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## Conference Paper

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8th Asia-Pacific Regional Conference of the International Telecommunications Society (ITS): "Convergence in the Digital Age", Taipei, Taiwan, 26th-28th June, 2011

## Provided in Cooperation with:

International Telecommunications Society (ITS)

*Suggested Citation:* Keesookpuna, Chutipong; Mitomob, Hitoshi (2011) : Examining the relationship of communication service utilisation and productivity of labour in the developing country: A case study of Thailand, 8th Asia-Pacific Regional Conference of the International Telecommunications Society (ITS): "Convergence in the Digital Age", Taipei, Taiwan, 26th-28th June, 2011, International Telecommunications Society (ITS), Calgary

This Version is available at:

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# Examining the Relationship of Communication Service Utilisation and Productivity of Labour in the Developing Country: A Case Study of Thailand

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## Abstract

It is widely acknowledged that there is a relationship between the use of ICT and economic growth. A number of works of literature point out such fact in the developed country. This study, however, attempts to examine the relationship of the use of ICT and labour productivity, which is one of the factors indicating the economic growth, in the developing country. Thailand is selected for the investigation with the country's data in the period of 1999 - 2010. The ICT is represented by communications consumption and investment throughout the paper. The author presumably proposes a framework in order to verify the relationship in an intuitive way. The quantitative analyses of OLS estimation and the bivariate autoregressive model, or the Granger-causality test, support the validity of the framework and clearly point out the one-way causal relationship flowing from the communications consumption to labour productivity; the communications investment to labour productivity, and the communications consumption to communications investment.

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## I. Introduction

Nowadays, there are a lot of investments in information and communication technology (ICT) with belief that they will result in economic prosperity. Many countries put telecommunications development as their priorities, especially those in the west. Indeed, developed countries' government try to promote the use of technology and desired outcomes in supporting the nation's development in various aspects on which economic prosperity is concentrated. Besides, it is something that the government can claim for its effective development policies and be re-elected.

The spread of telecommunications generates economic growth because it incurs a reduction in interaction costs, expansion of information flows and market boundaries. Countries with limited telecommunications infrastructure, like many in Africa, encounter several economic problems such as overpriced cost of interaction, limited information flows, reduced market opportunities and consequently low incomes (Davis & Ochieng, 2007).

The relationship of ICT and economic development varies among countries and aspects of the development. Some countries can witness a significant positive effect from the improvement of telecommunications infrastructure, while some may experience an unclear relationship or even insignificant correlation. This indeed depends on the characteristics of the country to which level it can utilise the benefits of the developed ICT infrastructure and services. Besides, it is concerned with a particular aspect of economic development upon which the analyses lie. For macro-economic aspect, examples include the improvement of GDP, interest rates, employment, etc.; while that of micro-economic perspective consists of the development of firm's advantages, consumer utility and market efficiency. Some literature regarding the relationship of ICT and particular aspects of economic growth are discussed in the later session.

Despite the fact that there are several aspects of economic growth to focus – each has pertinent influence – this paper focuses on the macro-economic perspective. Indeed, the productivity of labour is considered as an indicator of the economic growth. Communication services of both household and business are used as the representative of the ICT. Communications technology is said to be one major contributor to productivity growth in the western world as seen in a number of studies. Economic theories suggest that technological progress is a driving force that expands the production function resulting in a higher level output and productivity with the same number of worker. The communications technology is considered one of the technological progresses. With good communication services, individual workers can communicate with one another to share information about their job and learn from others to improve their functions. On the other hand, a private industry can utilise the communications technology in its production resulting in a more efficient and accurate process. Given a number of labour, more output can be manufactured. Drawbacks of human errors may be diminished.

The purpose of this study is to examine the causal relationship of labour productivity and utilisation of communication services and equipment for both households and businesses in macro perspective in a developing country. Because of the lack of studies regarding this issue, Thailand is selected as ground for the investigation. Upon conveying the analysis, a framework is proposed in order to understand the logic and its validity according to the country's statistical data.

This paper is divided into the following. Part II consists of relevant past literature while Part III discusses the theoretical foundation. Part IV explains the proposed framework. Part V shows the methodology and explains the data and

variables used in the analysis in detail in order to examine and endorse the framework. Part VI shows the empirical results and Part VII concludes the paper with some implications and recommendations of further research.

