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DOES INFORMATION AND COMMUNICATION TECHNOLOGY ELEVATE TAX REVENUE? PANEL DATA ANALYSIS USING INDONESIAN SETTING

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Abstract
Tax ratio in Indonesia is persistently below the international standard of 15%. Apart from that, there were only three periods recorded in the last 16 years where the realization of tax revenues exceeded the targets. This indicates that the tax authority's performance in Indonesia is nonoptimal. It is necessary to integrate digitalization in the tax system by seeking the use of Information and Communication Technology (ICT) to maximize tax revenue performance. The aim of this research is to examine the impact of ICT developments with the dimensions of access and infrastructure, use and skills on tax revenues in 34 provinces in Indonesia in 2017-2021. This research also considers control variables including Gross Regional Domestic Product (GRDP), foreign direct investment, population, inflation and the Covid-19 pandemic. A total of 170 panel data were evaluated using a fixed effect model approach. All data was obtained from the Indonesian Statistics Bureau (BPS). The research results show that only the dimension of use has a positive and significant influence on regional tax revenues. The dimensions of access and infrastructure, and skills, have a positive but not significant influence on regional tax revenues. The control variables that influence tax revenues in Indonesia are GRDP, population, and the Covid-19 pandemic, while foreign investment and inflation have no significant effect on tax revenues. At the end, this research also suggests further studies to know the influence of dimensions of ICT use on tax revenues under various conditions.
Keywords: ICT access and infrastructure, ICT use, ICT skills, Regional tax revenues

Abstrak
Saat ini, angka tax ratio Indonesia berada di bawah standar internasional sebesar 15%. Selain itu, tercatat hanya ada tiga periode dalam 16 periode terakhir di mana realisasi penerimaan pajak melampaui target yang telah ditetapkan pemerintah. Ini artinya, kinerja otoritas perpajakan di Indonesia belum sepenuhnya optimal. Untuk memaksimalkan kinerja penerimaan pajak, diperlukan adanya integrasi digitalisasi dalam sistem perpajakan dengan mengupayakan penggunaan Teknologi Informasi dan Komunikasi (TIK). Tujuan penelitian ini adalah untuk menguji dampak perkembangan TIK yang diukur dengan dimensi akses dan infrastruktur, penggunaan, dan keahlian terhadap pendapatan pajak di 34 provinsi di Indonesia pada 2017-2021. Penelitian ini juga mempertimbangkan variabel kontrol yang diduga memengaruhi penerimaan pajak di antaranya Produk Domestik Regional Bruto (PDRB), investasi asing, jumlah penduduk, inflasi, dan pandemi Covid-19. Sebanyak 170 data panel dievaluasi dengan menggunakan pendekatan fixed effect model. Seluruh data diperoleh dari Badan Pusat Statistik (BPS). Hasil penelitian menunjukkan bahwa

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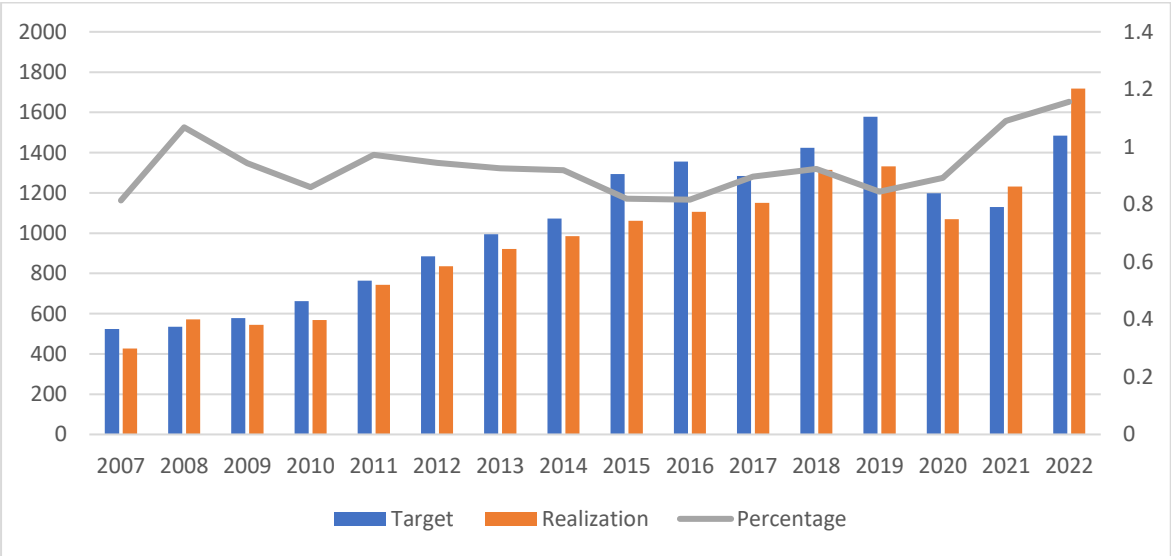
hanya dimensi penggunaan TIK yang memiliki pengaruh positif dan signifikan terhadap pendapatan pajak daerah. Dimensi akses dan infrastruktur, serta keahlian TIK berpengaruh positif namun tidak signifikan terhadap pendapatan pajak daerah. Variabel kontrol yang memengaruhi pendapatan pajak di Indonesia adalah PDRB, jumlah penduduk, dan pandemi Covid-19, sedangkan investasi asing dan inflasi tidak berpengaruh signifikan terhadap pendapatan pajak. Di bagian akhir, penelitian ini juga menyarankan studi lanjutan untuk melihat pengaruh dimensi penggunaan TIK terhadap pendapatan pajak dalam berbagai kondisi.
Kata kunci: Akses dan infrastruktur TIK, Penggunaan TIK, Keahlian TIK, Pendapatan pajak daerah

INTRODUCTION

Tax revenue is the main source of national income in most countries, including Indonesia. Realized tax revenue in Indonesia in 2022 reached IDR 1,717.8 trillion or contributed 65.4% to total national revenue (Indonesian Statistic Bureau, 2022). Considering the importance of taxes for a country, tax revenues must be mobilized optimally by expanding the tax bases. If we look at the last 16 years, the realization of tax revenues in Indonesia has often not reached the targets. Graph 1 shows that there were only three periods in the last 16 years where the realization of tax revenues reached the predetermined targets. Apart from that, the tax ratio in Indonesia is also below the international standard of 15%. Tax ratio in Indonesia in 2021 is only 10.9%. It is in the fifth lowest position in the Asia Pacific region in 2021 (Organization for Economic Co-operation and Development, 2021). This indicates that the tax authority's performance is not fully optimal. In the first period of the Covid-19 pandemic in 2020, tax revenues decreased by 19.65% from the previous period. However, in the last two periods (2021 and 2022), tax revenues showed good performance, marked by the fulfillment of the targeted tax revenue. In 2022, tax revenues will reach 115.6% of the target set in Presidential Regulation (Perpres) Number 98 of 2022.



