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The Causal Relationship between Information and Communication Technology and Foreign Direct Investment

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Abstract

This paper investigates the simultaneous causal relationship between investments in information and communication technology (ICT) and foreign direct investment (FDI), with reference to its implications on economic growth. For the empirical analysis we use data from 23 major countries with heterogeneous economics development for the period 1976–99. The results of unit roots and Johansen co-integration tests indicate variations in degrees of integration among the sample countries. Our causality test results suggest that there is a causal relationship from ICT to FDI interpreted as the higher level of ICT investment leads to increased inflow of FDI. ICT contributes to economic growth indirectly by attracting more foreign direct investment. In developed countries there already exist a build up ICT capacity which causes inflow of FDI, while in developing countries ICT capacity must be build up to attract FDI. The inflow of FDI causes further increases in ICT investment and capacity.

Keywords: foreign direct investment, FDI, information and communication technology, ICT, stationarity, co-integration, causality

JEL classification: C23, C33, C51, E22, F21

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1 Introduction

The growth of world foreign direct investment (FDI) in recent years has been exceptional. The US dollar value of world FDI inflows reached a record US$1.3 trillion in 2000 from just over US$200 billion in 1993. In 1980 FDI stock represented the equivalent of only 5 per cent of world GDP; this percentage had almost tripled to 14 per cent by the end of the 1990s (UNCTAD 2000). The share of developing countries in FDI inflows has been raised from 17.1 per cent in 1988–90 to 21.4 per cent in 1998–2000. Since the 1980s, attracting FDI has been one of the most important policy goals of both developing and developed countries. To achieve the objective, a number of countries have not only liberalized restrictions on FDI but also provided incentives to attract FDI.

The contribution of FDI to domestic productivity has been studied by previous research and there is a general agreement about the positive impacts of FDI on economic development (Baldwin *et al*. 1999; Eaton and Kortum 1997; Haddad and Harrison 1993; Aitken and Harrison 1999). Though some found negative results (Levine *et al*. 2000) but most empirical studies found a positive relation between FDI, productivity and growth (Markusen and Venables 1999; Xu 2000; Borensztein *et al*. 1998; OECD 1998; Blomstrom *et al*. 1994; Soto 2000).

A variety of factors are cited in the literature including infrastructure, human capital, political instability as determinants of FDI, however we must also take account of deeper and broader changes in the global economy, especially the spread of the 'New Economy', and the new information and communication technology (ICT). This factor is reshaping the global system. There is a large literature on FDI, some of it dating 40 years or more. But the global economy has undergone massive change over the last 20 years, and what was relevant to attracting FDI in the 1970s may no longer be the case today (Addison and Heshmati 2002).

Countries that successfully adopt ICT may be able to overcome barriers that have long held them back, particularly the constraint of a remote geography and an unfavourable climate that may otherwise adversely affect their ability to participate in global trade (Addison and Rahman 2002). In fact, the major global shift of the last twenty years is technological. The rapid spread of the Internet and use of the World Wide Web has opened up the possibility of accessing commercial and political information that was previously unavailable or severely restricted. In particular ICT has reduced many of the transactions costs of participating sub-contracting (through B2B interaction), and it is facilitating the operations of low-cost suppliers of IT services based in developing countries (Matambalya and Wolf 2001).

Therefore ICT needs to be considered in explanation of FDI flows. In a recent study Addison and Heshmati (2002) using a large sample of countries explored the determinants of FDI. Their findings suggest that ICT increases inflows of FDI to developing countries. ICT lowers the transaction and production costs of foreign investors, as well as improving their access to information about investment opportunities in poorer economies. Findings also suggest that there is weak cause effect from ICT on FDI in developing countries.

Motivation of this study is to examine the existence and nature of any causal relationship between ICT and FDI inflows. This issue can be analyzed using time series and panel data analysis tools. If non-stationary time series variables are not co-integrated, then a high degree of correlation between two variables does not mean a causal relationship between the variables. Time series methodology empowers us to recognize and avoid spurious results, which might happen using a simple OLS method.

