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RESEARCH PAPER

Assessing the Information and Communication Technology (ICT) Sector's Productivity in Pakistan: Input-Output Analysis

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ABSTRACT

Using input-output (IO) analysis, this study attempted to examine the productivity of information and communication technology (ICT) sector in developing countries, with a particular focus on Pakistan. The effects of ICT on national economies have been thoroughly studied, however most studies have focused on industrialized economies. Using estimates of Multi-Factor Productivity (MFP), this study examined the economic impact of ICT sector in Pakistan from 2000 to 2020. Leveraging Input-Output Tables sourced from the Asian Development Bank (ADB), productivity measures were derived based on output and input multipliers. Estimates of productivity measures provided insight into the ICT sector. Findings reveal a minimal growth trajectory in the productivity indicators of the ICT sector in Pakistan, with some indicators indicating stagnation over the reviewed data period. These findings highlight the need to accelerate ICT industry advancement to benefit other areas of the Pakistani economy.

KEYWORDS ICT, Input-Output Analysis, Multifactor Productivity

Introduction

Information and communication technology (ICT) has become an important part of our lives, both at home and at work. The advanced capabilities and technology of the Fourth Industrial Revolution have accelerated the world's current massive digital shift, as well as significant ramifications that have resulted from the Covid-19 outbreak. Business models and industrial production are being reshaped and redefined by the economy's continuing digital transformation (DT). Digital technologies have, of course, sparked a lot of academic curiosity at many levels. ICT today has been accepted as a main contributor of economic growth and a major factor for achieving sustainable economic development. (Jorgenson & Stiroh, 1999; Kuznets, 1965; Romer, 1986, 1990; Rosenberg & Nathan, 1982). In particular, the manufacturing sector of ICT industry has contributed significantly to the growth of labour productivity and overall productivity in many countries. When considering the asset mix of the capital stock, it has been shown that ICT equipment contributes significantly to output growth.

There are three ways that ICT sector helps the economy grow. ICT is a type of technology that can be used for many different things. First, it makes production more efficient across the economy. Second, users have seen prices go down a lot while quality has gone up for at least 20 years, because ICT equipment is made in a way that is affected by how quickly technology is changing. This suggests ongoing support for ICT investment. Third, there are signs that ICT, because it is flexible and used by a lot of people, may speed up technical change and, in turn, productivity and GDP growth. (Inklaar et al., 2005; O'Mahony & Timmer, 2009).

Pakistan's information and communication technology industry is rapidly expanding, with promising prospects for further development and expansion. In August of 2000, the first policy and plan for the implementation of IT were adopted, laying the groundwork for the growth of this industry. Over the past decade, Pakistan's government has offered incentives to IT investors, leading to the growth of the country's IT industry. (Masood & Malik, 2008). Significant for the development of the computer industry Between 2003 and 2005, the country had a rise in IT exports of nearly 50%, leading to a total of $48.5M in 2005. In 2004, the government of Pakistan formally recognized the telecom industry as a distinct sector of the economy. IT and allied services saw a CAGR of 18.85% between 2020 and 2021. .(Economic Survey 2021-22.) Recent startup successes in Pakistan's information technology sector include Careem, Daraz, and Airlift. The information and communications technology (ICT) sector is expected to add 1.2% to GDP this year. Information technology and telecommunications will account for 2.7% of GDP in Pakistan in 2024.

Figure No 1 shows ICT indicator derived from WDI indicators (*World Bank Open Data*, 2021)for ICT sector in Pakistan. The Indicator "Computer, communications and other services (% of commercial service exports)", entails actions that include international telecommunications, and postal and courier services. The Indicator shows an upward trend overtime from year 2000-2020. The figure shows a constant upward trend signifying that ICT services exports have been increasing over time from year 2000 to 2021.

