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Original Research

The Impacts of Digital Economy on Green Economy: The Indonesian Miyazawa Model

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Abstract

This paper aims to identify the impact of the digital economy, the so-called Information and Communication Technology (ICT) sectors, on output growth, CO_2 emission, and income distribution in Indonesia. These indicators are so-called green economy indicators. The method of analyzing the output and value-added multiplier of the ICT sectors and the impact of ICT sectors on CO_2 emission and income distribution is based on input-output analysis. The multiplier, elasticity, and Miyazawa income distribution analysis will be used. The ICT sectors have high output and value-added multipliers. This condition suggests that any change in the final demand, such as investment in these sectors, will highly impact the output and value-added. Regarding CO_2 emission, the ICT sectors contributed to less emission and are mostly regarded as insensitive to CO_2 emission, except three of the ICT sectors have elasticity above the average. The impact of the ICT development sectors can worsen income distribution. Policy measures should consider the implication of ICT development as the critical sector with the potential impact of worsening income distribution. Therefore, the government is suggested to encourage ICT sectors with extra concern for social inclusivity to achieve a green economy.

Keywords: CO_2 emissions, digital economy, income distribution, input-output analysis, sustainable development

Introduction

Currently, various countries have begun to implement economic development in a sustainable direction. A country's economic development orientation shifts from a brown economy focusing on increasing economic growth to a green economy concentrating on environmental sustainability. A tangible form of concern from various countries for environmental damage is available such as the Paris Agreement. The agreement contains countries' efforts to reduce emissions since 2015 at the United Nations Climate Change Conference. So far, several countries have allocated various stimuli to move towards a green economy. For example, the

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European Union has allocated 30% of its EUR 750 billion stimulus package for green investments [1]. In addition, Germany has also allocated EUR 15 billion for investment in environmentally friendly vehicles [2]. In Indonesia, the government has launched a green economy policy in the 2020-2024 National Medium-Term Development Plan/Rencana Pembangunan Jangka Menengah Nasional (RPJMN) with various emission reduction targets. The green economy is also one of the national economic transformation strategies to achieve Indonesia's 2045 vision and fulfill the Paris agreement. The Indonesian Government can follow the examples of developed countries in providing green economic stimulus. Besides, the Government of Indonesia needs to identify the economic sectors with low emissions in the production process, encouraging them to produce more goods or services. This condition is required since the Government has a limited budget. Therefore, the identification of ICT with low emissions is necessary. In addition, ICT-related sectors significantly impact economic, social, and environmental conditions. This impact is related to the green economy concept.

This paper developed input-output table, consisting of Miyazawa input-output table and energy input-output table so that this study has incorporated energy and emission data per sector. The utilization of these data makes the current study novel compared to other studies related to the ICT sector in Indonesia. In addition, 2016 IO Table is the most recent IO table published by BPS. There are no more recent IO table published by BPS-Statistics Indonesia or any other institutions. Therefore, this study is solely centered to the linkage between ICT sector and economic output/added value, CO_2 emissions, and income distribution, focuses only single year and does not focus on the analysis of the ICT sector over time, so an analysis with a longer temporal scope is not required. Only one period of analysis is sufficient.

One sector in line with the concept of the green economy is the Information and Communication Technology (ICT) sector. The ICT-related sectors have become more critical in recent years, especially in the pandemic era, as physical distancing and human mobility limitations are applied to contain covid 19. Indonesia is one of the most highly populated countries in the world. However, internet penetration is still limited. Therefore, ICT-related sectors contributed to improving economic growth and environmental transformation, including the production process. However, some studies show that ICT-related sectors support economic growth [3-12]. Also, other studies show a reverse impact [13, 14]. ICT-related sectors have positive and negative impacts on environmental matters. Some studies show that ICT-related sectors have positive impacts [15-18]. However, others show that ICT-related sectors have negative impacts [19-22] United Nation Environment Program explains that government policies should focus on the green sectors. Thus, there is a need to determine sectors satisfying the green economy conditions [23]. The present study aims to identify ICT-related sectors to support or meet the criteria of the Indonesian green economy concept. Thus, the industry is expected to have a high multiplier effect on the economy with relatively low elasticity emissions and better income distribution. According to [24], the Leontief Input-Output (IO) model is crucial for structural analysis and is widely used in the global academic community. Technically, this paper develops the standard IO into Miyazawa IO and has a more detailed energy balance to identify ICT-related sectors and support a green economy, promoting sustainable development. Thus, it is expected to provide helpful information for academics and policymakers regarding the priority ICT-related sectors of the green economy. In line with Indonesia's green economy strategies to achieve the vision in 2045, this study will be supplementary material for the Government of Indonesia to draw up solid sectoral policies. Based on previous research, identifying the ICT sector with positive contributions to the green economy using IO in Indonesia has not been performed. The present study fills the gap by identifying Indonesian green economy priority ICT-related sectors. The study contributes to the existing literature as very few studies have focused on developing nations. It used four indicators to identify green economy priority ICT-related sectors. Furthermore, it will contribute to examining the impact of ICT on the green economy in Indonesia by using the comprehensive framework of Input-Output (IO) Miyazawa by detailing household groups and adding energy balance.

