Impact of Information and Communication Technology on Economic Growth in Newly Industrialized Countries

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Abstract

Information and communications technology (ICT) is one of the key factors explaining growth differentials across countries. Basically, ICT is hypothesized to have positive effects on productivity, and therefore helps raise economic growth. The objective of this study is to analyze the impact of ICT on economic growth by using data of 9 newly industrialized countries (NICs) over the period 1994-2011. Panel data analysis is carried out to examine the factors affecting economic growth of 9 NICs. The regression model is modified to measure factors that influence economic growth which is represented by per capita gross domestic product (GDP). Internet user is used to represent the current state of ICT; while other macroeconomics factors such as gross capital formation, household consumption, government consumption and trade ratio are also used to estimate economic growth. Three specification; pooled-OLS, fixed effects, and random effects specifications are estimated and tested for the most appropriate model. Hausman test shows that fixed effects

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specification is the most appropriate model. The Internet has positive and significant effect on economic growth as expected. Moreover, gross capital formation, household consumption and trade ratio have significant positive effect on economic growth. However, government expenditure has not shown significant impact on economic growth.

Keywords: *Economic Growth, Information and Communication Technology, Internet User, Panel Data*

ผลกระทบของเทคโนโลยีสารสนเทศและการสื่อสาร ต่อการเติบโตทางเศรษฐกิจในประเทศอุตสาหกรรมใหม่

กาญจนา ส่งวัฒนา และ ศรัญยา แสงลิ้มสุวรรณ***

บทคัดย่อ

เทคโนโลยีสารสนเทศและการสื่อสาร (ไอซีที) เป็นหนึ่งในปัจจัยสำคัญที่มีอิทธิพลต่อการเติบโตของประเทศ โดยทั่วไปเป็นที่เชื่อกันว่าไอซีที จะส่งผลในเชิงบวกต่อผลิตผลทางการผลิต ซึ่งจะส่งผลดีต่อการเติบโตทางเศรษฐกิจ ดังนั้น วัตถุประสงค์ของการศึกษานี้จึงมุ่งเน้นที่การวิเคราะห์ผลกระทบของไอซีทีต่อการเติบโตทางเศรษฐกิจ โดยใช้ข้อมูลจาก 9 ประเทศอุตสาหกรรมใหม่ ในช่วงเวลา 1994-2011 ซึ่งเป็นการรวมข้อมูลอนุกรมเวลาและข้อมูลภาคตัดขวางเพื่อตรวจสอบปัจจัยที่มีอิทธิพลต่อการเติบโตทางเศรษฐกิจของ 9 ประเทศอุตสาหกรรมใหม่ซึ่งวัดจากผลิตภัณฑ์มวลรวมภายในประเทศต่อหัว ในขณะที่จำนวนของผู้ใช้อินเทอร์เน็ตจะเป็นตัวแทนของสถานะไอซีทีของประเทศนั้น นอกจากนี้ ปัจจัยทางมหภาคอื่น ๆ ที่ใช้ในการศึกษา ประกอบด้วย การสะสมทุน การบริโภคภาคครัวเรือน การบริโภคภาครัฐ และอัตราส่วนการค้า ทั้งนี้แบบจำลองที่ใช้ในการศึกษาจะถูกวิเคราะห์โดยวิธี Pooled – OLS Fixed Effects และ Random Effect จากนั้นจะใช้การทดสอบ Hausman ในการหาแบบจำลองที่เหมาะสมที่สุด ซึ่งผลการศึกษา พบว่า แบบจำลอง Fixed Effect เป็นรูปแบบที่เหมาะสมที่สุด โดยผลการศึกษาแสดงให้เห็นว่าจำนวนผู้ใช้อินเทอร์เน็ตหรือระดับไอซีทีมีผลกระทบเชิงบวกต่อการเติบโตทางเศรษฐกิจอย่างมีนัยสำคัญทางสถิติ นอกจากนี้ การสะสมทุน การบริโภคภาคครัวเรือน และอัตราส่วนการค้าส่งผลกระทบเชิงบวกต่อการเติบโตทางเศรษฐกิจอย่างมีนัยสำคัญ อย่างไรก็ดี การใช้จ่ายของภาครัฐไม่ส่งผลต่อการเติบโตทางเศรษฐกิจของประเทศ