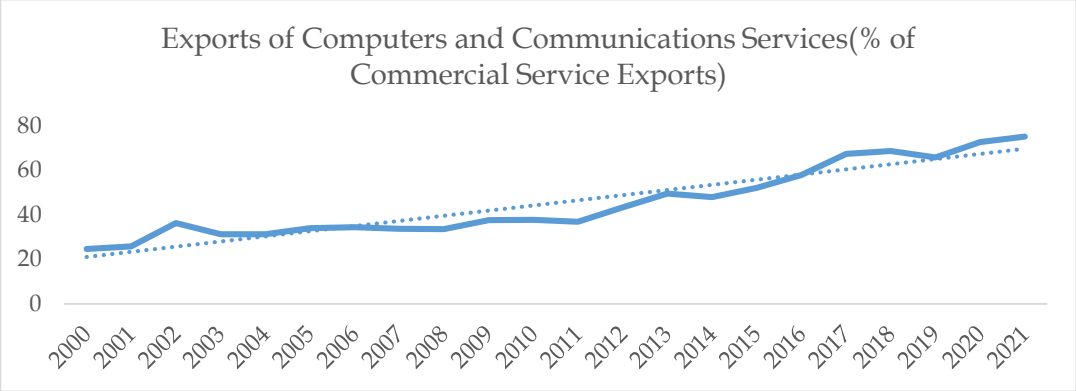

Figure No 1: ICT Indicators for Pakistan ICT Sector, Source: World Bank

Figure No 2 shows the second indicator "Information and communication technology goods exports" derived from WDI Indicators 2021.(*World Bank Open Data*, 2021). From 2000 to 2021, the numbers went decreasing. This reflects the reality that the ICT industry's performance in Pakistan has been inconsistent through this time.

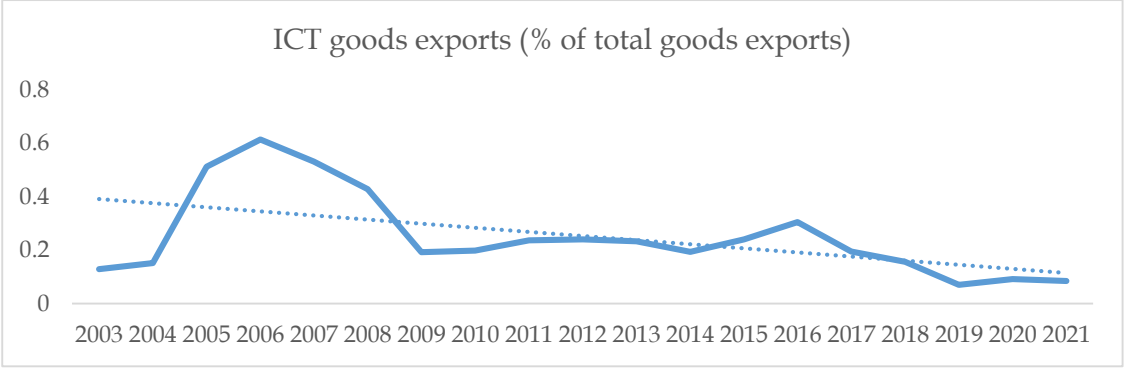

Figure No 2: Indicators for Pakistan ICT Sector, Source: World Bank

Increases in real income and standard of living are built on the shoulders of productivity increases. Low productivity growth dampens real income expansion and may lead to conflicting demands for distribution. (Englander & Gurney, 1994). As a result, metrics of productivity levels and productivity growth are quite useful. Productivity measurements can be broken down into two major groups: single-factor productivity measures (which compares one output to one input) and multi-factor productivity (MFP) measures. (where productivity of all or some of the inputs is calculated). (Schreyer & Pilat, 2001).

Wassily Leontief first proposed the Input Output technique in 1936 (W. Leontief, 1936), and it has since proven useful in a wide variety of policy contexts. The IO model is based on application of Input-output (IO) Tables. IO tables provide a comprehensive breakdown of economic intermediaries, allowing for a more complete description of the distribution and consumption of an economy's outputs. The IO tables also reveal the interconnection of various economic systems' industrial sectors. One of the most useful tools for studying a country's economic structure is the IO table. IO table provides details of all inputs used by a sector as well the outputs produced by the sector which are consumed as inputs by the other sectors and other Final Demand consumption in the economy. The IO model is adopted for carrying out impact analysis of any change in exogenous variables such as an surge in final demand of a given sector. It also allows to carry out an analysis of economic impacts of a change in government policy. The results obtained could be helpful in making informed policy decisions that can lead to economic growth for an economy. (Raa, 2006).

The input-output data and tables are used to calculate multipliers, that can be very instructive in economies. They have the potential to reveal insights into the composition of economies that can't be gleaned from other theoretical structures. In addition, they lay the groundwork for a variety of economic models that, with careful attention to their underlying assumptions, can be used to more accurately estimate the effects of policy changes. Based on IO tables, analysis of TFP differences in different sectors of a country can explain the aggregate total factor productivity (TFP). (Fadinger et al., 2022). According to a growing body of literature in development economics, IO links (expressed as IO Multipliers) between sectors have the potential to increase sectoral productivity gaps Hirschman (1958). Based on existing literature and the idea of multipliers, this research draws heavily from work of, (Bon, 2000) we will employ measures for productivity at the sector, intermediate, and comprehensive levels.

