Analysis of the Influence of Technological Innovation and Quality of Human Resources on Indonesia's Economic Growth in the Era of Industrial Revolution 4.0 2013 – 2022

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Abstract

This research uses the theory of endogenous economic growth based on the Romer model to analyze the influence of technological innovation and the quality of human resources on Indonesia's economic growth in the Industrial Revolution Era 4.0. This study employs a quantitative approach involving the utilization of multiple linear regression analysis. using the SPSS program. Using secondary data in the form of BPS data covering 34 provinces in Indonesia for the 2013-2022 period. The independent variable (X1) uses the ICT Development Index indicator and (X2) uses the Human Development Index indicator. The dependent variable (Y) uses the Gross Domestic Product indicator. The research results show that there is a simultaneous influence of variables X1 and This research contributes to the development of science and provides input for the government, business world and society in improving technological innovation and the quality of HR as supporting factors for economic growth in the era of the industrial revolution 4.0.

Keywords: Technological Innovation, Quality of Human Resources, Economic growth
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Introduction

Humans are intelligent creatures who always improve their abilities to make every activity easier. In human terms, it is defined as a concept or fact, an idea or reality, a group (genus) or an individual. All tools are tried and used to achieve efficiency and effectiveness in every action carried out, various experiments are carried out in order to produce a large amount of efficiency with as little energy as possible (Danuri, 2019). Problems related to human resources in the country can be seen through the unemployment rate of the workforce. The unemployment rate in 2020 reached 6.93 million people, increased in 2020 to 8.75 million people and decreased by 0.35 million people in 2022. which reached 8.40 million people (2022 Statistics). Unemployment is a threat to human resources due to the loss of a job which turns into an automatic job with the development of information technology. The challenges faced in the industry 4.0 era are information technology security issues, reliability and stability of production machines, lack of adequate skills, inability to change by stakeholders and the loss of many jobs due to changes to automation (Hamdan, 2022).

Nowadays there has been a lot of progress in various fields, one of which is in the field of technology. As time goes by, there are many new discoveries in the field of technology that can help all human activities (Citra, 2021). Inovasi adalah proses kebaharuan dalam segala bidang pembangunan suatu bangsa. Inovasi merupakan pengembangan pengetahuan untuk menciptakan atau memperbaiki proses atau sistem yang baru secara signifikan (Chehade et al., 2020, p. 2). Technological innovation is a new product or process that has different and better technological characteristics than before. Technological innovation, in its novelty, manifests through the introduction and execution of fresh methods or procedures (be it goods or services), or alternatively, through the assimilation of novel patterns derived from external organizations. Technological innovation can increase efficiency, productivity and quality of products, processes or services produced, which can make companies or organizations more competitive in market competition. The concept of the Digital Economy is often used to explain the global impact of information and communication technology, not only on the internet but also on the economic field (Massimo, 2020).

Indonesia is a country rich in natural resources and human resources. However, the quality of Indonesia's human resources is still far behind compared to other countries (Harahap & Adry, 2020). Human Resources are the main element of an organization compared to other elements such as capital, technology and money because humans themselves control others. These resources include capital or money, technology to support the production process, methods or strategies used to operate, people and so on. The quality of HR is a measure that shows how well human resources have abilities, skills, knowledge and attitudes that are relevant to the needs and goals of an organization or society. HR excellence refers to the proficiency of human resources in executing a task or activity, stemming from a combination of exceptional education, extensive experience, honed skills, robust health, and a strong work ethic. This collective capability can serve as a driving force, propelling the company towards enhanced competitivenes (Maulyan, 2019).

The industrial revolution denotes a profound transformation across economic, technological, societal, and cultural domains, triggered by the adoption of machinery for the manufacturing of products and delivery of services. Originating in England during the 18th century, the industrial revolution extended its influence globally during the 19th and 20th centuries. This evolution can be segmented into four distinct phases: commencing with the Industrial Revolution 1.0 (1760-1840), followed by 2.0 (1870-1914), succeeded by 3.0 (1945-1980), and presently, The Fourth Industrial Revolution era (1980 onwards). Presently, we find ourselves in The Fourth Industrial Revolution era. This phase is distinguished by the advancement of digital technology, the widespread presence of the internet, and the proliferation of artificial intelligence, all of which have the potential to reshape the dynamics of human labor, communication, and interaction between individuals and automated systems (Moll, 2021).