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Introduction

Information and communication technology (ICT) is a broad definition that covers information system, information technology and digitalization such as computer, radio, telephone line, wireless signal, and internet network. Global Knowledge Partnership defines ICT as technologies that facilitate communication and processing and transmission of information by electronic means. ICT has recently been one of the main factors contributing to economic growth, especially in the current knowledge and technology economy. Rapid technological progress in the production of ICT goods and service has reduced ICT user costs and enhanced ICT uses. ICT uses may reduce firm transaction costs, improve firm efficiency and consequently raise economic growth. Like road, bridge and other infrastructures, high speed internet and broadband service have stimulated economic growth as the essential trigger for empowering business and society. Saunders, Warford, & Wellenius (1994) found that telecommunication investments generate internal rates of return of approximately 20%. Madden & Savage (1998) stated that telecommunications can improve the organizational efficiency of firms and the efficiency of transactions between firms and individuals.

ICT has been significantly revolutionized over the time. Telegraph and telephone were then the invention of long distance communication in 1837 and 1876, respectively. Short wave radio began in 1926, and later long wave radio was innovated in 1946. The Internet began in 1970 and became popular in 1990s. The core of ICT in recent years has been improved both capabilities and capacity of the facilities used to communicate. Its impacts have been varied from job creation to productivity gain; however, all of these impacts have made an increasingly significant contribution to economic growth.

There has been a large volume of research that supports that the quantity of telecommunication infrastructure has the positive relationship with growth (Norton, 1992; Canning, 1997; Riaz, 1997, Madden & Savage, 1998, Roller & Waverman, 2001). Basically, the impact of ICT on growth can divide into three categories. First, ICT represents as a capital good. Investment in ICT contributes to improve capital deepening and therefore helps raise labor productivity. Colecchia & Schreyer (2001)

found that ICT investment has been expanded due to the steep decline in ICT prices. In addition, the United States, Australia and Finland experienced a strong increase in productivity growth due to investment in ICT during 1990s. Pilat, Frank & Bart (2002) stated that the contribution of ICT manufacturing to overall labor productivity growth has risen over the 1990s among most Organisation for Economic Co-operation and Development (OECD) countries. Second, technological progress in ICT may contribute to faster multifactor productivity growth. Pilat, Frank & Bart (2002) showed that ICT manufacturing made the largest contributions to aggregate productivity growth in Korea, Finland and Ireland during 1995-2000. Jorgenson (2001) stated that the contribution may come from rapid technological progress in the production of ICT goods such as semi-conductors. Triplett & Bosworth (2004) estimated that multifactor productivity growth in US wholesale trade accelerated from 1.1% annually to 2.4% annually during the period of 1987-1995 and 1995-2000, respectively. Moreover, the multifactor productivity growth in retail trade increased from 0.4% annually to 3.0%. Third, greater user of ICT may help firms, public and private institutions to increase their efficiency, develop new products and services, and, hence, it increases productivity growth. The impacts of ICT are found in improvement in productivity and economics growth at the level of firm (Brynjolfsson, Hitt & Yang, 1996) the economy overall (OECD 2004; Heshmati & Yang, 2006; Sridhar & Sridha, 2007, Jalava & Pohjola, 2008). Benhabib & Spiegel (2005) stated that cheaper information from internet usage can facilitate firm operation which again promotes economic growth.