The goal of this article is to highlight the Productivity measures using the IO approach. The study will try to predict the Comprehensive Productivity, Sectoral Productivity, and Intermediate Productivity of Pakistan's ICT sector from the years 2000 to 2020. This research aims to close a knowledge gap in productivity measurement techniques, namely Multi Factor Productivity, as they pertain to Pakistan's ICT industry. The remaining five portions of this work are as follows. The next section outlines the Literature Review, followed by methodology, data, Results and Conclusions and Recommendations. The Methodology section describes the IO Analysis and its use for productivity measures, while the Data section explains the data collection and input-output aggregations. The fourth section discusses the results. Finally, the last section contains the conclusions and recommendations.

Literature Review

Solow was the first to introduce the idea of multifactor productivity, and formulas for multifactor productivity. MFP was based under the presumptions of perfect

competition in factor markets. (Solow, 1956). In his pioneering work to assess productivity, (Diewert, 1976) derived the approach based on production theory. The approach also relied heavily on Index Number Theory. USA government used the productivity measures formulated by Diewert to measure industrial productivity in USA for year 1983. By studying the correlation between productivity and post-war U.S. economic growth, (Jorgenson, 1988) established a connection between these formulas and economic expansion.

Many research studies have analyzed TFP and MFP in a particular sector for given economies. The researches have focused especially on industrialized countries(Parham, 2005). For reviewing ICT sector's productivity and Growth. In a research exercise (Jalava & Pohjola, 2007) attempted to analyze how ICT impacts output and labour productivity growth. The research was carried out by adopting growth accounting methodology for Finland covering data from year 1995 to 2005

MFP frameworks based on input-output tables are useful for calculating productivity because they assess changes in output taking place due to per unit change of combined inputs. It permits the tracking of capital expenditures and the recording of intermediate goods transfers between sectors.(Klein, 2003). (Bon & Pietroforte, 1990) the pioneering researchers examined the impact of construction as a leading sector on economies of the United States, Japan, Italy, and Finland. They adopted IO tables containing data on given economies after World War II and estimated different productivity measures of construction sector. Their findings based on IO analysis reflected the productivity picture of construction industry's economic performance. In particular, it served as an invaluable blueprint for understanding the economic interactions between the construction sector and the rest of the country without incorporating role of prices in the model. The IO Analysis was used by (Pietroforte & Gregori, 2003), they applied IO Analysis using concept of Linkages and output multipliers for Developed economies. (Sulaiman, 2012) analyzed TFP expansion in the Malaysian industrial sector from 1983 to 2005. The findings showed that intermediate inputs played a big role in driving shifts in total factor productivity (TFP) in the manufacturing sector, but labour and capital played a much smaller role. Studies by (Liu & Song, 2005a, 2005b; Marconi et al., 2016; Yastremskii, 2020) all these research studies employed IO Analysis to evaluate the performance and productivity of various sectors, such as Real Estate and Construction in specific countries. These research endeavors employed economy-wide backward and forward linkages and output multipliers.

There is a dearth of research into the productivity measurement of Pakistan's ICT sector. The reason could be the availability of quality data available on the ICT. This research exercise will try to evaluate and assess the Productivity of ICT sector in Pakistan. It will be a comparative static analysis based on IO Model using ADB IO Tables for Pakistan economy from 2000-2020.

Material and Methods

Indicators of aggregate, intermediate, and sectoral productivity will be used in this study. These indicators are created using the principles of multipliers and IO Analysis. This research relies heavily on the productivity measures used by (Bon, 2000; Liu & Song, 2005a; Mattioli, 2013) in their works.

The Input Output (IO) approach is method which is employed for quantifiable macroeconomic analysis. Literature and theory shows that development of a national economy entails changes in economic structure, that are brought about owing to changes

in the growth rates of output in different sectors. IO approach can be best suited to analyze such in depth intersectoral interconnectedness that causes the changes in economic structure of a given economy. IO approach relies on the use of IO Tables which shows transaction flows across each sector for a given economy. It's a comprehensive snapshot of a market that allows for the methodical quantification of the complex web of relationships between a market's producers and consumers.

In a typical IO table, each sector is shown to produce some form of output and to consume some form of input from other sectors. Table No 1 given below represents the details of the IO Tables used in this study.

