpha} N_t^{1-\alpha} \tag{3.37}$$

where Y_t^s is total production for the Home country. (3.35) implies that the aggregate labor demand (left-hand side) equals to the aggregate labor supply (right-hand side). (3.36) implies that the aggregate demand for physical capital (left-hand side) equals to the aggregate supply of physical capital (right-hand side).

Substitution of $p_t(z)$ with the sub-price index (q_t) into (3.25) gives the aggregate demand for the Home good:

$$Y_t^d = \left[\frac{q_t}{P_t}\right]^{-\theta} Q_t \tag{3.38}$$

Equilibrium in the goods market requires that,

$$Y_t^s = Y_t^d = Y_t \tag{3.39}$$

Similarly, the market clearing conditions for the goods market and the factor market apply to the Foreign country.

The asset market also needs to clear. In the aggregate, the real domestic nominal money supply[17] must equal the real domestic money demand in each country. The market

[17] In this model, the Home and Foreign nominal money supplies are exogenously determined by corresponding central banks.

clearing condition for the bond market requires that the net supply of bond is zero, so that bonds held by Foreign agents are issued by Home residents. For bonds denominated in the Home currency, the zero net supply condition is:

$$(1-n)D_t + nF_t^* = 0 \tag{3.40}$$

For bonds denominated in the Foreign currency, the zero net supply condition is:

$$nD_t^* + (1-n)F_t = 0 \tag{3.41}$$

The aggregated profits of Home firms are

$$\pi_t = q_t Y_t - W_t N_t - P_t r_{K,t} K_t \tag{3.42}$$

By combining the agent's budget constraint (3.11), the Home government budget constraint (3.20), the aggregated profits (3.42), the consolidated budget constraint for the Home country is expressed as:

$$\begin{aligned} &P_t C_t + P_t[K_{t+1} - (1-\delta)K_t] + P_t X_{K,t} + P_t X_{F,t} + D_t + P_t I_{F,t} + P_t G_t \\ &-(1+i_{t-1})D_{t-1} - q_t Y_t = 0 \end{aligned} \tag{3.43}$$

Rearranging (3.43) gives:

$$\begin{aligned} &q_t Y_t - P_t C_t - P_t I_{K,t} - P_t X_{K,t} - P_t X_{F,t} - P_t G_t \\ &+i_{t-1} D_{t-1} + S_t i_{t-1} F_{t-1} = (D_t - D_{t-1}) + S_t (F_t - F_{t-1}) \end{aligned} \tag{3.44}$$

where the left-hand-side represents the current account balance which is equal to the sum of the value of goods produced by Home firms, net factor income from Home and Foreign bond holdings, and the expenditures on goods; and the right-hand-side represents the capital account balance which is equal to the sum of net capital flows.

3.3.2 Log- linearizing around the pre-shock steady state

The above model is solved by linearizing around initial pre-shock (or zero shock) steady state. In the initial steady state, asset bonds and government expenditures for the

Home and Foreign countries are assumed to be zero:

$$\bar{D}_0 = \bar{F}_0 = \bar{G}_0 = \bar{D}_0^* = \bar{F}_0^* = \bar{G}_0^* = 0 \tag{3.45}$$

where overbars denote the steady state and the zero subscript denotes the pre-shock period. In the initial steady state, prices are assumed to be equal across countries and are normalized to one. That is, $\bar{q}_0 = \bar{P}_0 = 1$, and $\bar{q}_0^* = \bar{P}_0^* = 1$. In addition, nominal and real interest rates are equalized in the initial steady state, i.e., $\bar{i}_0 = \bar{r}_0$ and $\bar{i}_0^* = \bar{r}_0^*$. The steady state real interest rate derived from the consumption Euler equation (3.13) is:

$$\bar{r} = \frac{1-\beta}{\beta} \tag{3.46}$$

The logarithmic deviation from the initial pre-shock steady state is denoted by a "hat". For any variable, $\hat{X}_t = (X_t - \bar{X}_0)/\bar{X}_0 \, \square \, Ln(X_t/\bar{X}_0)$. If the variable is at the steady state, its log-deviation is zero. A list of log-linearlized equations is provided in Appendix 3.1.

The equations for the Home country—the Fisher equation (3.12), the consumption Euler equation (3.13); the money demand condition (3.14); the labor supply condition (3.15); the demand for Home bonds (3.16); the capital accumulation (3.17); definitions of marginal costs; the world demand for the Home good (3.26); the price setting equation (3.29); the price index for the Home good (3.30); general price index (3.32); the aggregate output (3.37); the aggregate demand (3.38), the bond market clearing condition (3.40); and the consolidated budget constraint —along with their foreign equivalents; and the evolution of Foreign bonds (3.8), determine 33 endogenous variables. These variables are: C_t, C_t*, P_t, P_t*, $p_t(z)$, p_t*(z), i, i_t*, r, r_t*, $r_{K,t}$, $r_{K,t}$*, Y_t, Y_t*, F_t, F_t*, D_t, D_t*, q_t, q_t*, W_t, W_t*, $I_{F,t}$, $I_{F,t}$*, Q_t, Q_t*, N_t, N_t*, K_t, K_t*, MC_t, MC_t*, S_t. This system of equations is solved by using the method of undertermined coefficients with a minimal set of state variables, as descrbied in McCallum (1998, 1999).[18]

3.3.3 Calibration and Policy Shocks

The dynamics of the model are investigated by simulating a calibrated version of the log-linearized system of equations. Since annual data is used for empirical tests, annual calibrated parameters are used in the model. The numerical value of the parameters are taken from Sutherland (1996b)[19], except those that are related to physical capital, such as capital's share in production (α), the adjustment cost of physical capital (ψ_K), and the depreciation rate (δ). The annual real interest rate (in the steady state) is equal to 5%, so that the subjective discount rate β equals 1/1.05. For ψ_F—the parameter measuring the transaction costs of foreign bond investment—perfect and imperfect financial market integration are represented by ψ_F =0.01 and ψ_F =4 respectively. The frequency of the price adjustment parameter is assumed to be twice a year so that $\gamma = 0.5$.

Following Bergin and Tchakorv (2003), physical capital adjustment costs $\psi_K = 4$ are chosen. Capital's share in production α is set at 0.36. δ—the rate of depreciation—is set at 0.1, implying an annual depreciation rate of about 10%. From 1980 to 2003, the average consumption share and investment shares to GDP for ten Asian economies are 70.19% and 28.27% respectively.[20] The numerical values of the calibrated parameters are provided in Appendix 3.2.

This study's model is subject to monetary or fiscal shocks in each country. These

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[18] The Matlab files written by B. McCallum and E. Nelson are used for solving linear rational expectations models.
[19] As noted by Sutherland (1996b), most of the numerical values in his paper are taken from Hairault and Portier (1993).
[20] The data for Taiwan is obtained from the Economist Intelligence Unit and the data for the remaining countries are obtained from the World Bank Development Indicators.

shocks are log-normally distributed as follows:

$$\hat{M}_t = \rho_M \hat{M}_{t-1} + \varepsilon_{Mt} \tag{3.47}$$

$$\hat{G}_t = \rho_G \hat{G}_{t-1} + \varepsilon_{Gt} \tag{3.48}$$

where the "hat" denotes the logarithmic deviation from the initial steady state, and ε_{Mt} and ε_{Gt} are monetary policy and government spending shocks respectively. In the case of permanent shocks, ρ_M and ρ_G, are set at unity[21]. The value of the shock variable increases by one unit in period one, and returns to zero in the subsequent period. In addition, symmetric shocks do not give rise to international financial flows, and financial market integration has no effect on the model's response to symmetric shocks. Therefore, this study focuses on asymmetric shocks, which induce agents to trade foreign bonds. Whereas the Home monetary policy shock ε_{Mt} increases by one unit, the Foreign monetary policy shock ε_{Mt}* decreases by one unit. Similarly, ε_{Gt} increases by one unit while ε_{Gt}* decrease by one unit.

3.3.4 Simulation Results

Figure 3.2 describes the impulse responses of a permanent increase in a one unit of a monetary policy shock in the Home country. The responses of the Foreign country are mirror images of the Home country.[22] Output volatility—the focus of this section—is measured by the deviation of output from its initial steady state when a policy shock hits the system in the period one. Solid lines and cross lines represent the responses of low financial integration (or low capital mobility) and high financial integration (or high capital mobility) respectively. Impulse responses are plotted for twenty periods.

[21] In the case of temporary shocks, ρ_1, ρ_2, and ρ_3 are set at a value between zero and unity.
[22] These results are not reported.

In period one, the response of output to a monetary shock is higher in a more financially integrated (MFI) economy than in a less financially integrated (LFI) economy—1.1705 as opposed to 0.9517, as shown in panel (a) of Figure 3.2. These results are qualitatively similar to those in Sutherland (1996a).

The transmission mechanism is explained as follows. An unanticipated and once-for-all increase in the Home money supply leads to an increase in real money balance. In a MFI economy, given excessive real money balances, Home agents buy more Foreign bonds, leading to capital outflows and (real and nominal) depreciation of the Home currency. With the depreciation of the Home currency, the relative price of Home goods decreases, thus inducing greater domestic and foreign demand for Home goods. As a result, Home output increases [see (3.25)]. On the other hand, in a LFI economy, since Home agents are unable to freely purchase Foreign bonds, they respond to a permanent increase in the money supply by increasing their holdings of Home bonds. The limited capital outflows from a LFI economy leads to a less depreciation of the Home currency. Therefore, the increase in output is smaller in a LFI economy than in a MFI economy.

In addition to the above transmission mechanism, this study's model considers the presence of physical capital as providing another source of income and investment. A permanent increase in the money supply leads to an increase in investment of physical capital. Since an increase in capital stock is smaller in a LFI economy than in a MFI economy [panel (g) of Figure 3.2], output increases by less in the former than in the latter.

In sum, owing to a greater depreciation of the Home currency and a greater increase in physical capital in a MFI economy than in a LFI economy, the output volatility is higher in the former than in the latter, as shown in panel (a) of Figure 3.2.