Graph 1 Target and Realization of Tax Revenue in Indonesia 2007-2022

Source: Indonesian Statistic Bureau (BPS) (2022), processed

Low tax revenues indicate that taxpayer compliance is also low and there are still many taxpayers who avoid paying taxes (Kiema, 2017). Okunogbe & Santoro (2023) argued that low tax compliance in developing countries is caused by the high level of informality, or the tax system is not yet fully sophisticated so that taxpayers have the opportunity to avoid paying taxes. Low tax collection in developing countries is also supported by a bad public tax service system so that the tax mobilization process is long, impractical, and inefficient (Karimi et al., 2017). Therefore, in the future, developing countries must begin to integrate information and communication technology (ICT) into their tax systems so that the tax collection process becomes more effective and efficient so that tax revenues can be increased.

Currently, many countries in the world have utilized digital technology in their tax systems to mobilize tax revenue, including Indonesia. One form of digitalization of tax administration in Indonesia is marked by the existence of an online taxpayer's portal. It is a digital tax service that can be accessed via the internet in real time. Several digital tax service systems in the online DJP portal include e-registration, e-billing, e-filing, e-form, and e-tracking. With these various digital tax services, taxpayers get the benefit from a tax administration process. That is faster, easier, safer and paperless so that ultimately taxpayer compliance increases.

Considering the important role of ICT in mobilizing tax revenue, previous studies have investigated the influence of ICT developments on tax revenues. In previous studies, ICT development was mostly measured by the penetration of internet use, computers, mobile phones and fixed board brands (Adedeji, A., & Lipede, 2023; Koyuncu et al., 2016; Mallick, 2021; Shokrkhodaei & Salatin, 2018). However, these prior studies have limitations because digitalization only covers certain aspects such as ICT infrastructure. Even though this aspect is key to digitalization, but digitalization considers many aspects that are not only limited to ICT infrastructure. Apart from that, previous studies generally were microeconomic studies which only focused on discussing one particular region within a country (Adegbie et al., 2022; Adegbite et al., 2013; Chatama, 2013; Karimi et al., 2017; Kiema, 2017; Mascagni et al., 2021; Owino et al., 2017) so the results cannot be generalized to a wider regional level such as a country.

This paper aims to empirically test the impact of ICT developments on regional tax revenues in Indonesia, while still considering the multidimensional features of digitalization. Specifically, this paper aims to investigate ICT access and infrastructure, ICT use, and ICT skill on regional tax revenues in Indonesia. This study covers 34 provinces in Indonesia over a 5-year period. This research also considers other macroeconomic factors that are predicted to influence tax revenues to set the empirical results, such as Gross Regional Domestic Product (GRDP), inflation rate, population, and foreign direct investment (Asongu et al., 2021; Koyuncu et al., 2016; Nugrahani & Mahi, 2022). These factors are used as control variables in this research. This research also considers the Covid-19 pandemic as another control variable which is predicted to influence regional tax revenues in Indonesia. The main contribution of this research is to use a more comprehensive measurement of the digitalization phenomenon. This research not only considers the availability and affordability of ICT which can be measured from the dimensions of access and infrastructure, but also the ICT use and the ICT skill on the other hand.

LITERATURE REVIEW

Regional Tax Revenue

Law Number 8 (2009) defines regional taxes as follows:

"Compulsory contributions from the community to regional governments which are used to finance regional government interests or activities and are collected based on coercive laws, with no direct compensation"

Based on the definition of tax, it can be interpreted that regional taxes are one of the main and important sources of income for regional governments. As the main source of income for the region, regional taxes can be used to finance all regional government expenditures to advance and prosper the people. Regional tax policies must be based on the principles of equity and justice, community participation, and pay attention to regional potential to create a prosperous society and achieve regional independence (Thahir, 2019).

According to Mikha (2010), regional taxes have 2 functions: budget function and regulatory function. Taxes function as a budget indicates that taxes are a source of funds for local governments to finance all expenses in one period and taxes function to regulate because taxes are positioned as a tool to regulate and implement government policies related to the social and economic fields. In Law Number 8 (2009), regional taxes are divided into 2 types: regional taxes at the provincial and regional taxes at the district/city. In this research, regional taxes are represented by taxes received at the provincial. Taxes at the provincial consist of: 1) Tax on motor vehicles and vehicles on water, 2) Tax on transfer of title to motor vehicles and vehicles on water, 3) Tax on motor vehicle fuel, and 4) Tax on taking and utilization of underground and surface water.

Information and Communication Technology

Information and Communication Technology (ICT) is any form of technological device that can be used to process and convey information. One standard measure that can be used to describe the ICT development in a region is the ICT Development Index (IDI). Therefore, this research utilizes the IDI to measure ICT development in Indonesia. IDI can be used as a tool to measure the growth of ICT development, the digital divide and the potential for ICT development in the future. According to the Indonesian Statistic Bureau (2022a), IDI is compiled with 3 sub-index: ICT access and infrastructure, ICT use, and ICT skills. The IDI value ranges from 1 to 10. The higher the IDI value and closer to 10, the better the ICT development in the region. In general, the IDI aggregate index is formulated as follows:

$$IDI = 0{,}4\ (ICT\ access\ and\ infrastructure) + 0{,}4\ (ICT\ use) + 0{,}2\ (ICT\ skill) \quad (1)$$

Source: Indonesian Statistic Bureau (2022a)

ICT access and infrastructure describes ICT readiness. There are five indicators of ICT access and infrastructure, as follows: 1) Fixed telephone subscribers per 100 population, 2) Cellular telephone subscribers per 100 population, 3) International internet brand with (bit/s) per user, 4) Percentage households with computers, and 5) Percentage of households with internet access. The ICT use describes ICT intensity. This consists of 3 indicators, as follows: 1) Percentage of individuals who use

the internet, 2) Fixed broadband internet subscribers per 100 population, 3) Active mobile broadband internet subscribers per 100 population. This ICT skill describes the abilities required by individuals to use ICT. This consists of 3 indicators, as follows: 1) Average years of schooling, 2) Secondary gross enrollment rate, and 3) Tertiary gross enrollment rate.

Relationship between ICT and Tax Revenue

Low tax collection can be caused by a bad public tax service system (Karimi et al., 2017) which ultimately reduces taxpayer compliance in paying taxes (Mascagni et al., 2021). Therefore, increasing tax revenues can be done by increasing taxpayer compliance by building effective tax administration with ICT (Githinji et al., 2014). The use of ICT in the public tax service system is necessary to help countries reduce tax avoidance and increase tax revenues (Uyar et al., 2021).