This research is expected to provide significant output for researchers and policy authorities through empirical findings and enrich the literature by examining the ICT sectors influencing Indonesia's sustainable growth and development policies. It will be divided into several parts. Section 2 focuses on data models and methodologies. Section 3 presents the results and empirical discussion, while the conclusions and policy implications are presented in Section 4.

The concept of 'sustainable development was first established in the report of the World Commission on Environment and Development (WCEB) or the Brundtland Commission in 1987 entitled" "Our Common Future." It suggests that" humanity can make development sustainable to ensure that it fulfills the current needs without compromising the ability of the future generations to fulfill their own needs" [25].

The United Nations introduced Sustainable Development Goals in 2015, replacing the Millenium Development Goals consisting of 17 goals, including environmentally friendly economic development and environmental development. The United Nations Environment Program defines that a "Green Economy results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" [26]. The definition includes three essential aspects: low carbon, resource-efficient, and socially inclusive. Closely looking at the purpose of “green economy” with the terminology “sustainable development,” the “green economy” is the revival of “sustainable development” in other terms. The essence and purpose of both terminologies are identical.

Green economy policies in Indonesia have been included in the National Medium-Term Development Plan (NMTDP) 2020-2024 document. This document is the foundation of the implementation of National Development, which has 4 (four) pillars: stable political and legal institutions, increasing community welfare, a more robust economic structure, and the realization of preserved biodiversity [27]. The four pillars synergize with each other and are the embodiment of sustainable development.

The Indonesian government ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, the Kyoto Protocol, and the Paris Agreement to support climate change. The commitment is stated in Indonesia’s Nationally Determined Contribution (NDC) of 29% compared to the Business-as-usual (BAU) scenario in 2030 with domestic resources and 41% with international support.

Meanwhile, [28] tried to identify green economy sectors in Indonesia using the ESAM (Environmental Social Accounting Matrix) approach. Their study found eleven sectors satisfying green economy criteria that are agriculture-related. The study did not discuss the role of ICT in driving economic growth and carbon emission, with a significant role in recent years.

The ICT sector requires energy as a driver, so the increasing ICT sector can potentially increase energy use. Increased energy use has the potential to increase carbon (CO_2) emissions depending on the use of the type of primary energy. In several studies in various developed and developing countries, the rising energy use of ICT in multiple sectors of the economy shows a decrease in carbon emissions [29-32]. Meanwhile, some other researchers found that carbon emissions increase with ICT [33, 12]. Therefore, it is necessary to identify what causes the differences in ICT sectors leading to increased carbon emissions.

The impact of ICT on CO_2 emissions varies, some are positive, and some are negative, along with empirical studies showing the positive effects of ICT on CO_2 emissions, such as the findings that ICT benefits developing countries with relatively low incomes [34]. [35] Also, marketing channels through ICT have reduced carbon emissions in emerging markets, as well as the findings in China [30, 32]. The results showed that the impact of the ICT industry on CO_2 emissions contributed to reducing CO_2 spatially, which is more significant in the central region than in the eastern region [30]. On the other hand, [36] identified that many developed countries had reached a higher ICT development level, where CO_2 emissions decrease as tariffs improve. Hence, the positive impacts occurred in developing and developed countries.

