P-ISSN: 2709-6254	Journal of Development and Social Sciences	April-June 2023, Vol.4, No. 2
O-ISSN:2709-6262	http://dx.doi.org/10.47205/jdss.2023(4-II)55	[624-635]

Journal of Development and Social Sciences
www.jdss.org.pk

RESEARCH PAPER

Impact of ICT Access on Total Factor Productivity(TFP) in Asian Economies

[1]Nuzhat Falki [2]Dr. Tahir Mahmood

1. Ph. D Scholar, School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
2. Professor, Department of Economics, Karakoram International University, Gilgit Pakistan

***Corresponding Author:** nuzhatnaveed1996@gmail.com

ABSTRACT

Link between Information and Communication Technology (ICT) and Total Factor Productivity (TFP) has been explored in detail. Particularly in the industrialized world, the productivity conundrum has received much attention. This study aims to shed light on this connection within the context of the productivity riddle by empirically evaluating the effect of ICT Access on Total Factor Productivity in Nine Developing Economies in Asia from 2000-2018. The empirical research is based on a PCA representing the ICT Access and other control variables that can potentially impact growth of Total Factor Productivity (TFP). Study employed FE model with robust clustered standard errors. Outcomes designate that ICT Access, Investment (I), and, R&D impact the TFP growth of sample countries. The study contributes to the ICT and TFP relationship by dwelling deep into the component of ICT. The policy implications drawn from this research exercise point to the fact that ICT's total impact on TFP can only be realized by increasing access to ICT thereby reducing the digital divide and making ICT accessible for all in a given economy.

KEYWORDS Digital Divide, ICT Access, ICT, Technological Advancement, TFP

Introduction

Asia is widely regarded as the world's fastest-growing region. East Asian and Pacific (excluding high-income) economies have witnessed high GDP growth in the last few decades. According to the OECD Development Centre's Medium Term Projection Framework 2020, GDP growth in Emerging Asia is predicted to reach 5.7 percent on average in 2020–24. The World Bank claims that South Asian nations' chances of an economic recovery are improving as growth is anticipated to rise by 7.2 percent in 2021 and 4.4 percent in 2022. Sustainable development in Asian countries, like other countries, relies on the increase in the number of resources available for production or by the intensification of Total Factor Productivity (TFP)(Sedik et al., 2019). To a larger extent than in traditional growth models, neoclassical growth theories credit gains in productivity to innovations in technology and the management of production. Conversely, the New Growth paradigm places a greater emphasis on spending more on things like human capital, knowledge capital, and fixed-asset investment. (C. Hulten, 2000). "TFP is regarded residual part of the output that is not explained due to the increase of inputs. Rather it represents the increase in production due to better technology, innovation, specialization, and better organization"(Comin, 2010). The lack of production elements might be replaced through growth. in TFP to achieve sustainable economic growth, which is referred to be the shift from input-based growth to productivity-based growth.

The endogenous growth theory propagated technology and knowledge as significant determinants of growth (Lucas, 1988), (Romer 1986, 1990), (Grossman & Helpman 1994). Only technological progression will allow developing nations to catch up to advanced nations. Research in the last two decades shows that the growth and development disparities can be attributed to technological differences (Abramovitz, 1986).

(Howitt & Aghion (1998) also backed technology as the leading driver of TFP growth in developed economies.

ICT refers to the hardware as well as software that facilitate users' to electronically access, recover, save, consolidate, control, and present information. It also comprises the hardware, network, and software used to access and obtain data (such as phones, fax machines, modems, digital networks, and DSL lines). Treating ICT as an input, similar to labour and capital, is essential for boosting value added at the firm level. The importance of ICT to economic development and productivity is well acknowledged. (Jorgenson, 2001; K. J. Stiroh, 2002). In today's economies, the usage of ICT has transformed all aspects of life. It enables people to engage, network, seek assistance, access information, and learn in new, better, and faster ways. The ICT revolution has also led to a notable trend of Research focusing upon information technology (ICT) and its usage in modern economies. Empirical Research since the 1970s has tried to examine and quantify the influences of ICT on economic growth and productivity. Results of research produced mixed results. The empirical analysis reported that ICT productivity generally did not identify significant productivity improvements. (Brynjolfsson & Yang 1996). Robert Solow's famous remark appropriately described these outcomes, "You can see the computer age everywhere but in the productivity statistics." The productivity Paradox, conventionally known as Productivity Puzzle, is the unexplained decline in productivity growth despite advancements in technology, especially in the field of ICT. Many research' econometric estimates have revealed low IT capital productivity in various manufacturing and service industries. s. (Baily & Gordon, 1988)(Loveman, 1988) (K. Stiroh 2002).