## II. Literature Review

A lot of studies have been done on the issue of telecommunications and economic development. The focus is on different countries. Most of the time, a group of countries is selected as an experimental ground. Indeed, the applicability of the results is reliable when it is endorsed with the consistency in various countries ranging from developed to developing ones. There are studies on the developed and developing countries separately as well as on both of them simultaneously. Moreover, there are some studies focusing on a particular group of countries, or specific country. All of the past studies employ different methodologies according to the availability of the data and aspects of focus. In fact, the earlier studies mainly refer to telecommunication services as fixed-line telephony services, while the later researches have different definitions that include mobile telephony, Internet, and some other radio frequency-based communications.

To begin with literature covering various economies, the very early study on the usage of telephone and economic development is conducted on 60 countries – developed and developing countries – during 1960-1973. The number of telephone lines per household, or tele-density is used as a proxy for the usage of telephone while the GDP per capita is used to analyse the economic development. The regression results show that the tele-density has a significant impact on the GDP per capita (Hardy, 1980). In the same manner, Leff (1984), focusing primarily on telephones, examines the welfare effects of investment in telecommunications facilities in 47 developed and developing countries. The cross-sectional regression shows that the telecommunications infrastructure and economic growth have a significant and positive relationship. Dewan and Kraemer (2000) employing the Cobb–Douglas production function examine the annual data of 36 countries during 1985-1993. They use GDP as the output while labour hours, ICT, and non-ICT capital are used as inputs. The conclusion is that the ICT investment contributes to the economic growth of the developed countries, while it is not statistically significant for the developing countries. Madden and Savage (2000a) extensively study a sample of OECD and Asian countries in the period of 1980-1995 by using R&D activity as a link to technology progress. The regression outcome ensures that the R&D activity and national productivity have a positive relationship in the long run. Besides, such the benefit can be transferred to other countries through trade, especially, in information technology and telecommunications (ITT) equipment. Dutta (2001) studies 15 industrialised and 15 developing countries and finds that the causality flowing from telecommunications infrastructure to economic activity has a higher level of robustness than that of the opposite direction. Seo et al. (2009) have in one of their findings that even though the ICT investment does not have a strong independent relationship with economic growth, there is a positive correlation between the two in the analysis of 29 countries during 1992-1999. For a particular aspect, the impact of mobile telecommunications on economic growth and telecommunications productivity is studied by Lam and Shiu (2010). They use a panel data model with 105 countries during 1980-2006. Even though they find a bi-directional relationship between the mobile telecommunications and economic growth when measured separately, they conclude that countries that allow competition and privatisation in the telecommunications have a higher level of total factor productivity (TFP), which includes the ICT, compared to those with limited competition and privatisation.

For the research on developed countries, Cronin et al. (1991) study the time series of U.S. data in the period of 1958-1988 (31 years) and find a statistically relevant causal relationship between productivity growth and telecommunications. One of their outcomes is that the level of the telecommunications investment at any point in time can consistently predict the level of the economic activity at a later point in time. In addition, Greenwood et al. (1997) study the U.S. total productivity growth during 1954 – 1990 and point out a contribution of 42 and 58 percent from neutral and specific technological change, respectively. They define the specific technological progress as it includes only equipment, while the neutral technological progress consists of both equipment and structures. Oliner and Sichel (2000) experience a positive relationship of the ICT and economic development. Indeed, they find out that the use of ICT contributes more than 20 percent while the production of ICT components such as computer hardware and semiconductors contributes approximately 10 percent to the output growth of U.S. from 1996 to 1999. Besides, the labour-productivity growth also receives a contribution of 37 percent from the use of ICT. Similarly, Jorgenson and Stiroh (2000) study the labour productivity in the U.S. and point out a higher contribution of 43 percent to the growth during 1990's. Martínez et al. (2010) study the impact of ICT on the U.S. economic development using a dynamic general equilibrium approach during 1980-2004. They conclude that the ICT-specific technological change accounts for about 35 percent of the total labour-productivity growth in which the hardware equipment is the leading force. In contrast to the U.S. experience, Khan and Santos (2002) use a simple growth-accounting model based on Cobb-Douglas production function to analyse similar issue in Canada during 1988-2000 and find out that the use of ICT does not exhibit a persistent stream of contribution to the country's output and labour-productivity growth. Following the previous study of Greenwood et al. (1997), Bakhshi and Larsen (2005) find out that the specific technological change contributes around 20-30 percent to the U.K. total labour-productivity growth in the period of 1976-1998. Jha and Majumdar (1999) utilising panel data and stochastic production frontier estimation approach find out that the mobile-technology diffusion has a positive and significant impact on the productivity of the telecommunications sector in 23 OECD countries in the period of 1980-1995. Roller and Waverman (2001) analyse similar issues with the macroproduction function using data from OECD countries during 1970-1990. They point out a causal relationship between the telecommunications infrastructure and productivity that occurs only when the telecommunication services are universally or nearly universally provided. More importantly, Datta and Agarwal (2004) investigate the long-run economic growth and telecommunications infrastructure in 22 OECD countries and find out the positive correlation between the telecommunications and GDP per capita growth. They especially suggest that countries at an earlier stage can witness a more obvious impact of telecommunications investment because of diminishing returns. Another aspect of telecommunications is studied by Koutroumpis (2009) whose work focuses on the broadband penetration and economic growth in 22 OECD countries during 2002-2007. With macro-production function and micro-model for broadband investment, the results show a significant and positive causal relationship, particularly, when the broadband infrastructure is available at mass.