Some researchers argued that the use of ICT primarily increased energy consumption and CO_2 emissions, as well as the production of hazardous E-waste and ICT equipment and sizeable global data centers, including the use of mobile data traffic, pose a threat to environmental quality [12, 33, 37]. It seems that the role of ICT sectors has a mixed impact on CO_2 emission, and it is unclear in what condition the ICT reduced CO_2 emission [34]. Many empirical studies demonstrated the impact of ICT on income distribution, revealing that income inequality has increased in most OECD countries over the past few decades, especially the income share of 1% [38]. They explained that the growing importance of digital innovation in new products and processes based on software code and data had increased market rents, disproportionately benefiting top-income groups. Meanwhile, [39] found that there has been a polarization of middle-class incomes and the poor against the upper class in the United States. It is estimated that the middle class will shrink or disappear by 2050. On the other hand, some empirical findings demonstrated that the impact of ICT improved income distribution in Central European countries. They also argued that the United Kingdom had achieved a level of development and redistribution in the economy so that changes in labor productivity are not significantly associated with deepening income inequality [40]. The more economically developed a country is, the less impact on income inequality can be initialized by technological change. Case studies in Indonesia do not explain the problem of inequality, only indicating reducing poverty due to the creation of income as a result of transforming from a conventional economy into a digital economy [41]. However, [28] provided helpful insight regarding income distribution in their paper, discussing income distribution in the green economy. They used the Theil index to measure income distribution due to final demand change and found that most agricultural sectors improved income distribution if they became leading sectors [28]. Therefore, the impact of ICT and technological change is mixed. It is unclear in what condition ICT and technological change worsen income distribution. Research to measure the ICT impact on CO_2 emission and income distribution will benefit policymaking.

Material and Methods

The ICT sector in this research is based on the OECD definition of ICT [42]. Many researchers have used this definition of ICT [43-45]. However, the present authors extended to include sectors that heavily relate to ICT-related industries, such as printing and publishing. In the current IO table, the sectoral classification is too broad, and some of the sectors are only in the subsector of ICT sectors, such as Printing, and Publications, Commerce. The ISIC has 4 digits, including Printing, Publications, and Business Services [46]. Based on those classifications, the ICT-related sectors in Indonesia’s Input-output Table 2016 are as follows:

No. Sectors	Sectors
27	Printing and publishing
44	Oth. elect. machn. and apprts
48	Precision instruments
56	Commerce
64	Postal and telecomnc. serv.
67	Business services

Input-output analysis is one of the proper analytical tools to identify the interrelationships between sectors in the economy. It can locate sectors with forwarding and backward linkage, focusing on the ICT sectors. Besides, the input-output analysis also identifies vital economic sectors to determine development strategies by looking at industries with a high output multiplier.

The basic equation of the I-O matrix is as follows:

$$AX + Y = X \quad (1)$$

Where A is the n x n Leontief matrix with each element in the A matrix, a_{ij} represents the amount of sector I (row sector) production used as an intermediate input in the production of sector j (column sector) output.

$$A_{ij} = X_{ij}/X \quad (2)$$

Where *xij* is the value of the flow of goods or services from sector *i* to sector *j;*

Technology Coefficient Matrix (A)

The technological matrix is the aij cells, where the value is:

$$aij = xij/Xj \quad (3)$$

with aij = technology coefficient
xij = flow from industry i to j
Xj = total input for the sector j

Each column of matrix A indicates the composition of the use of inputs in sector i production processes, reflecting the technology used by that production sector. The IO analysis follows Leontief's production function, a constant return to scale.

Leontief Inverse Matrix (B)

Leontief inverse matrix is bij cells, where the value is:

$$B = (I - A)^{-1} \quad (4)$$

$$bij = (I - A)^{-1} \quad (5)$$

bij = Leontief inverse coefficient
xij = flow from industry i to j
Xj = total input for sector j

Each column of matrix B indicates the composition of the inverse of identity matrix (I) minus technology matrix (A matrix). In other words, the Leontief inverse matrix is the so-called multiplier that calculates direct and indirect effects due to initial shock in production processes [47].