To our knowledge, no attempts have so far been made to investigate the causal relationship between FDI and various determinants of FDI inflows based on a relatively large sample of countries, long time series and various causality analysis including time series Granger causality, least squares dummy variable (LSDV), and instrumental variables method for panel causality analysis. Here our focus is particularly on the relationship between ICT and FDI and its implications on economic growth. The main feature of this paper is its contribution to analysis of causality among the key variables of interest in a simultaneous framework. The hypothesis to be tested is whether the rich ICT infrastructure of the host country attracts more FDI. The ICT variable is from the ITU's (2002) World Telecommunication Indicators Database and other variables are from the *World Development Indicators* (World Bank 2002). We have chosen 23 developed and developing countries observed for the period 1976–99 based on data availability.[1]

The organization of the paper is as follows. Following the introduction and a brief review of the literature, we explain the data and methodology for time series analysis in Sections 3 and 4. In Section 5 various approaches to 'panel causality test' are outlined and discussed. In Section 6 the estimation results from the Granger causality tests is presented, and the conclusion appears in the final section.

2 A brief review of the literature

2.1 FDI and economic growth

The recent trend of FDI has posed opportunities and challenges for development and economic growth, especially for developing countries. International investment can impact economic growth in many ways, but it is possibly for increasing productivity by improvement in technology, including managerial knowledge and skills, is perhaps the most important one (Baldwin *et al*. 1999; Saggi 2000; UNCTAD 2000). The economic rationale for offering special incentives to attract FDI frequently derives from the belief that foreign investment produces externalities in the form of technology transfers and spillovers. Romer (1993) for example, argues that there are important 'idea gaps' between rich and poor countries, noting that foreign investment can ease the transfer of technological and business know-how to poorer countries.

This transfer may have substantial spillover effects for the entire economy. Thus, foreign investment may boost the productivity of all firms – not just those receiving

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1 The countries studied include Austria, Australia, Brazil, Canada, Colombia, Denmark, Finland, France, Iceland, India, Indonesia, Ireland, Italy, Japan, Korea, Malaysia, Mexico, Norway, Singapore, Sweden, Turkey, the United Kingdom and United States.

foreign capital (Rappaport 2000). The growth theories have identified the factors that play a role in promoting economic growth as follows: savings and investment (classical models), technical progress (neo-classical models), R&D, human capital, and accumulation and externalities (new growth theory). FDI has been integrated into theories of economic growth and there is a 'gains-from-FDI' approach. To the extent that FDI adds to the existing capital stock, it may have growth effects similar to that of domestic investment.

FDI may improve exports and help the access of domestic enterprises to international markets. Moreover there will be a spillover effect through the diffusion of the transferred technology. The entry of a multinational corporation (MNC) represents something more than a simple import of capital into a host country, which is generally how the matter is treated in models rooted in traditional trade theory.

2.2 What does FDI offer to a host country?

There is general agreement about the positive impacts of FDI on the welfare of receiving countries. The benefits of FDI concerning the capital market, technology transfer, market access, investment opportunities and export promotion are among the factors attracting FDI inflows from a host country perspective.

Capital: Multinational enterprises (MNEs) invest in long-term projects, taking risks and repatriating profits only when the projects yield returns.

Technology: Evidence provided by the vast majority of economic studies dealing with the relationship between FDI on the one hand and productivity and or economic growth on the other hand, has found that technology transfer via FDI has contributed positively to productivity and economic growth in host countries (OECD 1991).

Market access: MNEs can provide access to export markets. The growth of exports itself offers benefits in terms of technological learning, competitive stimulus, etc.

Increased domestic investment: Agrawal (2000) examined the data on five South Asian countries and found out that the increase in FDI inflows were associated with a many-fold increase in the investment by national investors (Borensztein *et al*. 1998; Agosin and Mayer 2000; McMillan 1999; Alfaro *et al*. 2001).