For the literature covering developing countries, Madden and Savage (1998) study transitional economies in Central and Eastern Europe (CEE) in order to examine the direction of influence, and timing, between gross fixed investment, telecommunications structure investment and economic growth. Their outcome indicates that the telecommunications investment measured mainly by number of telephone lines is significantly related to the economic growth of these countries. Despite the fact that the investment data of many developing countries is discretionary, mostly absent, Madden and Savage (2000b) propose another proxy for

telecommunications capital that is the tele-density. Along with the share of telecommunications investment in national income, they develop a supplyside growth model of which estimation results indicate a significant positive cross-country relationship between telecommunications capital and economic growth, when using alternative measures of telecommunications capital. Another interesting study by Chakraborty and Nandi (2003) shows that the causality runs from tele-density to GDP in 12 developing countries in Asia that have a low degree of privatisation, while it is bi-directional for the countries with a high degree of privatisation in both the short and long run. Sridhar and Sridhar (2004) also study the relationship of telecommunications and economic growth in developing countries. Using 3SLS, the estimation of a system of equations that endogenises economic growth, and telecommunications penetration and its growth along with the supply of telecommunications investment results in a significant impact of cellular services on national output when the capital and labour effects are controlled. However, they inevitably point out that the impact of the telecommunications penetration is weaker for developing countries compared to the statistics of OECD countries.

### III. Theoretical Foundation

This section employs a theoretical model in order to theoretically verify the relationship of the labour productivity and ICT. The outcome from this section will be used as a fundamental of the proposed framework in the following section.

According to a paper by Kim and Lau (1996), Thailand and most of the Asia-Pacific countries (APCs) exhibit a very low level of decreasing returns to scale with the values close to 1. Therefore, for simplicity, suppose the country's output is expressed in form of the Cobb-Douglas production function with constant returns to scale:

$$Y = AK^\alpha L^{1-\alpha} \quad (1)$$

where  $Y$  is the level of output,  $A$  denotes Total Factor Productivity (TFP) of which a major contribution is the technological progress, or the ICT (Quah, 2001).  $K$  and  $L$  are capital and employed labour, respectively. The parameter  $\alpha$  and  $1-\alpha$  are constructed such that their sum is equal to 1.

In order to generate the proxy of labour productivity, the equation (1) is divided by  $L$ . And the new function of output per capita can be constructed as follow:

$$\frac{Y}{L} = \frac{AK^\alpha L^{1-\alpha}}{L^\alpha L^{1-\alpha}} \quad (2)$$

where on the right-hand side of equation (2), the denominator  $L$  is decomposed. With a rearrangement, the new per capita equation is as follow:

$$y = Ak^\alpha \quad (3)$$

where the lowercase letter  $y$  and  $k$  represent the output per capita or, in this case, labour productivity, and the capital per capita or the capital-intensity ratio. The equation (3) shows that the employed labour variable does not have any impact on the level of labour productivity. To continue under the growth perspective, the logarithm function is formed from equation (3):

