What Causes What? Panel Cointegration Approach on Investment in Telecommunication and Economic Growth: Case of Asian Countries

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This study empirically examines long run relationship between investment in telecommunication and economic growth in selected Asian countries. We resort to econometric tests such as panel unit root tests and panel cointegration test purposed by Pedroni (1997, 1999) for annual data from 1990-2010 of 23 Asian countries. The empirical results suggest that there exists causality between economic growth and investment in telecommunication. Causality runs from investment in telecom to economic growth and not otherwise. Since telecommunication sector has an innate ability to contribute to economic growth in a dual fashion. Firstly, as a part of services sector and secondly as an expediter to other sectors of the economy. Policy recommendations are made on the basis of favorable findings in support of ICT-led growth.

Keywords: Telecommunication, Economic Growth, Panel Cointegration, Unit Root Tests, Network; Spillover.

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1. Introduction

Telecommunication is one of major components of information and communication technology (ICT).[3] Role of ICT in promoting economic growth of a country has been debated for the last twenty years or so. The results of empirical research have been inconclusive especially for developing countries. Considering the wonders that ICT has done for developed economies, it is desirable to research its impact for developing countries for confidently shaping an ICT-led growth policy. An example of it is Grameen Phone which is about providing mobile phone services in Bangladesh (OECD, 2004).

This study is yet another effort in providing empirical evidence of ICT and economic growth. Out of ICT, this study uses investment in telecommunication sector with private participation (ITPP). As can be observed in 'Private Participation in Infrastructure Project Database' relatively more data for this variable is available for Asian countries (WDI, 2010). Since the data includes the private sector participation, it is likely that the investment is more efficient owing to relatively efficient private sector (World Bank, 2003).[4]

[3] Information and Communication Technology (ICT) is defined as Information Technology (IT) plus Telecommunication Equipment and Services. The IT, in turn, refers to a combined industry, which includes IT hardware (office machines, data processing equipment, and data communications equipment), IT software, and IT services (WITSA, 2000).

[4] ITPP covers infrastructure projects in telecommunications that have reached financial closure and directly or indirectly serve the public. Movable assets are excluded. The types of projects included are operations and management contracts, operations and management contracts with major capital expenditure, greenfield projects (in which a private entity or a public-private joint venture builds and operates a new facility), and divestitures. Investment commitments are the sum of investments in facilities and investments in government assets. Investments in facilities are the resources the project company commits to invest during the contract period either in new facilities or in expansion and modernization of existing facilities. Investments in government assets are the resources the project company spends on acquiring government

2. Literature review

Empirical work on telecom sector and economic growth in case of Asian countries is limited (Wong, P., 2002). However, for Non-Asian countries empirical work is substantial. Among case studies, Doh, J. P. and Teegen, H. J. (2003) explore key location characteristics of private infrastructure projects in Latin America and Asia by using use a proprietary database of telecommunications projects in emerging markets. Their study detected economic, institutional, sectoral, and cultural variables that influence project structure, and compared these environmental and structural characteristics between and within the crucial regions. They found many differences between the investment projects in Latin America and Asia. Moreover they discovered that countries successful in attracting projects within regions have distinct environmental features that seem to pull that investment.

Bagchi, Solis, Adriano and Gemoets (2003) empirical found that telephone and cell phone adoptions in Latin American and Caribbean nations. They used exhaustive fixed-effect pooled regressions, using data for the period 1989-1999. The results showed that telephone and cell phone adoption processes were different in nature and had their typical impacts. The main factor, as per their findings, responsible for both telephone and cell phone adoptions in the region is diffusion. In addition, economic conditions and privatization are also positively related with the telephone and cell phone adoptions.

Hashim, Munir and Khan (2008) studies evidence empirical relationship between foreign direct investment (FDI) attraction in telecommunication sector of Pakistan and its constructive effects by employing regression analysis for a quarterly dataset (2000-Q1 to

assets such as state-owned enterprises, rights to provide services in a specific area, or the use of specific radio spectrums. Data are in current U.S. dollars.