While there are handful of literature related to impacts of ICT on economic growth, this paper specifically focuses on one aspect of ICT – internet usage. Internet usage is measured for people with access to worldwide network. The Internet has changed the way people work, socialize, and share information since the Internet enables the exchange of data across multiple locations and decentralizes information process. Moreover, the Internet combined with information technologies can also affect firm productivity, and economic growth. In addition, the Internet accounted for 21% of the world GDP growth over the past 5 years. However, most previous studied focused on impacts of ICT on developed countries. Roller & Waverman (2001) studied the relationship between the telecommunication

infrastructure and economic growth for 21 OECD countries and 35 other countries during 1970 to 1990, and found a positive relationship between telecommunication infrastructure and economic growth. Datta & Agarwal (2004) used data from 22 OECD countries during 1980-2001, and found the positive relationship between telecommunications infrastructure and economic growth. Recently, Choi & Yi (2009) used cross-country panel data to estimate the role of the Internet on economic growth for both developed and developing countries. This paper aims to bridge the gap and study the impacts of ICT on economic growth in countries which economies have not yet reached developed country status, but have outpaced most developing countries. Those countries are known as newly industrialized countries (NICs).

ICT and Economic Growth in NICs

NICs are countries that have recently experienced an economic shift to an open political and high GNI per capita with export-oriented economic policy. This term firstly applied to four Asian Tigers; Hongkong, Singapore, South Korea, and Taiwan, which had exceptional economic growth in the 1970s and 1980s. The current lists of NICs countries are Turkey, South Africa, Mexico, Brazil, China, India, Malaysia, Philippines, and Thailand (Bozyk (2006); Guillen (2003), Waugh (2000)).

Figure 1 presents economic status of NICs during 1994-2011. Per capita GDP and GDP per capita are normally the measurement of economic status. From Figure 1, all NICs have dramatically increased in their per capita GDP over time. However, Turkey has experienced relatively sharp swing in per capita GDP over time.

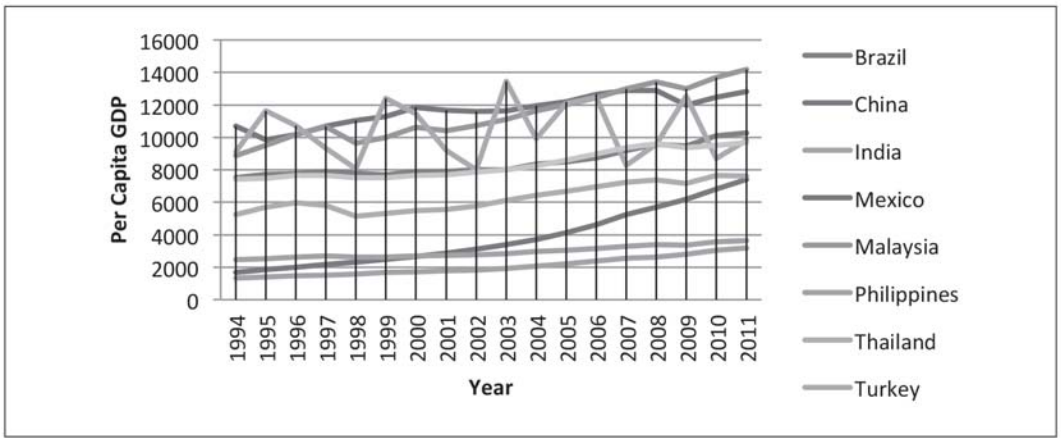

Figure 1: Per Capita GDP of NICs during 1994-2011

Table 2 presents internet users in NICs. The number of internet user per 100 people is normally a proxy for the level of ICT development. All NICs has been experiencing rapid increase in number of internet user since 1998. Malaysia has relatively high number of internet user among NICs; whereas India has relatively low number of internet user among NICs. Turkey has the most fluctuating number of internet user among NICs.