Analysis of Inter-Sector Relations

Relatedness analysis was initially developed by [48] and [49] to look at interrelationships between sectors, primarily to determine development policy strategies. There are two known types of interrelationships, namely (1) backward linkages, which are related to raw materials and calculated according to columns, and (2) forward linkages which are the linkages of sales of finished goods and are calculated by row. Both backward and forward linkages have two impacts, namely direct impact and indirect impact, which, in the form of mathematical formulas, can be written as follows (see [50]):

	Model Open I/O	Model Close I/O
Early impact =	1	1
Direct impact =	Σa_{ij} (6)	Σa_{ij}^* (7)
Indirect impact =	$\Sigma b_{ij} - 1 - \Sigma a_{ij}$ (8)	$\Sigma b_{ij} - 1 - \Sigma a_{ij}^*$ (9)
Total impact =	Σb_{ij} (10)	Σb_{ij}^* (11)

aij and *aij** are direct input *coefficients; bij* and *bij** are Leontief inverse matrix coefficients;
*calculation includes wages and salary row and Household consumption column in the model.

Multiplier Analysis

The matrix multiplier or Leontief Inverse Matrix is a matrix composed of $(I-A)^{-1}$ or also often named matrix B. This matrix determines how the output occurs if there is a change in the final demand.

Output Multiplier

The Output Multiplier analysis aims to determine the impact of changes in the final demand of a sector on all sectors existing for each unit of change type multiplier. The increase in final demand in sector j will increase the production output of sector j and the output of other economic sectors. The rise in the production of different sectors is created due to the direct and indirect effects of the increase in the final demand of sector j [50]. Thus, the formula of the total output multiplier (production) is as follows:

$$\text{Output Multiplier type I } O_j = \sum_{i=1}^{n} b_{ij} \quad (12)$$

$$\text{Output Multiplier type II } O_j * = \sum_{i=1}^{n} b_{ij} * \quad (13)$$

Where:
Oj and Oj*: a multiplier of sector j output at open and closed I-O

bij: Leontief inverse matrix
bij* is the Leontief inverse matrix in the Close I/O model where one column is added for the *share* of household consumption and one row for the wage and salary section per sector (condenses the consumption variable) i = rows 1, 2, ... n

$$E = \sum_{i=1}^{n} Vn + 1_i\ (bij)\ E = \frac{\sum_{i=1}^{n} Vn + 1_i\ (bij)}{Vn + 1ij} = \frac{\sum_{i=1}^{n} Vn + 1_i\ (bij)^*}{Vn + 1ij} \tag{14}$$

Elasticity Analysis

The elasticity by [51] reveals the increase in the percentage of emission in sector i (to total emission) in response to a 1% increase in value-added produced in sector j and can be interpreted as elasticity. The equation is as follows (for detail of the formula, see [51]):

$$E^v = \hat{g}(I - A')^{-1}\hat{s} \tag{15}$$

The characteristic of matrix element Ev, Evij, is the percentage increase of emission in sector i (to total emission) responding to a 1% increase of value-added produced in sector j.

Parameter and variable are as follows:
x: (n x 1) total production vector.
v: (n x 1) valued added vector.
A: (n x n) technical coefficient matrix.
s: (n x 1) value-added coefficient matrix. This condition shows the relationship between the value-added of sector i (vi) and the production of sector i; that is, vi/xi.
u: (n x 1) unitary vector.
c: (n x 1) vector of sectoral direct emissions.
C: a scalar that shows the level of total CO_2 emission
g: CO_2 coefficient
^: diagonal vector, thus, denotes a matrix whose out-of-the diagonal elements are zeros.
(‘) transpose matrix or vector.

The sum of column sector $\Sigma_i^n \Sigma^v_{ij}$ j is the percentage variation in CO_2 emission in the economy due to a 1% growth of value-added in sector j (total impact). The sum of each sector emission (direct effect) $\Sigma_i^n \Sigma^v_{ij}$ reveals that the sectoral distribution emission and an indicator of a 1% increase in real impact can affect the emission of each sector (direct hit).

Miyazawa Input-Output Model

The present study will divide income groups in the value-added row or primary inputs that are initially one household group into 10 groups using SAKERNAS and SUSENAS data. The wage and salary rows will be divided into 10 income groups. Meanwhile, the household consumption columns will be divided into 10 columns of household consumption. The exact method to calculate income distribution impact can be seen in [52]. Thus, there will be an analysis of the effects of the shock on potential income inequality, especially related to the digital sector of the economy. The impact analysis will determine which income groups benefit the most due to the development of critical digital economy sectors.

Data in this study are based on Input-output Tables, including energy row, employment row, wages/and salary, and household consumption divided into deciles for rural and urban areas in 2016 for 73 sectors. BPS processes this Table.