2006-Q4). Independent variables included market size, competition, literacy rate, foreign trade and per capita income. Authors emphasized on gauging the relative importance of the factors that may attract foreign direct investment in telecommunication sector. All variable were found to be statistically significant and economically meaningful. The choice of time period for analysis is well-known for boom in telecom industry in Pakistan and the regression coefficients are rightfully positive and significant.

Moradi and Kebryaee (2008) explore the effect of ICT investment on economic growth for a cross-section of 48 Islamic countries using the data over the period 1995-2005. Three ICT indicators are used to test ICT augmented Solow growth model, viz.; network index, ICT usage index, and ICT Opportunity Index. Three separate models were estimated for the entire panel as well as the two sub-panels distinguished by the level of ICT development indexes. The main causes of economic growth are ICT capital, non-ICT capital and human capital in a sample of 48 Islamic countries. Inflation has a negative impact on economic growth. While ICT investment has positive and significant effect on economic growth, the marginal products of ICT investment are smaller than the marginal products of investment in non-ICT capital confirming the productivity paradox of ICT. ICT investment has a stronger influence on economic growth in the sub-sample of 24 countries that have relatively a higher ICT Opportunity Index. Moreover, non-ICT investment has positive effect on economic growth. The speed of convergence in both sub-samples is close.

Chakraborty (2009) assesses the growth effect of telecommunications infrastructure investment in developing countries by employing country specific data on mainline tele-density and per capita growth to Granger causality test with a panel cointegration tests. Results suggest that growth effects vary widely across country groupings showing various levels of development. His findings reveal that

mainline tele-density and per capita growth strongly cointegrated for countries that are relatively less developed. A weak evidence of a bi-directional causal link between the two variables is found. These differences in mainline tele-density and per capita growth relationship suggest that investment in telecommunications infrastructure, with its potential to produce high growth, may serve as the critical engine for driving the development process forward in the less developed countries.

Building on Chakraborty (2009), a better proxy for telecommunication i.e. Investment in telecommunication with private participation (ITPP), this paper employs panel cointegration test and scrutinizes the following model:

$$\boldsymbol{GDPPCD_{it} = \alpha_0 + \alpha_1 ITPP_{it} + \varepsilon_{it}}$$

3. Research question

In this section, the precise question for empirical testing is formulated. The long run relationship and causality between the 'GDP per capita' and 'Investment in telecom with private participation' is to be scrutinized. The consequent research question is as follows:

RQ_1: Is there any causal long run relationship between GDP per capita and ITPP in Asian countries?

The superjacent research question can be empirically tested for the set of countries that have substantial data available for the two variables both in country and time dimensions. Subjacent is the description of data and methodology to be adopted.

4. Data

For scrutinizing this proposition, this empirical analysis is based upon panel data of selected Asian countries including Bangladesh, Indonesia, India, Iran, Jordan, Kyrgyzstan, Kazakhstan, Cambodia,

Laos, Lebanon, Maldives, Mongolia, Malaysia, Nepal, Pakistan, Philippines, Russia, Sri Lanka, Thailand, Tajikistan, Uzbekistan, Vietnam and Yemen. Annual data that spans from 1990-2010 on GDP per capita in USD and 'investment in telecom with private participation' (ITPP) is taken from World Development Indicators (WDI) 2010. Hence the data dimensions are n = 23 and t = 20. Here, n > t which is a suitable situation for panel data analysis. Moreover, the time dimension 't' is 20 years, which allows for ample period length to assess the long run causality between the two variables. Country selection out to of Asia is dictated by the availability of data. Most of countries in the region are developing countries and consequently investment in telecom is an emerging dimension of the economy.

5. Estimation Methodology

5.1 Panel Unit Root Test

For meeting the econometric needs of panel data, panel unit roots are devised for verifying the stationarity of series under-consideration. This study uses four of these tests out of which first three are; LLC (Levin, et al., 2002), IPS (Im, et al., 2003) and Maddala and Wu (1999) and Choi (2001) that suggested a more direct, nonparametric unit root test and proposed using the MW Fisher-ADF and MW Fisher-PP statistics. The fourth one is Hadri (2000) which is similar to the KPSS type unit root test. The null hypothesis of these tests is that the panel series has a unit root (non-stationary) except for the Hadri test. Table 1 shows the panel unit root test results, the statistics confirm that the two series (GDPPCD and ITPP) are cointegrated of order '1' and hence they are I(1) processes.