Figure 3.3 illustrates the effects of an unanticipated increase in one unit of Home government spending. The government expenditure is assumed to be financed by lump sum taxes. Since Home agents have to pay more tax, they reduce the consumption of Home and Foreign goods [panel (b)], and the holdings of Home and Foreign bonds [panel (f)]. As the demand for Home bonds decreases, the Home interest rate increases. In a MFI economy, the high real interest rate attracts Foreign agents to purchase more Home bonds, so that the Home interest rate immediately returns to its steady state [panel (e)]. In a LFI economy, due to the restrictions on capital inflows, the Home interest rate maintains at a high level.

Lower consumption and higher interest rate imply lower real demand for money. Since the nominal money supply (M) is held constant, there is an excess supply of real money balance. To restore the money market equilibrium, the general price index has to increase. As the domestic currency price of Home goods is sticky in this study, the Home currency is required to depreciate so as to raise the domestic currency price of Foreign goods, through which the Home price index rises [see (3.4)].

Further, combining the log-linear versions of money equilibrium condition in the Home country (3.14) and its foreign counterpart, and the purchasing power parity condition (3.6) yields:

$$(\hat{M}_t - \hat{M}_t^*) - \hat{S}_t = \frac{1}{\sigma\varepsilon}(\hat{C}_t - \hat{C}_t^*) - \frac{\beta}{\varepsilon}(\hat{i}_t - \hat{i}_t^*) \tag{3.49}$$

When compared to a MFI economy, a LFI economy has a slightly larger reduction in consumption (-0.5976 compared to -0.5947) and a bigger jump in nominal interest rate.

Using (3.49)[23], the Home currency depreciates by more in a LFI than a MFI economy. This in turn causes output to expand by more in a LFI economy [panel (a) of Figure 3.3].

In contrast to the case of a monetary shock, a government spending shock tends to dampen output fluctuations in a MFI economy, while magnifying output volatility in a LFI economy. Moreover, as shown in panel (a) of Figure 3.3, the difference in output responses between MFI and LFI economies is very small (0.7022 as opposed to 0.7109). All these results are qualitatively similar to those in Sutherland (1996a).

3.4 Empirical Analysis

Based on the above theoretical model, three hypotheses are proposed:

1. Expansionary (contractionary) monetary or fiscal policy has a positive (negative) impact on output.
2. If a monetary shock hits the system, high (low) financial integration led by high (low) ICT development or/and liberal (restrictive) financial liberalization measures tends to increase (reduce) output volatility.
3. If a government spending shock hits the system, high (low) financial integration led by high (low) ICT development or/and liberal (restrictive) financial liberalization measures tends to reduce (increase) output volatility.

To examine how output responds to monetary or fiscal policy shocks, a vector autoregression model is established first, and then impulse response analysis and variance decomposition are performed. The ordinary least squares (OLS) regression is also employed for robustness checks.

3.4.1 Panel Vector Autoregressions

[23] The Home and Foreign money supply (M and M*) are held constant.

3.4.1.1 Methodology

In estimating a vector autoregression (VAR) model, a choice can be made between a large model which includes many variables that may have important economic effects on each other, and a more parsimonious model which uses fewer degrees of freedom and enables more efficient estimation. Given the aim of estimating the impact of policy shocks on output volatility under different degrees of capital mobility, this study has chosen a small, three-variable VAR model.

The structural model takes the form of a first-order VAR system:

$$\begin{aligned} &POLICY_{j,t} = k_1 - a_{12}FDI_t - a_{13}Y_t + b_{11}POLICY_{j,t-1} + b_{12}FDI_{t-1} + b_{13}Y_{t-1} + \varepsilon_t^{policy} \\ &FDI_t = k_2 - a_{21}POLICY_{j,t} - a_{23}Y_t + b_{21}POLICY_{j,t-1} + b_{22}FDI_{t-1} + b_{23}Y_{t-1} + \varepsilon_t^{FDI} \\ &Y_t = k_3 - a_{31}POLICY_{j,t} - a_{32}FDI_t + b_{31}POLICY_{j,t-1} + b_{32}FDI_{t-1} + b_{33}Y_{t-1} + \varepsilon_t^{y}, \\ &j = 1,2 \end{aligned} \tag{3.50}$$

where FDI_t denotes capital flows; Y_t denotes aggregate output; and $POLICY_{1,t}$ and $POLICY_{2,t}$ denote monetary policy and government consumption respectively. $\varepsilon_t^{policy}, \varepsilon_t^{FDI}, \varepsilon_t^{Y}$ are three structural shocks (or pure innovations). They are white noise disturbances with zero means, and constant variances, all individually serially uncorrelated. Furthermore, ε_t are assumed to be uncorrelated with each other. That is,

$$E(\varepsilon_t \varepsilon_\iota') = \begin{cases} D & for\ t=\iota \\ 0 & otherwise, \end{cases} \tag{3.51}$$

where D is a diagonal matrix.

The system of equations (3.50) can be written in the compact form:

$$AX_t = K + B_1 X_{t-1} + \varepsilon_t \tag{3.52}$$

where $A=\begin{bmatrix}1 & a_{12} & a_{13}\\ a_{21} & 1 & a_{23}\\ a_{31} & a_{32} & 1\end{bmatrix}$, $X_t=\begin{bmatrix}POLICY_{j,t}\\ FDI_t\\ Y_t\end{bmatrix}$, $K=\begin{bmatrix}k_1\\ k_2\\ k_3\end{bmatrix}$ $B_1=\begin{bmatrix}b_{11} & b_{12} & b_{13}\\ b_{21} & b_{22} & b_{23}\\ b_{31} & b_{32} & b_{33}\end{bmatrix}$, and

$\varepsilon_t=\begin{bmatrix}\varepsilon_t^{policy}\\ \varepsilon_t^{FDI}\\ \varepsilon_t^{y}\end{bmatrix}$. Premultiplying both sides of (3.52) by A^{-1} gives the reduced form of VAR:

$$X_t=\Gamma_0+\Gamma_1 X_{t-1}+e_t \tag{3.53}$$

where $\Gamma_0=A^{-1}K$, $\Gamma_1=A^{-1}B_1$ and $e_t=A^{-1}\varepsilon_t$.

Turning to the estimation, since the regressors are correlated with the error term in each equation of the structural VAR (3.50), they cannot be estimated using ordinary least squares. For instance, FDI_t and Y_t are correlated with ε_t^{POLICY} in the first equation; $POLICY_t$ and Y_t are correlated with ε_t^{FDI} in the second equation; and $POLICY_t$ and FDI_t are correlated with ε_t^{Y} in the third equation. Similar problems do not exist for estimating the reduced form of VAR (3.53). However, VAR (3.53) only can provide estimates of 18 parameters[24], whereas the structural VAR (3.50) contains 21 parameters[25], so that it is impossible to recover all of the information present in (3.50) from (3.53). In other words, the reduced form of VAR (3.53) is underidentified. To overcome this identification problem, restrictions are imposed on the structural VAR (3.50) such that the matrix A is a lower triangular with $a_{12} = a_{13} = a_{23} = 0$. The ordering of the variables listed in (3.50) is based mainly on the present study's theoretical model. The policy variable—lending rate or government consumption—contemporaneously affects FDI_t and Y_t, but they do not influence the current value of the policy variable. The restrictions also require that FDI_t is

[24] The parameters include 12 coefficients of variables, 3 variances of e_t, and 3 covariances of e_t.

[25] The parameters include 18 coefficients of variables, and 3 variances of ε_t.

not influenced by the current value of Y_t, but by current $POLICY_{it}$. The last variable, Y_t, is influenced by both FDI_t and $POLICY_{it}$ contemporaneously.

Next, instead of pooling data from different countries to estimate the VAR model (3.53), this study introduces country fixed effects (f_i) to capture the differences in behavior across countries. (3.53) is expressed as:

$$X_{i,t} = \Gamma_0 + \Gamma_1 X_{i,t-1} + f_i + e_t \qquad i=1, \ldots, 10 \qquad (3.54)$$

where i denotes i^{th} country. In (3.54), f_i is correlated with the regressors due to the lags of the dependent variables, and using OLS yields biased and inconsistent estimators. Following Love (2004) and Gilchrist and Himmelberg (1998), (3.54) is transformed by forward mean differencing [also referred to as the Helmert procedure in Arellano and Bover (1995)] to remove the country fixed effects (f_i). The transformed model becomes:

$$\tilde{X}_{i,t} = \Gamma_1 \tilde{X}_{i,t-1} + \tilde{e}_t \qquad (3.55)$$

The regressors lagged by one period or more remain uncorrelated with the transformed error terms, and are considered to be valid instruments for $\tilde{X}_{i,t-1}$. The regressors lagged by one period (X_{t-1}) are chosen to be instruments, so that the number of regressors equals the number of instruments and the model (3.55) is exactly identified. The coefficients Γ_1 are then estimated by the generalized method of moments (GMM).

In estimating the impulse response functions, the first-order vector autoregressive model (3.53) is considered to be a vector moving average representation:

$$X_t = \mu + \sum_{s=0}^{\infty} \Gamma_1^s e_{t-s} \qquad (3.56)$$

where μ is a function of parameters. The impulse response of X_t to a one-unit shock to the j^{th} equation (i.e., e_{t-s}^j) is the j^{th} column of Γ_1^s. However, e_{t-s} are not of particular interest, because e_t^{policy}, e_t^{FDI}, and e_t^{Y} can be correlated with each other, so that it is unlikely to identify the effect of a policy shock on output while holding other shocks constant. Recall that ε_t are uncorrelated with each other and $e_t = A^{-1}\varepsilon_t$. (3.56) is rewritten in terms of ε_t:

$$X_t = \mu + \sum_{s=0}^{\infty} \Phi_s \varepsilon_{t-s} \tag{3.57}$$

where $\Phi_s = \Gamma_1^s A^{-1}$ is the orthogonalized impulse response of the j[th] column to a one-unit shock of ε_{t-s}. Thus, the impact of a policy shock (i.e., ε_t^{policy}) can be studied while holding other shocks (i.e., ε_t^{FDI} *and* ε_t^{Y}) constant.

