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Causal relationship between internet use and economic development for selected Central Asian economies

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Abstract. *The aim of this study is to examine the effects of information and communications technology (ICT) on economic development of several Central Asian countries. Dumitrescu and Hurlin (DH) panel causality test has been used for the relationship between ICT and economic development. The DH test results indicate that a unidirectional causality exists from GDP per capital to Inter-net use. These results suggest that an increase in GDP per capita can stimulate internet use. In addition, the cross-sectional dependence is examined using LM test of Breusch and Pagan and CD-LM and CD test of Pesaran. The results suggest that the null-hypothesis, no cross-sectional dependence exists among countries, is rejected for all the tests, suggesting an economic shock in a one country may have spillover effects on other countries.*

Keywords: internet use; economic development; panel causality test; cross-section dependence.

JEL Classification: B22, C12, C33, F62.

1. Introduction

Information and communications technology (ICT) includes the infrastructure, networking components, applications, and systems components that enable modern computing. ICT makes it possible for people and organizations to interact with other people, businesses, government agencies and nonprofit organizations in a digital environment. ICT has internet-based and mobile (wireless networks) components. ICT has enabled people and businesses to do transactions and interactions in many new ways. ICT brings about business growth and economic development. Many have argued that ICT has brought about the fourth industrial revolution.

Hoffman (2000) describes internet as the most important innovation since the development of the printing press. The internet gives instant access to an endless supply of knowledge and entertainment. The benefits of internet include knowledge sharing, and easy access to information and learning new things; opportunities for connectivity, communication and sharing; map and direct users to places; remote access to banking services (sending money and paying bills, etc.); a great shopping experience without leaving you home; opportunities to sell any product to customers anywhere in the world; collaborative work, work from home and access to a global work force; and access to an endless supply of entertainment (videos, movies, music, and games). The internet of things, controlled remotely, helps you connect your residence, businesses, and many helps many service providers save energy, money and time. Cloud computing and cloud storage devices can connect to remote data storage and more powerful computers to perform complex tasks. According to Riddle (1999), the internet is a rich resource of information for the market for competitors, suppliers, and customers. Internet use can encourage e-trade and reduce costs and increase competitiveness.

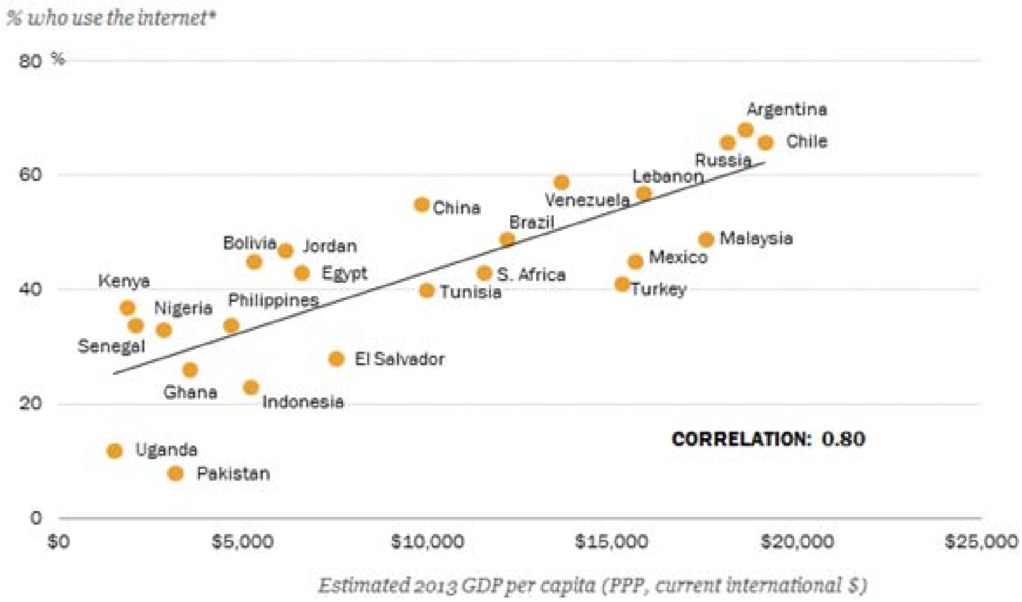
The aim of this study is to examine the effects of ICT, represented by internet use, on economic development, represented by per capita GDP, for six Central Asian developing economies for the 1990-2016 periods. Despite the fact that several studies have analyzed the factors that affect internet uses in order to determine the future of e-commerce and international globalization, the number of contributions focusing on the reciprocal relationship between internet use and economic growth is surprisingly scarce.