$$\log y_{t+1} - \log y_t = \log A_{t+1} - \log A_t + \alpha(\log k_{t+1} - \log k_t) \quad (4)$$

where equation (4) is the logarithm of equation (3) expressed in terms of first difference of the logged variables, or the growth rate of all variables. Finally, a new equation can be constructed with some denotations:

$$g(y) = g(A) + \alpha g(k) \quad (5)$$

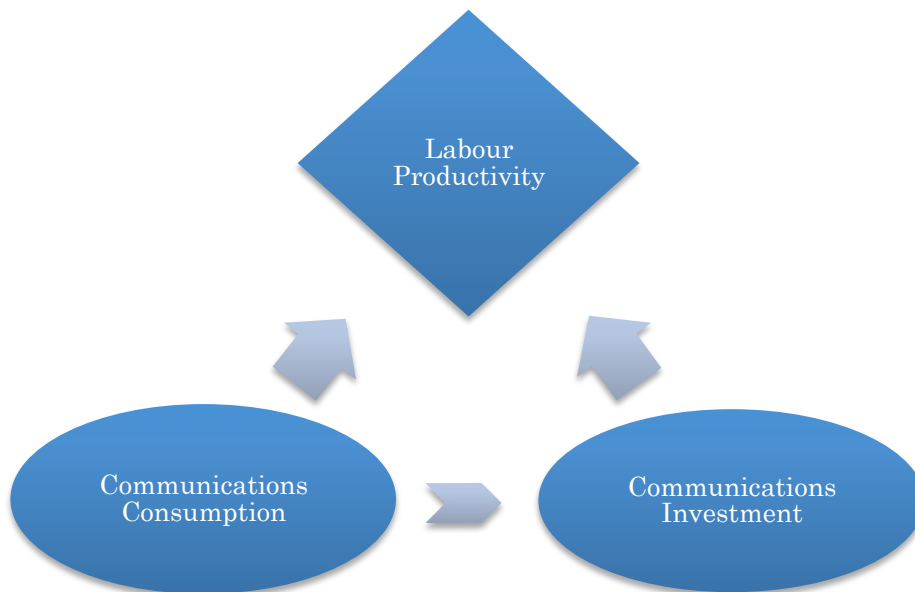
where the letter  $g$  represents the growth rate of each variable. The equation (5) concludes that the growth rate of output per capita or labour productivity depends only on the growth rate of TFP or the ICT, and the capital-intensity ratio.

The theoretical experiment endorses the fact that the level of labour productivity depends on the level of technological progress or the ICT, and capital per capita. The relationship of the variables is also the same for the growth rate perspective as seen from equation (3) and (5).

#### IV. Proposed Framework

From the previous section, it is to be remarked that the ICT is one of the variables contributing to the level of labour productivity as well as the capital per capita ratio. According to the fact that the ICT is considered a major part in the technological progress, the author believes that it also accounts for a great deal of contribution in the capital per capita. Indeed, the ICT is an intangible asset that can be built or installed within all kinds of capital at present. Therefore, the main focus here is on the ICT and its role in the development of the country's productivity.

**Figure 1** Communications and Labour Productivity Framework



*Source: The Author*

In the proposed framework, in order to define the ICT in a concrete way, a proxy of communications is used. In fact, the ICT as a whole includes computer, Internet, and telecommunications. The computer is there to transfer files among standardised systems while the Internet evolves as a means of the delivery of different online contents. The telecommunications system makes available the exchange of information among users. Evidently, communications is the main purpose and contribution in the ICT. Hence, using the communications as a proxy for the ICT is appropriate.

To begin, it is necessary to describe each of the factors shown in Figure 1. Labour Productivity denotes the level of output that an employed labour can produce at a point in time. There are several ways to measure the labour productivity. It can

be calculated as an index, or unit of output per labour. Communications Consumption consists of the private consumption of communication services and devices. Indeed, it ranges from household purchases of fixed-line telephone services to a very high-tech smart phone or laptop. Communications Investment, on the other hand, accounts for the investment in communication services, infrastructure and equipments by a business enterprise. This kind of investment ranges from a subscription for the Internet service to an installment of a dedicated database server. Putting all elements together, the framework points out the relationship that both demand and supply of the communications market, namely, consumption and investment, have an impact on the labour productivity as well as interrelationship between them.