Furthermore, the orthogonalized impulse response function depends on the ordering of variables. The residuals e_t is expressed as follows:

$$\begin{bmatrix} e_t^{policy} \\ e_t^{FDI} \\ e_t^{y} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_t^{policy} \\ \varepsilon_t^{FDI} \\ \varepsilon_t^{y} \end{bmatrix} \tag{3.58}$$

The policy variable is further justified to come first in the system of equations, as in (3.58). Such ordering implies that the effects of the shocks on the system are asymmetric. A change in policy shock, ε_t^{policy} directly affects e_t^{FDI} and e_t^{Y}, which in turn affect the time paths of $\{FDI_t\}$ and $\{Y_t\}$. However, a FDI shock ε_t^{FDI} or output shock ε_t^{Y} has no effect on the policy.

3.4.1.2 Data Issues

The sample of ten Asian developing economies—China, Hong Kong, India, Korea, Malaysia, Pakistan, the Philippines, Singapore, Taiwan, and Thailand—is chosen for two main reasons. First, early 1980s data is insufficient for many Asian countries. Second, these ten countries are representative of the economic development of the Asian region. Hong Kong, Singapore, Korea, and Taiwan[26] have grown rapidly since the early 1970s and were labeled as the high income group by the World Bank in the late 1980s. The economies of China, Malaysia, the Philippines, Thailand, and India are newly emerging economies. Moreover, the diversity of these Asian countries allows for a reasonable comparison of output volatility within a relatively small sample. Annual data of these Asian countries from 1980 to 2003 is extracted from different sources. The countries are selected in two steps. The countries that have no missing observation for the policy variables (lending rate and government consumption) are included first. Then, interpolation technique and forward projection[27] are used to fill out some missing observations of the other variables. After that, those countries still having more than two missing observations for each of the variables are dropped. The detailed data sources are provided in Appendix 2.

To estimate (3.50), the lending rate and government consumption expenditures are chosen to proxy for monetary and fiscal policy variables ($POLICY_{it}$) respectively. The aggregate output (Y_t) is represented by real gross domestic output (GDP) converted from local currency into US dollars. To measure capital flows (FDI_{it}), gross private capital flows (defined as the sum of the absolute values of inflows and outflows of foreign direct investment, portfolio and other investment) and gross foreign direct investment (defined as the sum of absolute values of inflows and outflows of foreign

[26] To describe the dynamics of their economic development, Hong Kong, Singapore, Korea, and Taiwan are called the four Asian dragons (or tigers).

[27] World Trade Analyzer provides data on trade in communications equipment up to year 2002. Therefore, the trade data for 2003 is obtained from the UN Comtrade and the forward projection model is applied. It is specified as:

$$ICT_{wta,t} = \beta_0 + \beta_1 ICT_{wta,t-1} + \beta_2 ICT_{un,t} \text{ for } t = 1981, \ldots, 2002.$$

where the subscript wta denotes World Trade Analyzer and the subscript un denotes UN Comtrade. The ordinary least squares regressions are run to estimate β_0, β_1 and β_2. The adjusted R-square for each country is 0.92 or above. Then the estimated β_0, β_1 and β_2 are used to predict $ICT_{wta,2003}$.

direct investment) can be used. The correlation test is performed[28] and shows that these two measures are positively and statistically significantly correlated in each sample country. Since gross private capital flows have a relatively large number of missing data[29], gross foreign direct investment is chosen to proxy for capital flows (FDI_{it}), as, for instance, in Agènor (2004).

To compare output volatility between high and low financially integrated economies, ten Asian economies are divided into two groups. As discussed earlier, financial liberalization measures and ICT development are two major underlying forces of the rapid increase in capital flows. Gross private capital flows are used to proxy for the degree of financial openness. The composite ICT index (ICT index) is constructed to measure the level of the availability and quality of the ICT infrastructure within a country.

The ICT index is composed of three variables: investment expenditure on telecommunications per capita, trade in communications equipment per capita, and the sum of fixed and mobile phone users as a ratio of 1000 people. The first variable—ICT investment expenditure—reflects the quality of the telecommunication infrastructure. The second—trade in communication equipment—is the sum of exports and imports of communications equipment, including television and radio receivers, telephone and switching equipment, and parts and transmission equipment. As discussed in the OECD Communications Outlook (2001), the trade data for communication equipment reflects the intensity of the development of the national communication infrastructure, and the

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[28] The results are not reported.

[29] The data on gross foreign direct investment is available for all sample countries in all years, except for China from 1980 to 1981. No data on gross private capital flows is recorded for Hong Kong from 1980 to 1997.

Internet and wireless communication revolutions. However, this variable has a potential limitation. As computing technology increasingly integrates into communications equipment, the data of trade in communications equipment alone will not be sufficient to track the development of communications technology. For instance, this dataset disguises the rise in some areas that make up the Internet network (i.e., routers, servers, and cables) and the fall in other areas (i.e., traditional telephony and switching equipment). Hence, the categories of trade in computer equipment need to be covered in future analysis. The third component of the ICT index—the fixed line and mobile telephone subscribers—measures the extent of the usage of communication equipment[30].

The composite indicator of ICT development is devised based on the principal components analysis. The mean values of the three index components from 1980 to 2003 are used for each country. Then, these variables are rescaled[31] to standard units having unit variances and zero means, so that they can be combined into a single index. The principal components are extracted from the correlation matrix of these standardized data. The first component accounting for 90% of the variance in the three variables is retained to compute scores for each country.

In order to compare the data across the ten countries, each country's raw index score is converted on a scale of 1 to 5 by using a linear transformation. The formula used to rescale the raw index score is:

$$ICT = 4\,x\left[(country\ value - sample\ min)/(sample\ max - sample\ min)\right] + 1 \quad (3.59)$$

[30] The number of Internet users and the number of computers are not included, because their data is available only since 1995 and 1988 respectively.

[31] For instance, $(Y_i - \bar{Y})/\sigma_Y$ where Y_i denotes the aggregate output of i^{th} country, $\bar{Y}$ represents the mean of aggregate output of all sample countries, and σ_Y is the standard deviation of Y.

From (3.59), the overall ICT index from 1980 to 2003 is obtained. This study repeats the aforementioned principal components analysis to construct the ICT sub-period index for every six years of the sample period from 1980 to 2003. Table 3.2 shows the overall ICT index, the sub-period indices and the ranking of each country.[32]

The existing data for measuring the quality of ICT infrastructure is the ICT infrastructure sub-index[33], which is compiled by the Global Information Technology Report (2003). However, this index is not used in the present study, because its coverage starts from 2001, and it excludes Pakistan, one of the sample countries.

3.4.1.3 Panel VAR Evidence

In estimating the panel VAR, all variables are in logarithms, except for the lending rate. The correct lag length selection is essential for panel VAR: while too short lags fail to capture the system's dynamics, leading to omitted variable bias, too many lags suffer from a loss of degrees of freedom, resulting in overparameterization. A common lag length is imposed on two groups to facilitate a comparison between their results. To estimate the correct lag length for all variables jointly, the multivariate generalization of the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) have been used.[34] The lag length is chosen based on the lowest AIC or SBC values. AIC indicates four lags as the appropriate lags for most countries, while SBC mainly suggests one lag or four lags. However, four lags are not accepted for estimating the impulse

[32] It is worth noting that India has one of the largest ICT workforce in the world, but is ranked low. The Global Information Report (2003) also finds that in 2002, India is at 70th place for infrastructure—very low compared to its overall position of 34 in environment—which is perhaps an indication of the heterogeneous proliferation of ICT across different socioeconomic and geographic segments in the country.

[33] This study's overall ICT index differs from the ICT infrastructure sub-index in terms of estimation methodologies and index components. The ICT infrastructure sub-index (in 2002) includes ten variables but does not contain annual ICT investment expenditure and the trade in ICT equipment.

[34] As Enders (2004, p.283) notes, the likelihood ratio test may not be very useful in the small samples, because it is based on asymptotic theory.

response functions owing to a nearly singular matrix of determinants. Rather, one lag is chosen.

Table 3.3 presents responses of GDP (Y_t) and gross foreign investment flows (FDI_t) to a contractionary monetary policy shock—a one-standard-deviation increase in lending rate shock (ε_t^{policy})—in the initial period (i.e., period zero). In case one, the median of the ratio of gross private capital flows to GDP among the sample countries is used as a criterion to split the sample countries. The countries with higher than the median ratio are classified as the more financially integrated (MFI) group, while those with lower than the median ratio are classified as the less financially integrated (LFI) group. As shown in column (1), the output responses in the MFI and LFI groups have the expected negative signs and are statistically significant, indicating that higher lending rate (i.e., contractionary monetary policy) reduces output while lower lending rate (i.e., expansionary monetary policy) increases output. When a monetary shock hits the system, the real GDP in the MFI group instantaneously drops from its equilibrium value by 0.0189, which is less than 0.0103 in the LFI group. Figure 3.4 also shows that the magnitude of the negative output response in the LFI group is higher than the MFI group in all periods.

In the second case, this study splits ten economies into two groups based on the overall ICT index (see Table 3.2). The top five countries are classified as the high ICT group, while the remaining five are labeled as low ICT group. In the present study's model, higher ICT development implies higher financial integration, so that the results of the output responses are expected to be the same as in the first case. As shown in case 2 of Table 3.3, the output responses to a monetary shock have the expected negative signs, and output fluctuations are higher in economies with high ICT development than in economies with low ICT development (i.e., 0.008 compared to 0.0049). As illustrated in Figure 3.4, output volatility is higher for the ICT group in all periods.

Given the small sample, the outlier effect may easily influence the result. For robustness checks, I exclude two countries with high ICT development but low capital flows, and another two countries with low ICT development but high capital flows Therefore, in the third case, the first group contains countries with high ICT development and high capital flows, and the second group includes countries with low ICT development and low capital flows. The signs of the output responses to monetary shocks remain negative. The first group's output response is slightly smaller than that of the second group in the initial period (t = 0), but the second group's responses become higher in the subsequent periods (i.e., t =1, …, 20), as shown in Figure 3.4. In sum, the findings in column (1) of Table 3.3 and Figure 3.4 provide evidence that if a monetary shock hits the system, higher output volatility—higher output deviation from its equilibrium level—occurs in the MFI (or high ICT) group than in the LFI (or low ICT) group.