In this study, the causal relationship between GDP per capita and internet use has been analyzed. Four kinds of hypotheses can be derived from this analysis. The first hypothesis is that the causal relationship can be directed from internet use toward increased GDP per capita because ICT is considered an indispensable asset in the fight against world poverty. According to Kamssu, Siekpe and Ellzy (2004), ICT provides developing nations with unprecedented opportunities to meet vital development goals, such as poverty reduction, basic healthcare, and education far more effectively than before. This hypothesis implies that there is a positive relationship between internet use and GDP per capita. In the study by Penard and Poussing (2010), the Internet is taken into account as a convenient and an efficient means of decreasing the cost of investing in social capital.

The second hypothesis is that increase in GDP per capita can stimulate internet use, meaning that a causal relationship can be described from GDP per capita to internet use. This hypothesis postulates that increase in GDP contributes to internet use. It is a fact that there is a technology inequality between rich and poor countries. Developed countries have well-established telecommunications systems and telephone infrastructure, enabling them to have widespread internet service available for connection. However, many less developed and developing countries do not have proper telephone infrastructure, which requires high cost investments.

Figure 1 shows technology usage versus GDP per capita for several developing countries. Figure 1 suggests that there is a positive correlation between GDP per capita and internet use.

Figure 1. *Internet use vs. GDP per capita*



Source: http://www.pewglobal.org/2014/02/13/emerging-nations-embrace-Internet-mobile-technology/

The third hypothesis is that bidirectional causality corresponds to the feedback hypothesis, which indicates that internet use and GDP per capita affect each other simultaneously. The validity of this hypothesis would show that the policies that help increase internet use may also increase economic growth and, which in turn encourage Internet use.

Finally, the neutrality hypothesis indicates that changes in economic growth do not affect internet use or vice versa. If this study concludes that there is a non-existence of a causal relationship between Internet use and economic growth, this hypothesis will be validated.

2. Economic model and methodology

In the Granger causality analysis, a variable y_t is said to Granger-cause another variable x_t, if x_t can be predicted with greater accuracy by using past values of y_t. The Granger causality test is based on a simple Wald test, which allows us to test the significance of lagged values of the second variable.

Even though the Granger causality test is a well-known econometric technique, it has some shortcomings; for example, the Granger causality test is not the proper test to apply for different frequencies. However, Geweke (1982) introduced a Wald test to analyze the existence of Granger causality in the frequency domain; using this test to make it possible to study the variations of a time series as a function of frequency as opposed to the time domain, where variance is examined as a function of time.

Breitung and Candelon (2006) advanced Geweke's Granger causality test. To study the large sample properties of the test, they analyzed the power against a sequence of local alternatives. The finite sample properties were investigated by means of Monte Carlo simulations. Their methodology was applied to investigate the predictive content of the yield spread for future output growth. Croux and Reusens (2013) investigated the predictive power for the future domestic economic activity included in the domestic stock prices, using a Granger causality analysis in the frequency domain.

This study uses Dumitrescu-Hurlin's (2012) panel causality test (hereafter DH). The DH is an elaborated version of the Granger causality test and it tests the null hypothesis of non-causality for the panel between the variables against the alternative one, which assumes that causality exists between the variables for at least one-cross section unit.

The DH causality test for the case of two stationary variables y_t and x_t can be illustrated as follows.

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} x_{i,t-k} + \varepsilon_{i,t} \tag{1}$$

where $x_{i,t}$ and $y_{i,t}$ are two stationary variables for individual i in period t. Here, coefficients are allowed to differ across individuals, but are assumed to be time-invariant. On the other hand, the lag order k is assumed to be identical for all cross-section units and the panel must be balanced.

The null-hypothesis is defined as follows:

$$H_0 : \gamma_{i1} = ... = \gamma_{ik} = 0 \qquad \forall i = 1,...,N$$

The null-hypothesis is that there is no causality for all individuals in the panel.

The alternative hypothesis assumes that causality exists between the variables for at least one cross-section unit.

The alternative hypothesis can be defined as follows:

$$H_0 : \gamma_{i1} = ... = \gamma_{ik} = 0 \qquad \forall i = 1,...,N_1$$

$$\gamma_{i1} \neq 0 \text{ or } \gamma_{ik} \neq 0 \qquad \forall i = N_1 + 1,...,N$$

where $N_1 \varepsilon [0, N-1]$ is unknown. If $N_1 = 0$, there is causality for all cross-section units in the panel. N_1 is strictly smaller than N, otherwise there is no causality for all cross-section units.

