Global Review of Business and Economic Research, Vol. 11 No. 2, (2015) : 157-174

INFORMATION TECHNOLOGY, FOREIGN INVESTMENT AND ECONOMIC GROWTH IN ELEVEN DEVELOPING COUNTRIES

Halima Qureshi
Alabama A&M University
Mamit Deme
Middle Tennessee State University

ABSTRACT

This paper examines the linkages and causality among GDP growth, FDI, and IT for eleven middle and high income developing countries using quarterly data from l976 to 2001. Cointegration tests reveal that the variables have long-run equilibrium relationships. The Granger causality test show six of the eleven countries have unidirectional causality running from GDP growth to FDI suggesting that a growing economy attracts FDI. Unidirectional causality running from FDI to GDP growth is found for only one of the eleven countries in our study. For three of the eleven countries we find a bidirectional causality between GDP growth and FDI. We also investigated the impulse response functions (IRF) from the vector autoregressive model (VAR) model. Although the magnitude and length of the impulse vary from country to country, the dynamic impact of GDP growth on FDI is positive for each of the countries in our study. The dynamic response of FDI to GDP growth is found to be positive for each of the countries in the chart with different length and magnitude of the impact.

Keywords: *GDP, FDI, Cointegration, Granger Causality VAR, IRF*

JEL Classification: *E22, E 24, F43, F47*

I. INTRODUCTION

In recent years, there has been a significant increase in the investment in information technology (Telecom investment) in developing countries. For example, during 1975 to 1997, the average growth rate of Telecom investment in China, Malaysia, Singapore, India, and Mexico were 32.17%, 22.80%, 20.27%, 13.90% and 12.92% respectively. Compare this to the average growth rate of Telecom investment in developed countries, such as the United States where the growth rate was only 3.97% during the same period, and one sees the magnitude of the difference. The increasing trend of Telecom investment in developing countries has attracted research attention to the possible relationship between economic growth and Telecom investment. Studies by Dutta (2001), Bebee and Gilling (1976), Bougheas, Demetriades and Mamuneas (2000), Gera, Gu and Lee (1999), Siegel and Griliches (1991), BrynJolfsson and Hitt (1995), and others have shown that Telecom investment does indeed have a strong positive effect on economic activities.

Improvement in telecommunication networks also contributes toward the overall efficiency of a country: it enhances the visibility of firms, reduces transaction costs, reduces the need for intermediaries, and facilitates the outsourcing of production activities by multinational corporations. Therefore, for developing countries, the chances of attracting foreign investment are higher if they have well developed communication networks. Along with Telecom investment, foreign direct investment (FDI) has also dramatically increased in developing countries during the 1980's and 1990's. According to a 1999 UNCTAD report, FDI in developing countries increased from $14 billion in 1985 to $166 billion in 1998, increasing approximately by 12%. Researchers such as Zhang (2001), Sun and Parikh (2001), Barell and Pain (1997), and others have shown that increased FDI has also been associated with higher economic growth in the host countries.

The purpose of our study is to investigate the relationship between information technology, foreign investment, and economic growth in eleven developing countries: Brazil, Ecuador, China, India, Indonesia, Korea, Malaysia, Mexico, Singapore, Thailand, and Turkey. Applying the quarterly data from 1976-2001 we have examined the long-run relationship between GDP, telecom investment and FDI for the countries mentioned above. Granger causality tests are performed to check the direction of the causality between Telecom investment and growth; between FDI and growth; and between Telecom investment and FDI. The organization of the paper is as follows. Section I provides the introduction of the paper. The models and the data sources are discussed in Section II. Section III provides methodology employed in this paper while the empirical results are presented in section IV. Finally, section V concludes the paper.

II. THE MODELS

The Harrod-Domar (Roy Harrod (1939) and Evsey Domar (1946)) growth model, with its assumption of a fixed capital output ratio, predicts that an economy can raise its long-run growth rate by simply increasing its saving-investment rate. Solow (1956) criticized the assumption of a fixed capital-output ratio in the Harrod-Domar model as unrealistic. By introducing the concept of diminishing returns to capital in his neo-classical growth model, Solow predicts that increasing the saving-investment rate will only increase the long-run steady state level of output - not the growth rate. Only through technological progress can an economy achieve long-run growth in Solow's model. In a mathematical form Solow's (l956) model can be represented by the following equation:

$$Y = A(t)F(K,L) \qquad ...(1)$$

where Y is output, K is capital, L is labor and A(t) is the level of technology that measures the cumulative effect of shifts of the production function over time. A slightly different way to write Solow's growth model with technological progress is:

$$Y = F(K,L.E) \qquad ...(2)$$

Here, the technological progress is assumed to increase the productivity of the workers. E is defined as the efficiency of the worker. The main weakness in Solow's model however, is that the technological progress is treated as exogenously determined.

Endogenous growth theory takes care of this weakness in Solow's model. If an economy's long-run growth depends upon technological progress, what determines technological progress is very important. Endogeneity of technological progress can be studied in three different ways. In the first version of the endogenous growth model, it is assumed that there is an interaction between capital accumulation and technological progress. This new version of technological progress, which is known as the Vintage model (see Johansen (1959), Solow (1960), Nelson (1964), DeLong and Summers (1991), Temple (1998), and others), points out that new technology is embodied in new capital goods. In a mathematical form this type of endogenous growth model can be represented by:

$$Y = F(K, L.E) \qquad \text{... (3)}$$

and,

$$E = DK^{\phi} \qquad \text{...(4)}$$

where D > 0, and ϕ > 0 are constants. Therefore in (3) and (4) the endogeneity of technological progress (E) which foster economic growth comes as an externality to capital investment.

In the second version of endogenous growth theory, technology is endogenized as "learning by doing." As the production process continues, more output can be produced with the same amount of inputs. Thus, in this version, technological progress comes as an externality to the production process. These learning by doing models were inspired by many studies that have found evidence of the above described phenomenon. For example, Irwin and Klenow (1994), Benkard (1999) and Bell and Scott-Kemmis (1990), Thomson (1999) and others have demonstrated how growth can come from learning by doing. The learning by doing model can be represented by the following equations:

$$Y = F(K, L.E) \qquad \text{...(5)}$$

$$E = BY \qquad \text{...(6)}$$

where B > 0. Therefore, in (5) and (6) technology is an externality to the production process.