Export promoting: It seems that FDI could be associated with export trade in goods, and the hosting country can benefit from an FDI-led export growth (Goldberg and Klein 1999; OECD 1998).

A time series study on China indicates a two-way Granger causality running between output growth and FDI inflows (Shan *et al*. 1997). Blomstrom *et al*. (1994) and Borensztein *et al*. (1998) show that there are many econometric specifications in which FDI is positively linked with long-run growth.

2.3 Determinants of FDI

Traditional factors: Many factors have been considered in the literature as determinants of FDI. However, the selection of determinants is often ad hoc. The selection process is determined by the availability of data and the nature of the relations studied.

The key determinants frequently appearing in the literature and their expected impacts, including natural resources, market size, sociopolitical instability, business operating conditions, wage costs, exchange rate, trade barriers, export orientation, openness of developing host countries, democratization and risk, in addition to one control for several other observable and unobservable time-specific and country-specific effects (see Dunning 1980; Lunn 1980; Root and Ahmed 1979; Chakrabarti 2001; Dollar 1992). A comprehensive study of determinants of FDI is beyond the scope of this paper. Here, the focus is on the causal relationship between FDI, ICT and economics growth.

New Factor: ICT is considered as the main new determinant of FDI (Addison and Heshmati 2002). The world is rapidly moving toward an economic system based on the continuous and pervasive availability of information. Recent advances in ICT has been an important vehicle in permitting information exchange to develop as a valuable commodity. Countries and sectors equipped with the requisite telecommunications systems have been rapidly moving into post-industrial, growth orientated information-based economy.

ICT offers a unique opportunity for countries to free themselves from the domination of geography. Similarly, goods and services from such countries can be offered on the global market as efficiently as those from any other country through the use of ICT. The ever-evolving and increasingly powerful ICT has fundamentally changed the nature of global relationships, sources of competitive advantage and opportunities for economic and social development. Technologies such as the Internet, personal computers and wireless telephony have turned the globe into an increasingly interconnected network of individuals, firms, and governments communicating and interacting with each other through a variety of channels.[2]

For the developing world, a modern telecommunications infrastructure is not only essential for domestic economic growth, but also a prerequisite for participation in increasingly competitive world markets and for attracting new investments. In the advanced industrial countries of Europe and North America, universal telecommunications services have penetrated every sector of society.

In many developing countries limited availability of ICT services is constraining economic growth. Economic development policies in the industrial countries increasingly include telecommunications as an essential component of the economic infrastructure. This realization has been initiated by industry's demand for advanced telecommunications equipment for competitive reasons. The lesser-developed countries have begun to recognize that inadequate telecommunications services will be a disincentive to new investment and place existing industry at a competitive disadvantage.

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2 Report of the Regional Round Table on Information Technology and Development, New Delhi, 21–22 June 2000.

Few domestic businesses and no international activities could operate competitively without modern telecommunications. The primary benefits include reduced transport costs, reduced transaction costs, improved marketing information and increased efficiency of industrial production. A wide range of studies indicates that expanded telecommunications investment is essential, not only for growth, but also to remain competitive within the increasingly information-oriented global economy (Addison and Heshmati 2002; Matambalya and Wolf 2001).

3 The data

The data used in this study consists of a sample of 23 countries observed for the period 1976–99. The ICT variable is from the ITU's (2002) World Telecommunication Indicators Database. Annual investment in telecommunications is a proxy for ICT. Following the tradition in the literature, we define FDI as net inflows of foreign direct investment expressed as a percentage of GDP (World Bank 2002). Data is a balanced panel and is chosen based on availability for ICT variable.