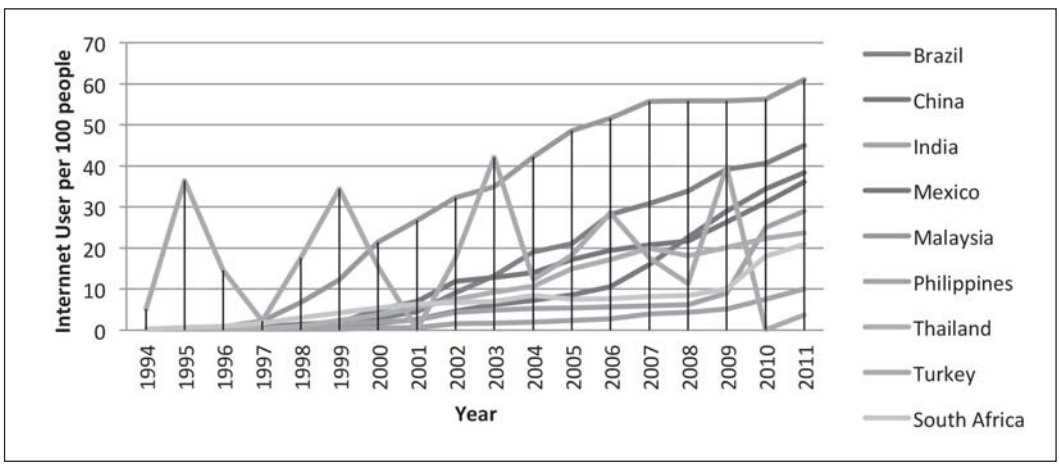

Figure 2: Internet User Per 100 People during 1994-2011

Theoretical Framework

After neoclassical revolution, the major contribution to development economics came from Schumpeter (1942) and Solow (1956). Schumpeter (1942) and Solow (1956) started growth theory with the basic idea that economic growth has been influenced by three factors in production, capital, labor, and productivity. Although neoclassical economists understood how important the technology is in economic growth and development, they cannot assess its impact due to its indirect effect. Later in neo-Schumpeterian model, a group of growth theorists improved neoclassical growth model with endogenous growth model that can explain explicit model (Lucas, 1988; Romer, 1990). Endogenous growth theory states that economic growth is primarily the result of endogenous, not only external factor. In addition, endogenous growth theory supports that human capital innovation and knowledge are significant contributor to economic growth. Hence, production function (Y) with physical capital (K), labor and knowledge or technology (A) can be expressed as $Y(t) = F(K(t), A(t), L(t))$. Since the high-speed internet via broadband infrastructure is one of important innovative capacities of the economy, this study will apply endogenous growth theory in order to analyze the impacts of the Internet on economic growth.

This study hypothesizes that the Internet plays a significant role in spreading knowledge in economy, and consequently economic growth. Economic growth is usually measured by GDP. GDP can be determined by three ways; product approach, income approach and expenditure approach. In economics, most products from production are marketable, therefore, measuring the total expenditure is a way of measuring production. From expenditure side, the component of GDP is a sum of consumption, investment, government spending, and net exports, which are the difference between gross exports and gross imports.

In addition, the interaction effect between the Internet and economic growth can be in reverse as known as the causality effect. While the Internet is the backbone behind economic growth, higher economic growth could lead to better internet infrastructure as well. Hence, this study also tests the granger causality between the Internet and economic growth by using the dynamic panel data model. There are several previous studies related to granger causality test (Granger

(1969); Hoffmann et al. (2005); Tervo (2009)); however this study focuses on granger causality test in panel data models. Granger causality test works more efficient with panel data because panel data can provide more flexibility in modeling with more degree of freedom in the cross-section than time-series analysis (Hood III et al. (2008))

Econometric Specification

Considering the effects of ICT on economic growth, this study focuses on internet usage. From literature review, the Internet could affect economic growth in several ways, for example, internet usage can improve firm productivity and directly enhance GDP. From the growth model and measurement of economic growth, this study chooses gross capital formation, household consumption expenditure, government consumption expenditure and trade composition as explanatory variables along with internet usage variable. In addition, trade composition depends on foreign direct investment, gross capital formation, internet usage. Hence, per capita GDP is determined by the Internet, gross capital formation, household consumption expenditure, government consumption expenditure, trade composition. The study sets the following economic growth equation for estimation.