Carbon (CO_2) emission calculation is based on the energy consumption of the respective sector converted into CO_2 emission depending on the type of energy used.

Results and Discussion

The Multiplier of ICT and Non-ICT

The figure shows the values of the output multipliers for various sectors of the Indonesian economy, with three ICT sectors that have output multipliers above the average. This high multiplier on ICT sectors indicates that these sectors provide a high output impact if there is an increase in final demand, such as investment and household consumption, including exports. In contrast, many sectors in the Non-ICT industries have high output multiplier. Some of these sectors are meat and meat products, rubber products, tea and coffee, knitting, thermal power, dairy products, leather and leather products, and other foods. Most of these sectors can be regarded as food and fiber manufacturing sectors, except thermal power. Those sectors have a less elastic income elasticity of demand, meaning that these sectors are not sensitive to the increase in income; in other words, the rise of 1 percent income causes less than 1 percent demand. The case is similar to those in Croatia and India, with a high multiplier of ICT sectors [43, 53]. In Indonesia, the ICT sectors having a value-added multiplier above the average are two, Printing and publishing and oth. elect. machn. and apprts, and precision instruments. However, other sectors in ICT that can be regarded as having high multipliers is the Business services sectors because the value of the multiplier is very close to the average.

CO_2 Emission Elasticity of ICT and Non-ICT

ICT-related sectors consisting of six sectors only contributed to 5.85% of the total CO_2 emission. Each ICT sector has less than 1% except Commerce which contributed 3.38%. The elasticity of CO_2 emissions is above the average for only 3 sectors in the ICT group, namely Commerce, Business services, and Postal and

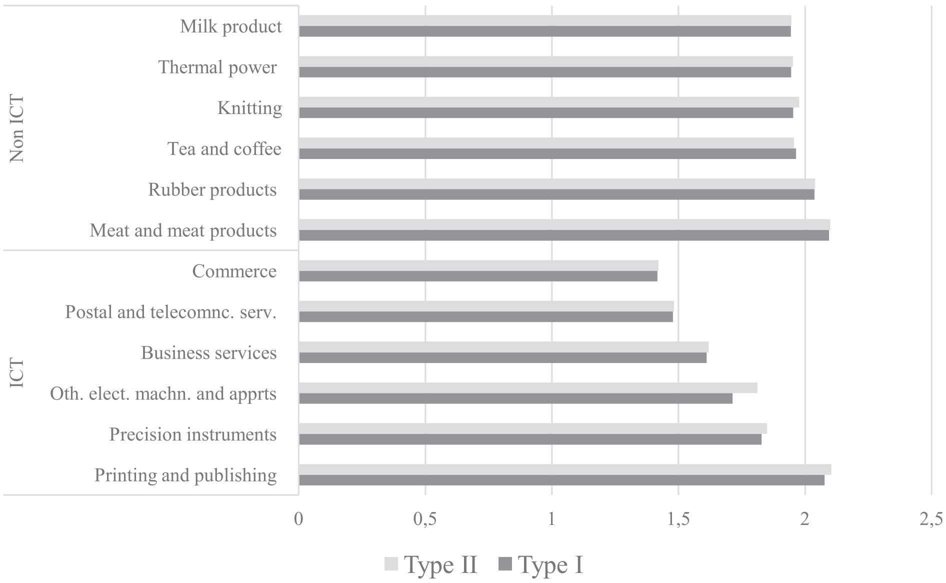

Fig 1. Output Multipliers of ICT and Non-ICT (the top six sectors).
Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors; Equations 17 and 18.

telecomnc. serv. For example, the elasticity of CO_2 emission in Commerce is 0.0879, meaning that if there is a 1% increase in value-added, the CO_2 emission will increase by 0.0879%.

The elasticities of the other three sectors are below the average, meaning that the ICT sector does not have the potential to provide high emissions when developed because only three sectors have elasticity above the norm. Moreover, the most significant contributor to CO_2 emissions, namely the Commerce sector, only accounts for about 3% of the total CO_2 emissions. The rest of the industry did not reach 1%. Thus, the ICT sectors have less potential to create high CO_2 emissions if chosen as future leading sectors.