4 Time series Granger causality analysis

Most of the economic variables are not stationary at their levels, therefore to study the long-run and short-run relationship we need to know each series' degree of integration. Therefore, we first perform the Augmented Dickey-Fuller (ADF) test to establish the order of integration of the variables (Dickey and Fuller 1979, 1981). Then, for the co-integration tests, we use the Johansen (1988) model, which was extended by Johansen and Juselius (1990) and Johansen (1991). This method applies the maximum likelihood procedure that is appropriate in a multivariate framework analysis.

Table 1 presents the results of the unit root tests. For each of the series examined, the test statistics suggest that the levels of the series are not stationary. They are integrated of order, 1 or 2, which means the first or second differences of the series are stationary. Now that we know the level of integration of the series we can proceed to test of co-integration. In testing the long-run relationship between ICT and FDI, the null hypothesis states there is no co-integration relation. If the null hypothesis cannot be accepted, we will test the hypothesis that there is at most one co-integration vector. The results of the Johansen trace and maximal eigenvalue tests are provided in Table 2. Results suggest that there is not enough evidence of long run relationship between FDI and ICT in most of the countries in our sample (18 out of 23 countries). Even for a few countries like Denmark, Japan, Malaysia, Singapore and Norway the significance level is weak. ICT and FDI do not seem to have a long-run relationship.

In the absence of the long-run relationship among economic variables, it still remains of interest to examine the short-run linkages among them (Manning and Adriacanos 1993). That is, even though a long-run relationship between the two variables cannot be established for this time period, it may still be possible that the variables are causally related in the short-run.

Table 1 Results of ADF unit root and Granger-causality tests

Country	Series	Degree of integration	*Hypothesis*	F statistics	Result	Country	Series	Degree of integration	F statistics	Result
Australia	FDI	I(1)	H_1	0.65336	No	Italy	FDI	I(0)	0.37756	No
	GDP	I(2)					GDP	I(1)		
	ICT	I(2)	H_2	2.70106	FDI→ICT**		ICT	I(2)	2.89714	FDI→ICT**
	Open	I(2)					Open	I(2)		
Austria	FDI	I(2)	H_1	6.43729	ICT→ FDI**	Japan	FDI	I(2)	0.096704	No
	GDP	I(1)					GDP	I(2)		
	ICT	I(1)	H_2	2.27179	No		ICT	I(2)	4.939314	FDI→ICT**
	Open	I(2)					Open	I(1)		
Brazil	FDI	I(2)	H_1	7.189705	ICT→ FDI**	Korea	FDI	I(2)	0.707121	No
	GDP	I(1)					GDP	I(0)		
	ICT	I(2)	H_2	4.880148	FDI→ICT**		ICT	I(1)	0.469025	No
	Open	I(2)					Open	I(2)		
Canada	FDI	I(1)	H_1	0.01624	No	Malaysia	FDI	I(2)	4.294396	ICT→FDI**
	GDP	I(2)					GDP	I(1)		
	ICT	I(1)	H_2	0.13601	No		ICT	I(2)	0.093856	No
	Open	I(2)					Open	I(1)		
Colombia	FDI	I(1)	H_1	2.002	No	Mexico	FDI	I(1)	2.44249	No
	GDP	I(1)					GDP	I(1)		
	ICT	I(1)	H_2	7.389356	FDI→ICT**		ICT	I(2)	0.46591	No
	Open	I(1)					Open	I(1)		
Denmark	FDI	I(2)	H_1	0.11748	No	Norway	FDI	I(1)	1.77301	No
	GDP	I(0)					GDP	I(2)		
	ICT	I(2)	H_2	0.26349	No		ICT	I(1)	1.54399	No
	Open	I(2)					Open	I(1)		
Finland	FDI	I(1)	H_1	6.76405	ICT→FDI**	Singapore	FDI	I(1)	3.94050	ICT→FDI**
	GDP	I(2)					GDP	I(2)		
	ICT	I(2)	H_2	4.39394	FDI→ICT**		ICT	I(1)	11.2395	FDI→ICT**
	Open	I(2)					Open	I(2)		
France	FDI	I(2)	H_1	0.329036	No	Sweden	FDI	I(2)	0.761774	No
	GDP	I(2)					GDP	I(2)		
	ICT	I(1)	H_2	0.089995	No		ICT	I(2)	2.981432	FDI→ICT**
	Open	I(2)					Open	I(2)		
Iceland	FDI	I(1)	H_1	4.14820	ICT→FDI**	Turkey	FDI	I(1)	0.98671	No
	GDP	I(2)					GDP	I(2)		
	ICT	I(2)	H_2	0.70144	No		ICT	I(1)	2.35631	No
	Open	I(2)					Open	I(2)		
India	FDI	I(0)	H_1	0.10198	No	UK	FDI	I(1)	3.065460	ICT→FDI**
	GDP	I(1)					GDP	I(2)		
	ICT	I(1)	H_2	2.24481	No		ICT	I(2)	0.743955	No
	Open	I(2)					Open	I(2)		
Indonesia	FDI	I(2)	H_1	12.76751	ICT→FDI**	US	FDI	I(2)	7.255016	ICT→FDI**
	GDP	I(1)					GDP	I(1)		
	ICT	I(2)	H_2	4.422206	No		ICT	I(2)	2.372927	No
	Open	I(2)					Open	I(2)		
Ireland	FDI	I(2)	H_1	4.366474	No					
	GDP	I(2)								
	ICT	I(2)	H_2	18.68057	FDI→ICT**					
	Open	I(1)								