Table 1
Panel Unit Root Tests (LLC, IPS, MW Fisher-ADF, MW Fisher-PP and Hadri)

	GDPPCD	GDPPCD	D(GDPPCD)	D(GDPPCD)	ITPP	ITPP	D(ITPP)	D(ITPP)
	Individual effects	Individual effects & linear trends	Individual effects	Individual effects & linear trends	Individual effects	Individual effects & linear trends	Individual effects	Individual effects & linear trends
LLC	-0.881	-9.387***	-4.539***	4.391	-0.256	0.202	-6.991***	-4.885***
IPS	1.675	-4.173***	-3.796***	2.441	-0.240	-0.180	-8.130***	-5.871***
MW Fisher-ADF	35.105	75.686***	75.771***	27.999	57.507**	48.690	139.841***	103.246***
MW Fisher-PP	14.084	50.636*	83.720***	58.299**	61.714***	56.004**	545.725***	265.621***
Hadri	9.222***	9.846***	9.872***	7.668***	10.398***	5.290***	0.475	6.928***

Notes:
GDPPC stands for 'GDP per capita' in USD and ITPP for 'investment in telecom with private participation'.
D signifies 1st difference.
LLC and IPS represent the panel unit root tests of Levine et al. (2002) and Im et al. (2003), respectively.
Fisher-ADF and Fisher-PP represent the Maddala and Wu (1999). MW Fisher-ADF and MW Fisher-PP panel unit root tests, respectively. The LLC, IPS, Fisher-ADF and Fisher-PP examine the null hypothesis of non-stationarity.
Hadri tests the stationary null hypothesis.
(***), (**) and (*) signify statistical significance at the 1%, 5% and 10% level, respectively.

Probabilities for Fisher-type tests were computed using an asymptotic χ^2 distribution, while rest of tests assumes asymptotic normality. EViews Standard Version 7.1 is used for all estimations.

5.2. Panel Cointegration Tests

Using heterogeneous panel cointegration test developed by Pedroni (1997, 1999), cointegration between GDP per capita and 'investment in telecom with private participation' (ITPP) is tested. Cross-sectional interdependence with different individual effects are allowed in this test. Pedroni (1999) proposes two types of residual-based tests as listed in Table 2. In first type, four tests are distributed as being standard normal asymptotically and are founded on pooling the residuals of the regression for 'within-group', viz.; Panel ν statistic, panel ϱ statistic, panel t statistic (Non-parametric) and panel t statistic (parametric). While in second type, three tests are also distributed as

being standard normal asymptotically but are built on pooling the residuals for 'between-group', viz.; group ϱ statistic (parametric), group t statistic (non-parametric) and group t statistic (parametric).[5]

Table 2

Test Statistics of Pedroni Residual Cointegration Test

1	Panel ν statistic	$T^2N^{3/2}Z_{\hat{V}N,T} \equiv T^2N^{3/2}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{e}_{i,t-1}^2\right)^{-1}$
2	Panel ϱ statistic	$T\sqrt{N}Z_{\hat{\rho}N,T} \equiv T\sqrt{N}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{e}_{i,t-1}^2\right)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\lambda}_i\right)$
3	Panel t statistic (Non-parametric)	$Z_{tN,T} \equiv \left(\tilde{\sigma}_{N,T}^2\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{e}_{i,t-1}^2\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\lambda}_i\right)$
4	Panel t statistic (parametric)	$Z_{tN,T}^* \equiv \left(\tilde{S}_{N,T}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{e}_{i,t-1}^{*2}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{e}_{i,t-1}^*\Delta\hat{e}_{i,t}^*\right)$
5	Group ϱ statistic (parametric)	$TN^{-1/2}\tilde{Z}_{\tilde{\rho}N,T-1} \equiv TN^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{e}_{i,t-1}^2\right)^{-1}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\lambda}_i\right)$
6	Group t statistic (non-parametric)	$N^{-1/2}\tilde{Z}_{tN,T-1} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\hat{\sigma}_i^2\sum_{t=1}^{T}\hat{e}_{i,t-1}^2\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\lambda}_i\right)$
7	Group t statistic (parametric)	$N^{-1/2}\tilde{Z}_{tN,T}^* \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{S}_i^{*2}\hat{e}_{i,t-1}^{*2}\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}^*\Delta\hat{e}_{i,t}^*\right)$