The majority of ICT and TFP research has concentrated on the industrialized world, and the conclusions are rather inconsistent. In recent times major economies worldwide have witnessed a deterioration in Productivity growth, both in measured business labor productivity (LP) and Total Factor Productivity (TFP). In the United States, aggregate business sector LP and TFP growth grew dramatically in the mid-1990s due to the Dotcom bubble, but has moderated since 2004. Moreover, the slowdown is broad-based across industries.(Byrne et al., 2016) Research that was primarily based on the aggregate output at the country level like (Oliner & Sichel, 2002) and (Jorgenson, 2001) indicated that acceleration in the productivity in the 1990s was attributed to the growing usage of ICT capital goods and rapid efficiency gains in the manufacturing of these items . Europe experienced a slower TFP productivity than the US during the mid-1990s.

For Asian economies, productivity and ICT study by (I. H. Lee & Khatri, 2003) studied how (ICT) helped drive growth in Asia in the second part of the 1990s. . Their study extended the traditional growth accounting approach. Estimates of the stock of ICT capital, which includes hardware, software, and telecommunications equipment, were used in the research. The study came to the conclusion that capital deepening was the key way that ICT contributed to growth in Asia throughout the 1990s. The majority of Asian nations had rather little TFP increase.

Ahmed, (2017) evaluated the productivity benefits of ICT and human capital spillovers . Malaysia, Indonesia, Philippines, Singapore, and Thailand are among the five ASEAN5 nations that were included in the study, along with three other East Asian nations (China, Japan, and South Korea). The study determined that determinants causing increase in TFP include physical capital, labour, ICT, and human capital. The results revealed that China has emerged as a productivity-driven economy. (Shiu and Hashmati, 2006) used the panel econometric estimation approach for measuring the technical change and TFP growth for 30 Chinese provinces from 1993 to 2003. They reported a positive increase in TFP in all provinces for the said time.

Saha, (2016) estimated TFP for the Indian economy using the conventional growth accounting method from 1961-2008. According to the study, the average rise of TFP was

about 1.5% for the years between 1961 and 1970. Positive but very modest TFP growth was seen between 1961 and 1970. The study reported a negative TFP growth from 1971 to 1980. The study came to the conclusion that internal causes like drought and external shocks like the price of oil and conflict were to blame for low output. The strict and rigid regulations of the Government were also responsible for the low productivity.

Mitra et al.,(2016) The role of infrastructure and ICT in the context of total TFP and technical efficiency (TE) of the Indian manufacturing sector from 1994 to 2008 was underlined in the study. The study's findings revealed that infrastructure and ICT had a comparatively significant impact. According to the study, the weak infrastructure had the greatest impact on the industries that were subject to a greater degree of international competition, such as transportation equipment, textiles, chemicals, metals, and metal products.

Most of the studies in the literature reviewed above suffer from some serious shortcomings. The Research on ICT and TFP in Asian countries, particularly South Asian countries, is not very vast. Research in this field is limited due to the lack of readily available data. Most of the studies use capital and labor for calculating the TFP using Growth accounting exercises. Most of the research studies have ignored the fact that capital can be considered as ICT capital and non ICT capital. The studies also vary in terms of defining the ICT and its measurement. Most of the research has concentrated on computers and related equipment. In modern times ICT involves much more complex and integrated networks that can affect the TFP through externalities generated by the production and usage of ICT. Therefore, a single measure of ICT can be insufficient to justify the contributions made by ICT towards the TFP growth. The study will make three different literary contributions; firstly, it will consider growth in TFP calculated by dividing the capital into ICT and non-ICT capital. Secondly, it will deliberate to employ a PCA Index of ICT Access as a component of ICT that can impact the growth of TFP, and thirdly it will be carried out for Asian economies. The PCA Index of ICT based on ICT Access will also reflect upon the Digital Divide.