Notes: **, * 5% and 10% significance levels respectively; H_1 denotes the alternative hypothesis that ICT does not Granger cause FDI, and H_2 denotes the alternative hypothesis that FDI does not Granger cause ICT

Table 2 Results of the Johansen co-integration test

Country	No. of co-integrating equation(s)	Eigenvalue	Trace statistic	10% CV	5% CV	Max-eigen statistics	10% CV	5% CV
Australia	None	0.339875	9.342091	15.41	20.04	9.137187	14.07	18.63
	At most 1	0.009271	0.204904	3.76	6.65	0.204904	3.76	6.65
Brazil	None	0.339875	9.342091	15.41	20.04	9.137187	14.07	18.63
	At most 1	0.009271	0.204904	3.76	6.65	0.204904	3.76	6.65
Canada	None	0.355510	11.65731	15.41	20.04	9.664523	14.07	18.63
	At most 1	0.086600	1.992785	3.76	6.65	1.992785	3.76	6.65
Colombia	None	0.350976	10.64254	15.41	20.04	9.077997	14.07	18.63
	At most 1	0.071794	1.564540	3.76	6.65	1.564540	3.76	6.65
Denmark	None *	0.447209	17.62515	15.41	20.04	11.85552	14.07	18.63
	At most 1 *	0.250600	5.769636	3.76	6.65	5.769636	3.76	6.65
France	None	0.473604	14.93944	15.41	20.04	12.83403	14.07	18.63
	At most 1	0.099919	2.105402	3.76	6.65	2.105402	3.76	6.65
Indonesia	None	0.400234	13.95718	15.41	20.04	10.73553	14.07	18.63
	At most 1	0.142223	3.221645	3.76	6.65	3.221645	3.76	6.65
Ireland	None	0.459974	15.31655	15.41	20.04	12.93889	14.07	18.63
	At most 1	0.107048	2.377664	3.76	6.65	2.377664	3.76	6.65
Japan	None **	0.884211	45.73395	15.41	20.04	40.96368	14.07	18.63
	At most 1 *	0.222029	4.770266	3.76	6.65	4.770266	3.76	6.65
Kenya	None	0.330483	14.35184	15.41	20.04	8.826360	14.07	18.63
	At most 1	0.222101	5.525475	3.76	6.65	5.525475	3.76	6.65
Korea	None	0.309321	8.474567	15.41	20.04	8.141772	14.07	18.63
	At most 1	0.015013	0.332795	3.76	6.65	0.332795	3.76	6.65
Malaysia	None **	0.736293	30.66006	15.41	20.04	26.65831	14.07	18.63
	At most 1 *	0.181341	4.001750	3.76	6.65	4.001750	3.76	6.65
Norway	None *	0.497217	15.50969	15.41	20.04	15.12713	14.07	18.63
	At most 1	0.017239	0.382555	3.76	6.65	0.382555	3.76	6.65
Singapore	None *	0.491645	19.23287	15.41	20.04	13.53150	14.07	18.63
	At most 1 *	0.248037	5.701369	3.76	6.65	5.701369	3.76	6.65
Sweden	None	0.279644	10.41375	15.41	20.04	6.888204	14.07	18.63
	At most 1	0.154547	3.525543	3.76	6.65	3.525543	3.76	6.65
Turkey	None	0.383233	12.66360	15.41	20.04	10.63181	14.07	18.63
	At most 1	0.088218	2.031790	3.76	6.65	2.031790	3.76	6.65
US	None	0.356793	12.07578	15.41	20.04	9.267078	14.07	18.63
	At most 1	0.125189	2.808705	3.76	6.65	2.808705	3.76	6.65