ICT has been proven to speed up the tax collection process. Carrying out activities such as filling out reports, tax forms and paying taxes electronically can help reduce collection and processing costs, thereby simplifying the tax collection process, increasing the efficiency of the tax system, and increasing tax revenues (Shokrkhodaei & Salatin, 2018). A sophisticatedly designed electronic tax system will make filing tax returns very simple thereby motivating taxpayers to pay their taxes (Adegbite et al., 2013). In addition, electronic tax management systems have an impact on the efficiency of tax revenue collection at the local government level (Owino et al., 2017). ICT can also reduce fraud, corruption and tax payment errors thereby covering the loss of tax revenue (Chatama, 2013).

Nugrahani & Mahi (2022) explained Small and Medium Enterprises (SMEs) that implement ICT level 5 are able to increase central tax revenue. In another studies, a positive and statistically significant relationship was found between ICT penetration and tax revenues (Adedeji, A., & Lipede, 2023; Adegbite et al., 2013; Chatama, 2013; Karimi et al., 2017; Kiema, 2017; Koyuncu et al., 2016; Owino et al., 2017). This means tax revenues will increase if ICT can be implemented in a country's tax system. In addition, the digitalization of government services through ICT is also able to reduce the level of tax avoidance. It makes tax revenues will be more optimal and ultimately increase tax revenues (Shokrkhodaei & Salatin, 2018; Uyar et al., 2021).

ICT development can be measured from three dimensions (ICT access and infrastructure, ICT use, and ICT skills). Mascagni et al. (2021) explains ICT infrastructure has a positive impact on tax revenues with an increase of at least 12% in income tax and 48% in Value Added Tax (VAT). However, in another research, ICT infrastructure does not have a significant influence on tax collection (Mallick, 2021). In addition, Brun et al. (2020) revealed that ICT readiness as measured by infrastructure does not have a significant effect on tax revenues, but ICT use has a positive and significant effect in increasing tax revenues, especially direct taxes and VAT. Asongu et al. (2021) found evidence ICT can increase goods and services tax revenues while mobilizing corporate taxes. Furthermore, the ICT use and ICT skills are the determining factor in mobilizing taxation.

Hyphotesis

Based on theoretical studies and previous research, this research develops the following hypothesis:

H1: ICT access and infrastructure have a positive and significant effect on regional tax revenues.

H2: ICT use has a positive and significant effect on regional tax revenues.

H3: ICT skills have a positive and significant effect on regional tax revenues.

RESEARCH METHOD

Data

A total of 170 panel data from 34 provinces in Indonesia within a five year period (2017-2021) were analyzed in this research. The research period was set for five years because in the 2016 period and the previous period there were differences in the measurement of IDI. Apart from that, the IDI report in this period was not detailed for each sub-index. In other words, data sources are quite limited to the 2016 period and previous periods. This is also found in the 2022 period where in this period the IDI report for each province has not yet been published. Data was collected using documentation techniques. Documentation techniques are a way of collecting research data indirectly, through supporting documents related to the data to be researched. In this research, documentation techniques are carried out by downloading data from official sources, then the data is tabulated according to the variable measurements determined in this study.

Variable Definition

The dependent variable in this research is regional tax revenue, while the independent variable consists of 3 IDI dimensions in the form of ICT access and infrastructure, ICT use and ICT skills. In addition, GRDP, inflation, investment, population, and Covid-19 are used as control variables. Each measurement and variable definition is explained in the Table 1:

Table 1 Variable Definition

Variable	Measurement	Hypothesis	Source
Dependent Variable			
Tax revenue	Natural logarithm of realized regional tax revenue (Rupiah)	-	Indonesian Statistic Bureau
Independent Variables			
ICT Access and infrastructure	Logarithm of ICT access and infrastructure (Index) Where: ICT access and infrastructure sub-index = 0.4 x the total sum of each indicator that makes up the sub-index *) Indicators that make up the access and infrastructure sub-index are 1) Fixed telephone subscribers per 100 residents 2) Cell phone subscribers per 100 residents 3) International internet bandwidth (bit/s) per user 4) Percentage of households with computers 5) Percentage of households with internet access	Positive significant (+)	Indonesian Statistic Bureau
ICT Use	Logarithm of ICT usage (Index) Where:	Positive significant (+)	Indonesian Statistic Bureau

Variable	Measurement	Hypothesis	Source
	ICT use sub-index = 0.4 x the total sum of each indicator that makes up the sub-index *) Indicators that make up the ICT use sub-index, namely 1) Percentage of individuals who use the internet 2) Fixed broadband internet customers per 100 residents 3) Active mobile broadband internet customers per 100 residents		
ICT Skill	Logarithm of ICT skills (Index) Where: ICT skills sub-index = 0.2 x the total sum of each indicator that makes up the sub-index *)Indicators that make up the ICT skills sub-index, namely 1) Average length of school 2) Secondary gross participation rate 3) Tertiary gross participation rate	Positive significant (+)	Indonesian statistic Bureau
Control Variables			
GDRP	Logarithm of Gross Regional Domestic Product at Current Prices (GRDP ADHB) by expenditure (Rupiah)	Positive significant (+)	Indonesian statistic Bureau
Foreign Direct Investment	Logarithm of total foreign direct investment realization (USD Million)	Positive significant (+)	Indonesian statistic Bureau
Inflation	Inflation rate in 34 provinces in Indonesia in 2017-2021 (%) Note: Due to the inflation data in BPS only includes inflation data from several districts/cities in each province in Indonesia *), the inflation rate in several districts/cities will be added up and then divided by the total districts/cities that contain inflation data in the province This is to describe the level of inflation in each province. Formula: $\text{INF} = \frac{\text{Inf}_1+\text{Inf}_2+\cdots+\text{Inf}_n}{n}$ (2) Where: $\text{Inflation} = \frac{\text{CPI this period}-\text{CPI previous period}}{\text{CPI previous period}} \text{ x } 100\%$(3) and $\text{CPI} = \frac{\text{Price this period}}{\text{Basic price}} \text{ x } 100$ (4) Note: INF is Inflation and CPI is the Consumer Price Index	Negative significant (-)	Indonesian statistic Bureau

Variable	Measurement	Hypothesis	Source
	*) 82 districts/cities in the 2017-2019 period and 90 districts/cities in 2020-2021.		
Population	Logarithm of the population in 34 provinces in Indonesia (people)	Positive significant (+)	Indonesian statistic Bureau
Covid-19	Dummy 1: Provinces with at least 1 case of the Covid-19 virus 0 : Provinces not exposed to Covid-19	Negative significant (-)	Ministry of Health