Table 1
An IO Table

		Domestic Intermediate Output							
		Sector 1	..	Sector j (ICT)	....	Sector 15	Total Intermediate Output	Final Demand	Total Output
Domestic Intermediate Inputs	Sector 1								
	..								
	Sector i (ICT)			X_{ij}			$X_{i.}$	Y_i	X_i
	...								
	Sector 15								
Total Intermediate Input				$X_{.j}$					
Value Added				V_j				$Y = V$	
Total Input				X_j					

Source: Adapted from R. Miller and P. Blair. 2009.(Miller & Blair, 2009)

As employed by studies of (Bon, 2000; Liu & Song, 2005a; Mattioli, 2013), the elements of a typical row in an IO table represents the outputs, it consists of X_{ij} that signifies intermediate output originating from a sector i and going to another sector j. Similarly, Total output of a sector is given as X_i. Total Output is divided into the Total Intermediate Output $X_{i.}$ and Final Demand Y_i like Consumption expenditures of Household, Firms' Investment Expenditures, and Government Expenditures. Similarly, columns in an IO Table signifies the inputs from a sector i to j. The Inputs are divided into the Value Added V_j and Total Intermediate Inputs $X_{.j}$ .Value Added signifies Labor and Capital costs primarily for the production process in each sector. It may also include all other value added such as Government services (paid for in taxes), land (rental payments) and entrepreneurship (profits).

Comprehensive Productivity Indicators

Following the lead of (Liu & Song, 2005) this research examined two comprehensive productivity measures. The first measure is "Total Output to Primary Input". This metric evaluates the ratio of main output to input, it illustrates how well primary input contributes to overall output. First metric is calculated as given by Equation No. 1.

$$\text{Total Output to Primary Input} = \frac{X_i}{V_j} \quad \text{.....(1)}$$

Second indicator "Multiplier Productivity", designates the ratio of output multiplier to input multiplier. This ratio is further multiplied by the ratio of final demand to the value added.

$$\text{Multiplier Productivity} = \frac{\sum_{i=1}^{n}(1-A_{ij})^{-1} \times Y_i}{\sum_{i=1}^{n}(1-B_{ij})^{-1} \times V_j} \ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

In equation no 2 above the $\sum_{i=1}^{n}(1-A_{ij})^{-1}$ is the output multiplier. It is calculated as summation of all possible values in individual columns of Leontief inverse matrix, based on IO table. It estimates how much of an overall change in output would result from a one dollar shift in the sector's final demand. Final demand of sector is multiplied by output multiplier to reveal the aggregate impact that occurs due to shift in sector i's final demand. Similarly the $\sum_{i=1}^{n}(1-B_{ij})^{-1}$ is the Input Multiplier, it is the summation of all row elements of Ghosh inverse matrix. It calculates the effect of a $1.00 change in the sector's primary inputs on input of all other sectors. The input multiplier basically shows the change brought about by one-unit monetary change in the primary inputs used in the production process of a given sector j. It can be treated as a detailed picture of interdependencies in terms of using outputs of one sector as input for other sector, that exist between industries. Input multiplier is multiplied by primary inputs i.e. value added, to give impact of the sector j's change in value added.

Gross Productivity and Efficiency

Term "productivity" refers to ratio of finished goods to the resources used to make them. The efficiency is measured by comparing actual output to the baseline output that could have been expected to be produced in the same amount of time with fewer inputs. (Sickles & Zelenyuk, 2019). Technical efficiency and allocation efficiency are two main pillars of the efficiency definition. When a firm maximizes its output for a given input cost, it is technically efficient. When a firm chooses the optimal input-to-output ratio, it has achieved allocation efficiency. Following (Bon, 2000; Liu & Song, 2005a), the technical and allocation efficiency in IO Analysis is given as below:

$$Technical\ Efficiency\ Indicator = \frac{X_{.j}}{X_j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Equation (1) depicts the j sector's industrialization as well as the fraction of intermediate input to total input. It also shows economic power of sector j. A high value of this metric for a sector j represents that technology associated with intermediate inputs used in sector j is much advanced. It also implies that sector j holds an important place in economy.

$$Allocation\ Efficiency\ Indicator = \frac{X_{i.}}{X_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Allocation efficiency metric of a given sector i in economy is given as in Equation (4). This indicator consists of dividing intermediate demand of a sector i with total output produced. In our case it will be for the ICT sector. If the score is higher, the allocation efficiency in the i-th sector is greater than other sectors. The Gross Productivity Indicator could be stated as

$$Gross\ Productivity\ Indicator = \frac{Y_i}{V_j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Equation (5) represents the proportion of final demand of sector j to the value added. When final demand is summed it represents gross national product in accordance with generally accepted accounting principles. While total value added in IO Tables, symbolizes gross national income. A higher value of Gross Productivity metric for a sector j signifies higher productivity of the sector j.