In the final version of endogenous technological progress, technological progress is assumed to come from a sector (i.e., Research and Development (R&D) sector) which produces productivity enhancing ideas. The R&D model of endogenous growth can be represented by the following equations:

$$Y = F(K, L, g) \qquad \text{...(7)}$$

$$g = f(\pi, L, \beta, r) \qquad \text{...(8)}$$

with π and L > 0; β, and r <0

where g is the number of innovations which depends upon profit (π), labor supply (L), the amount of resources needed to create an innovation (β), and interest rate (r). In this type of endogenous growth model ((7), and (8)), profit maximizing firms will intentionally devote scarce resources to create new ideas. The R&D based growth models were presented by Uzawa (1965), Shell (1973), Lucas (1988), Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and others. Their work supports the view that growth depends on technological progress which arises from intentional investment in the R&D sector by profit maximizing agents.

The main weakness of the above mentioned endogenous growth models is, however, how to measure technological progress. As discussed above, several authors have used different estimates to capture the effect of technological progress on growth. Our focus is to see how Telecom investment and FDI fits into the traditional growth theories. With regard to Telecom investment, we can treat it as capturing the effect of technological progress embodied in new capital (i.e., an externality to investment). For FDI, we can treat it as a technology spillover which arises from R&D investments in foreign countries.

Though there are a few studies which explore the relationship between output growth, Telecom investment and FDI (see introduction), there are some weaknesses in these studies. One of the weaknesses is that the effect of Telecom investment and FDI are studied separately. As mentioned in the introduction, since in developing countries we observe both Telecom investment and FDI increasing at a significant rate, there is a need to study them together in a single growth model.

To study the relationship between GDP, telecom investment and FDI we start with the following production function:

$$Y_t = F(L_t, K_{1t}, K_{2t}, A_t) \qquad ...(9)$$

where Y, L, *and* A are as defined earlier, and K_1, K_2, and t represent non-telecom-capital, telecom-capital, and time respectively.

The level of technology in our model has three sources: exogenous, externality to investment, and R&D activities. Therefore, we can write:

$$A_t = f(K_{1t}, K_{2t}, R_t, S_t, \alpha_g) \qquad ...(10)$$

where α_g = exogenous technological change, R = own R&D capital S= spillover from foreign direct investment. Substituting (10) into (9), we can rewrite our production function as:

$$Y_t = F(L_t, K_{1t}, K_{2t}, R_t, S_t, \alpha_g) \qquad ...(11)$$

Following the standard growth model, we assume that the production function given by (11) can be represented by a Cobb-Douglas production function:

$$Y_t = L_t^{\alpha_1} K_{1t}^{\alpha_2} K_{2t}^{\alpha_3} R_t^{\alpha_4} S_t^{\alpha_5} e^{\alpha_g} \qquad ...(12)$$

The exponents represent the elasticity of output with respect to the associated input. Expressing (12) in natural log form we get,

$$y_t = \alpha_0 + \alpha_1 l + \alpha_2 k_{1t} + \alpha_3 k_{2t} + \alpha_4 r_t + \alpha_5 s_t + \varepsilon_t \qquad ...(13)$$

where $\alpha_0 = \alpha_g$ and ε is the error term.

The model represented by equation 13 will be estimated to study the relationship between Telecom investment, FDI, and GDP growth. Based on the growth theories discussed in this section, we expect Telecom investment and FDI to have positive impact on GDP growth (i.e. α_3 > 0 and α_5 > 0).

III. METHODOLOGY

Augmented Dickey Fuller (ADF) Unit Root

ADF requires running a regression of the first difference of the series against the series lagged once, lagged difference terms, and a constant with a time trend such as

$$\Delta X_t = \lambda_0 + \lambda_1 X_{t-1} + \lambda_2 T + \Sigma\lambda_i \Delta X_{t-i} + \varepsilon_t$$
$$i = 1................k$$

where Δ is the first difference operator, ε_t is an error term, and k is the number of lagged first differenced term and is determined such that ε_t is approaching white noise. The H_0 hypothesis that X_t is non-stationary time series translates into H_0: λ_1 =0. The output of the ADF test consists of the i(tau)-statistic on estimated coefficient of the lagged variable (λ_1) and the critical values for the test of a zero coefficient. If the estimated ADF statistic is larger (in absolute) than its critical value then the null is rejected suggesting that the series is stationary (i.e., the H_0 is rejected if λ_1 is significantly negative). The choice of optimal lag-lengths used in the unit root tests is determined by applying Akaike (AIC) and Schwarz (SC) information criteria.

Cointegration

The theory of cointegration is introduced first by Granger (1981) and developed further by Granger (1986) and Engle and Granger (1987) integrates the short-run dynamics with long-run equilibrium relationship. The usefulness of cointegration is thus seen in the estimation of the short-run or disequilibrium parameters that will bring long-run equilibrium through the adjustment process known as error-correction model. A set of time-series variables are said to be cointegrated if they are integrated of the same order and a linear combination of them is stationary. Such linear combination would then point to the existence of a long-term relationship among the variables. If we have k endogenous variables, each of which is first-order integrated, there can be from 0 to k-1 linearly independent cointegrating vectors. If there are none, the conventional time series analysis such as vector autoregressive (VAR) applies to the first differences of the data. The Johansen ((1991) tests can be applied to determine the number of cointegrating equations (cointegrating rank). If there are k cointegrating equations, it means none of the series is actually integrated, and the VAR can be reformulated in terms of the levels of all of the series. Taking a VAR model, Johansen (1991) and Johansen and Juselius (1990) derived a maximum likelihood approach to estimation and testing the number of cointegrating relationships among components of a k-vector of x_i variables by trace test.