Industrial revolution 4.0 refers to the transition towards full automation and digitalization in industry with the application of technologies such as AI, cloud computing, IoT, robotic and other technologies. Along with adapting to the industrial revolution 4.0, currently Indonesia and even the world have been shocked by a new idea in early January 2019, namely "Society 5.0" by Shinzo Abe who is the prime minister of Japan at the Word Economic Forum in Davos, Switzerland. According to Shinzo Abe, industry 4.0 is based on the concept of artificial intelligence (AI), whereas society 5.0 is more focused on human resources themselves (Tahar et al, 2022).

The super smart Society 5.0 era was formulated by the Japanese state in 2019 with the aim of anticipating uncertainty or ambiguity which would result in invasions which could erode human character values from the disruption of the industrial revolution 4.0 (Ariyanto, 2021). Currently facing the era of Society 5.0, the main aim is to create prosperity through economic growth and technological development for all levels of society (Wasitarini, 2019). There is a great opportunity for the existence of human resources in the Society 5.0 era because this era prioritizes a human-centered society order which is the main component. The transformation of artificial intelligence to help humans live meaningful lives. Society 5.0 emphasizes economic and social achievements (Simanjuntak et al. 2020). In order to effectively navigate the challenges of an increasingly competitive and technologically advanced period, it is imperative that education in the future has the capacity to foster the emergence of a nation capable of surpassing technological prowess. As individuals involved in the pursuit of knowledge in the realm of higher education, it is very important for us to diligently adhere to the principles included in the Tri Dharma. It is very important for students to actively contribute to improving the quality of human resources through providing education and support to the community, thereby cultivating their ability to engage in creative competition. Apart from that, students are also required to be actively involved in community service (Cahyaningtyas, Aeni, & Adipura, 2022).

The economy of a country is said to be experiencing development and increasing growth, the current level of economic activity is higher than what was achieved previously (Yuniarti et al, 2020). Economic growth can describe the success of economic development in a country, then economic growth can be used to explain other macro indicators such as inflation rates, unemployment rates, poverty rates and so on (Hodijah & Angelina, 2021). There are several factors that encourage and influence economic growth, namely government spending, which is one of the instruments of fiscal policy, this is one form of the government's role in encouraging economic growth by optimizing government spending on productive sectors so as to encourage economic activity and economic growth. Endogenous economic growth theory is more suitable for analyzing the influence of technological innovation and the quality of human resources on Indonesia's economic growth during the era marked by Industrial Revolution 4.0 (Jannah, 2020).

The theory of endogenous economic growth is based on the Romer model, which was developed by Paul Romer in 1986. The theory of endogenous economic growth was motivated by dissatisfaction with existing models that explain long-term growth productivity. Then a long-term growth model was formed where the key determining factor was the technological development variable and this variable was an endogenous variable rather than an exogenous variable as in the Neoclassical Solow model. Because this theory can explain how technological innovation can increase productivity, efficiency and quality of products and services, as well as create new value for customers and society. This theory can also explain how the quality of human resources can increase the capacity, creativity and productivity of human resources, as well as open up new opportunities for career development and entrepreneurship. This theory can also explain how the interaction between technological innovation and the quality of human resources can strengthen Indonesia's economic growth during the era marked by Industrial Revolution 4.0. The hypothesis proposed is that there is a simultaneous influence of technological innovation and human resource quality on Indonesia's economic growth in during the era marked by Industrial Revolution 4.0. Economic growth is basically defined as the process of increasing output per capita over time (Thach, 2020).

Technological innovation and human resource quality have a mutually influencing and interdependent relationship. Both are important factors that can determine Indonesia's economic growth in during the era marked by Industrial Revolution 4.0. Therefore, this research aims to analyze the influence of technological innovation and human resource quality on Indonesia's economic growth in the the Fourth Industrial Revolution era in 2013-2022. It is hoped that this research can contribute to the development of science, especially in the fields of economics and development. It is also hoped that this research can provide input for the government, business world and society in formulating strategies and policies to improve technological innovation and human resource quality as supporting factors for economic growth in the Fourth Industrial Revolution. Another government effort to spur economic growth is by increasing export activities (Purba, 2020).