#### **a. Communications Consumption vs. Labour Productivity**

The author distinguishes the two kinds of communications consumption that are work-related communications consumption (WCC) and non work-related communications consumption (NWCC). The WCC consists of all kinds of communications consumption that can directly improve the quality and efficiency of a particular job of a worker. A purchase of an electronic organiser, PDA, for example, can be considered as WCC because it helps the user to organise work tasks and handle them in an efficient manner. In contrast, the NWCC means the consumption of communication services or devices that is not directly relevant to the improvement of work quality. When a worker decides to buy a game console for entertainment, he or she is considered engaging in the NWCC.

Both kinds of communications consumption have a significant influence on the labour productivity in a direct and indirect way. Obviously, the WCC results in better work outcome of the worker without having to increase the number of labour or capital for a particular job. Nonetheless, for the NWCC, the improvement in the labour productivity can also be obtained indirectly. Indeed, a worker who has purchased a number of NWCC devices or services is the one with a high level of utility. He or she is willing to perform the tasks pleasantly resulting in a more level of output without a change in any other factor. Therefore, it can be conclude that the communications consumption leads to an improvement in the labour productivity.

#### **b. Communications Investment vs. Labour Productivity**

Assuming that the firm acts according to business purposes, its investment in every aspect can be construed for profit-seeking objectives. In other words, there is only one kind of communications investment that is work-related communications investment (WCI). The WCI directly influences the labour productivity because it involves the establishment of the communication services and equipments that promotes the efficiency of the production originated from each worker as considered by the firm. A subscription of the enterprise Internet service can improve the efficiency and standardisation of production through online information gathering and benchmarking. It is a kind of technological progress which leads to the development of labour productivity as endorsed by the previous section. Another WCI instance is a purchase of computer hardware which can be considered as a contribution to both the technological progress and increase in capital per worker. This also theoretically and practically results in more output per worker. Hence, one cannot deny the influence of the communications investment or WCI on the development of the labour productivity.



### **c. Communications Consumption vs. Communications Investment**

These two elements are very interesting. In the same manner as each of them has a prominent impact on the labour productivity, they are somehow related. The author proposes that the increase in communications consumption – both WCC and NWCC – leads to a rise in communications investment. It is true that a higher level of the communications consumption means that individuals are readily able to adopt and utilise available communication services and devices in the market. Given such the information, private enterprises can then be certain about the effectiveness of the communication services and infrastructure investment resulting in a higher level of the WCI and the advancement in the technology.

In summary, the proposed framework consists of three elements, namely, the labour productivity, communications consumption, and communications investment. All combined can be used to intuitively explain the relationship between communications and labour productivity. Both of the communications consumption and investment lead to an improvement in the labour productivity. Moreover, both of the WCC and NWCC lead to a rise in the level of communications investment.

## **V. Data and Methodology**

Apart from the proposed framework, this section explains all the variables and methodology employed in further quantitative analyses in order to examine the relationship of the ICT and labour productivity.

### **a. Data**

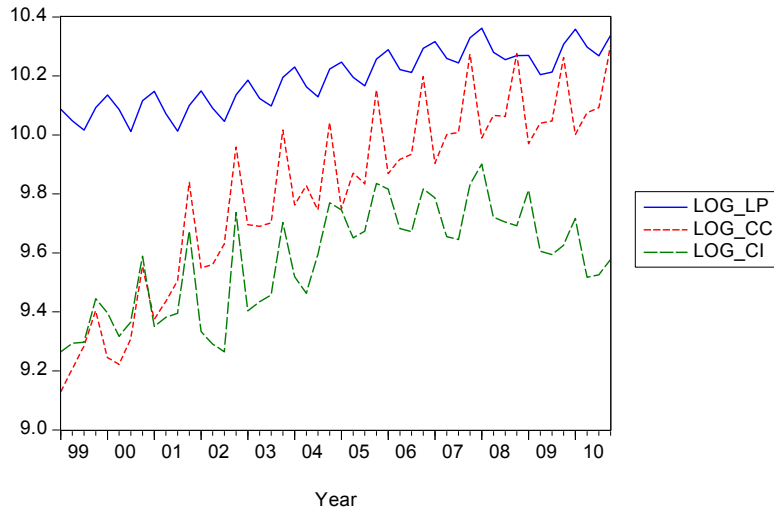
For the statistical data, there are three variables that are of concern, namely, the labour productivity, communications consumption, and communications investment. Note that the latter two are the proxy of the ICT. Thailand is selected as an experimental developing economy. All statistics are obtained from both the governmental unit and public non-governmental organisation. According to the availability of the data, all variables are in domestic currency unit in a quarterly basis ranging from 1999 to 2010. Each of the variables is measured as follow.