Intermediate Productivity Indicators

Two productivity indicators are mostly used to measure Intermediate Productivity (Bon, 2000; Liu & Song, 2005a). Intermediate Productivity measures are based on calculating how much the Intermediate output is affected by primary input and total inputs for a given sector i. The intermediate output refers to the part of output of a sector i that is used as inputs by the other sectors.

Present study will employ "Intermediate Output to Primary Input" as well as "Intermediate Output to total Input" indicators to assess the Intermediate Productivity of a sector i, in our case it will be the ICT sector.

$$\text{Intermediate Output to Primary Input} = \frac{X_i}{V_j} \quad \text{.....(6)}$$

$$\text{Intrmediate Output to Total Input} = \frac{X_i}{X_j} \quad \text{.....(7)}$$

Sectoral Productivity Indicators

Sectoral Productivity is measured in this study by employing two measures for sectoral productivity. These metrics are "Sectoral output to primary input" and "Sectoral input to total input"(Bon, 2000; Liu & Song, 2005a). These measures are given as in Equation No 8 and 9. Considering the output of a certain industry, these measurements of productivity reveal the weight of various inputs, including labour, capital, and the entire economy (ICT sector). Increases in efficiency across a sector is reflected in greater values.

$$\text{Sectoral Output to Primary Input} = \frac{X_{ij}}{V_j} \quad \text{.....(8)}$$

$$\text{Sectoral Input to Total Input} = \frac{X_{ij}}{X_j} \quad \text{.....(9)}$$

Data Collection

The research used IO Tables provided by the Economic Research and Regional Cooperation department (ERCD) of Asian Development Bank (ADB). The Input-Output Tables (IOTs) that ADB compiles offer thorough and detailed views on these economic relationships and make it possible to derive pertinent information about production, trade, and value chains. Intermediate consumption, final demand, payments to key factors of production, and net taxes are the three basic components of an IOT. The intermediate consumption block represents interindustry transactions; the final demand block represents output purchases made by households, the government, and non-profit organizations (value-added block). These are set up so that each industry can meet the market-clearing criterion of amount provided equal to quantity required.

The study used IO Tables for years 2000 to 2020. The choice of ADB IOT is based on the consideration that since the objective is to analyze the results of the study the basic data i.e. tables should be based on the same grounds. The choice of Years 2000 to 2020 is due to the fact that ICT as an Industry has picked up in Pakistan mostly after year 2000. Therefore, the results will also reflect light on the fact that how the ICT industry has evolved over time from year 2000 to 2020. The entire economy is broken down into 35 distinct productive sectors in the IO tables. (As explained in Appendix).

The (OECD Guide to Measuring the Information Society 2011 - OECD, 2011) defines ICT sector as a sector that basically deals with Information Processing and its electronic communication. It includes both production and provision of services. This study divided ICT-related economic activity into three broad groups based on the most

current revision of the International Standard Industrial Classification (ISIC Rev. 4). of All Economic Activities (United Nations, 2008): ICT manufacturing industries, ICT commerce industries, and ICT service industries.

Study used method followed by (Heng & Thangavelu, 2006; Van Ark et al., 2008) to categorize following 4 sectors aggregated as ICT sector. This includes Electrical and Optical Equipment, Wholesale trade and commission trade, Post and Telecom, and Education sectors. The ADB IO tables consist data on 35 sectors which for better understanding were aggregated as 15 sectors. In this research, we combined 35 industries from the IO tables into 15 broad categories. Since aggregated sectors share comparable characteristics, the findings are easier to perceive and understand. Aggregation criteria included resemblance based on production process and closeness in the productive chain; OECD (2011) classification of sectors; and alignment of sectors that generate manufactured, commodity, and non-tradable goods and services.

Results and Discussion

A reflective analysis is based on organizing the data systematically to obtain meaningful and reliable results. A comprehensive description of an economy's supply and demand for its outputs can be found in input-output tables. It also serves as a reflection of an economy's intermediate transactions. Unlike traditional national income and expenditure accounts, which focus solely on the end product rather than the intermediate flows of production, these provide detailed statistics supporting the national accounts for a given economy and time period, allowing for a more in-depth analysis of the productive system.

The study divided the data on input-output tables that are available from 2007-2020 for Pakistan economy into four phases and calculated the averages of the primary variables for a better understanding of the data. Table No 2 below shows the three-year averages of Pakistan's ICT sector's gross output.