Notes: **, * 5% and 10% significance levels respectively

Systematic testing and determination of causal directions became possible, after Granger (1969) and Sims (1972) developed the operational framework. In econometrics, the most widely used operational definition of causality is the Granger definition of causality, which is defined as follows: x is a Granger cause of y (denoted as $x \rightarrow y$), if present y can be predicted with better accuracy by using past values of x rather than by not doing so (Charemza and Deadman 1992: 190). After getting the stationary series (stationary series obtained from differencing), we use following vector autoregression (VAR) models estimated for each country separately. Here we have a number of key determinants of FDI, such as: ICT investment, openness, GDP growth. Openness of a country is the trade share of GDP (imports plus exports); there is a positive association between openness and FDI. GDP growth also has a positive impact on FDI. We have chosen theses key variables, which are the most common variables considered in previous studies.

$$FDI_t = \sum_{i=1}^{n} a_i FDI_{t-i} + \sum_{j=1}^{m} b_j ICT_{t-j} + \sum_{k=1}^{m} c_k GDP_{t-k} + \sum_{l=1}^{m} d_l OPEN_{t-l} + u_t \quad (1)$$

$$ICT_t = \sum_{i=1}^{n} e_i ICT_{t-i} + \sum_{j=1}^{m} f_j FDI_{t-j} + \sum_{k=1}^{m} g_k GDP_{t-k} + \sum_{l=1}^{m} h_l OPEN_{t-l} + \omega_t \quad (2)$$

where t indicate time period. We selected the lag structure of the model based on Akaike Information Criteria (AIC), at 5 per cent level reported by E-views 4.1.

5 Panel causality analysis

5.1 Least squares dummy variable (LSDV) approach

The introduction of a panel data dimension allows using both cross-sectional and time series information to test the causality relationships between y and x. In particular, it leads the researcher a large number of observations, increasing the degree of freedom and reducing the collinearity among explanatory variables. So, it noticeably improves the efficiency of Granger causality tests. Pooling cross-sectional units does have certain advantages; the assumption of time stationarity can be relaxed. We consider the following VAR model:

$$FDI_{it} = \alpha_1 + \sum_{m=1}^{M} a_m FDI_{i,t-m} + \sum_{n=1}^{N} b_n ICT_{i,t-n} + \sum_{l=1}^{L} c_l GDP_{i,t-l} + \sum_{k=1}^{K} d_k OPEN_{i,t-k} + u_{it} \quad (3)$$

$$ICT_{it} = \alpha_2 + \sum_{m=1}^{M} e_m ICT_{i,t-i} + \sum_{n=1}^{N} f_n FDI_{i,t-j} + \sum_{l=1}^{L} g_l GDP_{i,t-l} + \sum_{k=1}^{K} h_k OPEN_{i,t-l} + \omega_{it} \quad (4)$$