Theoretical Framework

According to the neoclassical growth theory, ICT raises output accumulating and consuming inputs. ICT as a form of capital contributes to the capitalization of a given economy. (Jorgenson, 2001). Due to ICT production and usage, capital deepening typically increases output with technological improvements. In the past two decades, ICT products have become less expensive. This cost advantage has allowed for the substitution of factors with alternative inputs. (Chwelos et al. 2010). The technological improvements through ICT enable higher output per worker; thus, capital deepening improves the productivity in a given economy. TFP quantifies the portion of output that cannot be explained by input utilization. (C. Hulten, 2000). The TFP measures the actual productivity attributed to an increase in technology. In neoclassical scenario with law of diminishing returns of inputs, continuous production and use of ICT can lead to Technological advancement that can counteract declining input returns. Neoclassical growth theorists contend that ICT only affects output through input usage. This viewpoint has led to the results in which ICT seems unrelated to TFP, thus leading to the observation of what is known as the Productivity paradox.

Endogenous growth theory (Romer, 1986, 1990) asserts that technological innovations in R&D and using ICT as a General Purpose Technology (GPT) can increase TFP. ICT can be categorized as a GPT that can impact the TFP since it meets the requirements of fast declining costs, abundant supply, and various applications to products and processes. (Miozzo & Walsh, 2006). We have based our research on exploring the effects of ICT on TFP, i.e., via the spillover effects induced by the network externalities and ICT-powered innovations. Figure No. 1 illustrates the conceptual framework that this research exercise uses to explore the effect of ICT on TFP.

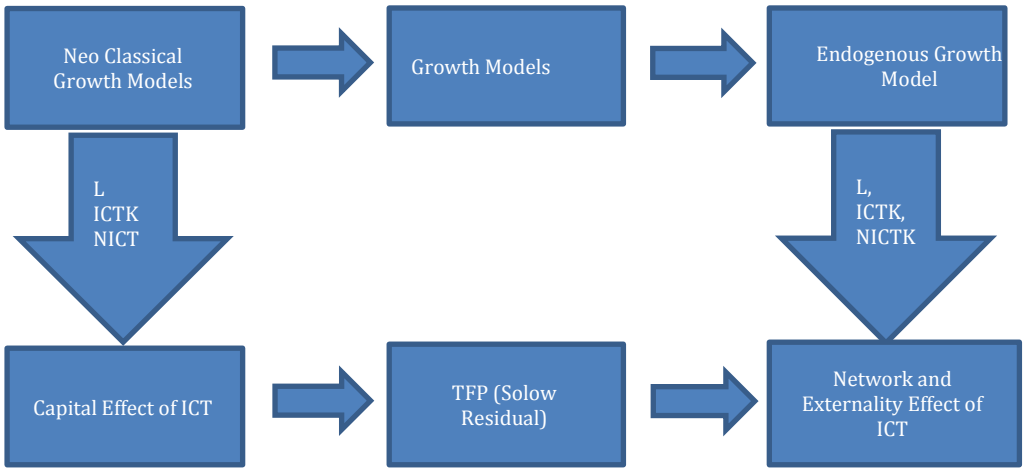

Figure No. 1: Conceptual Framework (Romer, 1986) and (Solow-Swan1957)

Modeling ICT Spillover effects on TFP

CT is no longer limited to production alone; it has become a significant component of the social and corporate environment that fosters productivity. The spillover effects of ICT on TFP are created due to network externalities such as computers creating value not just for its producer and purchaser. Still, it also creates value for other stakeholders. Examples include business-to-business (B2B) e-commerce systems. A few vital features attributed to ICT are a) Utilizing ICT enables firms and businesses to profit from specialization, economies of scale, and comparative advantages. b) Utilizing ICT ensures effective information management, minimal transaction costs, and improved organization-to-organization communication. c) Use of ICT leads to the reallocation of inputs more quickly and efficiently.

Our Research argues that ICT contributes to TFP through ICT-induced externalities that can be explored in detail by considering ICT as ICT Access and ICT usage. The impact of ICT on TFP can be challenging to capture as its Access and Usage impacts are intangible Gholami et al. (2006). We will focus more on the ICT Access as the component that primarily affects the TFP and also through helping to attract innovations. Figure No 2 represents how the ICT can affect the growth in TFP through network externalities and spillover effects.