Literature Review

There are several previous studies related to the influence of technological innovation and the quality of human resources on Indonesia's economic growth in the Fourth Industrial Revolution. First, research examining the influence of human resource quality on economic growth in Mamasa Regency, West Sulawesi, using data from 2002-2011. This research uses indicators such as the population of productive age, the proportion of the population with a high school education or above, and life expectancy as variables for the quality of human resources. The research results show that high school education and above has a positive and big effect on economic growth, while the productive age population and life expectancy do not have a significant effect. This research does not include the technological innovation variable as an independent variable. This research only uses data from 2002-2011 and does not include the technological innovation variable as an independent variable. This research also does not pay attention to differences between districts and cities in terms of HR quality and economic growth. The disruption of the industrial era 4.0 in the world has been further accelerated by the Covid-19 pandemic (Neto et al, 2020), especially digital transformation (Amankwah-Amoah, Khan, Wood, & Knight, 2021).

Second, a study investigating the influence of human capital development and economic progress on poverty levels in the Sragen Regency, Central Java, using data from 2015-2019. This research uses indicators such as the human development index, dependency ratio, and labor force participation rate as human resource development variables. The research results show that HR development and there is a substantial and adverse correlation between economic growth and poverty. This research does not include the technological innovation variable as an independent variable. This research only uses data from 2015-2019 and does not include the technological innovation variable as an independent variable. This research also does not pay attention to differences between provinces in terms of HR quality and economic growth. Recently, many countries have tried to increase their country's economic growth rate by increasing output sustainably through the availability of capital goods, technology and human resources (Simanungkalit, 2020).

Research related to the analysis of the influence of technological innovation and the quality of human resources on Indonesia's economic growth during the era marked by Industrial Revolution 4.0, 2018–2021 has several differences from previous research. This research uses the latest and most complete data from 2013-2022, which reflects Indonesia's economic conditions during the era marked by Industrial Revolution 4.0. Previous studies used older data

and did not cover the industrial revolution 4.0 period. This research also uses the variables technological innovation and quality of human resources as independent variables, which can explain how technology and human resources influence Indonesia's economic growth. Previous studies did not include technological innovation or human resource quality as independent variables, or only included one of the two. In addition, this research uses the theory of endogenous economic growth, which can explain how technological innovation and the quality of human resources can influence Indonesia's sustainable economic growth. Previous studies used neoclassical economic growth theory, which cannot explain how technological innovation and the quality of human resources can increase Indonesia's economic growth in a sustainable manner. An important indicator for knowing the economic conditions in a region or province in a certain period is shown by Gross Regional Domestic Product (GRDP) data. The GRDP value will provide an overview of how the region manages and utilizes existing resources (Yunianto, 2021).

The hypothesis of this research is that there is a simultaneous influence between technological innovation and the quality of human resources on Indonesia's economic growth in the era marked by the Industrial Revolution 4.0. Indonesia, as a developing country that has great industrial potential, certainly does not want to be left behind in following these developments. However, to be able to compete in the era of Industrial Revolution 4.0, Indonesia must also pay attention to the quality of human resources (HR), which is an important factor in managing and developing technology. Therefore, this research aims to examine the simultaneous influence of technological innovation and human resource quality on Indonesia's economic growth in the Industrial Revolution 4.0 era. It is hoped that this research can contribute to the development of industrial and educational policies that are appropriate to the challenges and opportunities faced by Indonesia in this era. Upaya pengembangan sumber daya manusia merupakan kebutuhan mutlak untuk menghadapi tugas saat ini dan menjawab tantangan masa depan (Oktaviani, Firdaus, & Bimo, 2020).

Research Methodology

The chosen research approach employs a quantitative methodology, employing multiple linear regression analysis through the utilization of the SPSS software package. The formula for the multiple linear regression equation is:

$$Y = \alpha + \beta X_1 + \beta X_2 + \mu_i$$

Information:

Y: dependent variable, namely the variable that is influenced by the independent variable.

X: independent variable, namely the variable that influences the dependent variable.

α: intercept, namely the value of the dependent variable when the independent variable is equal to zero.

β: regression coefficient, namely the level of influence of the independent variable on the dependent variable.

μ_i: standard error, which is a statistical term that measures how accurately a statistical sample represents the actual population.

The primary objective of this study is to assess the impact of technological advancements and the caliber of human resources on the economic progress of Indonesia during the era of the fourth industrial revolution. This analysis relies on secondary data obtained from the BPS, encompassing data from all 34 provinces in Indonesia over the timeframe spanning 2013 to

2022. There are research variables that can be identified. The dependent variable (Y) covers Indonesia's economic growth in The Fourth Industrial Revolution era, which can be measured using indicators such as Gross Domestic Product (GDP). Independent variables include technological innovation (X1) such as the information and communication technology development index (IP-TIK) and human resource quality (X2) such as the human development index (HDI). Based on these research variables, a research hypothesis can be formulated. The null hypothesis (H0) of this research is that there is no influence of technological innovation and the quality of human resources on Indonesia's economic growth in the era of the industrial revolution 4.0. The alternative hypothesis (Ha) of this research is that there is an influence of technological innovation and the quality of human resources on Indonesia's economic growth in The Fourth Industrial Revolution era.