$$GDP_{it} = \alpha_0 + \beta_1 Internet_{it} + \beta_2 Capital_{it} + \beta_3 Consumption_{it} + \beta_4 Government_{it} + \beta_5 Trade_{it} + u_{it}$$

Where $u_{it} = \eta_{it} + \gamma_{it} + \varepsilon_{it}$, η_{it} is a country effect. γ_{it} is a time effect and ε_{it} is independently and identically distributed among countries and years. $Growth_{it}$ is per capita GDP of country i at year t; while $Internet_{it}$ is people with access to the worldwide network. $Capital_{it}$ is gross capital formation. $Consumption_{it}$ is household final consumption expenditure. $Government_{it}$ is general government final consumption expenditure. $Trade_{it}$ is the net trade share of exports and imports.

In addition, this paper also aims to investigate the direction of causation in the granger test between the Internet and economic growth by adapting the model proposed by Hurlin & Venet (2003). These methods represent the causality relationship at the cross country unit by treating the autoregressive coefficients as constant. Hence, the following models are estimated.

$$\Delta GDP_{i,t} = \sum_{k=1}^{p} \beta_k \Delta GDP_{i,t-k} + \sum_{k=0}^{p} \theta_k \Delta Internet_{i,t-k} + u_{i,t}$$

$$\Delta Internet_{i,t} = \sum_{k=1}^{p} \beta_k \Delta Internet_{i,t-k} + \sum_{k=0}^{p} \theta_k \Delta GDP_{i,t-k} + u_{i,t}$$

Where p is the number of lags, β_k represent the autoregressive coefficient and θ_k represent regression coefficient. Since there are the different sources of heterogeneity in panel data, three different types of causality hypothesis are tested. First, homogenous and instantaneous non-causality hypothesis (HINC) is tested whether θ_k of $Internet_{i,t-k}$ are simultaneously equal to zero for all country i and all lag k. If HINC hypothesis is rejected, homogenous causality hypothesis (HC) is tested whether θ_k are identical for all lag k and are statistically different from zero. If HC hypothesis is also rejected, it implies that there is no homogenous causality relationship between the Internet and economic growth. Finally heterogeneous non-causality hypothesis (HENC) is tested whether all coeffcients of the lagged internet variable for each country (θ_k^i) is zero. If HENC hypothesis is failed to reject, the result will imply that there is at least on country that internet does not lead to higher economic growth.

Data

The data is taken from several databases such as World Development Indicators, and OECD Stat Extracts Database. The data consists of a panel of 9 NICs from 1994 through 2011. Internet user is the number of people with access to the worldwide network. Per capita GDP is gross domestic product converted to international dollars using purchasing power parity rates. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are in constant 2005 international dollars. Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction

of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Household final consumption expenditure is the market value of all goods and services, including durable products purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. In addition, household consumption expenditure includes the expenditures of nonprofit institutions serving households. General government final consumption expenditure consists of all government current expenditures for purchases of goods and services (including compensation of employees). Government expenditure also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. Net trade share is the sum of exports and imports of goods and services measured as a share of gross domestic product.

Result and Discussion

Table 1 lists the regression results. We estimated the growth equation (1) by various estimation methods: (a) pooled ordinary least squares (OLS), (b) individual fixed effects, (c) individual random effects.

Table 1: The Internet and Economic Growth

GDP	Pooled OLS	Fixed Effects	Random Effects
	(a)	(b)	(c)
internet user	143.1202***	66.73779***	66.92481***
	(17.11)	(3.28)	(3.28)
gross capital formation	-2.60E-09*	2.82E-09***	2.80E-09***
	(1.47e-09)	(3.32e-10)	(3.32e-10)
household consumption	41.98416	48.70729**	49.34623***
	(38.61)	(18.92)	(18.92)
government consumption	159.3034**	40.91582	40.6351
	(79.46)	(38.88)	(38.88)
trade of gdp	8.206583	7.769922**	8.06887***
	(7.80)	(3.11)	(3.11)
Constant	666.9448	2029.283	1936.381
	(3585)	(1252.73)	(1252.73)

a) ***, **, and, * indicate significance at the 1%, 5%, and, 10% levels, respectively.