These seven test statistics are to test the null of no cointegration between two variables. Resorting to Monte Carlo simulation experiments, Pedroni (1999, 2004) exhibited that the panel ADF-

[5] These statistics are hinged on estimators that simply average the individually estimated coefficients for each member, and individual specific short-run dynamics, individual specific fixed effects and deterministic trends, as well as individual specific slope coefficients are accommodated by each of these tests (Pedroni, 2004).

statistic and group ADF-statistic tests have better small-sample properties than the others, making them more reliable.

5.3. Panel Cointegration Test Results

Pedroni residual cointegration test presents seven statistics for testing the null of no cointegration among series in panel data. Table 3 reports these seven statistics for GDPPCD and ITPP cointegration tests. Pedroni cointegration test using 'individual intercept', reveal a strong evidence of panel cointegration since all seven statistics are with the desired signs (Panel v statistic positive and rest with negative sign). Moreover all statistics are significant at 1% significance level with the exception of 'group ϱ statistic' which is significant at 5%. In addition to 'individual intercept' if test is undertaken with 'individual intercept & individual trend', the panel cointegration is still evident. This modification occurs at the cost of significance of 'group ϱ statistic' and decline of significance of 'panel v statistic' from 1% to 5%. Signs of all the statistics, however, remain desirable.

Table 3

Results of Pedroni Residual Cointegration Test

	Statistics of Pedroni Residual Cointegration Test	Individual Intercept	Individual Intercept & Individual Trend
Within Dimension	Panel v statistic	2.4395***	1.8237**
	Panel ϱ statistic	-3.0545***	-2.3950**
	Panel PP statistic	-4.7803***	-4.8587***
	Panel ADF statistic	-4.5729***	-4.7479***
Between dimensio	Group ϱ statistic	-2.3042**	-0.3746
	Group PP statistic	-5.1451***	-6.7633***
	Group ADF statistic	-5.0063***	-5.0468***
Null: No Cointegration between GDPPCD and ITPP			
(***) and (**) signify statistical significance at the 1% and 5% level, respectively.			

Notes:
EViews Standard Version 7.1 is used for all estimations.

Next step is to identify the direction of causality between the variables. In table 4, results of panel data Granger causality are depicted. The causality from LITPP (log of ITPP) to LGDPPCD (log of GDPPCD) is significant, while for opposite, it is not. Such conforms to the 'ICT led Growth' hypothesis.[6]

Table 4

Panel Granger Causality Test Results

Null Hypothesis	F-Statistic	Prob.
LITPP does not Granger Cause LGDPPCD	3.1633	0.0435
LGDPPCD does not Granger Cause LITPP	2.3046	0.1013

Notes:
EViews Standard Version 7.1 is used for all estimations.

6. Conclusions

This paper investigated the existence of long run relationship between investment in telecom and GDP per capita for selected Asian countries. Findings are encouraging, since strong evidence of cointegration is found between the two variables using Pedroni (1999) panel cointegration technique. Causality analysis reveals that direction of causality runs from investment in telecom to GDP per capita and not otherwise. It is in lines with the standard theory, where investment in ICT is likely to bring favorable change in an economy. Since most of Asian countries are the adopters of ICT, such strong evidence of cointegration indicates towards the proper utilization of usable capacity in telecommunication sector mainly through its ability to generating employment, income and hence increasing GDP per capita,

[6] Idea that economic growth is caused by information and communication technology is termed as ICT-led economic growth.

both directly and indirectly.[7] From policy perspective, Asian (developing) countries can benefit further from the spillover network effects of investment in telecommunication sector by continued investment. Furthermore indigenous development of telecommunication hardware should also be encouraged for self-sufficiency in telecommunication sector. Findings of this paper are in conformity to Chakraborty (2009). Lack of causality from GDP per capita to investment in telecom is evident since increased GDP does not necessarily increase investment in telecom sector only. These results, however, must not be generalized to all forms of ICT, since the mechanisms through which different forms of ICT affect economies are different from one another. Further research can be carried out on other forms of ICT.

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