Source: Data processed from researchers, 2023

Methodology

Guided by previous literature related to tax mobilization (Baunsgaard & Keen, 2010; Brun et al., 2020; Clist & Morrissey, 2011), this research develops three empirical models as follows:

$$Log(Tax) = \alpha + \beta Log(ICTaccess)_{i,t} + \beta X_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$Log(Tax) = \alpha + \beta Log(ICTuse)_{i,t} + \beta X_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$Log(Tax) = \alpha + \beta Log(ICTskills)_{i,t} + \beta X_{i,t} + \varepsilon_{i,t} \quad (7)$$

Where: ***Tax*** is the total provincial tax revenue in Indonesia. ***ICTaccess***, ***ICTuse*** and ***ICTskills*** represent 3 dimensions in ICT development in province i in period t. $X_{i,t}$ includes control variables or determinants of regional tax revenue according to previous literature. Control variables are GRDP, foreign direct investment, inflation, population, and Covid-19. ***ε*** is the error component of the regression equation. ***α*** is a constant or intercept, while ***β*** is a variable coefficient or slope. ***i*** is a cross section in the form of 34 provinces in Indonesia (i=1, 2,..., 34) and ***t*** is a time series in the form of the research period (t=2017, 2018,.., 2021). From the equation (5), (6), and (7), it can be interpreted that every increase of $Log(ICTaccess)$, $Log(ICTuse)$ or $Log(ICTskills)$ 1% will increase the value $Log(Tax)$ by a certain percentage (depending on the regression coefficient).

Based on the results of chow test and hausman test (Table 2 and Tabel 3), the fixed effect panel model (FEM) is the best model for the three regression equation models compared to the common effect model (CEM) and the random effect model (REM).

Table 2 Chow Test Result

Effect test	Model 1 Statistic (Probability)	Model 2 Statistic (Probability)	Model 3 Statistic (Probability)
Cross-section F	79.190311 (0.0000)	90.342834 (0.0000)	85.607836 (0.0000)
Cross-section Chi-square	518.393786 (0.0000)	539.795189 (0.0000	531.035683 (0.0000)
Decision	**Choose FEM over CEM**	**Choose FEM over CEM**	**Choose FEM over CEM**

Source: Secondary data 2023, processed

Table 3 Hausman test result

Test summary	Model 1 Chi-Sq. Statistic (Probability)	Model 2 Chi-Sq. Statistic (Probability)	Model 3 Chi-Sq. Statistic (Probability)
Cross-section random	31.729097 (0.0000)	37.252835 (0.0000)	28.497643 (0.0001)
Decision	**Choose FEM over REM**	**Choose FEM over REM**	**Choose FEM over REM**

Source: Secondary data 2023, processed

Before testing the fixed effect model, the data was explained using descriptive statistics to see the data in more detail. A scatter plot test was carried out to see the relationship between the independent variables and tax income. Also, the data must undergo a correlation test to identify the existence of a strong relationship between explanatory variables.

RESULT

Data Description

Based on Table 4, it can be seen that the average score for ICT access and infrastructure in 34 provinces iin 2017-2021 was 5.79 or in the medium category. Jakarta leads as the province with the highest ICT access and infrastructure score in Indonesia, reaching 8.27 in 2022 (high category), while Papua is the lowest with a score of 3.68 in 2020 (low category). Figure 1 explains that the access and infrastructure scores in 2017-2021 show an increase every year, although slightly. However, growth in access and infrastructure scores tends to decline from year to year. In 2018, growth in access and infrastructure scores reached 3.13% from the previous year, then to 2.87% (2019), and 2.47% (2020). In 2021, growth in access and infrastructure scores reached its lowest point, only 0.51%. In other words, the growth in access and infrastructure scores in 2018-2020 was around 2-3%, while in 2021 it was only 0.51%. In the period before Covid-19, the government was consistent in investing and building ICT infrastructure in all provinces in order to support ICT readiness so that the access and infrastructure index scores increased. This condition was different during the Covid-19 pandemic period where investment funds to build ICT infrastructure tended to decrease because the government allocated more funds for dealing with the Covid-19 disaster. As a result, although it continues to increase, growth in access and infrastructure scores is relatively lower than in the pre-pandemic period.

Table 4 Data Description

Variable	Observations	Average	Std.Deviation	Maximal	Minimal
Tax revenue (IDR trilion)	170	3,94	6,94	40,3	0,24
ICT Access (Index)	170	5,79***	0,81	8,27****	3,68**
ICT Use (Index)	170	4,5**	1,09	7,59****	2,1*
ICT Skill (Index)	170	6,02***	0,55	7,68****	4,65**
GDRP (IDR trilion)	170	455,75	650,44	2912,56	32,27
FDI (USD Million)	170	879,51	1206,24	5881	5,9
Population (Million)	170	7,94	11,15	49,4	0,68

Variable	Observations	Average	Std.Deviation	Maximal	Minimal
Inflation (%)	170	2,6	1,1	6,5	-0,025
Covid-19 (*Dummy*)	170	0,4	0,49	1	0

Note: ICT category according to Indonesian Statistic Bureau = Very low* (0 - 2.5), Low** (2.51 - 5.0), Medium*** (5.01 – 7.5), High**** (7.51 – 10.0)

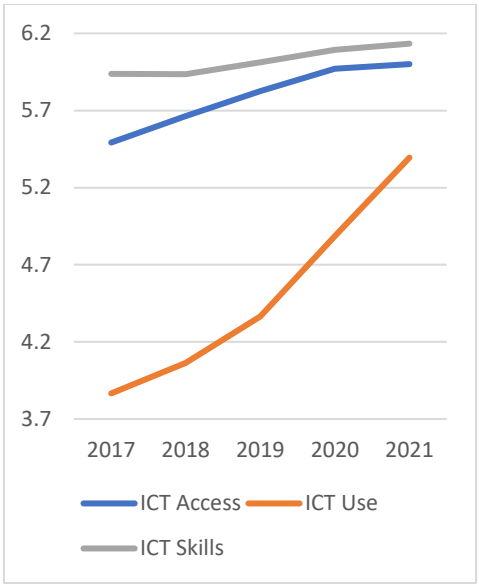
Source: Data processed from researchers, 2023

ICT use is the sub-index with the lowest average score if compared with the other 2 ICT sub-indices. The average ICT use score in all provinces in Indonesia in 2017-2021 was only 4.5 and was in the low category (Table 4). Jakarta (2021) is the province with the highest ICT use score of 7.59 (high), and Papua (2019) is the province with the lowest ICT use score of 2.1 (very low). However, ICT use is the fastest growing sub-index when compared with ICT access and infrastructure and skills (Figure 1). In the pre-pandemic period (2017-2019), the increase in ICT use was only around 5-7% compared to the previous period, while in the pandemic period (2020-2021), the growth in ICT use was higher, namely around 10-11%. This can be explained because during the Covid-19 pandemic, people tended to access technology more, especially the internet. During the Covid-19 period, the government implemented many work from home policies so that ICT use was higher compared to the pre-pandemic period.