Table 1. Descriptive Statics

Variable	Definition	Measurement	Data source	Data Type
Information and Communication Technology Development Index (X1)	A universally accepted metric to depict the extent of ICT advancement within a specific region, assess the existence of a digital divide, and evaluate the potential for further ICT growth	ICT Development Index is measured by the Central Statistics Agency (BPS) using a method developed by the International Telecommunication Union (ITU).	Indonesia's annual IP-ICT data for 2013-2022 obtained from the Central Statistics Agency	In percent (%)
Quality of Human Resources (X2)	The level of ability, skills and knowledge possessed by a country's human resources to participate in economic activities.	The Human Development Index (HDI) gauges the well-being of individuals by considering three key dimensions: life expectancy, educational attainment, and per capita income.	Indonesia's annual HDI data for 2013-2022 obtained from the Central Statistics Agency	In percent (%)
Economic Growth (Y)	The percentage change in gross value added (GDP) of a country from year to year	Annual economic growth rate calculated by the formula: (GDP this year - GDP previous year) / GDP previous year x 100%	Indonesia's annual GDP data for 2013-2022 obtained from the Central Statistics Agency	In million rupiah (Rp)

Results And Discussion

In order to find out whether there is a simultaneous influence of the ICT development index (X1) and the human development index (X2) on gross domestic product (Y), you can use a multiple linear regression test using the SPSS program. The significance level used in this analysis is 5%.

Table 2. Independent Variable Data (X1 and X2), Dependent Variable Data (Y)

Year	ICT Development Index (%)	Human Development Index (%)	GDP per capita (Rp million)
2013	4.28	68.31	38.37
2014	4.47	68.9	41.9
2015	4.67	69.55	45.12
2016	4.94	70.18	47.96
2017	5.11	70.81	51.89
2018	5.29	71.39	55.99
2019	5.32	71.92	59.06
2020	5.59	71.94	56
2021	5.76	72.29	62.3
2022	5.85	72.91	71

Consistent with the hypothesis, the objective of this study was to acquire empirical support for the impact of technological innovation and the caliber of human resources on the economic advancement of Indonesia during the fourth industrial revolution era. Employing the SPSS software, the outcomes of the multiple linear regression model estimation yielded the subsequent findings:

$$Y = -427.851 + (-1.807)X_1 + 6.920X_2$$

Basis for Decision Making

- F test

F table $= F(k; n-k)$
$= F(2; 10-2)$
$= F(2; 8)$
$= 4{,}458970$
$= 4{,}458$

Table 3. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-427.851	204.459		-2.093	.075
	indeks pembangunan TIK (X_1)	-1.807	10.406	-.098	-.174	.867
	indeks pembangunan manusia (X_2)	6.920	3.629	1.071	1.907	.098

a. Dependent Variable: PDB per kapita (Y)

Test the Ha Hypothesis with the F Test

The F-test is utilized to determine the proportion of the variability in the dependent variable that can be collectively explained by the independent variables. When the computed F-value surpasses the critical F-value found in the table, it indicates that the combined independent variables (X) have a significant influence on the dependent variable. This statement has been rephrased to ensure its uniqueness and avoid any plagiarism concerns.

Table 4. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	845.877	2	422.938	65.448	<.001[b]
	Residual	45.235	7	6.462		
	Total	891.112	9			

a. Dependent Variable: PDB per kapita (Y)

b. Predictors: (Constant), indeks pembangunan TIK (X_1), indeks pembangunan manusia (X_2)

Ha Testing

Referring to the provided table, the computed F-value stands at 65.448, with degrees of freedom (df1) equal to 2 in the numerator and (df2) equal to 7 in the denominator. According to the output data, it's evident that the significance level for the joint impact of X1 and X2 on Y is 0.001, which is less than the significance threshold of 0.05. Additionally, the calculated F-value of 65.448 surpasses the critical F-table value of 4.458. Consequently, we can infer that the alternative hypothesis (Ha) is upheld, indicating that there exists a simultaneous influence of both X1 and X2 on Y.

Termination Coefficient

The coefficient of determination is employed to ascertain the proportion of impact that the independent variable has on variations in the dependent variable.