VAR and Impulse Response Function

If there is true simultaneity among a set of variables, they should all be treated on an equal footing; there should not be any a priori distinction between the endogenous and exogenous variables. It is in this spirit that Sims (1980) developed the VAR model. The VAR model avoids the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all endogenous variables in the system. The VAR is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. Since the individual coefficients in the estimated VAR models are often difficult to interpret, the practitioners of this technique often estimate the so-called impulse response function (IRF). The IRF traces out the response of the dependent variable in the VAR system to shocks in the error terms. Innovations or surprise movements are jointly summarized by the error terms of the VAR model. There is one impulse response function for each innovation and each endogenous variable. Mathematical formulation of a VAR of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t,$$

where y_t is a *k*-vector of endogenous variables, x_t is a *d* vector of exogenous variables, A1,…….., Ap and B are matrices of coefficients to be estimated, and ϵ_t is a vector of stochastic error terms, called, innovations or impulses or shocks. The lag order of the VAR plays a crucial role in the empirical analysis and it is often selected arbitrarily with recommendation which suggests setting it long enough to ensure that the residuals are white noise and the remaining sample for estimation is large enough for the asymptotic theory to work reasonably well. Before estimation, we have to decide on the maximum lag length p. However, choosing large lag might lead imprecise estimates because of multicollinearity . The optimal lag length can be selected using the Akaike information criteria (AIC) or the Schwarz Bayesian criteria (SC).

Granger Causality

The Granger (1969) approach to the question of whether *x* and *y* is to see how much of the current *y* can be explained by past values of *y* and then to see whether adding lagged values of *x* can improve the explanation. *y* is said to be Granger-caused by *x* if *x* helps in the prediction of *y*, or equivalently if the coefficients on the lagged *x*'s are statistically significant. Note that two-way causation is frequently the case; *x* Granger causes *y* and *y* Granger causes *x*., It is better to use more rather than fewer lags, since the theory is couched in terms of the relevance of all past information. You should pick a lag length, ℓ, that corresponds to reasonable beliefs about the longest time over which one of the variables could help predict the other.

Eviews runs bivariate regressions of the form

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_\ell y_{t-\ell} + \beta_1 \chi_{t-1} + \cdots + \beta_\ell \chi_{t-\ell}$$
$$\chi_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_\ell y_{t-\ell} + \beta_1 \chi_{t-1} + \cdots + \beta_\ell \chi_{t-\ell}$$

for all possible pairs of (χ, y) series in the group. The reported *F*-statistics are the Wald statistics for the joint hypothesis

$$\beta = \cdots = \beta_\ell = 0$$

for each equation. The null hypothesis is therefore that χ does *not* Granger-cause *y* in the first regression and that *y* does *not* Granger-cause χ in the second regression.

$$Y_t = \alpha_{10} + \Sigma\, \alpha_{1i} X_{t-i} + \Sigma\, \beta_{1j} Y_{t-j} + \varepsilon_{1t} \qquad ...(1)$$
$$X_t = \alpha_{20} + \Sigma\, \alpha_{2i} X_{t-i} + \Sigma\, \beta_{2j} Y_{t-j} + \varepsilon_{2t} \qquad ...(2)$$

With respect to this model we can distinguish the following cases:

(i) If $[\alpha_{11}, \alpha_{12}, \ldots\ldots\ldots, \alpha_{1p}] \neq 0$ and $[\beta_{21}, \beta_{22}, \ldots\ldots\ldots, \beta_{2q}] = 0$, there exists a unidirectional causality from X_t to Y_t, denoted as $X \rightarrow Y$.

(ii) If $[\alpha_{11,} \alpha_{12,} \ldots\ldots\ldots, \alpha_{1p}] = 0$ and $[\beta_{21,} \beta_{22,\ldots\ldots\ldots\ldots\ldots,} \beta_{2q}] \neq 0$, there exists a unidirectional causality from $Y_{t,}$ to X_t, denoted as $Y \rightarrow X$.

(iii) If $[\alpha_{11,} \alpha_{12,} \ldots\ldots\ldots, \alpha_{1p}] \neq 0$ and $[\beta_{21,} \beta_{22,\ldots\ldots\ldots\ldots\ldots,} \beta_{2q}] \neq 0$, there exists a bidirectional causality between X_t to $Y_{t,}$ denoted as $X \leftrightarrow Y$.

IV. EMPIRICAL RESULTS

The first step in our empirical analysis involves testing whether the time series variables in our study are stationary. The ADF test procedure is used to test for a unit root. Table 1 summarizes the ADF Tests. All variables are found to have unit root at the levels, however first difference series are found to be stationary. We then tested the long-run relationships among the variables

Table 1
Unit Root Tests

Variables	*ADF coefficients in levels* τ_m	*Mackinon critical value* τ_t	*ADF coefficients in first difference* τ_m	*Mackinon critical value* τ_t
LnGDP	-2.14	-3.146	-8.25**	-4.12
LnFDI	-2.95	-4.13	-11.40**	-4.13
LnIT	-2.44	-4.12	-5.14**	-4.12

Note: ** indicate rejection of null hypothesis of unit root (non-stationary) at the 1% level of significance. *Mackinnon critical value for rejection of hypothesis of a unit root has been applied at the 1% level. Optimum lag structures are determined by the Akaike and Schwarz information criteria.*

employing Johansen's (1990) cointegration technique. The cointegration estimation results are reported in Table 2. Next, we assess the direction of causality among GDP, FDI, and telecom investment applying a vector autoregressive approach. The estimated F-statistic for block exogeniety is used to determine Granger causality. The results of the Granger causality tests are reported in Table 3. We further estimate impulse response functions to assess the dynamic relationships among these variables. The impulse response functions are estimated for the variables that showed a statistically significant causal link with each other.

Column 1 of Table 2 shows the null hypothesis on the number of cointegrating vectors, where r stands for the number of cointegrating vectors. Column 2 of the same table shows the 5% critical values of the trace statistic associated with each null hypothesis. We reject the null hypothesis if the estimated trace statistic exceeds the critical value in Column 2. The tests exhibit a long-run relationship among the variables for each country. Yet, for most of the countries in our study, we find more than one cointegrating vectors. Table 2 exhibits two cointegrating vectors for Brazil, Thailand, and Turkey; three cointegrating vectors for China; four cointegrating vectors for Korea; five cointegrating vectors for India, Indonesia, Mexico, and Singapore; and one cointegrating vector each for Ecuador, and Malaysia. Hence, most of the cointegrating vectors obtained from these results fail to show a unique relationship among the variables examined, except for the two countries, Ecuador, and Malaysia. Therefore, we can not infer much from the estimated coefficients of the cointegrating vectors about the long-run relationship between GDP growth and the remaining variables.