b) Standard errors are in parentheses.

c) P-value of Hausman test is 0.0385

According to the pooled OLS regression (column (a) in Table 1), the estimated coefficient of the Internet is 143.12 and significant at the 1% level as expected. This means that when the internet-user ratio increases by 1 point, per capita GDP increased by $143.12. The estimated coefficient of gross formation capital is -2.60E-09 and significant at the 10% level. This means that when gross formation capital increases, per capita GDP decreases. The estimated coefficient of government consumption is 159.30 and significant at the 5% level. However, the pooled-OLS specification completely disregards information about the time and cross-sectional dimensions of the panel data. In addition, the classical regression assumptions of homoskedasticity and cross-sectional correlation where possibly sample correlated are violated. Thus, the pooled-OLS estimators may be both biased and inconsistent (Gujarati, 2003; Wooldridge, 2006). In order to solve this problem, fixed effects and random effects specification are adopted.

As the study uses panel data from 9 NICs during 1994-2011 in regressions, the results shows the estimated coefficient by individual fixed effects (column (b) in Table 1), individual random effects (column (c) in Table 1). Hausman test is used to check the more the more efficient random effects model against a less efficient but consistent fixed effects model. The significant p-values of the Hausman tests show that fixed effects model is preferred as p-value of the Hausman test is 0.038. Hence, the fixed effects specification is the most appropriate for this study. The fixed effects specification is better suited to cases of unobservable country-effects. On the other hand, if the unobserved individual heterogeneity is uncorrelated with the explanation variable, the random-effects model is a better choice (Greene, 2003).

The estimated coefficient of the Internet is 66.74 and significant at the 1% level as expected. This means that when the Internet-user ratio increases by 1 point, per capita GDP increased by $66.74. The estimated coefficient of gross formation capital is 2.82E-09 and significant at the 1% level. The estimated coefficient of household consumption is 48.70 at the 5% level. The estimated coefficient of trade is 7.77 at the 5% level. The estimated coefficient of government consumption is insignificant. This means that when gross formation capital, household consumption and trade of GDP increase, per capita GDP increases. To sum up, the effect of the Internet on economic growth is positive and significant across all the regressions. Furthermore the coefficients of gross formation capital, household consumption and trade are positive and consistent with the expectation. Higher capital formation, household consumption and net trade along with the Internet have a positive effect on economic growth.

Besides, the causality between GDP and the Internet is also examined. The two lag lengths of both variables are determined by Akaike Information Criterion (AIC). Consequently, the non-causality (HINC) and the homogeneous causality (HC) are tested by Wald test as shown in Table 2 The results show that there is causality relationship between GDP and the Internet since the null hypothesis of the HINC hypothesis is rejected. Furthermore, the results also show that there is nonexistence of homogeneous causality between GDP and the Internet since the null hypothesis of the HC is also rejected as shown in Table 2. In order to examine

individual countries' influences on the causality, HENC hypothesis is tested for each individual countries. The results show that four of nine countries or about 44% of countries have causality from GDP to the Internet and the Internet to GDP. In addition, if countries are ranked by GDP per capita in year 2010, the results show the interesting pattern. The Granger causality between GDP and the Internet occurs in NICs countries with the top four GDP per capita of NICs countries. This finding is important as it shows that biodirectional Granger causality relationship between GDP per capita and the Internet among NICs countries with relatively high income. The internet infrastructure also has a positive impact on GDP per capita as GDP per capita influences on the internet infrastructure allocation. However, Granger causality is no longer existed among NICs countries with relatively low income.