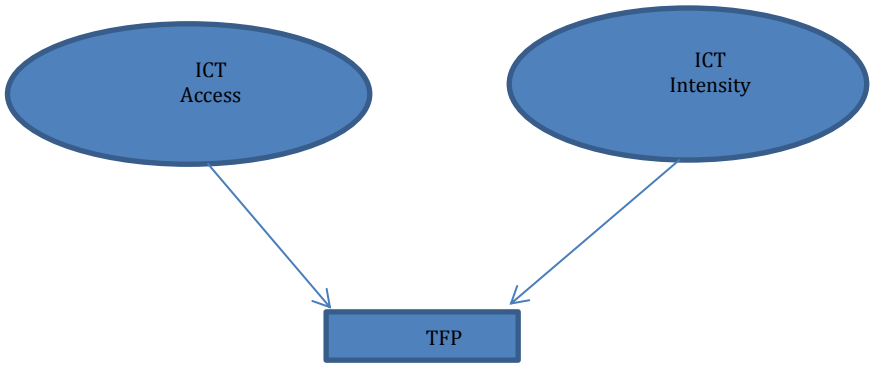

Figure No 2: ICT Spillovers and TFP

This study, like other empirical productivity calculations as in Growth Accounting(Chou et al., 2014; Timmer et al., 2003)used the Cobb Douglas production

function. The growth accounting methodology heavily employs the aggregate production function with Hicks neutral technical change.. The Hicks neutral technical change, for a given capital-labor ratio, the ratio of marginal products remains constant, and there are constant returns to scale.

$$Y_t = A_t F(K_t, L_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Y_t is the aggregate output, K is capital stock, and L is the labor. The Hicksian A_t measures the shifts in the production function at given levels of labor and capital. (C. R. Hulten, 2000). Applying Logarithm to both sides of the equation yields

$$lnY_t = \ln A_t + ln(K_t, L_t) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Using differentiation with time and applying

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + \frac{Fk}{F[K(t), L(t)]}\dot{K}(t) + \frac{Fl}{F[K(t), L(t)]}\dot{L}(t) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Using Equation No 1

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + \frac{A(t).Fk}{Y(t)}\dot{K}(t) + \frac{A(t).Fl}{Y(t)}\dot{L}(t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

After rearranging and assuming that the Capital and Labor markets are competitive, the share of the factor will be equal to their prices. Consequently, using Equation No. 1 with (r) as the cost of capital and (w) as the salary, we obtain

$$\frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}(t)}{Y(t)} - r\frac{K(t)}{Y(t)}\frac{\dot{K(t)}}{K(t)} + w\frac{L(t)}{Y(t)}\frac{\dot{L}(t)}{L(t)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The preceding formula can be used to compute the TFP. The form of the function used for Growth Accounting is an enhanced Neoclassical model of economic growth. (Solow, 1956). The basic Solow model is extended to include ICT capital along with physical capital and labor as inputs.(S.-Y. T. Lee et al., 2005; Venturini, 2009)

$$Y = A\ ICT^{\beta_1} NICT^{\beta_2} L^{\beta_3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where Y is Output (GDP), L is Labor input, Capital K input is decomposed into ICT, and Non-ICT (NICT), and A is a constant that represents other unobservable factors of production. The β_1, β_2, and β_3 are the elasticities of production inputs. This functional form has to be converted to log-linear form and differenced:

$$\Delta\ln(Y) = \alpha + \beta_1 \Delta\ln(ICT) + \beta_2 \Delta\ln(NICT) + \beta_3 \Delta\ln(L) \ldots\ldots\ldots\ldots (7)$$

In other words, Growth in TFP could be stated as

$$tfpg = y - f_{ict} ict - f_{nict} nict - f_l l \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The study used the measure of TFP derived from The Conference Board Total Economy Database (TED), April 2019. The Total Economy DatabaseTM (TED) is a comprehensive database containing annual data for 123 countries covering GDP, population, employment, hours, labour quality, capital services, labour productivity, and total factor productivity. The data set is unique as it calculates the TFP using Growth Accounting technique by dividing the capital input into ICT and Non ICT capital. The input Labor is used as Labor quality. At the same time, the Capital input is measured as the growth

of capital services provided by non-ICT assets, and the ICT capital is calculated as the growth of the capital services provided by the ICT assets.

The data is unique because the TFP calculated through growth accounting included ICT and Non ICT capital and labor as inputs for the production process. Many studies in the past have estimated TFP without dividing the capital into the ICT and Non ICT components. Thus, the TFP increase employed in this study can be seen as indicating the impact of technical progress, efficiency improvements, innovation, and our incapacity to capture and measure the contribution of all other inputs. (other than ICT capital, Non-ICT capital, and labor).

The purpose of this study is to investigate the relationship between ICT and TFP and to establish whether ICT Access affects the expansion of TFP. The main purpose is to objectively examine the null hypothesis that there is no correlation between ICT and TFP growth. The alternative hypothesis posits a positive correlation between ICT and TFP growth. We have used the following general linear regression model for panel data:

$$GTFP = \alpha + \beta_1 ICTA + +\beta_2 CV + \mu_i + \xi_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

Where ICTP represents the PCA for ICT infrastructure/Access and the CV represents control variables. The μ_i captures the individual heterogeneity and $\xi_{i,t}$ represents the idiosyncratic error.