ICT skills has the highest average score if compared to the other 2 ICT sub-index, which reached a score of 6.02 (medium category). Yogyakarta (2021) has the highest ICT skills score reaching 7.68 (high category), while Papua (2017) has the lowest ICT skills score, only 4.65 (low category). During the 2017-2021 period, the average ICT skills index score was in the medium category and better compared to the other 2 ICT sub-index, however the increase in ICT skills scores tended to stagnate (Figure 1). This can be explained because the ICT skills is a supporting variable for the digitalization process where basic skills related to ICT actually already exist. The government is more focused on improving other ICT sub-index including ICT access and infrastructure and ICT use.

In addition, based on Table 4, the number of observations is only 170, which indicates a relatively small sample for panel data estimation. This is caused by the available data only covers 5 years (2017-2021). The year 2022 has not been published by BPS and the data for 2016 and before, there are differences in the ICT assessment method by BPS, so it is not included in this research. However, according to Sugiyono (2017), the appropriate sample size in a study is between 30 and 500. This indicates that the data used in this research is considered suitable for further analysis. However, this research still suggests, at the end of this paper, to increase the amount of data.

On the other hand, the average tax revenue in all provinces in 2017-2021 reached IDR 3.94 trillion. Jakarta is the province with the highest regional tax revenue, which reached IDR 40.29 trillion in 2019, while North Maluku is the province with the lowest tax revenue in Indonesia with IDR 0.24 trillion in 2017. Based on Figure 2, the trend in tax revenue before the Covid-19 always increases every year. However, in the first period of Covid-19, the average regional tax revenue decreased quite significantly, reaching 13.28%. Then, the average tax revenue increased again in the second period of Covid-19, although the value was not as large as the period before the pandemic (2019). In the first period of Covid-19, the economy in Indonesia was paralyzed due to the many socio-economic restriction policies implemented by the government, while the second period of the pandemic tended to be better as social restrictions began to loosen because the vaccine policy had been implemented in this period.



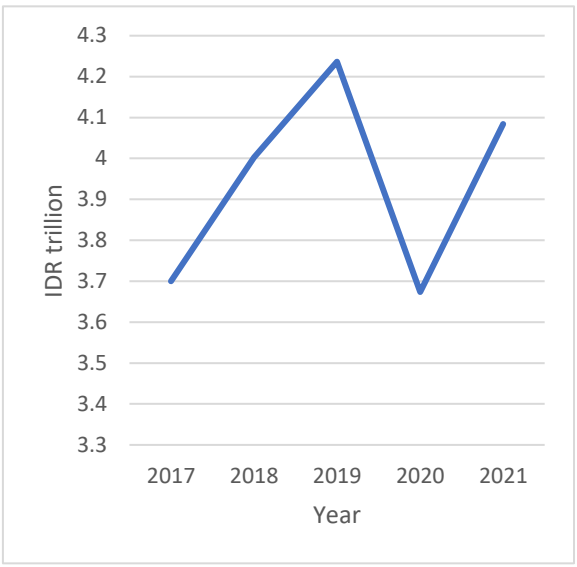


Figure 1 ICT Sub-Index Trend in 2017-2021 **Figure 2 Tax Revenue Trend in 2017-2021**

Source: Data processed from researchers, 2023

Furthermore, the scatter plot shows the relationship between ICT access and infrastructure and tax revenue has a positive correlation (Figure 3). This condition is also found in the relationship between ICT use and tax revenue (Figure 4). However, this seems to be reversed in the relationship between ICT skills and tax revenues because it is above the specified threshold (Figure 5). Moreover, it can be seen that the scatter plot values are widely spread around the expected trend. This shows that the relationship between the two variables is not linear, and it is possible that there are a number of other predictor variables that influence tax revenues in Indonesia. Therefore, this research includes a number of other variables described in logarithms to take into account the influence of other variables on tax revenues in Indonesia. This technique provides advantages such as limiting the magnitude of value asymmetry (Gnangnon, 2020) and reducing the influence of outliers (Brun et al., 2020).