First, the labour productivity (LP) is constructed as a ratio of real GDP, or the GDP at 1988 prices, per number of employed person. This is to avoid the inflationary effect of the output. The real GDP figures are obtained from the Office of the National Economic and Social Development Board (NESDB) while the number of employed workforce is from the labour force survey of the National Statistical Office (NSO). Second, the communications consumption (CC) is measured as the value of post and telecommunication services consumption from the table of private consumption expenditure at 1988 prices published by the NESDB. Note that the value of CC also includes the consumption of handsets and equipments apart from the services. Third, the communications investment (CI) is derived from the difference of the total value of the post and telecommunications taken from the table of GDP originating from transport, storage and communications at 1988 prices and the value of the CC. Even though this is not a perfect proxy for the value of private CI because it also takes into account the value of the investment by the government, it is the best approximation provided that the government CI only shares a part of less than 10 percent of the total value.

After deriving all the variables, the growth rate is considered instead of the raw figure in order to smoothen the huge difference in value of each variable, especially between the LP and CC, or CI. By doing so, the logarithm of all series is constructed. The log-transformed variables are denoted as LOG\_LP, LOG\_CC, and

LOG\_CI corresponding to the original series of LP, CC, and CI, respectively. Some descriptive statistics are shown here.

**Figure 2** All Variables in Logarithmic Transformation



Source: The Author

**Table 1** Descriptive Statistics of All Variables

Descriptive Statistics	LOG_LP	LOG_CC	LOG_CI
Mean	10.19	9.80	9.57
Median	10.20	9.87	9.60
Maximum	10.36	10.30	9.90
Minimum	10.01	9.13	9.26
Std. Dev.	0.10	0.32	0.18
Jarque-Bera	2.10	2.97	2.99
Probability	0.35	0.23	0.22

Source: The Author

**Table 2** Correlation Coefficients of All Variables

Variable	Value
LOG_LP and LOG_CC	0.82
LOG_LP and LOG_CI	0.76
LOG_CC and LOG_CI	0.74

Source: The Author

One can see that the LP and CC have an increasing trend, while the CI shows a decline in the last three years as illustrated in Figure 2. From Table 1, it is to be noted that all series are normally distributed with approximately similar values of the basic statistics. Moreover, Table 2 shows that both CC and CI can be used to explain the LP variable at a reliable level because of the greater influence they have on the LP rather than themselves.

## b. Methodology

As mentioned earlier, this study tries to examine the relationship of the labour productivity and communications. There are two ways of analysis. First, the

author proposes a framework to intuitively point out the relationship. Second, quantitative analyses are used.

The OLS estimation is used as a statistical endorsement in order to verify the validity of the proposed framework. The estimating equation is as follow:

$$LOG\_LP_t = \alpha + \beta_1 LOG\_CC_t + \beta_2 LOG\_CI_t + \varepsilon_t \quad (6)$$

where under this simple regression model, the results of high explanatory power and level of significant coefficients are expected. The variable LOG\_LP, LOG\_CC, and LOG\_CI stand for the log-transformation of LP, CC, and CI, respectively.

For the quantitative analysis, in order to examine the causal relationship of each pair of the variables, the bivariate-autoregressive model or Granger-causality test is used (Granger, 1969). Moreover, the author also simplifies the model used in the recent study by Lam and Shiu, 2010, which employed similar approach, and adapts to this study according to the availability and reliability of the data. The models are as follows:

The causal relationship of LP and CC is estimated by:

$$LOG\_LP_t = \alpha_1 + \sum_{n=1}^N \beta_n LOG\_CC_{t-n} + \sum_{n=1}^N \gamma_n LOG\_LP_{t-n} + \varepsilon_{1t} \quad (7.1)$$

and

$$LOG\_CC_t = \alpha_2 + \sum_{m=1}^M \tau_m LOG\_LP_{t-m} + \sum_{m=1}^M \omega_m LOG\_CC_{t-m} + \varepsilon_{2t} \quad (7.2)$$