Table 2
Gross Output in $ Million (ICT Sector)

Years (3 Years Average)	Gross Output
2007-2009	21187.65
2010-2012	26548.07
2013-2015	33246.72
2016-2018	38064.18
2019-2020	21288.61

Source: Author's calculation based on ADB IO Tables

The table shows that GO of the ICT Sector has increased from 2007 to 2018. However, the GO shows a decline in 2019-2020, owing to the COVID-19 crisis. Table No. 3 shows the three-year averages of the GVA of ICT sector in Pakistan. Analysis reveals that GVA has been increasing in Pakistan's economy over the years.

Table 3
GVA ($ Millions) of ICT Sector-Pakistan

Years(3 Years Average)	GVA
2007-2009	21187.65
2010-2012	26548.07
2013-2015	26334.5
2016-2018	29979.04

2019-2020	31932.91

Comprehensive Productivity Indicators

Considering first comprehensive Productivity Metric "Total Output to Primary Input Indicator" of ICT sector in Pakistan, the results are presented in Table No.4. Analyzing second metric "Multiplier Productivity" of ICT sector in Pakistan, the results are shown in Figure No 3. A measure of how well main input contributes to total output, the indicator for total output to primary input measures total output to primary input. Table No. 4 displays the ICT sector's overall output to primary input indication according to Eq No. (1). The results reveal that the value of indicator has been steadily increasing with little decrease in some years, indicating that MFP productivity has been gradually increasing in ICT Sector of Pakistan for the given years.

Table 4
Total Output to Primary Input ICT Sector-Pakistan

Years	Total Output To Primary Input
2000	1.30
2007	1.31
2009	1.31
2012	1.28
2015	1.28
2018	1.30
2020	1.28

The multiplier productivity indicator is regarded as an important indicator. It is calculated as ratio of output multiplier to input multiplier, multiplied with ratio of final demand to value added of ICT sector (as per Equation No.2). It gauges overall effectiveness of the sector's production owing to all final demand sales. Final demand is the total amount spent by consumers, businesses, and governments on ICT-related goods and services. Output Multiplier calculates the direct and indirect effect of change in final demand of ICT sector in Pakistan for a given year on the output of ICT sector itself and production of all other sectors. While Input Multiplier shows the direct and indirect impact of one monetary unit change in value added of ICT sector in Pakistan for a given year on value added of ICT sector itself and all other sectors.

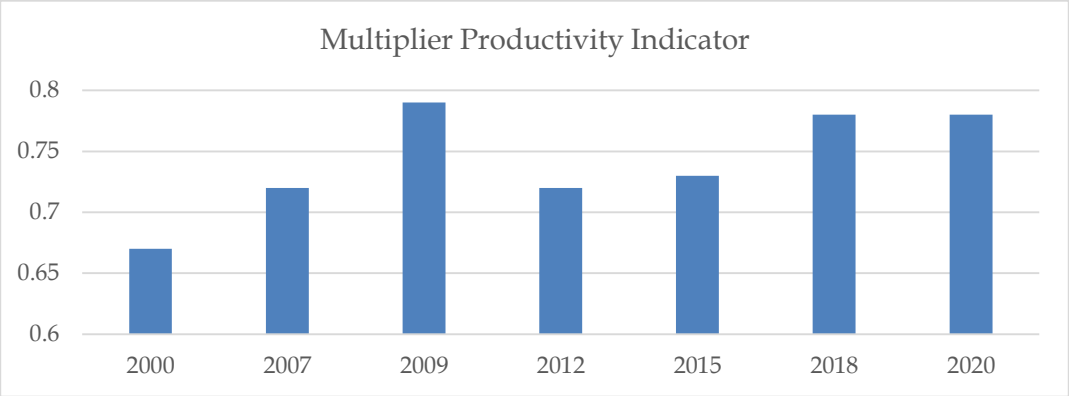

Figure 3: Multiplier Productivity Indicator ICT Sector-Pakistan

Figure No. 3 shows that over the course of years, multiplier productivity showed a modestly ascending trend, with highest value of 0.78 in Year 2018 and becoming constant in year 2020. Numerous factors have affected the output of ICT sector in

Pakistan, such as composition of output, i.e. more focus on services then on production, lack of friendly business policies, absence of economies of scale, and lack of adoption of new techniques have all contributed to this performance. Since Multiplier Productivity metric also involves the Input multiplier, the mixed outcome of the indicator can be attributed to factors like adverse capital-labor ratio, deficiency of high quality work force, and lack of training of skilled staff required for ICT sector have affected productivity development in the ICT sector in Pakistan. In actuality, productivity of ICT sector has been greatly impacted by global technological advancement.