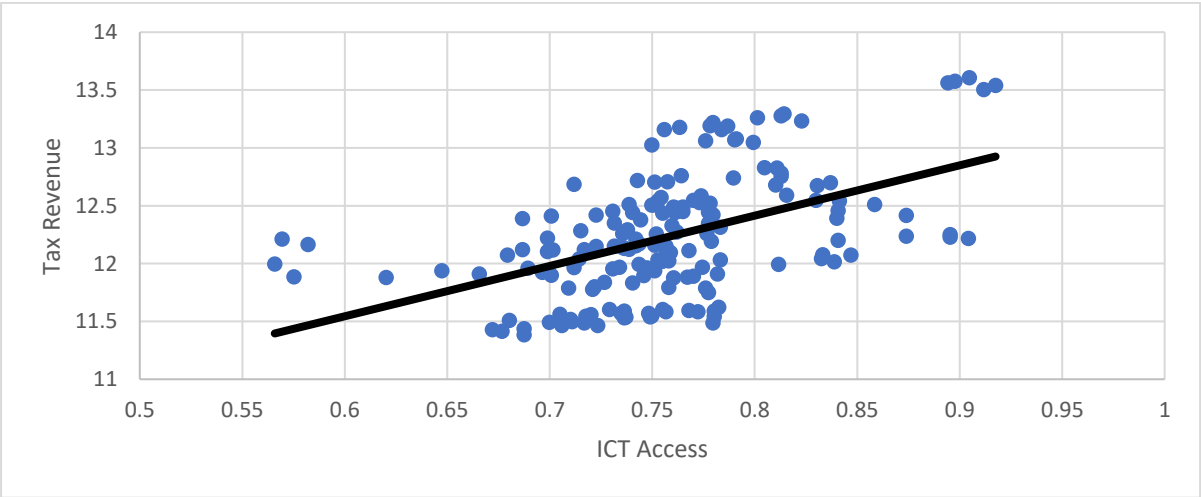


Figure 3 Scatter Plot ICT Access and Tax Revenue

Source: Data processed from researchers, 2023

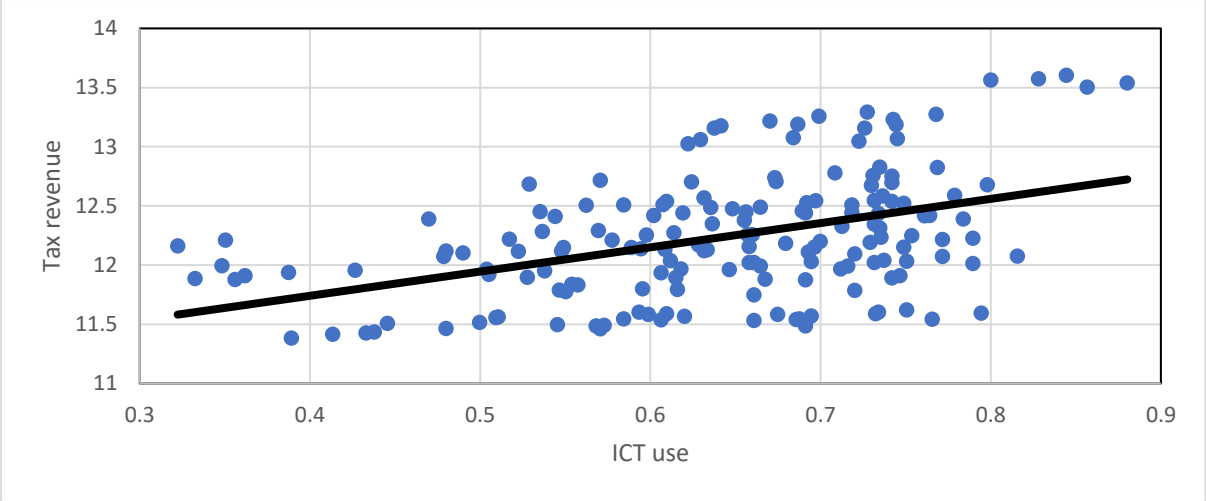


Figure 4 Scatter Plot ICT Use and Tax Revenue

Source: Data processed from researchers, 2023

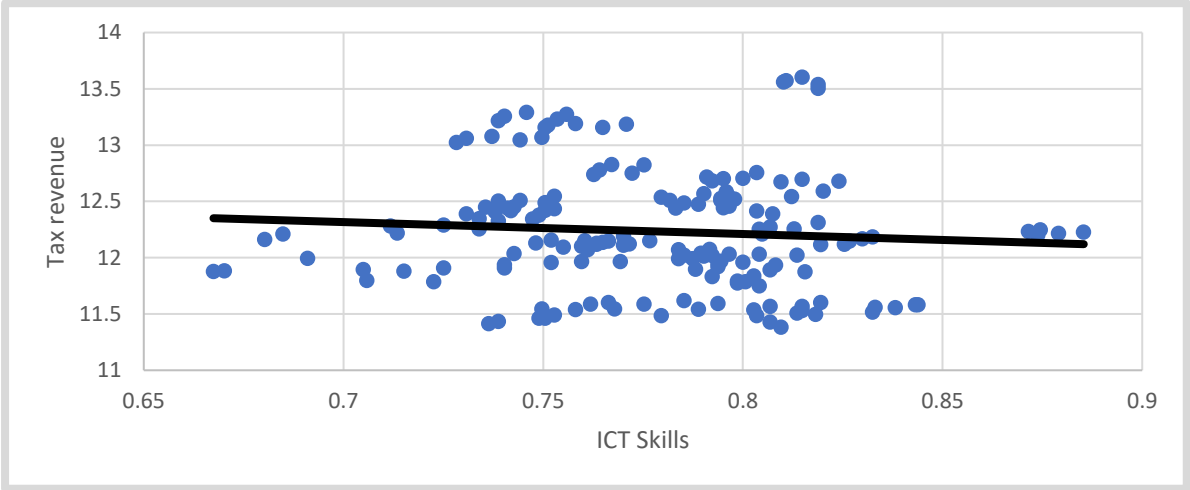


Figure 5 Scatter Plot ICT Skills and Tax Revenue

Source: Data processed from researchers, 2023

Correlations Test

Regression tests using a panel data approach must ensure that each independent variable included in the regression model does not have a strong correlation with one another. This research applies a correlation test to check this problem.

Table 5 Correlations Test

	Access	Use	Skills	GDRP	Invest.	Population	Inflation	Covid-19
Access	1.00							
Use	0.89	1.00						
Skills	0.50	0.36	1.00					
GDRP	0.44	0.43	-0.09	1.00				
Investment	0.18	0.17	-0.17	0.69	1.00			
Population	0.42	0.29	0.12	0.41	0.24	1.00		
Inflation	-0.11	-0.15	-0.06	-0.036	0.039	-0.02	1.00	

Covid-19	0.20	0.44	0.14	0.047	-0.051	0.016	-0.46	1.00

Source: Data processed from researchers, 2023

The correlation test shows only the Access and Use variables have a strong correlation with each other with a correlation coefficient of 0.89. Therefore, this research does not combine the three ICT dimensions into one regression model, but rather divides them into 3 regression models (such as equations 5, 6 and 7) to overcome this problem. This method was also applied in previous research such as Brun et al. (2020).

Main Result

The empirical results of 3 research models with a fixed effect panel approach are presented in Table 6 as follows:

Table 6 The Effect of ICT Access, ICT Use and ICT Skills on Tax Revenues

Variable	**Model 1** **t-statistic** **(Coefficients)**	**Model 2** **t-statistic** **(Coefficients)**	**Model 3** **t-statistic** **(Coefficients)**
Constant	-4.904172*** (-8.083482)	-3.407014*** (-5.897972)	-5.165485*** (-8.345837)
ICT Access	**1.078004** **(0.236813)**	-	-
ICT Use	-	**3.348033***** **(0.331233)**	-
ICT Skills	-	-	**1.058297** **(0.912979)**
GDRP	7.729154*** (0.826415)	5.735769*** (0.646329)	8.530927*** (0.844607)
ForeignDirect Investment	0.766271 (0.008690)	0.929965 (0.010152)	0.890905 (0.010111)
Population	6.166180*** (1.243326)	6.803922*** (1.299766)	5.914867*** (1.163521)
Inflation	1.189147 (0.018880)	0.640256 (0.009672)	1.068266 (0.016675)
Covid-19	-4.998034*** (-0.039288)	-5.951121*** (-0.061404)	-4.321918*** (-0.043558)
Adjusted R-Square	0.995943	0.996232	0.995942
F-Statistic	1064.840***	1146.664***	1064.497***
Observations	170	170	170

Note: ***)p < 0.001

Source: Data processed from researchers, 2023

Based on Model 1, the ICT access and infrastructure variables show a positive, but not significant, influence on local tax revenues in all provinces in Indonesia. Thus, the first hypothesis which states that ICT access and infrastructure has a positive and significant effect on tax revenues is rejected. The same results are also found in Model 3 where in this study ICT skills statistically have

a positive, but not significant, influence on tax revenues in Indonesia. Therefore, the third hypothesis is rejected. In model 2, the ICT use variable shows a positive and significant influence on tax revenue with a coefficient of 0.331233. This can be interpreted that every 1% increase in ICT use in all provinces in Indonesia can increase tax revenue by 0.33%. Thus, the second hypothesis is declared accepted.