The causal relationship of LP and CI is estimated by:

$$LOG\_LP_t = \alpha_1 + \sum_{n=1}^N \beta_n LOG\_CI_{t-n} + \sum_{n=1}^N \gamma_n LOG\_LP_{t-n} + \varepsilon_{1t} \quad (8.1)$$

and

$$LOG\_CI_t = \alpha_2 + \sum_{m=1}^M \tau_m LOG\_LP_{t-m} + \sum_{m=1}^M \omega_m LOG\_CI_{t-m} + \varepsilon_{2t} \quad (8.2)$$

The causal relationship of CC and CI is estimated by:

$$LOG\_CC_t = \alpha_1 + \sum_{n=1}^N \beta_n LOG\_CI_{t-n} + \sum_{n=1}^N \gamma_n LOG\_CC_{t-n} + \varepsilon_{1t} \quad (9.1)$$

and

$$LOG\_CI_t = \alpha_2 + \sum_{m=1}^M \tau_m LOG\_CC_{t-m} + \sum_{m=1}^M \omega_m LOG\_CI_{t-m} + \varepsilon_{2t} \quad (9.2)$$

where each pair of equations, namely, (7.1) and (7.2), (8.1) and (8.2), and (9.1) and (9.2), indicates the model that will be estimated separately from one another. Totally, there are three models. The letter  $n$  and  $m$  represent the number of lag for each equation in a pair. Their value can be equal. The error terms are denoted by  $\varepsilon_{1t}$  and  $\varepsilon_{2t}$  for each particular equation in a pair.

## VI. Empirical Results

Regarding the endorsement of the framework, the OLS estimation is conducted on the series of LP, CC, and CI at both level and log-transformation. After checking the reliability of the data by using some descriptive statistics and tests, which some have been shown, the results are, not surprisingly, similar. Therefore, for the growth perspective and the ease of the magnitude of the series, the log-transformation can be considered.

The model incorporates LOG\_LP, LOG\_CC and LOG\_CI where the latter two are the independent variables. The main focus is on the level of explanatory power and significance of the coefficients. The result is interesting and convincing that both of the two variables have a high level of significance of both 5 and 1 percent. In addition, they are positively correlated with the dependent variable, LOG\_LP. The explanatory power of this estimation is very high, reaching more than 85 percent. Indeed, there is only about 15 percent left for the other unknown factor as shown by the R-squared in Table 3. Therefore this model is an appropriate estimator of the LOG\_LP taking into account LOG\_CC and LOG\_CI altogether.

**Table 3** Results of the OLS Estimation of LP, CC and CI in Logarithmic Transformation during 1999Q1 – 2010Q4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LOG_LP				
LOG_CC(-1)	0.23	0.03	7.46	0.00*
LOG_CI(-8)	0.18	0.04	4.79	0.00*
Constant	6.21	0.27	23.21	0.00*
R-squared	0.87	Durbin-Watson stat.	1.39	
Adjusted R-squared	0.86	Log likelihood	81.45	
S.E. of regression	0.03	F-statistic	119.63	
Sum squared residual	0.04	Prob. (F-statistic)	0.00	

*Notes:* The number of lag is shown in brackets.

\* indicates the significance level of both 5 and 1 percent.

From Table 3, it is to be construed that all the three variables have a significant relationship that the independent variables are good explaining variables for the log-transformed LP. The growth rate of either CC or CI, or approximately the percentage change, positively induces the growth of LP. Indeed, a growth rate of 1 percent in the communications consumption may result in an increase of 0.23 percent growth of the labour productivity. Similarly, the communications investment growth of 1 percent can bring about 0.18 percent growth of the labour productivity. Previously, a various number of lags are attempted. The best-resulted number of lag for both variables states that it takes 3 months and 2 years to witness the effect of communications consumption and investment, respectively.

Another quantitative analysis is conducted with the same set of data. After some specific adjustments, all variables in log-transformation are included in the bivariate autoregressive model, or the Granger-causality test. According to the fact that this test identifies the causal relationship in terms of time of occurrence, the variables are analysed in pair in order to see a clear relationship between the two variables in the pair. Hence, there are 3 sets of equation in total.