Meanwhile, the Non-ICT sectors having elasticity above the average (CO_2 emission) are fifteen. These sectors are predominantly heavy metal manufacturing, plastic, and cement. These sectors have the highest elasticity. They also contribute to approximately 75% of total CO_2 emissions. Therefore, these sectors are the most sensitive or highly elastic with high CO_2 emissions. The elasticity of CO_2 emission on other fabricated metal products is 0.2408, meaning that if there is an increase of value added by 1%, the CO_2 emission of Other fabricated metal products will increase by 0.2408%. Besides, [28] also found that Commerce has a high carbon emission multiplier meaning that this sector provides high carbon emissions when shocks

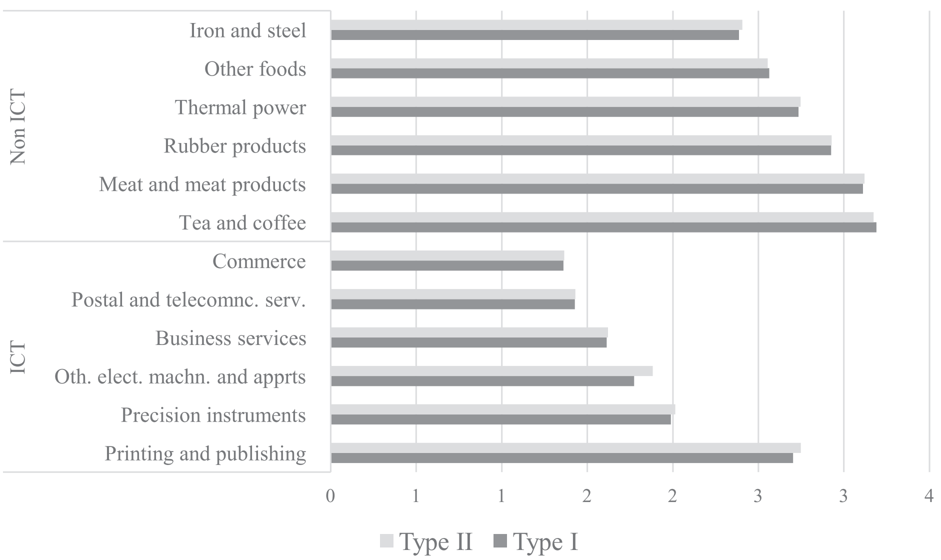

Fig 2. Elasticity of CO_2 Emission Due To Value Added Changes*.
Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors; * Equation 22.

occur in final demand. Therefore, it is unsurprising that Commerce has sensitive carbon emissions due to final demand or value-added change. Meanwhile, Indonesia has an upward trend in export carbon emission intensity due to the product manufacturing of computer, electronic and optical products, signifying that the export technology of its ICT manufacturing sector has not yet shown much carbon emission reduction potential [54].

The Impact of Investment on ICT-Related Sectors and Income Distribution

Fig. 3 shows the impact of investment in ICT-related sectors on household income. The simulation results show that the higher the income level, the higher the income effect, especially for a household with the highest income level (decile 10). Rural households in the top 10% income rise around 0.5 million IDR from the 6 million ICT investment. In comparison, the whole 10% urban household significantly increases by about 1.2 million IDR from the same investment. Comparing the top 10% income level effect with other households, the product is visible in decile 10, especially in urban areas. The result supports the argument that ICT investment may increase income inequality in urban and rural areas [55]. This phenomenon is not unusual as it happened in OECD and developed countries with digital innovation causing the worsening of the income distribution [38, 39, 40].

Comparing rural and urban households, urban household income rises higher than rural households at all income levels. A high-income household has sufficient education and skills to be employed in the ICT-related sectors compared to a low-income household. Thus, it is logical that the respective household got the highest effects, especially considering the accessibility of urban and high-income households to the ICT-related sectors compared to rural households.

Fig. 3 shows the impact of ICT-related sectors. In summary, there are two findings according to the figure. First, all ICT-related sectors show that the highest income group received more benefits than the lowest household income in rural and urban areas. The impact also indicates that households with the most insufficient income have minimal effect in both areas for all ICT-related sectors. ICT is highly required for a household with higher income in all related sectors as this group tends to have busier activities, and the world is heavily connected through ICT. This condition applies to all ICT-related sectors.