Where *FDI* is the FDI share of GDP of country i (i = 1,…, N) in period t (t = 1,…, T), u_{it} is the error term. The error term follows a two-way error component structure

(Baltagi 2001) and can be broken down into an unobservable country specific (μ_i), a time specific (λ_t), and a random error term (v_{it}) components as:

$$u_{it} = \mu_i + \lambda_t + v_{it} \tag{5}$$

The error term v_{it} represents measurement errors in the dependent variable and omitted explanatory variables. The error term is assumed to be independently and identically distributed with zero mean and constant variance, σ^2. Similar decomposition applies to ω_{it} The country and time specific effects μ_i (country dummies) and λ_t, are factors representing country heterogeneity and exogenous technological change respectively and assumed to be independent of each other and regressors.

In the literature, the time effects λ_t are often replaced with a time trend reducing the two-way error component model to one-way error component model. In the panel literature the estimation of the model (7) has been developed in two directions, the fixed effect (FE) model where μ_i is assumed to be fixed and correlated with explanatory variables, and the random effects (RE) model where μ_i is assumed to be random and not correlated with the explanatory variables. In this study we use the FE model since we have a relatively small sample of countries not chosen randomly. Furthermore, the country heterogeneity effects are important with regard to the flow of FDI.

5.2 A method of instrumental variables

To date, most causality tests have used time-series data. However, it is difficult to control for measurement errors and omitted variable problems. To overcome these problems, we apply an instrumental variable 2SLS technique to conduct the causality test. The idea is to account for the endogeneity of regressors using instrumental variable methods. This method can be used when standard regression estimates of the relation of interest are biased because of reverse causality, selection bias, measurement error, or the presence of unmeasured confounding effects.

The central idea is to use a third, instrumental variable to extract variation in the variable of interest that is unrelated to these problems, and to use this variation to estimate its causal effect on an outcome measure. The 2SLS estimator increases computational efficiency without significantly detracting from its effectiveness. A typical example of traditional panel data causality testing is Holtz-Eakin *et al*. (1988). The Holtz-Eakin *et al*. model is:

$$y_{it} = \alpha_1 + \sum_{j=1}^{m} \alpha_j y_{i t-j} + \sum_{j=1}^{m} \delta_j x_{it-j} + f_i + u_{it} \tag{6}$$

where i =1…N. In order to eliminate the fixed effects, f_i the authors difference the data leading to the model:

$$y_{it} - y_{it-1} = \sum_{j=1}^{m} \alpha_j (y_{it-j} - y_{it-j-1}) + \sum_{j=1}^{m} \delta_j (x_{it-j} - x_{it-j-1}) + (u_{it} - u_{it-1}) \tag{7}$$

This specification introduces a problem of simultaneity because the error term is correlated with the regressor $y_{it-j} - y_{it-j-1}$. Therefore, a 2SLS instrumental variables procedure with a time-varying set of instruments is used to estimate the model.

Anderson and Hsiao (1982), suggest IV on the differenced model using *y* lagged twice, $y_{(-2)}$ and differenced *x*'s as instruments (Δx). The authors then equate the question of whether or not *x* causes *y* with a test of the joint hypothesis:

$$\delta_1 = \delta_2 = ... = \delta_m = 0 \tag{8}$$

In the estimation, some attention is paid to the validity of the instruments. Here are two problems with instrumental variables methods:

i) the instruments should be uncorrelated with the error term, or the orthogonality conditions should be satisfied by the data (exogeneity requirement);

ii) the instruments should have a strong correlation with the regressors of the model (relevance requirement).

For estimation purposes, we have used the 2SLS estimation procedure available in E-views.