It is a fact that the world economy has been experiencing a rapid globalization and increasing economic and financial integration, thus panel data methodologies should take into account the cross-sectional dependence, otherwise the results will be unrealistic. Therefore, this study examines whether there is a cross-sectional dependence among the countries examined by using LM test of Breusch and Pagan (1980), and CD-LM and CD test of Pesaran [10].

The basic Pesaran test statistics can be showed as follows.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij} \right) \tag{2}$$

where CD cross-dependency in the panel, T is the time dimension of the panel, N is the cross-sectional dimension in the panel, and $\hat{p}_{ij}$ is correlations coefficients, which are calculated from residuals. The distribution of the Pesaran (2004) test is N (0, 1).

3. Data and empirical results

This study used annual data obtained from the World Bank for Kyrgyzstan, Kazakhstan, Turkmenistan, Uzbekistan, Azerbaijan, and Tajikistan from 2000 to 2016 to test the causality between Gross Domestic Product (GDP) per capita and percentage of individuals using internet. The logarithmic form of GDP per capita and percentage of individuals using internet are used in this study.

At the first step, the variables examined were tested whether they are stationary or not using Levin, Lin, Chu, and Im, Pesaran and Shin panel unit root tests, which allowed us to test the null of the unit root for the whole panel against the alternative hypothesis, which claims that there is at least one stationary series in the panel. The tests results are illustrated in the Table 1.

Table 1. *Unit root test results*

Series	Levin, Lin and Chu	Im, Pesaran and Shin	
		Level	First difference
Lint	-2.24346 (0.0124)**	-0.41506 (0.3390)	-5.59572 (0.0000)*
GDP	-2.17355 (0.0149)**	0.11307 (0.5450)	-1.55735 (0.05)**

Note: Numbers in the parenthesis show the *p*-values.
*Significant at the 1% level. ** Significant at the 5% level.

The test results, presented in the Table 1, exhibit that both variables are stationary at level $I(0)$ when the Levin, Lin and Chu unit root test is allowed, thus it does not need to take differences of the series to test the Granger causality. Yet, when the Im, Pesaran and Shin method is considered, both variables are not stationary at level, but they become stationary after taking first differences of the variables.

This study uses Dumitrescu and Hurlin's (DH) Panel causality to observe the relationship between two series. The DH test in different lag lengths is presented in the Table 2.

Table 2. *Results of DH causality test*

	K=1		K=2	
Null hypothesis	W-Stat.	Zbar-Stat	W-Stat.	Zbar-Stat
LINT. does not homogenously cause LGDP	0.12773	-1.31987	1.41645	-0.82005
LGDP does not homogenously cause LINT.	3.48985	2.81862*	5.74818	2.25553**

Note: K shows the lag lengths.
*Significant at the 1% level. **Significant at the 5% level.

The DH test results given in the Table 2 indicate that a unidirectional causality exists from LGDP to LINT, which is the percentage of individuals using the internet. This conclusion confirms our second hypothesis, which we have already written. So the increase in GDP stimulated the use of the internet.

The cross-sectional dependence is examined and the empirical results are given in the Table 3. According to the results, the null-hypothesis that no cross-sectional dependence exists among countries is rejected for all tests. This conclusion means that if a shock occurs in one sample country, it may in turn have a spillover effect on other countries. It is a fact that internet has not only dispersed quickly from cities in a country but also has had increasingly significant effects on neighbouring countries.

Table 3. *Cross-sectional dependence*

Statistics		*P-value*
Cross-sectional dependence		
BP_{LM}	185.3752*	0.0000
$Pesaran_{LM}$	30.01*	0.0000
$Pesaran_{CD}$	4.4679*	0.0000

Note: *indicates significance at 1 % level.
BP_{LM} – Breusch-Pagan LM test.
$Pesaran_{LM}$ – Pesaran scaled LM test.
$Pesaran_{CD}$ – Pesaran cross-sectional dependence.

4. Concluding remarks

In this study, the relationship between internet use and economic development is examined using the Dumitrescu and Hurlin (DH) panel causality test for some selected Asian Countries. The DH test results indicate that a unidirectional causality exists from GDP per capital to internet use. These findings confirm the second hypothesis presented, which postulates that increase in GDP per capita can stimulate internet use because less developed and developing countries do not have proper telephone infrastructure, which require high levels of investments.

In addition, the cross-sectional dependence is examined using LM test of Breusch and Pagan and CD-LM and CD test of Pesaran. The results suggest that the null-hypothesis, no cross-sectional dependence exists among countries, is rejected for all the tests. This conclusion means that if a shock occurs in a one sample country, it may have spillover effects on other countries.

Future studies may examine geographic inequality in internet use and economic development for a country or a group of countries.

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