The following Figure shows that the three ICT-related sectors, determined mainly by ICT development in urban areas, are precision equipment, printing and publishing, and business services. On the other hand, the most beneficial sector of ICT investment in a rural areas is business services. This result can be found in both regions' online shopping activities in Indonesia. Besides, business services and Commerce increase the benefit by 23.40% and 18.43%, respectively, due to the increase in Final Demand such as Investment or Exports.

Second, the impact can also be more significant in urban areas than rural ones. Besides, the impact gap between both regions is substantial in all sectors for households with the highest income level. Rural areas do not have many high-tech sector workplaces that require ICT development compared to urban areas. Therefore, ICT development is less impacted. However, the lowest income in both areas has a similar impact.

Examining the impact proportionately with the shock of each sector by Rp1 million, the impact on various sectors can be seen in decile income groups 1

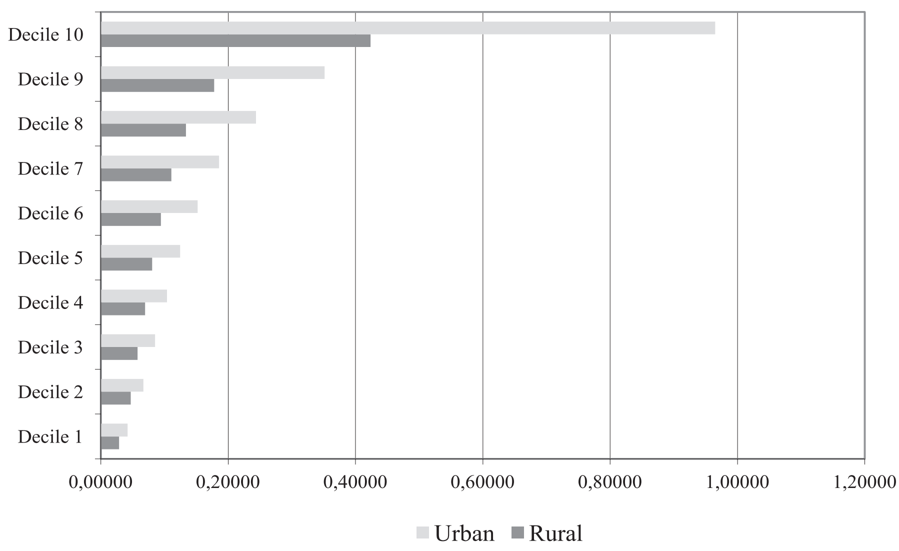

Fig 3. The Impact of Investment on ICT Related Sectors by Rp 1 million to Income Group.
Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors.

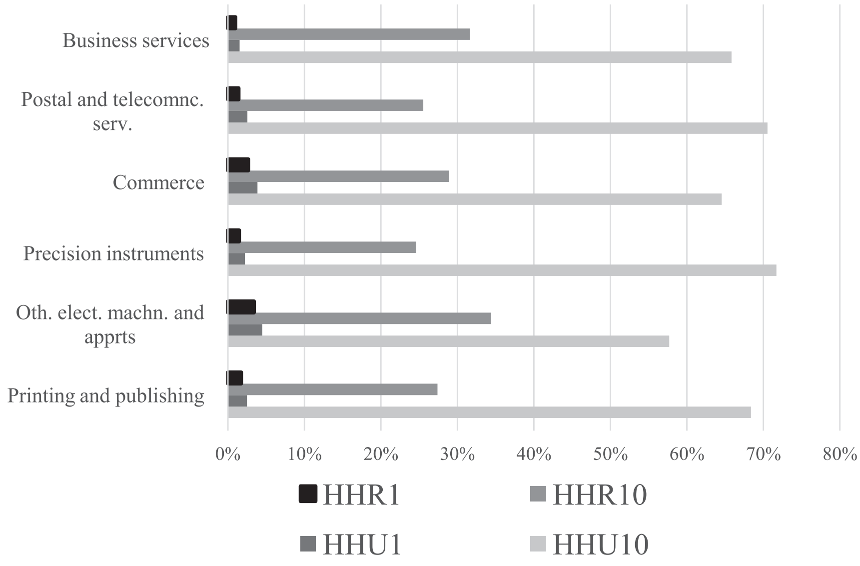

Fig 4. The Recipient Income Group Benefit of the Final Demand Change of Each ICT related Sectors by IDR 1 million in Urban and Rural Areas (Percent). Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors. HHU = Household in Urban Areas, HHR = Household in Rural Areas

Table 1. Criteria of Green Economy on Economic and Environment Indicators.