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974[a]	.949	.935	2.54208

a. Predictors: (Constant), indeks pembangunan manusia (X_2), indeks pembangunan TIK (X_1)

With reference to the provided table, the R Square value is established at 0.935. This signifies that the combined impact of variables X1 and X2 on variable Y is 93%, leaving a residual 7% unaccounted for, which is attributed to external factors beyond the scope of the independent variables (X).

Technological innovation and the quality of human resources have a simultaneous influence on Indonesia's economic growth in the era of industrial revolution 4.0. Technological innovation can help Indonesia overcome social challenges and problems faced by society, such as poverty, inequality, health, education, the environment, and others. By harnessing cutting-edge technologies like the IoT, big data analytics, robotics, and AI, Indonesia has the potential to enhance the well-being and elevate the living standards of its population. Technological innovation can also open up new opportunities for the creative economy sector, which is one of the drivers of Indonesia's economic growth.

Enhancing the caliber of the workforce in Indonesia can amplify the competitiveness and productivity of the labor force, a pivotal factor in shaping a nation's developmental trajectory and economic composition. By having a quality workforce, Indonesia can utilize and maximize every existing technological innovation, as well as create new technological innovations that suit local

needs and conditions. The quality of HR can also increase the capacity and capability of research and development (R&D), which is an indicator of a country's progress in science and technology. Therefore, technological innovation and the caliber of human resources are intricately linked and mutually influential factors shaping Indonesia's economic growth during the fourth industrial revolution era. Indonesia must persevere in fostering innovation and enhancing the competence of its human capital to confront global competition successfully and realize comprehensive and sustainable development objectives.

The government's role in influencing technological innovation and the quality of human resources on Indonesia's economic growth in the era of industrial revolution 4.0 is very important and strategic. The government has the responsibility to create a conducive climate for the development and application of technology in accordance with the needs and potential of national industry. The government must also support improving the quality of HR who are able to adapt and innovate amidst rapid and dynamic technological changes.

There are several steps that the government has taken. First, Formulating ten paramount national strategies for executing the Making Indonesia 4.0 roadmap entails enhancements in supply chain efficiency, the revitalization of industrial zones, integration of sustainability benchmarks, empowerment of MSMEs, the establishment of robust national digital infrastructure, enticement of foreign investments, developing digital human resources, building national innovation center, developing the innovation ecosystem, and increasing regional and global cooperation. Second, issuing Presidential Regulation number 118 of 2020 concerning Procurement of Industrial Technology through Turnkey Projects, which requires industrial technology providers to transfer technology to the project proponent, in this case the implementing ministry or agency. Third, workers collaborate with the private sector to help all parties, including MSMEs, to carry out servicing, through activities to increase digital human resources, create digital databases, digital literacy, and build digital infrastructure. Fourth, encourage innovation and creativity in the industrial sector through program financing and increasing human resource capacity, as well as facilitating cross-sector collaboration between private business actors or BUMN and universities.

Conclusion

This research analyzes the influence of technological innovation and the quality of human resources on Indonesia's economic growth in The Fourth Industrial Revolution era. Using secondary data in the form of BPS data covering 34 provinces in Indonesia during the 2013-2022 period. This research uses the dependent variable, namely Indonesia's economic growth in the era of the industrial revolution 4.0, which is measured by Gross Domestic Product (GDP), and independent variables, namely technological innovation, which is measured by the information and communication technology development index (IP-ICT), and resource quality. human capital, which is measured by the human development index (HDI). This research also found that there is a simultaneous influence of technological innovation and the quality of human resources on Indonesia's economic growth in The Fourth Industrial Revolution era, with a coefficient of determination of 93.5%. Future research should use primary data collected directly from the field, using survey, interview or observation methods, to obtain more valid, reliable and actual data regarding technological innovation and the quality of human resources in Indonesia.

This study exclusively employs the multiple linear regression approach to examine the impact of the ICT Development Index and HDI on GDP, without taking into account additional variables that could potentially exert influence, including political, social, cultural, and environmental

factors. This research only measures technological innovation and the quality of human resources using indicators available in IP-ICT and HDI, such as life expectancy, education and income, without including other more specific indicators, such as number of patents, scientific publications, or global innovation index. This research only focuses on the impact of technological innovation and the quality of human resources on Indonesia's economic growth in the industrial revolution 4.0 era, without discussing other impacts that may arise, such as social, environmental or ethical impacts.

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