Gross Productivity and Efficiency

The Allocation Efficiency Indicator basically is obtained by dividing Summation of Intermediate output by Total output produced in a ICT sector in Pakistan for a given year. On the other hand, ratio of total intermediate input to total input in the information and communication technology sector is the basis for the Technical Efficiency Indicator. (as per equation No 3 & 4) (Bon, 2000) Indicator value demonstrates that proportion of Intermediate Output (rather than the final demand) of the ICT sector to Total Output of ICT Sector is larger. Results obtained by the study reveal that the Allocation Efficiency was high initially in year 2000, and decreased for next two years before picking up and declining again in the given years. Table No. 5 below gives the values of Allocation Efficiency Indicator and Technical Efficiency Indicator. The main reason seems to be that ICT sectors output is demanded more in other sectors production as compared to its Final demand which consists demand of Household, Investment and Government Demand. Considering the Technical Efficiency Indicator has shown same behavior as Allocation Efficiency Indicator

Table 5
Technical and Allocation Efficiency Indicators ICT Sector-Pakistan

Years	**Technical Efficiency Indicator**	**Allocation Efficiency Indicator(In % Terms)**
2000	39	40
2007	38	39
2009	38	36
2012	36	38
2015	34	36
2018	33	34
2020	33	33

Source: Author's calculation based on ADB IO Tables

Results for Gross Productivity Indicator of ICT Sector in Pakistan for selected years (as per Eq No 5) is given in Figure No 4. The indicator is calculated by dividing the ICT industry's total final demand by its value added. The Indicator had its highest value in 2018 and sustained its value again in 2020. The Increased value shows that the Productivity of The ICT Sector has been increasing in Pakistan steadily from year 2000 to 2020 though the increase has been modest. The study's two metrics of productivity both point to the same trend: a slight uptick in ICT sector productivity in Pakistan. There are a number of obstacles slowing down the ICT sector's development in Pakistan including inability to use internet payment methods like PayPal and the supply of financing facilities via Employment programmes administered by the state (Raza, 2018). Pakistan's ICT sector faces problems like finding and keeping the right people to work in the sector, Keeping Up with the World's Rapidly Changing Technology, and facilitating the entry of foreign IT companies and enablers into Pakistan's market.

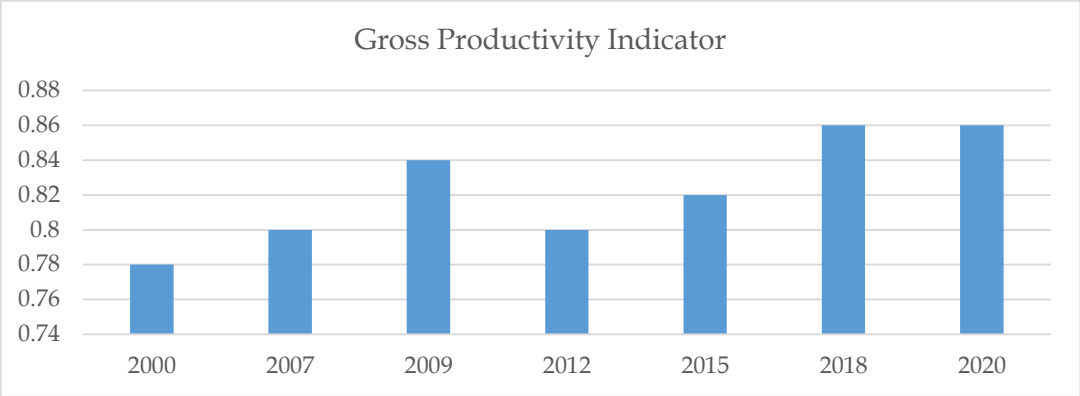

Figure 4: Gross Productivity Indicator ICT Sector-Pakistan

Intermediate Productivity Indicators

Intermediate productivity indicators measure the influences of Primary Input i.e. labor and capital, and total inputs (which include all other inputs like energy) to the Intermediate Output. (as per Eq. No. 6 and 7). The Intermediate Output reflects the output produced by ICT sector which is used by the other sectors. If the value is greater, then the intermediate productivity is also greater. Table No 6 and Figure No 5 below shows the results of the Indicators. The values show a decrease signifying the fact that Intermediate productivity has been declining in the given period owing to the rising prices of inputs. The Indicator has been increasing till 2012 and witnessed a moderate decline.