Table 2
Summary Results of Johansen's Multivariate Cointegration Tests

Variables GDP, FDI, IT, L, K
Assumption: linear deterministic trend.
Lag structure : 1 to 1.
Sample: Quarterly data from l976-2001 .
Johansen's Trace Test

Null Hypothesis	*5% Critical Value*	*Brazil*	*China*	*Ecuador*	*India*	*Indonesia*	*Korea*	*Malaysia*	*Mexico*	*Singapore*	*Thailand*	*Turkey*
$r = 0$	68.52	93.19*	93.93*	80.87*	95.92*	89.14*	91.24*	70.81*	87.36*	106.28*	81.84*	81.86*
$r \leq 1$	47.21	47.33*	61.15*	46.53	59.02*	56.17*	58.51*	40.19	54.65*	67.07*	53.16*	49.41*
$r \leq 2$	29.68	27.57	32.35*	28.40	36.91*	30.35*	36.23*	22.32	32.74*	36.89*	28.32	28.22
$r \leq 3$	15.41	11.33	11.71	14.03	22.39*	16.13*	17.46*	7.13	16.33*	16.39*	11.32	10.36
$r \leq 4$	3.76	3.53	2.98	3.22	8.83*	5.41*	3.45	0.01	5.80*	5.74*	0.95	0.87

Having found long run relationships among the variables for each country we proceed to test the direction of causality between GDP, and FDI; GDP, and telecom investment; and telecom investment, and FDI. The first two rows of Table 2 report the estimated Granger causal links between FDI and GDP growth obtained from a vector autoregressive procedure. For Brazil, India, Mexico, Singapore, Thailand, and Turkey the results hint a direction of causality running from GDP growth to FDI growth. The implication of these results is that that countries with potentially strong market power can attract FDI. These results are also consistent with of Chakrabarti (2001) who argues that market size measured by the size of the GDP affects FDI.

The results suggest a feedback relationship between FDI growth and GDP growth for Ecuador, Korea, and Malaysia suggesting that FDI growth and GDP growth reinforce each other. When a technologically progressive multinational corporation undertakes FDI in a less developed economy the introduction of new technologies and ideas as well as capital may alter the production possibilities of the host country thereby raising productivity (Barrel and Pain, l997). Barrel and Pain (l997) argue that even when FDI involves simply mergers and acquisition, the associated reorganization and the introduction of new ideas can raise the rate of technical progress and thus the long-run rate of economic growth. For Indonesia the results show a one way causality running from FDI to GDP growth. The tests failed to demonstrate a statistically significant causal link between GDP growth and FDI growth for China. This could be because of the fact that the FDI activities are more of a recent phenomenon for China relative to the longitudinal data that we used in our study.

Our findings for Brazil, Thailand are consistent with Zhang (2001). However, our findings for Indonesia, Korea, and Mexico vary from that of Zhang's (2001); Zhang (2001) finds a feedback relationship between GDP and FDI for Mexico and Indonesia, and a causality running from GDP to FDI for Korea. Overall, our results show a strong causal link between FDI growth and GDP growth; yet, though a one way causality running from FDI growth to GDP growth is shown only for one of the eleven countries in our study. As Borensztein et al. (l998), and de Mello (l999) suggest FDI may contribute to growth only in countries that posses growth-enhancing resources that are complementary to FDI.

The 3rd and 4th rows of table 3 show the empirical causal links between telecom investment and GDP. The results suggest a one way causal link running from growth in telecom investment to growth in GDP for Brazil, Ecuador, and Indonesia. These results are consistent with the findings of Bougheas, Demetriades and Mamuneas (2000), Bibee and Grilling (1976) which conclude that telecom investment leads to economic growth. The findings support the notion that reliable and high quality telecommunication facilities allow an economy to function more efficiently leading to economic growth. Telecommunication, which includes voice, data, message, and image communications is a crucial factor of production for many firms. Businesses, including Airlines, banks, credit card companies, insurance companies, investment firms rely heavily on high-speed, high quality communication facilities to conduct business competitively. Our empirical results show causality running from GDP growth to growth in telecom investment for India, Korea, Malaysia, Mexico, and Thailand. The results suggest a feedback relationship between telecom investment and GDP growth for Singapore, but they failed to show a statistically significant causal link between telecom investment and GDP growth for China,

Table 3
Summary Results of Granger Causality Test

Null Hypothesis	*Brazil*	*China*	*Ecuador*	*India*	*Indonesia*	*Korea*	*Malaysia*	*Mexico*	*Singapore*	*Thailand*	*Turkey*
FDI =/=>	0.03	0.79	3.44*	2.03	16.53***	2.52*	4.26**	1.48	0.33	0.08	1.48
GDP	lag = 2	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2
GDP =/=>	4.95***	0.80	4.05**	5.65***	0.13	4.81***	6.16***	3.93**	4.66***	7.19***	4.18***
FDI	lag = 2	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2
TELECOM =/=>	3.53**	1.35	9.58***	1.73	13.08***	0.46	0.62	1.28	6.50***	1.30	1.80
GDP	lag = 2	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2
GDP =/=>	0.35	0.91	2.39	7.45***	0.36	4.76***	4.92***	8.13***	2.67*	2.36*	1.47
TELECOM	lag = 2	lag = 2	lag = 1	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2
TELECOM =/=>	7.87***	1.54	70.3***	3.28**	0.20	0.91	4.01**	2.12	0.03	4.90***	0.19
FDI	lag = 2	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 1
FDI =/=>	0.19	2.70*	5.45**	1.28	0.44	0.95	8.12***	5.65***	3.13**	5.42***	3.45**
TELECOM	lag = 2	lag = 2	lag = 1	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 2	lag = 1

* The sign, =/=> implies does not "Granger cause". The signs, ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

and Turkey. Our findings for Brazil, India, Indonesia, Malaysia, Mexico, and Thailand are not consistent with Dutta (2001). He conducted a test on the Granger causal link between telecommunication facilities (telephones per 100 people) and GDP growth. His study indicates a one way causal link running from telecommunications structure to GDP growth for India and Mexico; a feedback relationship between the two variables for Brazil, Indonesia, and Thailand; and an insignificant causal link between the two variables for Malaysia.