**Table 4** Results of the Causality Tests of LP, CC, and CI during 1999Q1 – 2010Q4

Null Hypothesis	F-Statistic	Prob.	Result
LOG_CC does not Granger Cause LOG_LP	42.38	0.00*	CC --> LP
LOG_LP does not Granger Cause LOG_CC	0.00	0.99	
LOG_CI does not Granger Cause LOG_LP	8.24	0.01**	CI --> LP
LOG_LP does not Granger Cause LOG_CI	0.03	0.86	
LOG_CI does not Granger Cause LOG_CC	1.17	0.29	CC --> CI
LOG_CC does not Granger Cause LOG_CI	8.17	0.01**	

*Notes:* The maximum lag up to 8 periods is added, while the best results arise from 1 period.

\* indicates the significance level of 5 and 1 percent.

\*\* indicates the significance level of 5 and 1 percent when extended to 4 decimal digits.

By running the Granger-causality test on each pair of equations, the results in Table 4 show a clear one-way causal relationship between each pair of variables. After altering the number of lags, it results that such the one-way causality occurs at 1 period, or 3 months according to the data. There is a causality running from the communications consumption to labour productivity. In the same way, the communications investment is proved to be the cause of the change in labour productivity. Remarkably, the causality flowing from the communications consumption to communications investment is found.

Intuitively speaking, the results in Table 4 support three important statements. First, a change in the level of communications consumption causes a change in the level of labour productivity. Second, a change in the level of communications investment is also the cause of a change in the level of labour productivity. Third, a change in the level of communications consumption leads to a change in the level of communications investment. According to the OLS result, it is to be noted that such the change of labour productivity originated from either the communications consumption or investment is positive.

## VII. Conclusion and Implications

Despite the fact that there have been quite a number of studies regarding the ICT and economic growth, developing countries are mostly a small part, or left out of the research. The author believes in the importance of the use of ICT, or communication services and equipment in developing countries as an improvement of the country's economic growth. With several relevant works of literature, mostly done in developed countries, both one and bi-directional causality have been found. This paper attempts to find the relationship of communications and a factor indicating the economic growth that is the labour productivity. Thailand is selected as a developing economy of the investigation in the period of 12 years, from 1999 to 2010.

The theoretical foundation shows a relationship of the labour productivity, technological progress or the ICT, and the capital per capita. Indeed, with the derivation, the labour factor disappears. The author then captures the theoretical relationship in the proposed framework in which the ICT is represented by communications consumption and investment. Apart from the intuitive understanding of the relationship of all elements in the framework, some quantitative analyses are conducted.

Indeed, the results of the OLS and bivariate autoregressive model, or the Granger-causality test, not only statistically support the validity of the proposed framework, but also provide clarifications for the causality of the variables. There are some implications as follows.

First, it is clear that the two variables, which are communications consumption and investment altogether, can be considered sufficient in explaining the change in the labour productivity as of high explanatory power and level of significance. Therefore, the framework of all three variables is reliable.

Second, from the causality test of all variables, only the one-way causality is found. The communications consumption is the cause of change for the labour productivity because both of the WCC and NWCC are to some extent the driver of an improvement in the level of productivity as explained by the framework. Indeed, the purchase of a personal computer, or smart phone by an employee is considered additive to his level of utility; hence, beneficial to the company in terms of higher level of productivity as well as the worker buying the work-related devices. Similarly, the communications investment is proved to be the cause of change for the labour productivity. A straightforward implication is that such the investment by the firm is considered efficient and effective to the extent that a major part of it can be utilised for the benefit of the firm since the management are assumed to know what is best for the company and selectively make important decisions. Therefore, there is only one kind of communications investment, which is work-related, and it helps improve the labour productivity through the channel of technological progress in the firm's production function. Incidentally, the relationship between either communications consumption or investment and the labour productivity is found to be positive as endorsed by the preceding ordinary regression. The last implication of the causality test arises from the causality running from the communications consumption to investment. This can also be understood as a higher level of the communications adoption by employees raises a higher level of the firm's awareness regarding such investment. In fact, the firm can be certain about its effectiveness of the investment because the employees are ready to operate various high-tech devices. This results in a higher level of the communications investment.

Further research on similar issue may consider different time frame, countries, or measurement of the variables. However, it is appreciated that more detailed research can be conducted in other particular developing countries in order to be able to generalise a novel aspect of economic development originated from the utilisation of the ICT or communications services and equipment.

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