Data and Variables

This Research is based on the analysis of 9 Asian countries, including South Asia, East Asia, and the Pacific. The countries included in sample are India, Pakistan, Indonesia, Malaysia, the Philippines, China, Korea, Thailand, and Hong Kong. The study extracted the annual data on variables of interest from the year 2000 to the year 2018. As the study's objective is to explore the Productivity Paradox phenomenon for Asian countries, the study's dependent variable is TFP. The data on TFP is extracted from the "The Conference Board Total Economy Database" (TED). The data of TFP is used in growth rates as derived from the source.

The dependent variables in the study are primarily ICT-based variables. As ICT is a broad concept that cannot be represented by one proxy variable, therefore in this study, we have used a host of variables that capture an essential dimension of ICT, primarily as ICT Access. Using the method of Principal Component Analysis (PCA), an index has been calculated for the component of ICT Access. PCA is primarily used as a procedure to reduce data. It includes substituting a set of principal uncorrelated 'principal components' for a large number of correlated variables, which together can explain a large amount of variance and indicate previously unobserved aspects of the population. PCA seeks to accomplish the following goals: i) identifying and reducing the data set's dimensionality and ii) to discover new significant underlying variables. Most of the overall variation is accounted for by the first main component. The Index is composed using a linear combination of their representative variables.

Normalized data were used for all of the indicators that went into the Index's construction. Since the variables used for the construction of the Index were measured in different units, therefore mini-max normalization method was adopted to convert data into a uniform scale ranging from 0 to 1. The data gaps were filled by averaging the relevant observations from the two years prior and the two years after. The ICT Access Index was constructed based on four variables (details given in table No 1). The variables used to create the ICT Access Index had been drawn from the World Development Indicators Database 2020(WDI) and International Telecommunication Union Database 2020(ITU).

The TFP is affected by ICT and other determinants as well. The study used foreign direct investment net inflows (FDI) as a control variable. The FDI can affect TFP by bringing better technology and management techniques to the country receiving FDI. Therefore, FDI can improve productivity and efficiency in a given economy. (Madsen & Philip, 2006). Study by (Savvides & Zachariadis, 2005) considered FDI to be one of the indications of the spread of technology. Foreign direct investment (FDI) is correlated with total factor productivity (TFP) growth because it introduces beneficial externalities, such as new technologies and academic insights. The study employed the total investment-to-GDP ratio as a proxy for Investment that can also affect TFP. It captures the increase in the efficiency of the economy's capital stock and the value of any new capital stock. According to research (Ahmad, H.K. 2011), a higher Investment to GDP ratio is associated with faster TFP growth.

Table 1
Details of Variables

	Source
Variables for ICT Access/Infrastructure Index	
Fixed Broadband Subscriptions (per 100 inhabitants) (FBS)	ITU
Fixed telephone subscriptions(per 100 people)(FTS)	ITU
Individuals using the Internet (% of the population)(IUI)	WDI
International Internet bandwidth per Internet user(IIBPU)	ITU
Independent Variables	
Investment as a percentage of GDP(I)	WDI
Domestic credit as percent of GDP(DC)	WDI
School enrollment, tertiary (% gross)(SET)	WDI
Research and development expenditure (% of GDP)(R&D)	WDI
FDI as a percentage of GDP(FDI)	WDI

There are two possible pathways through which domestic credit can affect TFP: the quantity channel and the quality channel. The financial sector's potential to alter the rate of capital accumulation is described by the quantity channel effect. The relevance of financial services that might impact the pace of technological advancement is emphasized by the quality channel effect. (Khan, 2006). Endogenous growth theory explains long-run growth from factors such as R&D and education like secondary and tertiary school enrollment, leading to spillover effects that can enhance TFP for a given economy. This completes our model for analysis purposes. Table No 2 presents the descriptive statistics of the variables.