The last two rows of Table 3 report our empirical findings on the link between FDI and telecom investment for each country in the Table. The results support a causal link between FDI and telecom investment for nine of the eleven countries suggesting a strong causal link between the two variables. The evidence shows a feedback relationship between telecom investment and FDI for Ecuador, Malaysia, and Thailand, and a one way causal link running from telecom investment to FDI for Brazil, and India. These findings suggest that a well developed telecommunications infrastructure can attract FDI. For China, Mexico, Singapore, and Turkey the results in Table 2 indicate a one way causal link running from FDI to telecom investment. These results are consistent with the theory that FDI facilitates technological progress. The tests failed to suggest a statistically significant causal link between the two variables for Indonesia, and Korea.

The figures of IRF exhibit the dynamic relationship of the variables that show a statistically significant causal link. The impulse response of GDP to a one-time positive shock in telecom investment is shown for four countries: Brazil, Ecuador, Indonesia, and Singapore. For three of these four countries the impulse response of GDP to a one-time shock in telecom investment seems to be positive and long lasting. GDP rises, reaches a peak, and then slows down, but remain positive for the quarters shown on the chart exhibiting the expected positive impact of telecom investment. For one of the four countries, Singapore, GDP growth falls, reaches a throw and rises but remains negative for the period shown on the chart. One factor that contributes to the negative relationship is the cost of investment in telecommunications infrastructure. Unless the investment is able to stimulate growth in GDP, the cost of the investment to income (through taxation, etc) can be reflected in the GDP growth. Another plausible factor is the l990s East Asian economic crisis during which other factors played a major role in causing GDP plummet beginning l997. Hence if telecom investment was rising while GDP was falling, the data on the chart can reflect this negative correlation. A one-time positive shock in GDP growth causes telecom investment to rise, reach a peak, and then fall. However, with the exception of Singapore, the positive impact lasts for more than ten quarters for each country on the chart.

The impulse response of FDI to a one-time shock in GDP appears to be positive and long lasting for most of the countries exhibited in the chart. For Ecuador, India, and Thailand, FDI rises, reaches a peak level, and remains at the peak rate; and for Korea and Malaysia, it rises, reaches a peak, and goes back to its initial level. GDP rises, reaches a peak, and starts falling (but remains positive) for Mexico; and remains rising for Turkey. These results confirm the theory that FDI is attracted by economic growth.

FIGURE 1: Impulse Response Functions

The horizontal axis represents the years, the vertical axis measures the response of a variable due to an impulse or shock of its own or another variable in the model.