Table 6
Intermediate Output to Primary Input Indicator ICT Sector-Pakistan

Years	**Intermediate Output to Primary Input Indicator**
2000	0.52
2007	0.51
2009	0.47
2012	0.48
2015	0.46
2018	0.44
2020	0.43

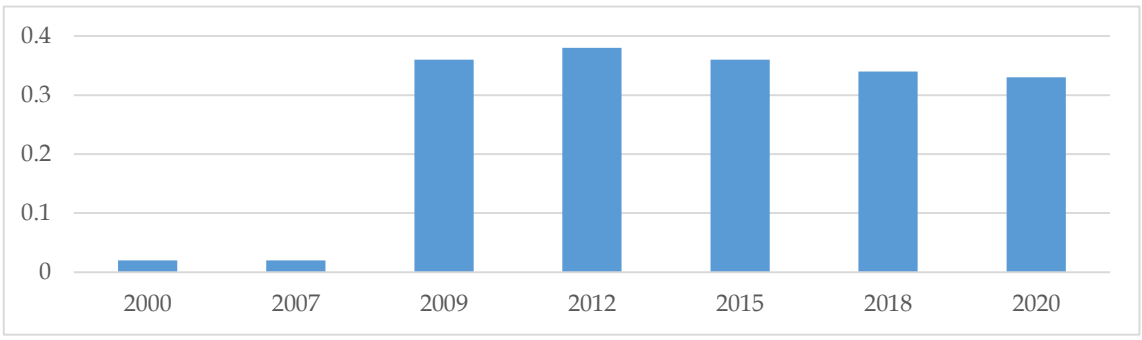

Figure 5: Intermediate Output to Total Input Indicator ICT Sector-Pakistan

Sectoral Productivity Indicators

This study employed Sectoral productivity measurement indicators suggested by (Liu & Song, 2005) "Sectoral Output to Primary Input Indicator" and "Sectoral Output to Total Input Indicator" as given by equation No7 and 8. Primary inputs as measured in IO tables consists of labour and capital. Therefore, the primary inputs include salaries and wages of labor, capital consumption allowances given to firms, earnings of firms, net interest charges levied on credit, and taxes paid by the firms. All primary as well as intermediate inputs (in the given IO Tables) are added together to form the total input.

Given the production flow from one sector to another, from ICT sector in our case to other sectors, Sectoral Output to primary input indicator displays capital and labour efficiency. A higher value indicates greater efficiency in use of capital and labour in ICT sector of Pakistan for the given year, and thus a higher level of output.

Table 7
Sectoral Output to Primary Input and Sectoral Output to Total Input ICT Sector-Pakistan

Years	**Sectoral Output to Primary Input**	**Sectoral Output to Total Input**
2000	0.03	0.02
2007	0.03	0.02
2009	0.02	0.02
2012	0.02	0.02
2015	0.02	0.02
2018	0.03	0.02
2020	0.02	0.02

The results reveal that both the sectoral productivity indicators, for ICT sectors in Pakistan for the years reviewed in the study have shown an almost stagnant behavior. The result as shown in Table No 7 above reflect the fact that both indictors have not shown any remarkable increase in ICT sector in case of Pakistan economy. The results are likely due to Pakistan's high cost of primary input, especially capital input needed for the ICT sector. Both sectoral productivity indicators exhibited same behavior over the given sample time period for ICT sector in Pakistan.

Conclusions

This study uses a novel productivity measuring framework for the ICT industry in Pakistan, which is grounded in ADB 2020 IO database. Indicators of productivity by the sector, intermediate, and aggregate levels are derived from existing literature and theoretical notions of multipliers. The focus of this metrication scheme is on product flows within an industry, with both direct and indirect input and output effects taken into account. Furthermore, this paradigm allows us to quantitatively assess the multifactor productivity of a given industry. The study's findings, based on the MFP indicators used, demonstrate that the ICT industry in Pakistan is seeing sustained growth. This exemplifies the significance and interdependence of Pakistan's ICT sector with the whole economy. However, by tackling its challenges—such as developing and retaining the suitable talent pool for the industry and keeping up with the rapid pace of global technologies—a rise in productivity is feasible. Additionally, lowering of market access restrictions imposed on foreign IT companies and enablers, and factors such as lack of accessibility to online payment systems like PayPal, and provision of financing facilities under government-run employment schemes can boost productivity in ICT sector in Pakistan. The findings can aid policymakers and academics in evaluating the competitiveness of the ICT sector by clarifying the interplay between technological, organizational, and policy implications on productivity growth.

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