The second column of Table 3.3 shows that output responds positively to a one-standard-deviation increase in a government spending shock. This expected positive sign means that an expansionary (contractionary) fiscal shock has a positive (negative) effect on output. In case one, the MFI group has higher output responses in the initial period (t = 0). However, as shown in Figure 3.5, the output responses in the LFI group become higher from period one onwards. In cases two and three, the output responses in the first group (high ICT or both MFI and high ICT) are higher than in the second group (low ICT or both LFI and low ICT). All these findings are generally in line with the model's prediction that output volatility is slighter lower in more financially open economies than in less financially open economies.

In overview, the output responses reported in Table 3.3 support the hypotheses that the high financially integrated economies (labeled as MFI or high ICT) experience higher output fluctuations under a monetary shock, but less output fluctuations under a fiscal shock.

To assess the relative importance of the monetary and fiscal shocks, the forecast error variance decomposition of real GDP for the 20-year time horizon is performed. The forecast error variance decomposition provides the proportion of the variations in output due to a GDP shock versus a monetary (or government spending) shock and a capital flows shock. Table 3.4 and Table 3.5 reveal two interesting findings.

First, as shown in column 1 of Table 3.4, a monetary shock is increasingly important for the determination of output over time, particularly in MFI or high ICT economies. For instance, in case one, the fluctuations in real GDP that are explained by a monetary shock increases from 3.7 % in the first year to 19% in the fifth year for the MFI group. The findings in the first and second cases also indicate that a monetary shock explain a higher fraction of the variation in the first group than in the second. On the other hand, column (1) of Table 3.5 shows that a government spending shock has the predominant weight in determining the fluctuations in output regardless of the degree of financial integration. For the MFI and LFI groups in case one and case two, about 70% of the variance in output is explained by a government spending shock in period one.

The second interesting result is that a capital flows shock plays a very small role in explaining the variation in output in LFI or low ICT economies. Column (2) of Table

3.4 and Table 3.5 show that the LFI or low ICT economies are better insulated from a capital flows shock, which accounts for only about 5% of the variance in output. These findings substantiate the present study's criteria—the ratio of gross private capital flows to GDP or the ICT overall index—for splitting the more and less financially integrated economies.

3.4.2 OLS Regressions

An alternative specification and methodology are employed for robustness checks. For the OLS regressions below, output volatility is measured by the standard deviation of band-pass filtered[35] real GDP over a span of time. The sample period is 24 years, so that a time span of six years is chosen. It is a reasonable choice because business cycles are typically considered as movements in time frequencies ranging from 6 quarters to 32 quarters (Stock and Watson, 1999).

A monetary shock is measured by the standard deviation of lending rate. A government spending shock is proxied by the standard deviation of band-pass filtered[36] real government consumption. Financial openness is proxied by the ratio of gross foreign direct investment flows to GDP, and ICT development is measured by ICT sub-period indices. The model specification is:

[35] For annual macroeconomic data, Baxter and King (1995) recommend using a band-pass (2, 8) filter which retains cyclical components between two and eight years.
[36] A band-pass (2, 8) filter is used.

$$\begin{aligned} Volatility(ln\ real\ GDP)_{i,t} = &\beta_1 Volatility(Ln\ lending\ rate)_{i,t} \\ &+\beta_2 Volatility(Ln\ real\ gov't\ consumption)_{i,t} \\ &+\beta_3 Ln(FDI/GDP)_{i,t} + \beta_4 (ICT\ sub\text{-}period\ index)_{i,t} \\ &+\beta_5 (Interaction\ Term)_{i,t} \\ &i=1,...,10; \\ &t=1980\text{-}1985,\ 1986\text{-}1991,\ 1992\text{-}1997, 1998\text{-}2003 \end{aligned} \tag{3.60}$$

where Ln is a natural logarithm; i and t denote country and period respectively; and the Interaction Term represents various variables: (ICT sub-period index)$_{it}$ x Ln(FDI/GDP)$_{it}$, Ln(FDI/GDP)$_{it}$ x Volatility(Ln lending rate)$_{it}$, Ln(FDI/GDP)$_{it}$ x Volatility(Ln real government consumption)$_{it}$, (ICT sub-period index)$_{it}$ x Volatility(Ln lending rate)$_{it}$, and (ICT sub-period index)$_{it}$ x Volatility(Ln real government consumption)$_{it}$, which are entered (3.60) alternatively. Pooled regression is performed on (3.60). As shown in column (1) of Table 3.6, the coefficient of foreign direct investment flows (FDI/GDP) is negative and statistically insignificant. That is, after controlling for monetary and fiscal shocks, financial openness is not associated with output volatility. These findings support Buch, Döpke and Pierdzioch (2002), and Kose, Prasad and Terrones (2003) who do not find any statistically significant relationship between financial openness and output volatility. Furthermore, the coefficient of the interaction term between financial openness and the ICT index in column (2)—which indicates the combined effect of financial openness and the ICT index on output volatility—is not statistically significant.[37]

In column (3) of Table 3.6, the interaction term between financial openness and monetary shocks is introduced into (3.60). The coefficient of this interaction term is

[37] This result also holds when the ICT index is replaced by the components of the ICT index.

positive and statistically significant, indicating that monetary shocks have greater impact on output volatility in a more financially integrated economy than in a less financially integrated economy. In column (4) of Table 3.6, the coefficient of this interaction term does not meet the expected negative sign, but the difference in the impact of fiscal shocks between more and less financially open economies is statistically insignificant.

In columns (5) of Table 3.6, the positive sign of the interaction term between the ICT index and a monetary shock is statistically significant, indicating that the economies with higher ICT development experience higher output volatility in the case of monetary shocks. The interaction term in column (6) of Table 3.6 suggests that the difference in the impact of fiscal shocks on output fluctuations between high and low ICT samples is statistically insignificant.

3.5 Conclusions

This study applies a two-country dynamic general equilibrium model, in which an advance in ICT or the financial liberalization lowers the transaction costs of trading international financial assets and so promotes capital flows. This model predicts that financial market integration tends to magnify or dampen output volatility depending on the nature of policy shocks. The panel VAR evidence reported in Table 3.3 supports this model's predictions, suggesting that the group of economies with an advanced ICT or/and the financial liberalization experience higher output volatility in the face of a monetary policy shock, and lower output volatility in the face of a fiscal policy shock

For robustness checks, the ICT index is explicitly introduced into the regression model. The finding of the combined impact of ICT and monetary shocks on output volatility [column (5) of Table 3.6] is robust, while the interaction term between ICT and fiscal shocks [column (6) of Table 3.6] does not have the expected negative sign, but statistically insignificant. The latter result weakly supports the simulation finding [panel (a) of Figure 3.5], which suggests a very small difference in output volatility between more and less financially integrated economies in the case of a government spending shock.

In sum, the theoretical and empirical results of this study have two policy implications. First, for those countries which adjust their monetary policy actively, their short term output fluctuation would be exacerbated by the high financial integration. Second, the similar findings in a more financially integrated group and a high ICT group indicate that an advance in ICT could render capital control less effective.

Moreover, the findings reported in Table 3.3 and Table 3.6 confirm the results of Buch, Döpke and Pierdzioch (2002) who suggest that policy shocks are relevant in determining the relationship between financial integration and output volatility, even though the present study differs from theirs in terms of explanatory variables, sample countries, sample periods, and estimation methodology.

Buch, Döpke and Pierdzioch (2002), and Kose, Prasad and Terrones (2003) report that the direct effect of financial openness on output volatility is not statistically significant. The present study's analysis, which includes ICT, does not change their conclusions. As shown in column 2 of Table 3.6, the coefficient of the interaction term between ICT and FDI indicates that the combined effect of ICT and FDI on output volatility is statistically insignificant. However, the transmission mechanism between ICT and capital flows deserves a more detailed examination to assess the robustness of this result.

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Tables

Table 3.1.Output volatility

Country	1980-1985	1986-1991	1992-1997	1998-2003	1980-2003
China	3.44	7.40	6.77	0.31	5.70
Hong Kong	1.09	2.27	0.83	3.08	2.87
India	2.51	3.84	3.77	1.51	3.48
Korea	3.30	4.67	7.11	15.40	6.99
Malaysia	2.85	1.52	5.75	8.17	5.53
Pakistan	1.28	1.82	3.05	0.62	2.03
The Philippines	12.36	5.52	5.49	7.21	7.22
Singapore	3.81	2.73	3.87	4.22	3.81
Taiwan	2.77	4.68	1.48	5.46	4.09
Thailand	5.43	2.28	5.92	10.31	5.02
Overall Mean	3.88	3.67	4.40	5.63	4.67

All data here are real GDP and are logged. They are then detrended using a band-pass (2, 8) filter. Volatility is measured by the standard deviation (in percentage).

Table 3.2. ICT index

Country	Overall Index	Ranking (overall index)	1980-1985	1986-1991	1992-1997	1998-2003
Hong Kong	5.00000	1	3.62675	4.26263	5.00000	5.00000
Singapore	4.34035	2	5.00000	5.00000	4.34392	3.77545
Korea	2.67739	3	2.41964	2.98873	2.90745	2.47613
Taiwan	2.60672	4	2.66480	3.20415	2.74039	2.43238
Malaysia	1.85405	5	1.91418	1.71658	2.15868	1.76749
Thailand	1.22770	6	1.09090	1.15667	1.33203	1.24513
China	1.13488	7	1.00000	1.00000	1.09245	1.20874
The Philippines	1.12544	8	1.09857	1.06217	1.15150	1.14652
India	1.00002	9	1.01785	1.01353	1.00000	1.01206
Pakistan	1.00000	10	1.02819	1.02100	1.02090	1.00000

ICT index is constructed by author using principal components analysis.