Figure 1.1

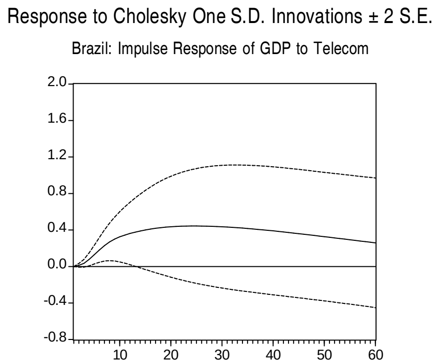


Figure 1.2

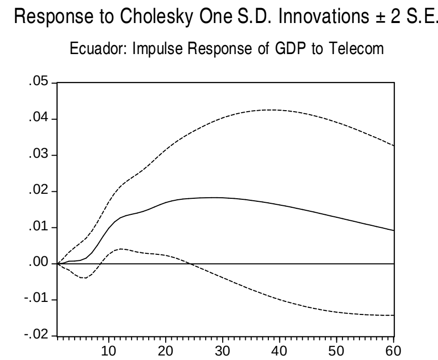


Figure 1.3

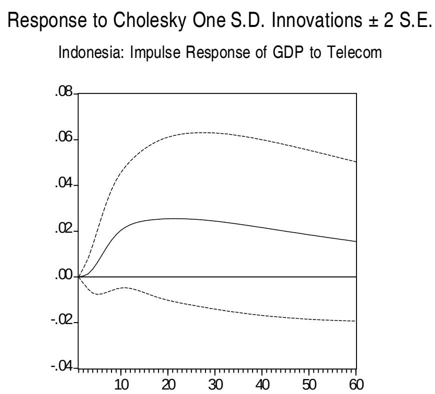


Figure 1.4

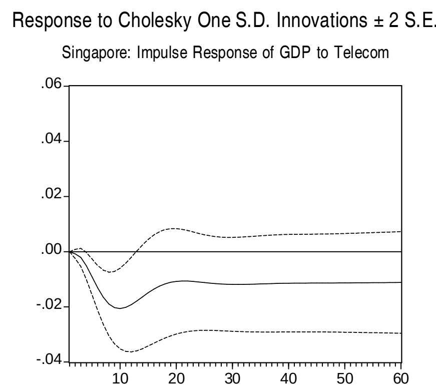


Figure 2.1

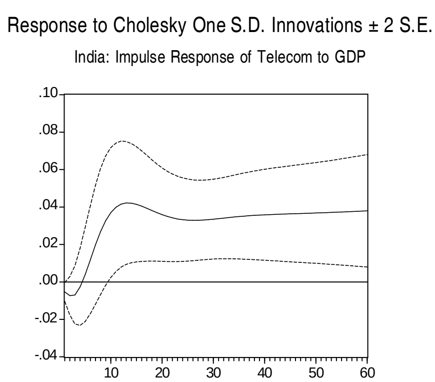


Figure 2.2

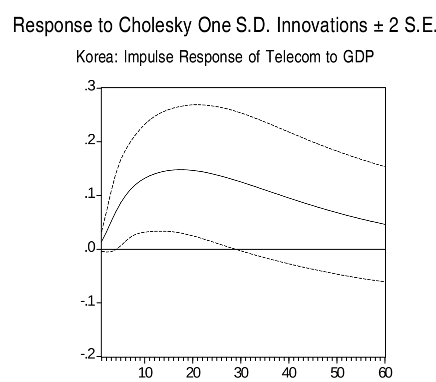


Figure 2.3

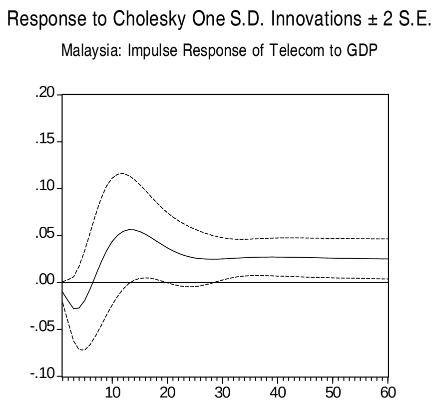


Figure 2.4

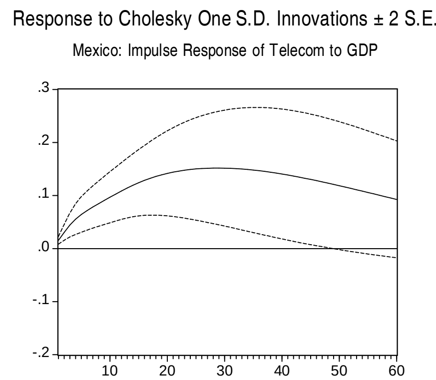


Figure 2.5

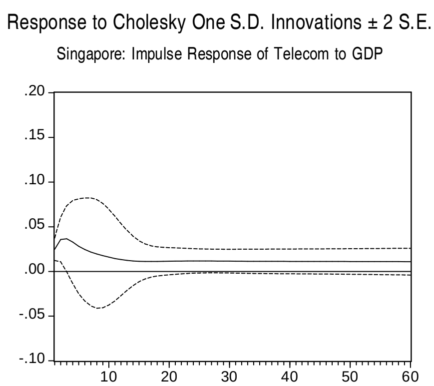


Figure 2.6

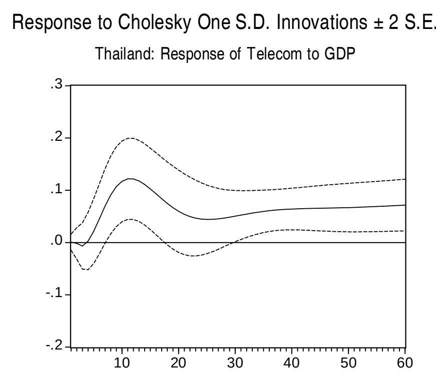


Figure 3.1

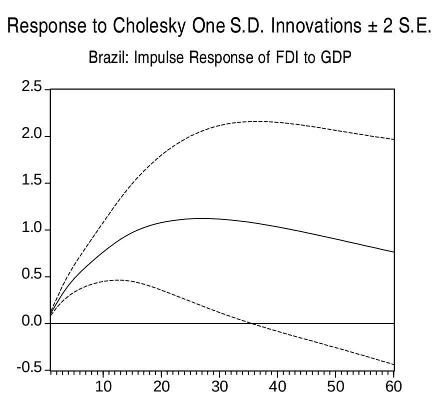


Figure 3.2

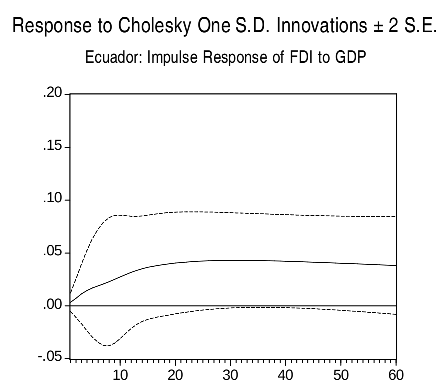


Figure 3.3

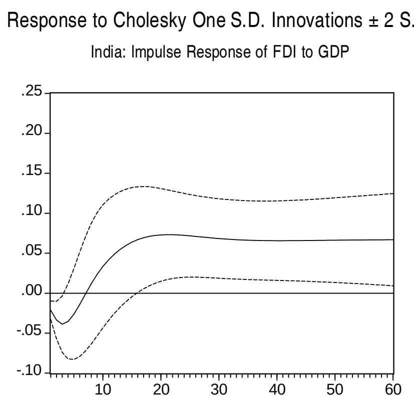


Figure 3.4

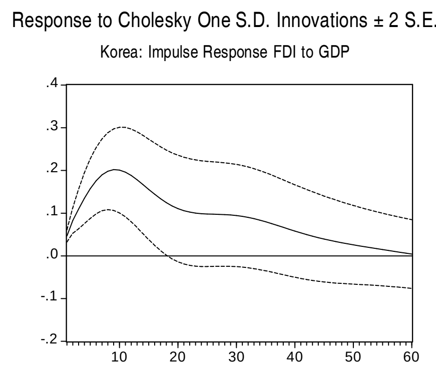


Figure 3.5

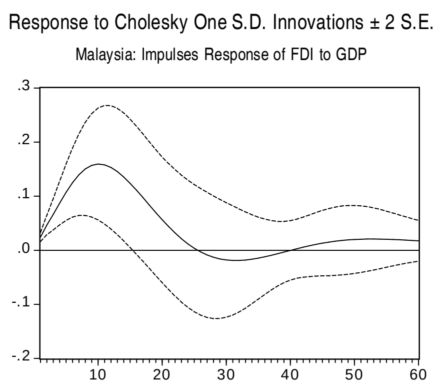


Figure 3.6

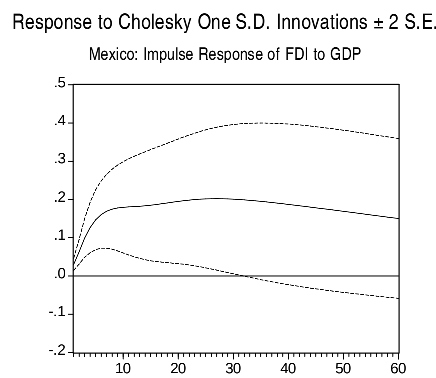


Figure 3.7

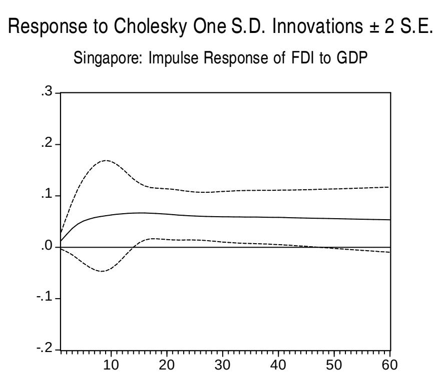


Figure 3.8

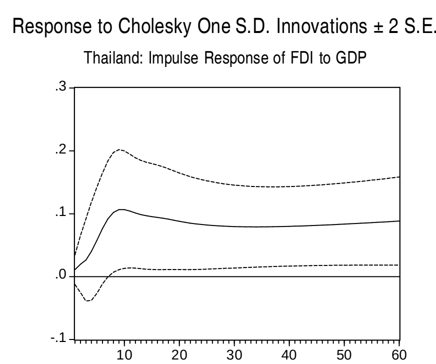


Figure 3.9

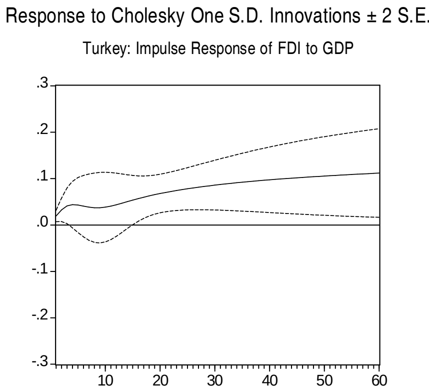


Figure 4.1

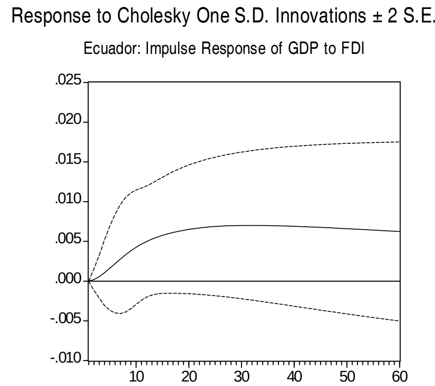


Figure 4.2

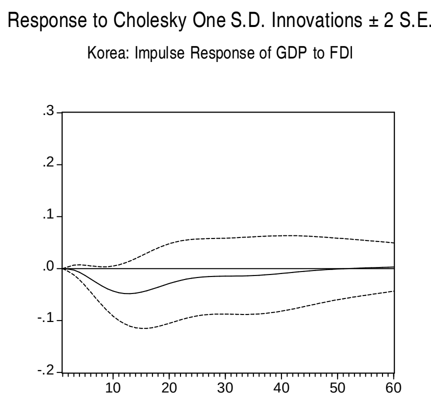


Figure 4.3

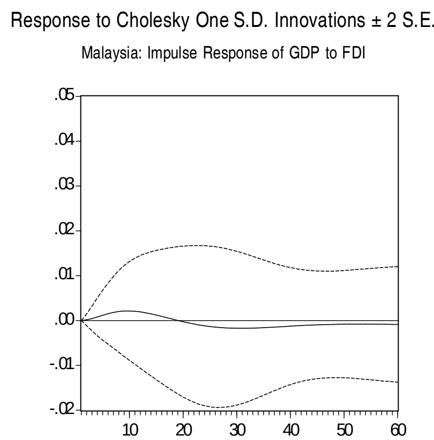
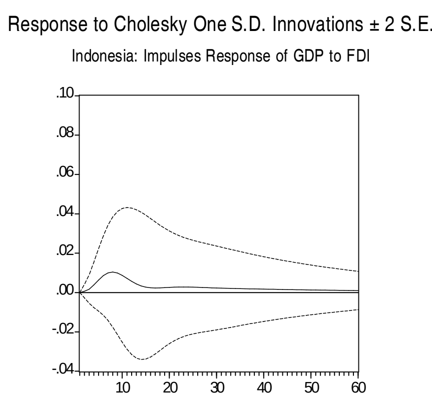


Figure 4.4



Only four, Ecuador, Indonesia, Korea, and Malaysia, of the eleven countries, show a statistically significant causal link running from FDI growth to GDP growth. Among these four countries a definitely positive impulse response is exhibited only for Ecuador; for this country, GDP growth rises, and remains close to its peak level for the sixty quarters shown on the chart. For Korea and Malaysia the impulse response is low and mostly negative; the l990s East Asian crisis may explain the negative correlation. For Indonesia the impulse response of GDP to a one-time shock in FDI, though positive, is very low.