For the control variables included in the 3 empirical models, there are 3 variables that show a significant influence on tax revenue, while the other variables do not show a significant influence on tax revenue. First, the GRDP variable has a significant influence on tax revenue with the regression coefficient showing a positive number for all models. This result is in accordance with the initial assumption which states that GRDP can increase regional tax revenue. GRDP is a condition that describes the economic performance of a region. If the GRDP value is high, then the economic performance in that area is considered good, vice versa. If economic conditions are considered good, the local government can collect tax revenues from economic activities that occur in the area (Asongu et al., 2021).

Second, the population variable shows a positive and significant influence on tax revenues in Indonesia for the three empirical models. These results are also in line with initial predictions. This can be explained because as the population increases, it is possible for higher levels of economic activity to occur in the area such as the production of goods and services, investment, and trade. All sectors in this economic activity will be taxed by the government so that it can increase tax revenue in the area (Lumy et al., 2018).

Table 6 explains the Covid-19 pandemic has a negative and significant impact on regional tax revenues in Indonesia for all empirical models. These results are also in accordance with the initial hypothesis. This happens because the Covid-19 pandemic has caused regional economic conditions to paralyze as a result of the many social restriction policies implemented by the government to prevent the spread of the virus. The paralysis of the regional economy means that the government cannot collect regional taxes optimally because many business sectors have gone bankrupt. In the end, tax revenues decreased, while on the other hand government spending increased to overcome the socio-economic impacts caused by the Covid-19 pandemic (Siregar, 2021).

The foreign direct investment shows a positive effect, but not significant, on local tax revenues in Indonesia. This can be explained because of the fiscal incentives in taxation that foreign investors receive. In order to increase investment from foreign investors, foreign investors who invest their capital in Indonesia will receive a number of tax incentives such as income tax for investment in certain business fields or in certain areas (tax allowance) and reduction in corporate income tax (tax holidays). With these various incentives, even though the value of foreign investment increases, it cannot influence or increase regional tax revenues in Indonesia (Puspasari & Gazali, 2022).

Last, but not least. The inflation also does not show a significant influence on local tax revenues in Indonesia for all estimation models. This is also not in line with the initial hypothesis which suggested that inflation could affect regional tax revenues in Indonesia. This is possible because taxes are generally imposed on real income, not nominal income. Nominal income is income that has not been adjusted for price increases or inflation, while real income is income that has taken into account price increases or inflation. Even though nominal income was increased due to an increase in prices, this cannot affect regional tax revenues in Indonesia (Triastuti & Pratomo, 2016).

DISCUSSION

The ICT access and infrastructure do not have a significant effect on regional tax revenues in Indonesia. According to BPS, the ICT access and infrastructure describes the ICT readiness as measured by 5 ICT infrastructure indicators including ownership of fixed telephones, cellular telephones, international internet bandwidth, internet, and computers. All of these ICT infrastructure indicators will be useful for mobilizing local tax revenues if they are utilized optimally by users (Brun et al., 2020). In reality, not all ICT infrastructure indicators are used optimally by users. Several ICT infrastructure ownership have actually decreased, such as fixed telephones and computers. This makes sense because these indicators are considered to be obsolete and replaced by other, more sophisticated technology such as cell phones which are experiencing rapid growth along with the increase in internet subscribers (Mallick, 2021).

The same results were also experienced by the ICT skills dimension which showed an insignificant influence on tax revenues in Indonesia. ICT skills describe an individual's ability to use ICT with indicators of average years of schooling, secondary gross enrollment rate and tertiary gross enrollment rate. This dimension is a supporting dimension in the ICT digitalization process so that it cannot directly boost regional tax revenues in Indonesia (Asongu et al., 2021). Whether there is a digitalization process or not, ICT skills will definitely remain because this dimension is related to the basic education that society must have. Therefore, the growth of this dimension tends to be stagnant if compared to other ICT dimensions (Figure 1). This dimension will work optimally if it is supported by other ICT dimensions.

Panel data regression results confirm that ICT use is a determining factor in regional tax mobilization in Indonesia. Although ICT access and infrastructure are the foundation of the digitalization process and ICT skills is a supporting factor, this must be accompanied by the ICT use to make sure the effects of digitalization can be felt (Brun et al., 2020). ICT use describes how far ICT has been used by society in an area, such as individual internet use, fixed broadband internet use and mobile broadband internet use. Even though ICT use is the dimension with the lowest index score, the increase is the fastest compared to other ICT dimensions, and the effect was even more rapid during the Covid-19 pandemic (Figure 1). As more people use ICT, tax mobilization becomes faster, more efficient and easier so that ultimately tax revenues increase.

Further Studies

In the rest of the paper, this research will focus on ICT use because it has been proven to influence regional tax revenue in Indonesia. This research applies further studies using ICT use for few matters and conditions. *First*, this research examines the ICT use impact on regional revenue indicators other than regional taxes, regional levies, to see whether the effect remains the same as regional tax revenues or vice versa.

Table 7 The Effect of ICT Use on Regional Levies

Variable	t-statistic (Coefficients)
Constant	-1.022915 (-12.68579)
ICT Use	**-0.745226 (-0.516246)**

Variable	t-statistic (Coefficients)
GDRP	2.620864*** (2.090164)
Foreign Direct Investment	-1.079262 (-0.082288)
Population	-0.825569 (-1.650318)
Inflation	-0.709761 (-0.955751)
Covid-19	-2.325566** (-0.165579)
Adjusted R-Square	0.823958
F-Statistic	21.28194***
Observations	170
Number of provinces	34

Note: ***)p < 0.01, **)p < 0.05, *)p < 0.1

Source: Data processed from researchers, 2023

Table 7 confirms the influence of ICT use on regional levies is not significant in Indonesia. This rejects the notion that the use of ICT also has a positive and significant impact on other regional original income indicators, including regional levies. This is possible because the levy administration system in Indonesia is not as advanced as the taxation system, where levies are mostly still collected using conventional methods (Amalia, 2021).

Second, this research estimates the ICT use impact on tax revenues based on regional location: western and eastern. This is reasonable because in general provinces in the western tend to be more advanced in terms of ICT use if compared to the eastern. Provinces are divided into 2 regions based on time zones. There are 18 provinces in the western and 16 provinces in the eastern. The results are reported in Table 8 as follows.