Table 2
Descriptive Statistics of Variables

	FBS	**FTS**	**IUI**	**IIBPU**	**I**	**DC**	**SET**	**R&D**	**FDI**	**GTFP**
Observations	171	171	171	171	171	171	171	171	171	171
Mean	9.03	19.06	32.24	333119.5	27.48	82.47	36.33	0.93	5.02	1.50
Std. Dev	12.35	19.65	27.80	1727755	7.95	59.59	26.25	1.02	9.69	1.95
Min	0.001	1.318	0.05	42.66	14.12	15.38	2.70	0.04	-2.75	-5.73
Max	41.59	60.24	95.89	1.77e+07	48.00	233.21	104.27	4.81	58.51	8.52

Results and Discussion

In this work, we employed a panel data estimate technique to analyze how ICT affects TFP. Therefore, equation No 9 was estimated using Panel data estimation. Compared to cross-sectional data, panel data provides a higher degree of freedom and sample variability and can take into account the complexity of human behavior. By combining the data, panel data provides more precise forecasts for outcomes. (Hsiao, 2007). The choice between Fixed Effect (FE) modelling and Random Effect modelling (RE) forms the basis of the panel data estimate. The association between explanatory factors and individual heterogeneity is where FE and RE diverge, with FE allowing the correlation and RE

presuming there is none. (Wooldridge, 2001). We utilized the FE model since the null hypothesis that there are no systematic differences between the FE and RE coefficients was rejected by the Hausman test (Cameron & Trivedi, 2009).

Since study employed more than 10 years of data, Wooldridge's test for autocorrelation in panel data was conducted. The study also performed the Pesaran CD test (Pesaran, 2004) and modified Wald statistic for group-wise heteroscedasticity in the residuals of a fixed effect regression model. The results showed that our data had no cross-sectional dependence. To consider the autocorrelation and heteroscedasticity, we adopted robust clustered standard errors. (Hoechle, 2007). Therefore, the study used the FE model with robust clustered standard errors. The results of the estimations are given in Table No 3 below:

Table 3
Coefficient Estimates of the Models

	Model 1	Model II	Model III	Model IV	Model V	Model VI
Intercept	1.501	1.542	2.350	2.630**	3.322*	3.235*
	(2.9600)	(1.3772)	(1.4363)	(1.2901)	(1.8855)	(1.8374)
ICT Access	0.052**	0.048**	0.045***	0.0542***	0.059***	0.059***
	(0.0232)	(0.0210)	(0.0141)	(0.0178)	(0.0179)	(0.0179)
I		0.0349***	0.033***	0.032**	0.036**	0.036**
		(0.0120)	(0.0127)	(0.0163)	(0.0172)	(0.0172)
DC			-0.013	-0.013	-0.013	-0.013
			(0.0141)	(0.0137)	(0.0108)	(0.0108)
R&D				0.054**	0.056**	0.059**
				(0.0276)	(0.0268)	(0.0279)
SET					-0.016	-0.019
					(0.0290)	(0.0306)
FDI						0.022***
						(0.0853)
F-Statistics	31.07	33.24	27.73	27.02	29.34	29.21
p-value	0.000	0.000	0.000	0.000	0.000	0.000
R^2	0.34	0.36	0.41	0.41	0.42	0.42
Observations	171	171	171	171	171	171

Note: Standard errors in parentheses; - '*,' '**,' '***' stands for 10%, 5%, and 1% level of significance, respectively

The study's independent variables and their effects on TFP are listed in Table No. 3. The result suggests model as a whole is a good fit and significant. The results show that the primary variable of interest, ICT Access has a positive and significant influence on the Asian economies under review for the given time period. Most of the Asian economies started adopting ICT after 1995 and reported accelerated Investment in ICT producing sectors. Based on our findings, an increase of 10% in the ICT Access index score is associated with a 0.5% increase in TFP. The findings lend credence to the idea that economies in development can improve their total factor productivity (TFP) by increasing their use of information and communications technology (ICT), not only in the sense of putting it to better use, but also, and perhaps more importantly, by increasing their level of investment in the production of ICT and the provision of ICT access and infrastructure within the economies.

Other variables that are also considered the determinants of TFP, such as Total Investment (percentage of GDP) and R&D expenditure, also have positive coefficients signifying a positive impact on TFP. The result is in line with a study like (Farrokh & Martin, 1995). Since theorizing suggests that more recent gear and equipment will increase output, a positive sign for the total investment coefficient is to be expected. So, it has a positive and important effect on the growth of total productivity. The coefficient value is about 0.03, which indicates that 10% growth in gross domestic Investment leads to 0.3% growth in TFP. The R&D shows a coefficient value of 0.05 which indicates that 10% growth in R&D leads to 0.5% growth in TFP. The results are also in line with (Abidin & Shaari, 2021)