V. CONCLUSIONS

This paper examines the linkages and causality among GDP growth, FDI, and IT for eleven middle and high income developing countries using quarterly data from l976 to 2001. Though the level series are not stationary by ADF unit root test, however the first difference series are found to be stationary. Johansen's multivariate cointegration tests reveal that the variables have a longrun relationship. The tests also reveal more than one cointegrating vectors for nine of the eleven countries suggesting a lack of a unique relationship among the variables.

The Granger causality test is applied to examine the direction of causality between the variables of interest in our paper. For six of the eleven countries in our study the results show unidirectional causality running from GDP growth to FDI suggesting that a growing economy attracts FDI. Unidirectional causality running from FDI to economic growth is found for only one of the eleven countries in our study. For three of the eleven countries we find a feedback or bidirectional causality between GDP growth and FDI. With regard to telecom investment our study shows one-way causality running from telecom investment to GDP growth only for three of the eleven countries. The results reveal GDP growth Granger causes telecom investment for five of the eleven countries suggesting that economic growth is a crucial factor in the development of information technology. For one country we find a feedback relationship. For two of the eleven countries the data shows a unidirectional causality running from telecom investment to FDI, four of the eleven countries it shows a unidirectional causality from FDI to telecom investment, and three countries it shows a feedback relationship.