Table 3.3. Impulse responses of output to lending rate shocks and government consumption shocks in the initial period (t=0)

		(1) Response of Ln(real GDP) to a lending rate shock	(2) Response of Ln(real GDP) to a government spending shock
Case 1	MFI Group	-0.0189	0.0821
	LFI Group	-0.0103	0.0788
Case 2	High ICT	-0.0080	0.0783
	Low ICT	-0.0049	0.0842
Case 3	MFI and high ICT	-0.0061	0.0566
	LFI and low ICT	-0.0069	0.1311

Case 1: MFI group includes Hong Kong, Malaysia, Singapore, Philippines and Thailand. LFI group includes Korea, Taiwan, China, India and Pakistan. Case 2: High ICT group includes Hong Kong, Korea, Malaysia, Singapore and Taiwan. Low ICT group includes. LFI group includes China, India, Pakistan, Philippines and Thailand. Case 3: MFI and high ICT economies include Hong Kong, Malaysia and Singapore. LFI and low ICT economies include China, India and Pakistan.

Table 3.4. Forecast error variance decomposition of output in the case of a monetary policy shock

		Time horizon	(1) Lending rate shock	(2) Capital flows shock	(3) GDP shock
Case 1	MFI Group	1	0.0374	0.0591	0.9035
		3	0.1154	0.0751	0.8095
		5	0.1926	0.0914	0.7160
		10	0.3159	0.1253	0.5587
		20	0.3910	0.1575	0.4516
	LFI Group	1	0.0125	0.0320	0.9555
		3	0.0519	0.0237	0.9244
		5	0.0942	0.0188	0.8870
		10	0.1661	0.0142	0.8197
		20	0.2083	0.0129	0.7788
Case 2	High ICT	1	0.0070	0.1803	0.8127
		3	0.1797	0.2598	0.5605
		5	0.3285	0.2363	0.4352
		10	0.4768	0.1744	0.3488
		20	0.5198	0.1491	0.3312
	Low ICT	1	0.0024	0.0084	0.9892
		3	0.0247	0.0084	0.9668
		5	0.0591	0.0198	0.9211
		10	0.1447	0.0338	0.8215
		20	0.2384	0.0299	0.7316
Case 3	MFI and high ICT	1	0.0059	0.2343	0.7597
		3	0.1903	0.3446	0.4651
		5	0.3806	0.3080	0.3114
		10	0.5878	0.2163	0.1959
		20	0.6560	0.1786	0.1654
	LFI and low ICT	1	0.0087	0.0217	0.9696
		3	0.0391	0.0131	0.9478
		5	0.0776	0.0092	0.9132
		10	0.1670	0.0058	0.8272
		20	0.2642	0.0071	0.7287

Table 3.5. Forecast error variance decomposition of output in the case of a government consumption shock

		Time horizon	(1) Government spending shock	(2) Capital flows shock	(3) GDP shock
Case 1	MFI Group	1	0.6961	0.0121	0.2918
		3	0.6002	0.0355	0.3643
		5	0.5198	0.0607	0.4195
		10	0.3935	0.1077	0.4989
		20	0.3128	0.1396	0.5476
	LFI Group	1	0.7358	0.0036	0.2606
		3	0.7387	0.0046	0.2566
		5	0.7409	0.0056	0.2536
		10	0.7438	0.0075	0.2487
		20	0.7451	0.0095	0.2454
Case 2	High ICT	1	0.6858	0.0294	0.2847
		3	0.6946	0.1127	0.1927
		5	0.6806	0.1762	0.1432
		10	0.6564	0.2421	0.1015
		20	0.6487	0.2576	0.0936
	Low ICT	1	0.7622	0.0023	0.2355
		3	0.7521	0.0034	0.2445
		5	0.7447	0.0047	0.2506
		10	0.7346	0.0089	0.2566
		20	0.7297	0.0166	0.2537
Case 3	MFI and high ICT	1	0.4980	0.0960	0.4060
		3	0.4302	0.2590	0.3107
		5	0.3857	0.3591	0.2552
		10	0.3428	0.4576	0.1996
		20	0.3309	0.4917	0.1774
	LFI and low ICT	1	0.5345	0.0070	0.4585
		3	0.6606	0.0339	0.3054
		5	0.7330	0.0444	0.2225
		10	0.7973	0.0641	0.1385
		20	0.8215	0.0900	0.0885

Table 3.6. OLS regressions

Dependent variable: Volatility of Ln(real GDP)

	(1)	(2)	(3)	(4)	(5)	(6)
Volatility of Ln(lending rate)	0.073**	0.072**	0.067**	0.078**	-0.02	0.097**
	(0.029)	(0.031)	(0.026)	(0.032)	(0.067)	(0.039)
Volatility of Ln(government consumption)	0.955***	0.953***	0.984***	0.945***	1.024***	0.680***
	(0.108)	(0.107)	(0.109)	(0.099)	(0.122)	(0.182)
Ln(FDI/GDP)	-0.117	-0.083	-0.312**	-0.239	-0.089	-0.077
	(0.133)	(0.197)	(0.142)	(0.206)	(0.128)	(0.131)
ICT[1]	0.107	0.143	0.065	0.13	-0.341	-0.386
	(0.22)	(0.334)	(0.215)	(0.228)	(0.296)	(0.373)
ICT[1]*Ln(FDI/GDP)		-0.019				
		(0.098)				
Ln(FDI/GDP) x Volatility of Ln(lending rate)			0.022**			
			(0.009)			
ICT[1] x Volatility of Ln(lending rate)					0.037*	
					(0.021)	
Ln(FDI/GDP) x Volatility of Ln(government consumption)				0.031		
				(0.039)		
ICT[1] x Volatility of Ln(government consumption)						0.139
						(0.089)
Observations	40	40	40	40	40	40
Adjusted R-square	0.80	0.79	0.83	0.79	0.80	0.80

Robust standard errors are in parentheses. * denotes significance at the 10% level. ** denote significance at the 5% level. *** denote significance at the 1% level.

Note: Real GDP and real government consumption are logged and then detrended using a band-pass (2, 8) filter. Volatility is measured by the percentage standard deviation.