Table 2: Test Results for Homogenous Causality Hypotheses

Country Group	Test	Causality from the Internet to GDP	Causality from GDP to the Internet
NICs	HINC	1.989*	7.737*
	HC	0.847*	9.219*

* Reject H0 at 1% level of significance

Table 3: Test Results for Heterogeneous Causality Hypotheses (HENC)

Country	Causality from the Internet to GDP	Causality from GDP to the Internet
South Africa	19.41*	6.27
Mexico	21.23*	22.45*
Brazil	40.13*	11.45*
China	31.18*	5.67
India	9.46*	1.90
Malaysia	8.10*	7.25*
Phillipines	7.33*	1.49
Thailand	4.09*	2.22
Turkey	7.13*	13.02*

* Reject H0 at 1% level of significance

Table 3 shows the results for heterogeneous causality hypothesis (HENC). All nine countries show strong support for causality from GDP to the Internet. The results show that the Internet has significant impact on GDP in NICs countries. These findings support the positive impact of internet on economics growth for all nine NICS countries. Meanwhile, four out of nine countries, Mexico, Brazil, Malaysia, and Turkey show the bidirectional causality both from GDP to the Internet and the Internet to GDP. Therefore, any policies aiming to stimulate the Internet is likely to have positive impact on GDP and any policies aiming to stimulate GDP is likely to have positive impact on the Internet. Interesting point is that the evidence of bidirectional causality is found among the top four NICs countires ranking by GDP per capita, which can imply that those countries have higher development level than others. The bidirectional causality among those countries can be caused by the following reasons. First, the Internet has become the basic input for every sector once the countires have reached the certain level of development and economic growth usually leads the expansion in all economic sectors which require the Internet in order to increase their productivity. Second, once the countires have reached the certain level of development, the Internet has become a mandatory in every household among these countries. As income rise, households in these countries tend to change their lifestyle and adopt higer technological devices such as internet TV, smart phone, computer that requires the Internet.

Table 4: Test Results for VAR Fixed Effects Model

	Dependent Variable	
	ΔGrowth	**ΔInternet**
ΔGrowth(-1)	0.51**	0.15
	(3.42)	(0.11)
ΔGrowth(-2)	-0.05**	-0.80
	(4.55)	(0.52)
ΔInternet(-1)	0.44	0.25
	(0.40)	(0.09)
ΔInternet(-2)	-0.07	-0.15
	(0.75)	(0.01)

** indicates significance at the 5%

Table 4 presents the estimated VAR from fixed effects specification for NICs countries. By using panel VAR approach, this study can compensate for data limitation and endogeniety among economic development and the Internet. The empirical results show that the Internet has positive impact on GDP; however, GDP has no significant impact on the Internet. The fact that the Internet can lead to higher GDP level of NICs countries can be explained as follow. Higher internet penetration can improve communication, social involvement, economic activity and productivity in economic sectors such as agriculture, industry, service, and social development. As technology develops, the internet has the potential to further impact of economic development through the provision of faster online service and communication between businesses and consumers.

Summary and Concluding Remarks

Internet is assumed to contribute to knowledge and productivity. Therefore, the increase in the internet usage is hypothesized to have a positive impact on economic growth as represented by per capita GDP. Using panel data from 9 newly industrialized countries (NICs) from 1994 to 2011, this study found that fixed effects specification is the most appropriate model for analysis. The result from fixed effects specification found that the internet plays positive and significant role in economic growth after all other factors such as household consumption, gross capital formation government consumption and trade ratio were constant in the growth equation. This result suggests yet again that the way to attain higher economic growth is increase the number of internet user, which can be achieved from increasing internet infrastructure or technology. In the meantime, the results also show that higher in gross capital formation, household consumption and trade ratio play statistically significant role in higher economic growth as measured by per capita GDP. As the national level of NICs countries, the study shows that the internet has been used as a key part for their overall economic strategy to boost up their economic status. Moreover, gross capital formation, household consumption and export role which are also associated with economic growth have sufficient evidence that improve per capita GDP among NICs during the past decade. Hence, development policies should be included all these factors in order to boost countries' economic growth.

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