The impulse response functions reveal that impact of telecom investment on GDP growth is positive and permanent and negative for one countries. Although the magnitude and length of the impact vary from country to country, the dynamic impact of GDP growth on telecom investment is positive for each of the countries in our study. The dynamic response of FDI to GDP growth is found to be positive for each of the countries in the chart with different length and magnitude of the impact. Except for only one of the countries, the impulse response of GDP growth to a one-time shock in FDI is very low. Our overall empirical findings reveal that FDI, IT, and GDP growth have positive and significant link, but their impact on each other is country specific.

References

Aghion, P. and P. Howitt. (1992), "A Model of Growth Through Creative Destruction," *Econometrica*, Vol. 60, pp. 323-351.

Barrell, Ray and Nigel Pain. (1997), "Foreign Direct Investment, Technological Change, and Economic Growth Within Europe," *The Economic Journal*, Vol. 107, Issue 445, pp. 1770-1786.

Bebee, E.L, and E.T.W Gilling. (1976), "Telecommunications and Economic Development: A Model For Planning and Policymaking," *Telecommunication Journal*, Vol. 43, Issue 8, pp. 537-43.

Bell, R.M. and D. Scott-Kemmis. (1990), "The Mythology of Learning - by- Doing in World War II Airframe and Ship Production,'' Mimeo.

Benkard, C. Lanier, (1999), "Learning and Forgetting: The Dynamics of Aircraft Production," NBER Working Paper No. W7127.

Borensztein, E., J. De-Gregorio and J.W. Lee. (1998), "How Does Foreign Direct Investment Affect Economic Growth?" *Journal of International Economics*, Vol. 45, Issue 1, pp. 115-135.

Boughes, Spiro, Ponicos O. Demetriades, and Theotaris P. Mamuneas. (2000), "Infrastructure, Specialization, and Economic Growth," *Canadian Journal of Economics*, Vol. 33, No. 2, pp. 506-522.

Brynjolysson, Erik and Lorin Hitll. (1997), "Paradox Lost? Firm-Level Evidence of the Returns To Informations System Spending," *Management Science*.

Chakrabarti, Avik. (2001), "The Determinant of Foreign Direct Investment: Sensitivity Analysis of Cross-Country Regressions," *KYKLOS*, Vol. 54, pp. 89-114.

De Long, J. Bradford and Lawrence H Summers. (1991), "Equipment Investment and Economic Growth," *Quarterly Journal of Economics*, Volume 106, Issue 2, pp. 445-502.

Dickey, D.A. and W.A. Fuller. (1979), "Distribution for the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, Vol. 74, pp. 427-431.

Domar, Evsey D. (1946), "Capital Expansion, Rate of Growth, and Employment," *Econometrica*, Vol. 14, Issue 2, pp. 137-144.

Dulta, Amitava, (2001), "Telecommunications and Economic Activity: An Analysis of Granger Causality", *Journal of Management and Information System*, Vol. 17, No. 4, pp. 71-95.

Gera, Sandra; Gu, Wulong and Lee, Frank C. (1999), "Information Technology and Labor Productivity Growth: An Empirical Analysis for Canada and United States," *The Canadian Journal of Economics*, Vol. 32, Issue 32, pp. 384-407.

Grassman, Gene M., Elhanan Helpman. (1989), "Product Development and International Trade," *The Journal of Political Economy*, Vol. 97, Issue 6, pp. 1261-1283.

Harrod, Roy F. (1939), "An Essay in Dynamic Theory," *Economic Journal*, pp. 14-33.

Irwin, Douglas A. and Peter J. Klenow. (1994), "Learning by Doing: Spillovers in the Semiconductors Industry," *Journal of Political Economy*, Vol. 102, Issue 6, pp. 1200-1227.

Johansen, Leif. (1959), "Substituting Versus Fixed Production Coefficients in the Theory of Economic Growth: A Synthesis," *Econometrica*, Vol. 27, Issue 2, pp. 157-176.

Johansen, Soren. Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Growth: A Synthesis," *Econometrica*, Vol. 59, Issue 6, pp. 1551-1580.

Lucas, R.E. "On The Mechanics of Monitory Economics," Vol. 22, (1988), pp. 3-42.

Nelson, Richard R. (1964), "Aggregate Production Function and Medium Range Growth Projections," *American Economic Review*, Vol. 54, Issue 5, pp. 575-606.

Romer, Paul M. (1990), "Endogenous Technological Change," *The Journal of Political Economy*, Vol. 98, Issue 5, Part 2, pp. 71-102.

Solow, Robert M. (1960), "Investment and Technical Progress," *Mathematical Methods in Social Sciences*, Eds: Kenneth J. Arrow, Samuel Karlin, and Patric Suppes. Stanford: Stanford U. Press, pp. 89-104.

Solow, Robert M. (1956), "A Contribution to the Theory of Economic Growth," *The Quarterly Journal Economics*, Vol. 70, Issue 1, pp. 65-94.

Shell, K. "Inventive activity, Industrial Organization and Economic Growth", In *Modules of Economic Growth*, J. A. Mirrlees and N. H. Stern eds., (London: Macmillan,1973).

Siegal, D. and Griliches. (1991), "Purchased Services, Out Sourcing, Computers And Productivity In Manufacturing," *NBER* Working Paper no. 3678.

Sun, Haishan and Ashok Parikh. (2001), "Export, Inward Foreign Direct Investment (FDI) and Regional Economic Growth in China," *Regional Studies*, Vol. 35.3, pp. 187-196.

Temple, Jonathon, (1998), "Equipment Investment and the Solow Model," *Oxford Economic Papers*, Vol. 50, pp. 39-62.

Thompson, Peter. (1999), "How Much Did the Liberty Shipbuilders Learn? New Evidence for an Old Case Study," Memeo, p 33.

United Nations Conference on Trade and Development (UNCTAD). World Investment Report 1999, New York; Untied Nations, 1999.

Uzawa, H. "Optimum Technical Change in an Aggregative Model of Economic Growth," *International Economic Review*, Vol. 6, (1965).

Zhang, Kevin Honglin. "Does Foreign Direct Investment Promote Economic Growth? Evidence From East Asia and Latin America," *Contemporary Economic Policy*, Vol. 19, No. 2, (Apr. 2001), pp. 175-185.