The variable of domestic credit shows a negative sign and is also insignificant that reflects the case that financial markets in Asian and particularly South Asian economies have yet not reached the stage where the financial sector can affect the TFP very strongly. The state of financial inclusion in South Asia is comparatively weak compared to other parts of the world, as reported by (Mani, 2016) based on eighty-nine indicators. There is a general lack of reliance on financial institutions, as evidenced by the low rates of use for checking and savings accounts, debit and credit card transactions, and bank loans. Mobile banking, however, is on the rise despite the fact that e-banking usage is at a historic low. The other variable is tertiary school enrollment, which has a negative and insignificant effect on TFP. The result probably reflects that growing Asian economies have a demographic change termed demographic dividend. No people under 30 years of age have increased in the last twenty years. On the other hand, tertiary or higher education has not picked up the pace with increased demand. Reaping this dividend is expected to require a well-educated workforce, which means, at a minimum, rising enrollment rates and educational quality. (Najam & Yusuf, 2013)

Since Asian economies have benefited from both inbound and outward FDI over the past two decades, the findings support the idea that FDI has a beneficial impact on TFP. Ten percent more FDI leads to a 0.2 percent increase in TFP, according to the coefficient's approximate value of 0.02. Since FDI brings better production methods and better managerial practices, it is believed that FDI can get foreign exposure needed for the economic growth of developing economies.

Conclusion and Recommendations

This research exercise aimed to explore the concept of the productivity paradox in the context of Asian economies. The Research tried to investigate the relationship between ICT and TFP for Asian economies. From 2000 to 2018, a panel of nine Asian developing economies were investigated in this study. For this purpose, the impact of ICT Access and provision of ICT infrastructure on the growth of TFP was analyzed. Determinants like Tertiary Education, Research and Development (R&D), Domestic Investment (I), Domestic Credit (DC), and Foreign Direct Investment (FDI) were used as control variables. The effects have been examined empirically by using Fixed Effects model. We used rigorous statistical and mathematical methods to create the Index of ICT Access.

Positive and statistically significant effects of ICT Access and capital intensification due to gross domestic investment on TFP growth were found for the sample nations. Expenditures on research and development (R&D) are shown to be a significant determinant of TFP growth, as shown by the results, and to have a positive correlation with TFP. Therefore, the productivity paradox can be refuted for the present research exercise but needs more detailed analysis as ICT has a complex interactive impact on the economies that involves many intangible effects that are hard to measure.

There needs to be policy focus on expanding access to ICT all throughout the world particularly developing world. ICT Access need to be facilitated and updated to enable ICT use so that digital divide can be narrowed. Increasing the availability and usage of ICT as well as investing heavily in improving R&D competence, the quality of capital stock, and the education system can all lead to greater gains in total factor productivity.

References

Abidin, N. Z., & Shaari, M. S. (2021). The impact of research and development on TFP growth in selected ASEAN+3 countries. *AIP Conference Proceedings*, *2339*(1), 020087.

Abramovitz, M. (1986). Catching Up, Forging Ahead, and Falling Behind. *The Journal of Economic History*, *46*(2), 385–406.

Ahmed, E. (2017). ICT and Human Capital Spillover Effects in Achieving Sustainable East Asian Knowledge-Based Economies. *Journal of the Knowledge Economy*, *8*(3), 1086–1112.

Baily, M. N., & Gordon, R. J. (1988). The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power. *Brookings Papers on Economic Activity*, *1988*(2), 347.

Brynjolfsson, E., & Yang, S. (1996). Information Technology and Productivity: A Review of the Literature. In *Advances in Computers* (Vol. 43, pp. 179–214). Elsevier.

Byrne, D. M., Fernald, J. G., & Reinsdorf, M. B. (2016). Does the United States Have a Productivity Slowdown or a Measurement Problem? *Brookings Papers on Economic Activity*, 109–157.

Chou, Y.-C., Hao- Chum Chuang, H., & Benjamin., B. M. S. (2014). The impacts of information technology on total factor productivity: A look at externalities and innovations & , & , Benjamin. (2014). *International Journal of Production Economics*, *158*, 290–299.

Chwelos, P., Ramirez, R., Kraemer, K., & Melville, N. (2010). Research Note —Does Technological Progress Alter the Nature of Information Technology as a Production Input? New Evidence and New Results. *Information Systems Research*, *21*, 392–408.

Comin, D. (2010). Total factor productivity. In S. N. Durlauf & L. E. Blume (Eds.), *Economic Growth* (pp. 260–263). Palgrave Macmillan UK.