Sector	Output Multiplier Type 2*	CO_2 Emission Elasticity**
Printing and publishing	2.1037	0.001757
Oth. elect. machn. and apprts	1.8495	0.006180
Precision instruments	1.8125	0.001039
Commerce	1.6199	0.087929
Postal and telecomnc. serv.	1.4819	0.014758
Business services	1.4211	0.032211
Average of all sectors	1.6732	0.013699
Standard Deviation of all sectors	0.2278	0.031968

Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors; Equations 13 and 15.
*the value > the average is dot grey
**the value < the average is light grey

and 10. The sectors that have minimal impact on the increasing income inequality are the Other sectors elect. machinery. and apparatus and Commerce providing benefits of about 58% and 65%, respectively, in urban areas. Likewise, these sectors have minimal impact on rural areas because the decile group of 10 only gets 34% and 29%, respectively. For urban areas, in decile income group 1, Other. elect. machinery and apparatus and Commerce also have higher benefits than those of other sectors, 4.5% and 3.9%, respectively. This proportion is much higher compared to that of different sectors. This condition means that these two sectors, other sectors. elect. machn. and apparatus and Commerce provide less income inequality if these two sectors become an engine of growth compared to other ICT-related sectors for urban and rural areas.

A summary of sectors that fulfill the green economic criteria based on various indicators previously discussed can be seen in Tables 1 and 2. The tables show that none of the ICT-related sectors

Table 2. Criteria of Green Economy on Social Inclusiveness Indicators.

Sector	Income Rising due to Final Demand shock by Rp 1Million in respective sectors			
	HHU10	HHU1	HHR10	HHR1
Printing and publishing	68.36%	2.49%	27.40%	1.74%
Oth. elect. machn. and apprts	57.68%	4.51%	34.39%	3.43%
Precision instruments	71.70%	2.21%	24.61%	1.47%
Commerce	64.54%	3.87%	28.92%	2.68%
Postal and telecomnc. serv.	70.53%	2.54%	25.53%	1.40%
Business services	65.83%	1.54%	31.63%	1.00%

Source: BPS, IO Energy Miyazawa Table, 2021, calculated by Authors;

meet all green economic criteria. Therefore, choosing ICT-related industries that can be used as leading sectors in boosting economic growth with low-carbon emissions and reducing income inequality is challenging. In making policies to develop ICT-related sectors, the choice is to create several ICT-related sectors with minimal impacts along with other policies to mitigate the unwanted effects.

Conclusions and Policy Implications

The role of ICT sectors is relatively small, ranging from 12-16% in terms of final demand, intermediate output, and output. However, its contribution in terms of employment is almost 20%. This amount is significant because the ICT sectors only consist of six industries. Besides, the contribution of CO_2 emission to the ICT sectors only represents 5.38% of the total emission.

The ICT sectors have high output and value-added multipliers regarding the multiplier effect. This condition indicates that any change in the final demand, such as an investment in these sectors, will cause a high impact on value-added.

In terms of CO_2 emission, the ICT sectors contributed to less emission and are mostly regarded as the sectors insensitive to the CO_2 emission, except three of the ICT sectors that have elasticity above the average, including Commerce which contributed to 3% of the total emission. The rest of the three sectors have less than the average CO_2 emission elasticity.

Unfortunately, the impact of the development of ICT-related sectors can worsen income distribution if any positive change in final demand occurs. For example, any investment in ICT-related sectors will create unequal income distribution. The highest decile income group benefited from any positive change in final demand for rural and urban income groups, the top gainer in the top decile of the urban income group.

– Policy measures should consider the implication of developing ICT sectors as some critical sectors potentially impact worsening income distribution. Therefore, the government is suggested to encourage ICT sectors as drivers of sustainable economic growth. However, the government needs to pay attention to the ICT sector by considering several policy strategy options, namelyGiven that the ICT sector contributes to the creation of an unequal distribution of income, there needs to be a supportive policy strategy to reduce uneven distribution, such as the massive exposure of ICT to micro, small and medium enterprises.
– Regarding the ICT sectors that are still contributing to increased emissions, such as Commerce, it is necessary to consider encouraging these ICT sectors to make energy-efficient or promote energy use with low carbon content.

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Conflict of Interest

The authors declare no conflict of interest.

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