1. ICT here is proxied by ICT sub-period index

Figures

Figure 3.1. Relationship between capital flows and ICT development

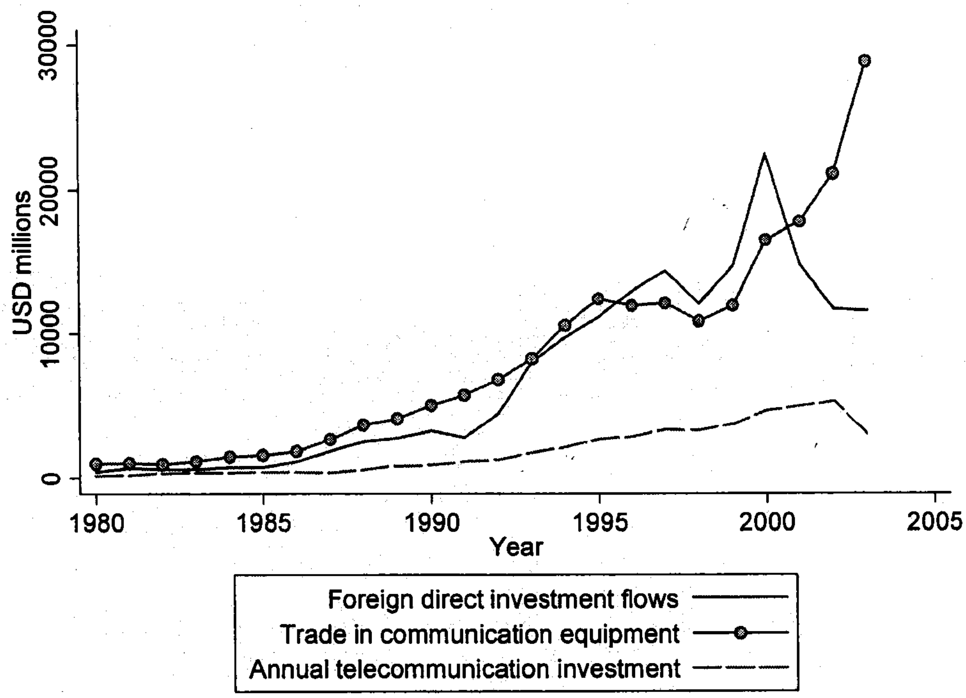
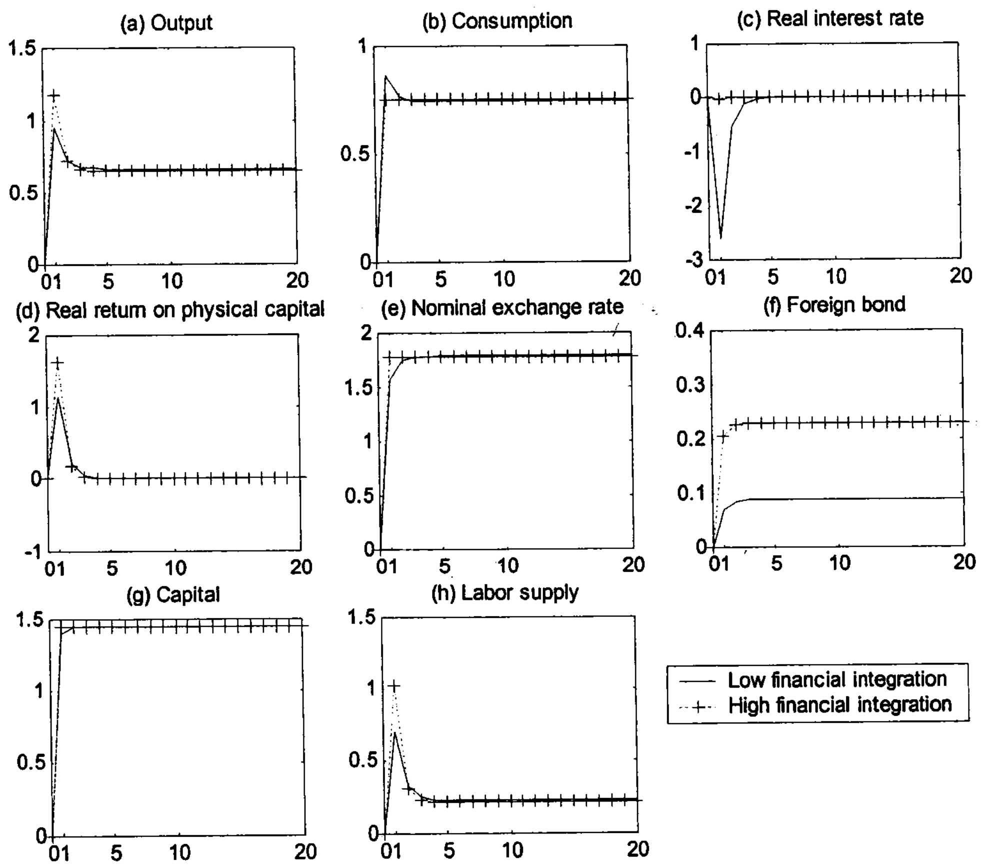
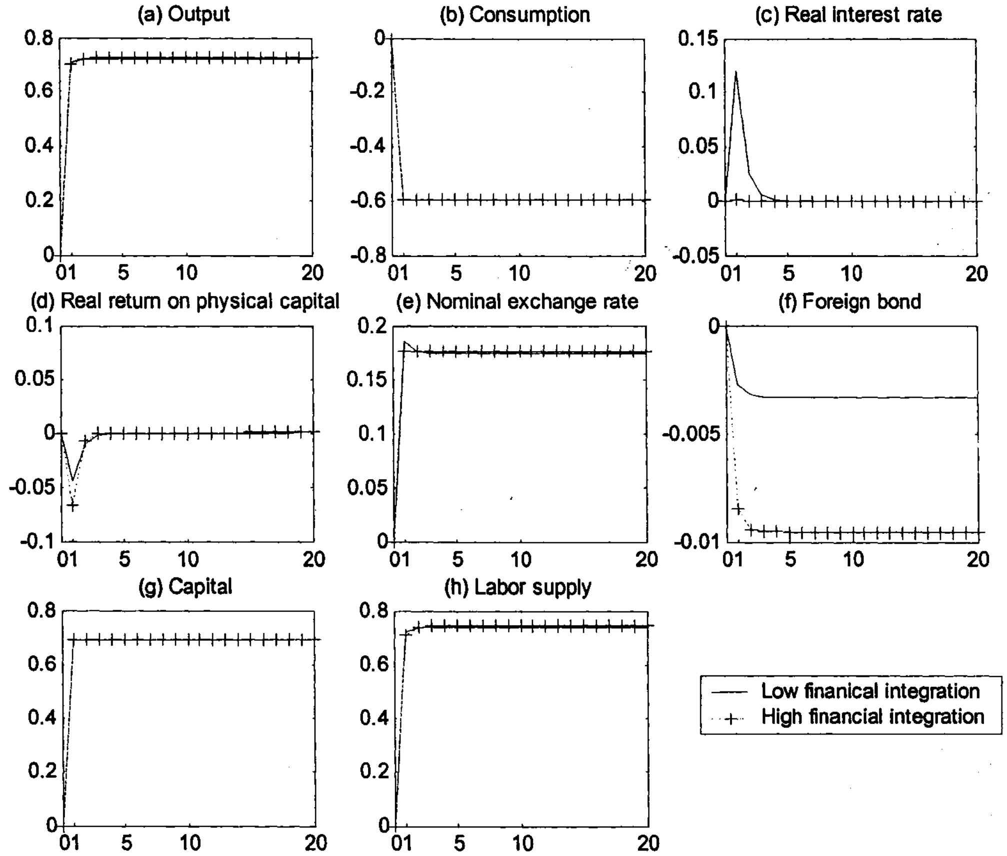


Figure 3.2. Responses to a monetary shock



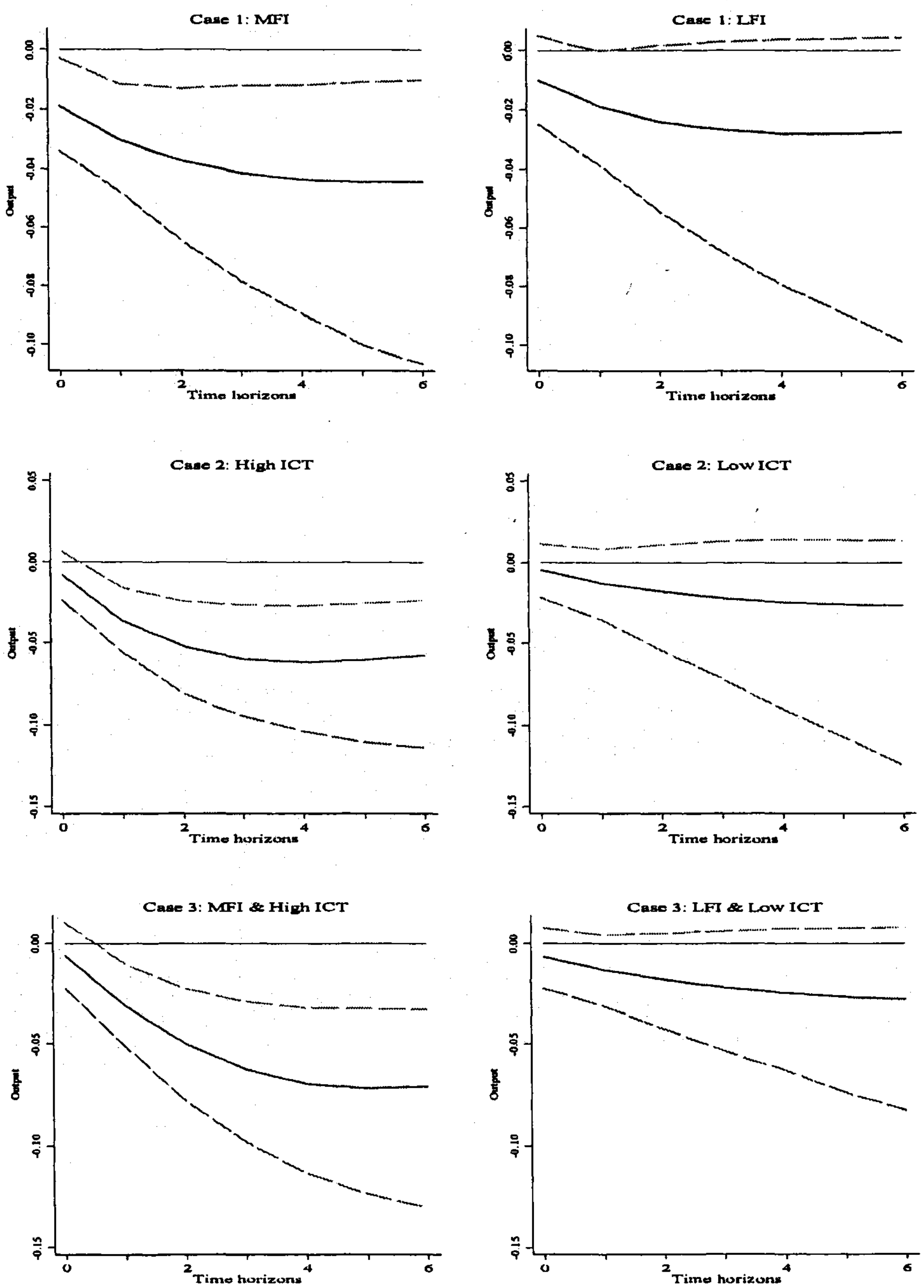
Notes:
The output, consumption, real interest rate, real return on physical capital, nominal exchange rate, capital and labor supply are measured in terms of percentage deviation from the initial steady state. The foreign bond holdings are measured in terms of deviation from its initial steady state as a percentage of initial output level.

Figure 3.3. Responses to a government consumption shock



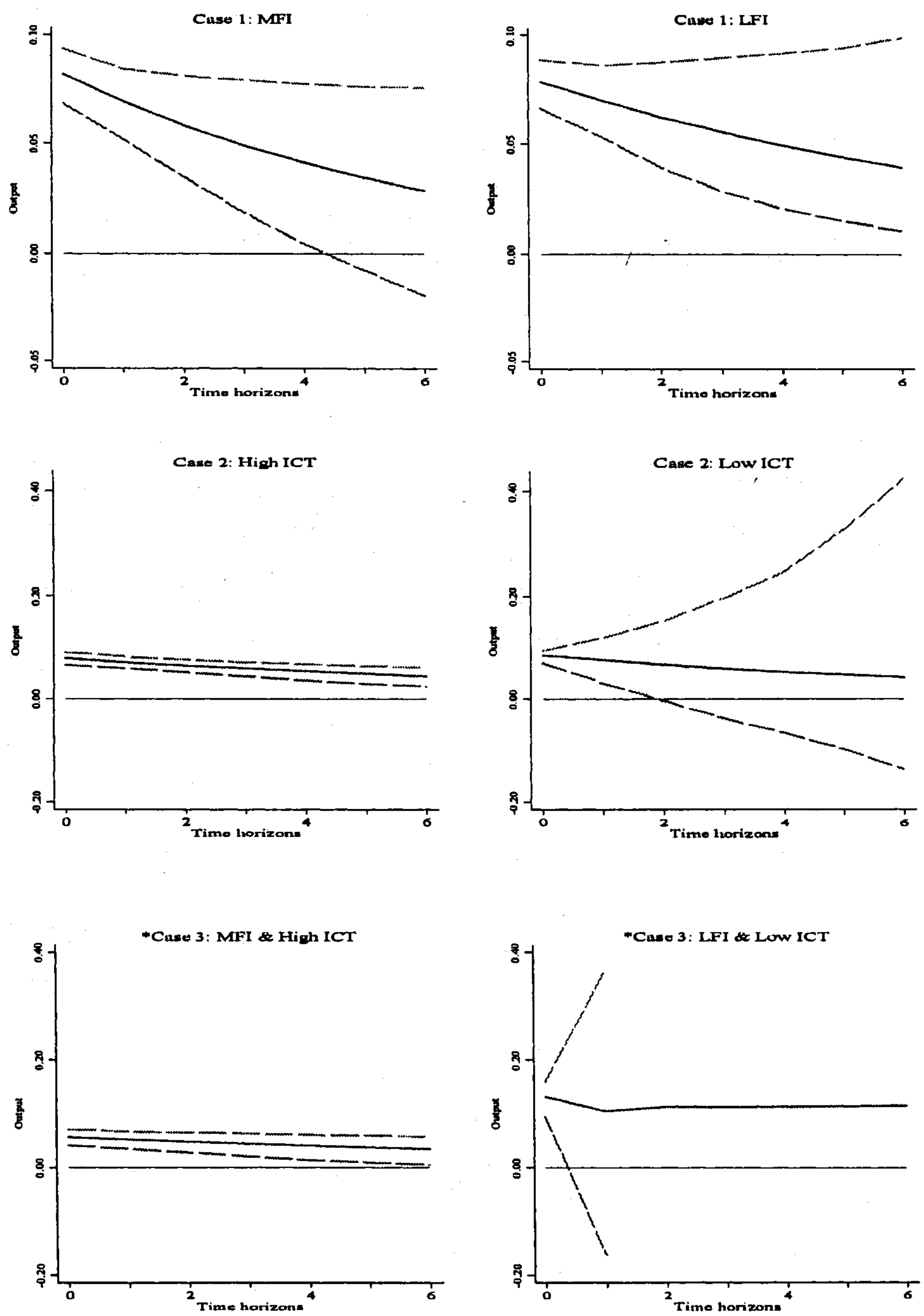
Notes:
The output, consumption, real interest rate, real return on physical capital, nominal exchange rate, capital and labor supply are measured in terms of percentage deviation from the initial steady state. The foreign bond holdings are measured in terms of deviation from its initial steady state as a percentage of initial output level.