Farrokh, N., & Martin, D. V. (1995). Public capital formation and productivity growth: Some international evidence. *Journal of Productivity Analysis*, *6(4)*, 283–295.

Gholami, R., Lee, S.-Y., & Heshmati, A. (2006). The Causal Relationship Between Information and Communication Technology and Foreign Direct Investment. *World Economy*, *29*, 43-62.

Grossman, G. M., & Helpman, E. (1994). Endogenous Innovation in the Theory of Growth. *Journal of Economic Perspectives*, *8*(1), 23–44.

Hoechle, D. (2007). Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence. *The Stata Journal*, *7*(3), 281–312.

Howitt, P., & Aghion, P. (1998). Capital Accumulation and Innovation as Complementary Factors in Long-Run Growth. *Journal of Economic Growth*, *3*(2), 111–130.

Hsiao, C. (2007). Panel data analysis—Advantages and challenges. *TEST: An Official Journal of the Spanish Society of Statistics and Operations Research*, *16*(1), 1–22.

Hulten, C. (2000). *Total Factor Productivity: A Short Biography* (No. w7471; p. w7471). National Bureau of Economic Research.

Hulten, C. R. (2000). Total Factor Productivity: A Short Biography. *NBER Working Paper No. 7471. Massachusetts: National Bureau of Economics Research.*

Jorgenson, D. W. (2001). Information Technology and the U.S. Economy. *American Economic Review*, *91*(1), 1–32.

Khan, S. U. (2006). *Macro Determinants of Total Factor Productivity in Pakistan*. *2*(2), 19.

Lee, I. H., & Khatri, Y. (2003). Information Technology and Productivity Growth in Asia. *IMF*, *Working Paper No. 03/15*.

Lee, S.-Y. T., Gholami, R., & Tong, T. Y. (2005). Time series analysis in the assessment of ICT impact at the aggregate level – lessons and implications for the new economy. *Information & Management*, *42*(7), 1009–1022.

Loveman, G. W. (1988). Loveman, G.W. An Assessment of the Productivity Impact on Information Technologies. MIT Management in the l990s Working Paper #88-054, (July, 1988). *MIT Management in the 1990s Working Paper*, 88–054.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*(1), 3–42.

Madsen, J. B., & Philip, D. E. (2006). Equity prices, productivity growth and the new economy. *The Economic Journal*, *116*, 791–811.

Miozzo, M., & Walsh, V. (2006). *International Competitiveness and Technological Change*. Oxford University Press.

Mitra, A., Sharma, C., & Véganzonès-Varoudakis, M.-A. (2016). Infrastructure, ICT and Firms' Productivity and Efficiency: An Application to the Indian Manufacturing. In F. De Beule & K. Narayanan (Eds.), *Globalization of Indian Industries* (pp. 17–41). Springer Singapore.

Najam, A., & Yusuf, M. (2013). *South Asia 2060: Envisioning Regional Futures*. Anthem Press.

Oliner, S. D., & Sichel, D. (2002). Information Technology and Productivity: Where Are We Now and Where Are We Going? *Journal of Policy Modelling*, *25*(3), 15–44.

Pesaran, M. H. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. *IZA Discussion Paper*, 1222–1229.

Romer, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, *94*(5), 1002–1037.

Saha, S. (2016). Total Factor Productivity Trends in India: A Conventional Approach. *The NEHU Journal*, *XII* (1), 95–106

Sedik, T. S., Chen, S., Feyzioglu, T., Ghazanchyan, M., Gupta, S., Jahan, S., Jauregui, J. M., Kinda, T., Long, V., Loukoianova, E., Mourmouras, A., Nozaki, M., Paroutzoglou, S., Sullivan, C., Yoo, J., & Zhang, L. (2019). *The Digital Revolution in Asia and Its Macroeconomic Effects*. 33.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65.

Stiroh, K. (2002). Are ICT spillovers driving the New Economy? *Review of Income and Wealth*, *48*, 33–57.

Stiroh, K. J. (2002). Are ICT Spillovers Driving the New Economy? *Review of Income and Wealth*, *48*(1), 33–57.

Timmer, M. P., Ypma, G., & Ark, B. van der. (2003). *IT in the European Union: Driving productivity divergence?* Groningen Growth and Development Centre,University of Groningen.

Venturini, F. (2009). The long-run impact of ICT. *Empirical Economics*, *37*(3), 497–515.

Wooldridge, J. M. (2001). *Econometric Analysis of Cross Section and Panel Data | The MIT Press*.