Table 8 The Effect of ICT Use on Tax Revenues in the West and East Province

Variable	West t-statistic (Coefficients)	East t-statistic (Coefficients)
Constant	-0.680535 (-1.905124)	-2.883716*** (-6.971132)
ICT Use	**1.696360* (0.212288)**	**2.890610*** (0.444245)**
GDRP	4.357396*** (0.781781)	3.878392*** (0.613685)
Foreign Direct Investment	-1.408628 (-0.018081)	1.682020* (0.027156)
Population	1.318638 (0.424541)	5.755486*** (1.545448)
Inflation	1.790719* (0.680525)	-0.591985 (-0.250531)

Variable	West t-statistic (Coefficients)	East t-statistic (Coefficients)
Covid-19	-4.092203*** (-0.042703)	-4.537416*** (-0.083017)
Adjusted R-Square	0.997857	0.990385
F-Statistic	1802.894***	388.4726***
Observations	90	80
Number of provinces	18	16

Note: ***)p < 0.01, **)p < 0.05, *)p < 0.1

Source: Data processed from researchers, 2023

Table 8 confirms that the effect of ICT use on regional tax revenues remains consistent, even though the province is divided into 2 regions. This was possible because the ICT use growth was evenly distributed throughout the region, especially in the Covid-19 pandemic. However, the ICT use effect in the western region tends to be weaker (p value < 10%) if compared with the previous regression estimation model, while in the eastern region it tends to remain strong (p value < 1%).

Third, tax revenue is strongly influenced by corrupt behavior in the regional government (Safira, 2020). Therefore, this study estimates the effect of ICT use on tax revenues based on the integrity of local government. This is applied to find out whether the use of ICT remains significant in influencing tax revenues in areas with the highest and lowest integrity. Provinces are divided into 2 regions based on the Integrity Assessment Survey (SPI) from the Corruption Eradication Commission (KPK): the highest and lowest SPI ratings. The SPI data used is the SPI for the 2021 period. The higher the SPI index, the more the provincial government has integrity and is far from corrupt practices, and vice versa. The 17 provinces with the highest SPI were declared as provinces with high integrity, and the rest are provinces with low integrity.

Table 9 Effect of ICT Use on Tax Revenues in Provinces with Highest and Lowest Integrity

Variable	Highest Integrity t-statistic (Coefficients)	Lowest Integrity t-statistic (Coefficients)
Constant	0.229268 (0.470468)	-2.057854** (-6.642284)
ICT Use	**3.591010*** **(0.389032)**	**2.249691**** **(0.352143)**
GDRP	8.098908*** (0.823887)	2.499131** (0.573877)
Foreign Direct Investment	0.074182 (0.000879)	1.110422 (0.018485)
Population	-0.135939 (-0.039972)	5.830869*** (1.552756)
Inflation	1.592486 (0.482583)	-0.266474 (-0.117884)
Covid-19	-6.386449*** (-0.066499)	-3.603777*** (-0.058501)

Variable	Highest Integrity t-statistic (Coefficients)	Lowest Integrity t-statistic (Coefficients)
Adjusted R-Square	0.998314	0.994663
F-Statistic	2261.693***	712.6549
Observations	85	85
Number of provinces	17	17

Note: ***)p < 0.01, **)p < 0.05, *)p < 0.1

Source: Data processed from researchers, 2023

In Table 9, it can see that ICT use continues to show a positive and significant influence on tax revenues, both in provinces with high and low integrity. This shows that ICT use continues to provide benefits for tax mobilization, even in areas with low integrity. However, the effect is more significant in areas with high integrity compared to areas with low integrity (p value 1% < 5%) and greater in areas with high integrity than in areas with low integrity (coefficient 0.389 > 0.352).

In the end, tax income is also positively correlated with tax compliance (Monica & Andi, 2019). Therefore, this research divides 34 provinces in Indonesia into 2 regions based on tax compliance. The ICT use was tested for its effect on tax revenues according to tax compliance in the region to see whether the effect of ICT use remained the same in regions with high and low tax compliance. The tax compliance can be measured by tax ratio (Ezer & Ghozali, 2017). The higher the tax ratio, the more obedient regional taxpayers are in paying taxes. In this research, the average tax ratio in 34 provinces in Indonesia for 5 years (2017-2021) is sorted from highest to lowest. The 17 provinces with the highest average tax ratio are classified as compliant provinces, while the rest are classified as non-compliant provinces.

Table 10 Effect of ICT Use on Tax Revenues in Provinces with the Highest and Lowest Tax Compliance

Variable	High Compliance t-statistic (Coefficients)	Low Compliance t-statistic (Coefficients)
Constant	0.166822 (0.458238)	-2.331291*** (-5.452662)
ICT Use	**2.789831***** **(0.317055)**	**2.547653**** **(0.382696)**
GDRP	5.742860*** (0.892716)	3.230110*** (0.513703)
Foreign Direct Investment	-0.442450 (-0.005163)	1.466806 (0.026560)
Population	-0.448706 (-0.164621)	6.394508*** (1.530083)
Inflation	1.452249 (0.540820)	-0.714899 (-0.282544)
Covid-19	-5.331918*** (-0.060724)	-3.554821*** (-0.056553)
Adjusted R-Square	0.998098	0.994527

Variable	High Compliance t-statistic (Coefficients)	Low Compliance t-statistic (Coefficients)
F-Statistic	2005.106***	694.7636
Observations	85	85
Number of provinces	17	17

Note: ***)p < 0.01, **)p < 0.05, *)p < 0.1

Source: Data processed from researchers, 2023

Table 10 explains the ICT use remains consistently showing a positive and significant influence on tax revenues, both in compliance provinces and non-compliance provinces. This proves the ICT use provides benefits in increasing regional tax revenues, even in provinces with low tax compliance.

CONCLUSION

Overall, this research finds empirical evidence that the ICT development in Indonesia can increase regional tax revenues. More specifically, the ICT use plays a greater role in increasing regional tax revenues in Indonesia, if compared with ICT access and infrastructure and ICT skills. This makes sense because ICT use has increased rapidly in recent years along with the digitalization process expansion. Furthermore, the high ICT use also has a positive impact on tax revenues in provinces with low compliance, and in provinces with low government integrity. In addition, ICT use also has a big impact in the western and eastern regions. However, this research found some evidence that ICT use can increase other indicators of local revenue including regional levies.

In terms of policy implications, this research confirms ICT is a relevant tool for mobilizing taxation in Indonesia. The ICT infrastructure must be expanded throughout the region in order for the benefits of ICT on regional tax revenues to truly be felt. Furthermore, it would be good if local governments should also start digitizing taxation by building new technology to modernize the regional taxation system. However, this effort will be great if it is followed by optimal ICT use in the tax administration system.

This research has several limitations. *First*, due to the differences in ICT measurement methods before and after the 2016 period, this research only takes a short research period. Therefore, further research can expand the research period. *Second,* further research can consider other measurements or indicators in the IDI index, especially in the ICT skill. *Third*, further research can also examine the influence of ICT on tax revenue components such as value added tax, income tax and other types of taxes to provide more specific results.

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