Figure 3.4. Output response to a monetary policy shock



- - 95 % confidence intervals are constructed using Monte Carlo with 1000 repetitions

Figure 3.5. Output response to a fiscal policy shock



- - The 95 % confidence intervals are constructed using Monte Carlo with 1000 repetitions.
* For "LFI & Low ICT", the confidence intervals lie outside the graph when the time horizon is greater than 1.

Appendices

Appendix 3.1. A List of log-lineralized equations

Households

Log-linearalizing the Home consumption Euler equation (3.13) and its foreign counterpart yields:

$$\frac{1}{\sigma}E_t\widehat{C}_{t+1}=\frac{1}{\sigma}\widehat{C}_t+(1-\beta)\hat{i}_t+\widehat{P}_t-E_t\widehat{P}_{t+1} \tag{3.61}$$

$$\frac{1}{\sigma}E_t\widehat{C}^*_{t+1}=\frac{1}{\sigma}\widehat{C}^*_t+(1-\beta)\hat{i}^*_t+\widehat{P}^*_t-E_t\widehat{P}^*_{t+1} \tag{3.62}$$

where the "hat" denotes the log deviation from the initial pre-shock steady state. Log linearalizing the Home money demand function (3.14) and its foreign counterpart yields:

$$\widehat{M}_t-\widehat{P}_t=\frac{1}{\varepsilon\sigma}\widehat{C}_t-\frac{\beta}{\varepsilon}\hat{i}_t \tag{3.63}$$

$$\widehat{M}^*_t-\widehat{P}^*_t=\frac{1}{\varepsilon\sigma}\widehat{C}^*_t-\frac{\beta}{\varepsilon}\hat{i}^*_t \tag{3.64}$$

Log-linearalizing the Home labor supply rule (3.15) and its foreign counterpart gives:

$$\widehat{N}_t=\widehat{W}_t-\widehat{P}_t-\left(\frac{1}{\sigma}\right)\widehat{C}_t \tag{3.65}$$

$$\widehat{N}^*_t=\widehat{W}^*_t-\widehat{P}^*_t-\left(\frac{1}{\sigma}\right)\widehat{C}^*_t \tag{3.66}$$

Log-linearlizing (3.16) and its foreign counterpart yields:

$$-(1-\beta)\hat{i}_t+E_t\hat{S}_{t+1}-\hat{S}_t+(1-\beta)\hat{i}^*_t-\psi_F\bar{y}_0\hat{I}_{F,t}+\psi_F\bar{y}_0E_t\hat{I}_{F,t+1}=0 \tag{3.67}$$

$$-(1-\beta)\hat{i}^*_t+E_t\hat{S}_{t+1}-\hat{S}_t+(1-\beta)\hat{i}_t-\psi_F\bar{y}_0\hat{I}^*_{F,t}+\psi_F\bar{y}_0E_t\hat{I}^*_{F,t+1}=0 \tag{3.68}$$

where the variables $\hat{I}_F$ and $\hat{I}^*_F$ are defined as $I_F/\bar{y}_0$ and $I^*_F/\bar{y}_0$ respectively. The log deviations cannot use $\overline{I}_{F,0}$ and $\overline{I}^*_{F,0}$, since their initial steady state values are zero.

Log-linearlizing the physical capital accumulation (3.17) and its foreign counterpart yields:

$$\frac{1}{\beta}\psi_k\widehat{K}_t+\frac{-1-\beta}{\beta}\psi_k E_t\widehat{K}_{t+1}+\psi_k E_t\widehat{K}_{t+2}+\frac{1}{\sigma}(\overline{r}_K+1-\delta)\widehat{C}_t$$
$$-\frac{1}{\sigma}(\overline{r}_K+1-\delta)E_t\widehat{C}_{t+1}+\overline{r}_K E_t\hat{r}_{K,t+1}=0 \tag{3.69}$$

$$\frac{1}{\beta}\psi_k\widehat{K}_t+\frac{-1-\beta}{\beta}\psi_k E_t\widehat{K}^*_{t+1}+\psi_k E_t\widehat{K}^*_{t+2}+\frac{1}{\sigma}(\overline{r}^*_K+1-\delta)\widehat{C}^*_t$$
$$-\frac{1}{\sigma}(\overline{r}^*_K+1-\delta)E_t\widehat{C}^*_{t+1}+\overline{r}^*_K E_t\hat{r}^*_{K,t+1}=0 \tag{3.70}$$

The log-linear version of the evolution of foreign bonds (3.8) is:

$$\widehat{F}_t-\frac{1}{\beta}\widehat{F}_{t-1}-\hat{I}_{F,t}=0 \tag{3.71}$$

Log-linearizing (3.12) and its foreign counterpart yields:

$$(1-\beta)E_t\hat{i}_{t+1}=\hat{P}_{t+1}-\hat{P}_t-(1-\beta)E_t\hat{r}_{t+1} \tag{3.72}$$

$$(1-\beta)E_t\hat{i}^*_{t+1}=\hat{P}^*_{t+1}-\hat{P}^*_t-(1-\beta)E_t\hat{r}^*_{t+1} \tag{3.73}$$

Firms

Log-linearizing (3.23) and aggregating labor and output across firms yields:

$$\widehat{MC}_t=\widehat{W}_t-\hat{P}_t-\hat{Y}_t+\widehat{N}_t \tag{3.74}$$

Its foreign counterpart is:

$$\widehat{MC}^*_t=\widehat{W}^*_t-\hat{P}^*_t-\hat{Y}^*_t+\widehat{N}^*_t \tag{3.75}$$

Log-linearizing (3.24) and aggregating physical capital and output across firms yields:

$$\widehat{MC}_t=\hat{r}_{K,t}-\hat{Y}_t+\widehat{K}_t \tag{3.76}$$

Its foreign counterpart is:

$$\widehat{MC}_t^* = \hat{r}_{K,t}^* - \hat{Y}_t^* + \hat{K}_t^* \tag{3.77}$$

Log-linearlizing the Calvo price-setting rule (3.29) and its foreign counterpart gives:

$$\hat{p}_t(z) = \beta\gamma E_t \hat{p}_{t+1}(z) - (1-\beta\gamma)\widehat{MC}_t \tag{3.78}$$

$$\hat{p}_t^*(z) = \beta\gamma E_t \hat{p}_{t+1}^*(z) - (1-\beta\gamma)\widehat{MC}_t^* \tag{3.79}$$

Log-linearlizing (3.30) and (3.31) yields:

$$\hat{q}_t = (1-\gamma)\hat{p}_t(z) + \gamma E_t \hat{q}_{t-1} \tag{3.80}$$

$$\hat{q}_t^* = (1-\gamma)\hat{p}_t^*(z) + \gamma E_t \hat{q}_{t-1}^* \tag{3.81}$$

Log linearlizing the general price index (3.32) and its foreign counterpart gives:

$$\hat{P}_t = 0.5\hat{q}_t + 0.5\hat{q}_t^* + 0.5\hat{S}_t \tag{3.82}$$

$$\hat{P}_t^* = 0.5\hat{q}_t^* + 0.5\hat{q} - 0.5\hat{S}_t \tag{3.83}$$

Market Clearing and Consolidated Budget Constraint

Log-linearlizing the Home aggregate output (3.37) and its foreign counterpart yields:

$$\hat{Y}_t = \hat{A}_t + (1-\alpha)\hat{K}_t + \alpha\hat{N}_t \tag{3.84}$$

$$\hat{Y}_t^* = \hat{A}_t^* + (1-\alpha)\hat{K}_t^* + \alpha\hat{N}_t^* \tag{3.85}$$