6 Results of causality test

Tables 1 and 3 present the results of the Granger causality test using time series data, LSDV and 2SLS methods using panel data. H_1 denotes the alternative hypothesis that ICT does not Granger Cause FDI, and H_2 denotes the alternative hypothesis that FDI does not Granger Cause ICT. Results significantly suggest that there is a causal relationship between ICT and FDI in the sample countries. Results of causality test from the LSDV approach based on pooled data suggest that in developed countries ICT causes FDI, which means in developed countries there is a basic ICT infrastructure which the host country can invest in and that attracts foreign investors to come and invest, whereas in developing countries FDI causes ICT which means inflows of FDI generate new ICT investment to facilitate production potential. A developing country with poor ICT infrastructure has no possibility to internally finance ICT capacity themselves. FDI could cause ICT, given that the FDI flow is to branches producing product requiring advanced (ICT) technologies. Causality results from the 2SLS approach only suggest that in developed countries ICT does cause FDI.

Table 3 Results of panel causality tests from LSDV and instrumental variable estimation

Group	***Hypothesis***	**F statistics (LSDV)**	**Result**	**F statistics (2SLS)**	**Result**
Developed countries	H_1	2.630453	ICT→FDI**	5.414236	ICT→FDI**
	H_2	0.142199	No	0.366966	No
Developing countries	H_1	2.407414	No	0.535967	No
	H_2	3.193571	FDI→ICT**	0.490896	No

Notes: **, 5% significance level; H_1 denotes the alternative hypothesis that ICT does not Granger cause FDI, and H_2 denotes the alternative hypothesis that FDI does not Granger cause ICT

Increases in information and knowledge result in more efficient cooperation and coordination. Commerce is essentially an information processing activity. Effective buying, selling and brokerage rely on access to current information on the availability and price of goods and services. Telecommunications increases the available of information and thereby increases the efficiency of commercial activity. Considering the findings of this paper, which suggest a causal relationship from ICT to FDI, it seems ICT contributes to economic growth indirectly by attracting more FDI.

Telecommunications can also reduce transaction costs, widening the scope of markets and thereby increasing competition and efficiency. Another possible interpretation is that the growth in ICT is simply a passive consequence of development. The advanced nations have more telephones because they are able to afford them. In all economic sectors manufacturing and services-advanced telecommunications systems are becoming an integral part of business operations. It seems the lesser-developed countries should accelerate their application of telecommunications technology or fall further behind in economic competitiveness.

7 Conclusion

The relationship between FDI and economic growth has been thoroughly studied by previous research and there is general agreement about the positive impacts of FDI on economic development of the host countries through capital, technology transfer, market access, investment opportunities and export promotion. So governments, especially in developing countries, have not only liberalized restrictions on FDI but also provided incentives to attract FDI. A variety of factors are cited in the literature including infrastructure, human capital and political instability, as determinants of FDI however we must also take account of deeper and broader changes in the global economy, especially the spread of the New Economy, and the new ICT. Recent studies show ICT has a positive effect on FDI inflows.

In this study, we examined this issue using the time series analysis tools, panel causality including LSDV and instrumental variables 2SLS estimation methods. Results from the Granger causality test indicate that there is a significant causal relationship in the sample countries. In developed countries existing ICT infrastructure attracts FDI; a higher level of ICT investment leads to a higher level of FDI inflows suggesting ICT contributes to productivity and economic growth indirectly by attracting more FDI. But in developing countries the direction of causality goes from FDI to ICT.

In developed countries there already exist an ICT capacity which causes inflow of FDI, while in developing countries ICT capacity must be build up to attract FDI. The inflow of FDI causes further increases in ICT investment and capacity. The rapid expansion of world FDI resulted from several factors including technical progress in telecommunication services and major currency realignment. Technical progress in telecommunication services facilitates international communications involving parent companies and their overseas affiliates, while major currency realignment has provided companies with the opportunities for making profits by undertaking FDI.

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