Log-linearlizing the Home aggregate demand (3.38) and its foreign counterpart yields

$$\hat{Y}_t = -\theta\hat{q}_t + \theta\hat{P}_t + \hat{Q}_t \tag{3.86}$$

$$\hat{Y}_t^* = -\theta\hat{q}_t^* + \theta\hat{P}_t^* + \hat{Q}_t^* \tag{3.87}$$

where Q is the world per capita consumption of the Home representative goods. Log-linearlizing (3.26) and its foreign counterpart yields:

$$\widehat{Q}_t = 0.5[\frac{\overline{C}_0}{\overline{Y}_0}\widehat{C}_t + \widehat{G}_t + \frac{\overline{K}_0}{\overline{Y}_0}E_t\widehat{K}_{t+1} - (1-\delta)\frac{\overline{K}_0}{\overline{Y}_0}\widehat{K}_t] + 0.5[\frac{\overline{C}_0^*}{\overline{Y}_0^*}\widehat{C}_t^* + \widehat{G}_t^* + \frac{\overline{K}_0^*}{\overline{Y}_0^*}E_t\widehat{K}_{t+1}^* - (1-\delta)\frac{\overline{K}_0^*}{\overline{Y}_0^*}\widehat{K}_t^*] \quad (3.88)$$

$$\widehat{Q}_t^* = 0.5[\frac{\overline{C}_0^*}{\overline{Y}_0^*}\widehat{C}_t^* + \widehat{G}_t^* + \frac{\overline{K}_0^*}{\overline{Y}_0^*}E_t\widehat{K}_{t+1}^* - (1-\delta)\frac{\overline{K}_0^*}{\overline{Y}_0^*}\widehat{K}_t^*] + 0.5[\widehat{C}_t + \widehat{G}_t + \frac{\overline{K}_0}{\overline{Y}_0}E_t\widehat{K}_{t+1} - (1-\delta)\frac{\overline{K}_0}{\overline{Y}_0}\widehat{K}_t] \quad (3.89)$$

where $\widehat{G}$ and $\widehat{G}^*$ are defined as $G_t/\overline{y}_0$ and $G_t^*/\overline{y}_0^*$ respectively, since $\overline{G}_0 = \overline{G}_0^* = 0$. In the initial steady state, $\overline{Y}_0 = \overline{Y}_0^* = \overline{Q}_0 = \overline{Q}_0^*$, $\overline{C}_0 = \overline{C}_0^*$, and $\overline{K}_0 = \overline{K}_0^*$.

Log-linearlizing the consolidated Home budget constraint (3.43) and its foreign counterpart yields:

$$\frac{\overline{C}_0}{\overline{Y}_0}\widehat{C}_t + \frac{\overline{K}_0}{\overline{Y}_0}E_t\widehat{K}_{t+1} - \frac{\overline{K}_0(1-\delta)}{\overline{Y}_0}\widehat{K}_t - \frac{1}{\beta}\widehat{D}_{t-1} + \widehat{D}_t - \hat{q}_t - \widehat{Y}_t + \hat{I}_{F,t} + \widehat{P}_t + \widehat{G}_t = 0 \quad (3.90)$$

$$\frac{\overline{C}_0}{\overline{y}_0}\widehat{C}_t^* + \frac{\overline{K}_0}{\overline{Y}_0}E_t\widehat{K}_{t+1}^* - \frac{\overline{K}_0(1-\delta)}{\overline{Y}_0}\widehat{K}_t^* - \frac{1}{\beta}\widehat{D}_{t-1}^* + \widehat{D}_t^* - \hat{q}_t^* - \widehat{Y}_t^* + \hat{I}_{F,t}^* + \widehat{P}_t^* + \widehat{G}_t^* = 0 \quad (3.91)$$

where $\widehat{D}, \widehat{G}, \widehat{F}, \widehat{D}^*, \widehat{G}^*$ and $\widehat{F}^*$ are defined as $D/\overline{Y}_0$, $G/\overline{Y}_0$, $F/\overline{y}_0$, $D^*/\overline{Y}_0^*$, $G^*/\overline{Y}_0^*$, and $F^*/\overline{Y}_0^*$ respectively, since the initial steady values of D, G, F, D*, G* and F* are zero.

Log-linearlizing (3.40) and (3.41) yields:

$$0.5\widehat{D}_t + (1-0.5)\widehat{F}_t^* = 0 \quad (3.92)$$

$$(1-0.5)\widehat{F}_t + 0.5\widehat{D}_t^* = 0 \quad (3.93)$$

Appendix 3.2. The Calibration Parameters

Descriptions	Notations	Values
subjective discount rate	β	1/1.05
Intertemporal elasticity of substitution	σ	0.75
Elasticity of substitution between varieties of goods	θ	6
Consumption elasticity of money demand	ε	9
Capital share in production	α	0.36
Probability that firm cannot reset price	γ	0.5
Transaction costs for taking positions in international bond market if capital mobility is high (low)	ψ_F	4(0.01)
Physical capital adjustment costs	ψ_k	4
Depreciation rate	δ	0.1
Consumption share to GDP		0.70
Investment share to GDP		0.28
ρ_M autoregressive coefficient of the money supply process	ρ_M	1
ρ_g autoregressive coefficient of the fiscal policy process	ρ_g	1

Appendix 3.3. Definition of variables

Variables	Description	Sources
Annual telecommunication investment, local currency units	The expenditure associated with acquiring the ownership of telecommunication equipment infrastructure (including supporting land and buildings and intellectual and non-tangible property such as computer software). These include expenditure on initial installations and on additions to existing installations.	International Telecommunication Union and World Development Indicators
Export and import of communications equipment1	Communications equipment includes television receivers SITC 761; radio receivers SITC 762; telephone and switching equipment SITC 7641; transmission equipment SITC 7643 and 7648; and parts 7649.	World Trade Analyzer, and UN Comtrade
FDI inflows and FDI outflows (US$)	FDI inflows and outflows comprise capital provided (either directly or through other related enterprises) by a foreign direct investor to a FDI enterprise, or capital received by a foreign direct investor from a FDI enterprise. FDI includes three components: equity capital, reinvested earnings and intra-company loans. .	UNCTAD Handbook of Statistics
Fixed line and mobile phone subscribers (per 1,000 people	Fixed lines are telephone mainlines connecting a customer's equipment to the public switched telephone network. Mobile phone subscribers refer to users of portable telephones subscribing to an automatic public mobile telephone service using cellular technology that provides access to the public switched telephone network.	World Development Indicators, International Telecommunication Union, and Global Market Information Database
Real government final consumption expenditure, constant US$	General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation.	World Development Indicators, and National Statistics of Taiwan, Republic of China
Gross private capital flows/GDP	Gross private capital flows are the sum of the absolute values of direct, portfolio, and other investment inflows and outflows recorded in the balance of payments financial account, excluding changes in the assets and liabilities of monetary authorities and general government.	World Development Indicators, and National Statistics of Taiwan, Republic of China

Variables	Description	Sources
Lending rate	Lending interest rate is the rate charged by banks on loans to prime customers.	World Development Indicators, International Financial Statistics, Hong Kong Monetary Authority, Central Bank of China and Economic Intelligence Unit
Local currency/US$		International Financial Statistics
Real GDP, constant local currency units	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.	World Development Indicators, and National Statistics of Taiwan, Republic of China
Total Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin.	World Development Indicators, and National Statistics of Taiwan, Republic of China

Conclusions

In the first essay, although this study's baseline specification differs from Choi (2003) in terms of explanatory variables, dataset, sample countries, time periods, and estimation procedure, the results are complementary to Choi's conclusion that Internet development stimulates inward FDI stocks. The findings on the causality direction running from the Internet to FDI are robust to the AH and the GMM estimators, whereas the evidence on the reverse direction is weak. The findings on the causality direction running from the Internet to FDI are robust to the AH and the GMM estimators, whereas the evidence on the reverse direction is weak. These results further support the hypothesis that Internet development promotes inward FDI stocks.

This study also makes a contribution to literature on the Internet by explicitly capturing three channels through which the Internet affects FDI. Three hypotheses are proposed. First, using the Internet, MNCs can obtain accurate and timely information, thereby reducing the need for inventories and lowering inventory costs. Second, the Internet helps MNCs to search investment-related information, so that their entry costs to developing economies are lower. Third, the Internet acts as an effective channel for controlling corruption in developing countries, and thus reduces bribes paid by the MNCs. The findings strongly support the first two hypotheses. For the third, this study offers evidence that the Internet helps combat corruption, but their combined impact on FDI is ambiguous due to the unclear effect of corruption on FDI.

The findings in the second essay reveal the presence of negative Internet spillovers in developing countries and positive Internet spillovers in developed countries. The empirical evidence also indicates that in the presence of positive Internet spillovers, increasing Internet usage in developed countries considerably reduces the distance barrier so as to attract more FDI. On the other hand, in the presence of negative Internet spillovers, increasing Internet usage in developing countries does not statistically significantly reduce the distance barrier to FDI. It may even amplify the negative impact of distance on FDI. With regard to the impact of the Internet on agglomeration effects of FDI, the present study finds that the Internet favors the self-reinforcing process of FDI (proxied by lagged FDI), but tends to reduce the effect of the historical FDI [proxied by $(FDI/CAPITA)_{1994}$].

All in all, to fully realize the benefits of the Internet, developing countries need not only to increase the popularity of Internet usage, but also to improve their telecommunication infrastructure such as bandwidth per capita. Two benefits exist for using the Internet to attract FDI. First, the distance barrier is no longer beyond the control of policy makers. In the presence of a high quality telecommunication infrastructure, the Internet can reduce the distance barrier to MNCs, creating new opportunities for poor countries that are located far away from the major foreign investors. Second, the results concerning agglomeration forces indicate that an opportunity exists for developing countries to attract FDI. Since the Internet is able to change the effect of past FDI, poor countries that improve their investment environment could bring in new FDI. Then the self-reinforcing process is in force and the comparative advantage starts to accumulate, thereby attracting more FDI in the long term.

The panel VAR evidence reported in the third essay suggests that the group of economies with an advanced ICT or/and the financial liberalization experience higher output volatility in the face of a monetary policy shock, and lower output volatility in the face of a fiscal policy shock. In sum, the theoretical and empirical results of this study have two policy implications. First, for those countries which adjust their monetary policy actively, their short term output fluctuation would be exacerbated by the high financial integration. Second, the similar findings in a more financially integrated group and a high ICT group indicate that an advance in ICT could render capital control less effective.