SUSTAINABLE DEVELOPMENT AND GOOD GOVERNANCE TOWARDS DIGITALIZATION: A QUANTILE ANALYSIS

ALEX CHENG HENG SIANG

BACHELOR OF ECONOMICS (HONOURS)
GLOBAL ECONOMICS

UNIVERSITI TUNKU ABDUL RAHMAN

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DEPARTMENT OF ECONOMICS

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BY

ALEX CHENG HENG SIANG

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) The word count of this research report is **12234**.

Name of Student:	Student ID:	Signature:
Alex Cheng Heng Siang	2004147	

Date: 3 May 2023

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DEDICATION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

IoT	Internet of Things
ICT	Information and Communication Technology
AI	Artificial Intelligence
OECD	Organisation for Economic Cooperation and Development
ITU	International Telecommunication Union
SDGs	Sustainable Development Goals
ECLAC	Economic Commission for Latin America and the Caribbean
IMF	International Monetary Fund
IDI	ICT Development Index
IMD	International Institute for Management Development
DESI	Digital Economy Society Index
GCI	Global Competitiveness Index
GDP	Gross Domestic Products
WGI	Worldwide Governance Indicators
GMM	Generalized Method of Moments
GWR	Geographically Weighted Regression
FDI	Foreign direct investment
PC	Personal Computer

ABSTRACT

Sustainable development, good governance, and digitalization are the important concerns for a country in the aspect of economy, social, and environmental. This thesis aims to examine the relationship between sustainable development, good governance, and digitalization, the direct effect of achieving sustainable development and upholding good governance towards digitalization, and the indirect effect from good governance also has been explored. The research apply quantile regression analysis, focuses on 50 countries that are included in the study of IMD World Digital Competitiveness, with the year data from year 2013 to 2020. The results show that achieving sustainable development will reduce a country digitalization level at higher quantile, there is no significant relationship between sustainable development and digitalization at lower and middle quantile. Good governance shows a highly significant positive relationship with digitalization at all quantile, this implies that good governance is an important factor that determine a country's digitalization level. Specifically, good governance also shows a significant moderating effect on reducing the contradiction between achieving sustainable development and digitalization. Our study provide empirical findings for policy makers on promoting policy coherence and coordination between different sectors and stakeholders, to ensure that sustainable development policies and digitalization strategies are aligned and mutually reinforcing.

Keywords: IMD Digital Competitiveness, Digitalization, Sustainable Development Goals, Good Governance, Quantile Regression

Chapter 1 Research Overview

1.0 Introduction

This chapter included an overview of this study. In Section 1.1, the background of the study is being discussed, and we discussed the importance of digitalization, sustainable development, and good governance. Section 1.2 consists of the problem statement, we discussed the motivation of this study, stated what points of view we can enter regarding to the nexus of sustainable development and digitalization. The research objective and research questions are included in sections 1.3 and 1.4, respectively, in which we discussed the aim of doing this research and the questions we intend to answer with the study. Then, in section 1.5, the significance of the study will be discussed, what knowledge can we contribute to the academy. In section 1.6, the chapter layout will be shown. Lastly, this chapter will sum up in section 1.7, the conclusion.

1.1 Research Background

In the early 21st century, the world witnessed a significant global transformation marked by the rapid development of digital technologies, a revolution in the information space, and the digitalization of the economy. Information has become a crucial resource in the government and business sectors, and the focus has shifted towards incorporating information technology into industries since the early 1970s. This move aimed to accelerate economic growth during the third industrial revolution, which lasted until the diffusion of the internet in the 1990s (Sadorsky, 2012). Following this revolution, Industry 4.0 emerged as the new paradigm, reflecting the evolution of the information society. Technological development associated to digitalization has been identified as the most significant pathway in

transforming both society and business, it's the main driver at the core of Industrial 4.0 (Parviainen et al., 2017).

Digitalization can be defined in multiple ways, including as a shift from analogue to digital forms of communication and value creation, or as the transformation of all information types into digital language through the development of digital technologies. Machekhina (2017) and Parviainen et al. (2017) describe digitalization as the transformation of various types of information into digital language, while (Srai & Lorentz, 2019) link it to the technology of digitalizing information. Furthermore, digitalization is not a new revolution but a synergy of digital innovations across the whole economy and society. It involves restructuring social life around digital communication and media infrastructures, including the transformation of previously non-digital socio-technical structures into digitized ones (Ringenson et al., 2018; Valenduc & Vendramin, 2017).

According to Morley et al. (2018), "encompassing a range of digital technologies, concepts and trends such as artificial intelligence, the "Internet of Things" (IoT), and the Fourth Industrial Revolution," digitalization is the process by which non-digital artefacts are replaced by digital ones in the mediation of social and technical systems. In a broader sense, digitalization can enhance customer-company interactions, which in turn benefits the economy and society as a whole (Reis et al., 2020). This is all thanks to the proliferation of digital technologies, such as information and communications technology (ICT), which translate analogue information into a digital language.

The utilization of digitalization offers numerous opportunities for productivity growth, new market opportunities, and the creation of new jobs, including flexible and greener jobs, as well as enhancing work-life balance and income (Charles et al., 2022). Furthermore, it enables fast and dependable connectivity, which enhances interactions among individuals, organizations, and machines, facilitating the usage of connected devices in vital contexts like health, manufacturing, and transport (OECD, 2022). Governments in developing countries work with the Digital Development Global Practice to create the basis for inclusive and responsible digital transformation, including their transition to digital economies, governments, and

societies (World Bank, 2022a). Digitalization can promote innovation and entrepreneurship in every sector and facilitate a just transition to a low-carbon economy. Digital financial services have the potential to reach millions of people and businesses, particularly micro and small enterprises, in rural and remote areas, and encourage their transition from the informal to the formal economy (ILO, 2022).

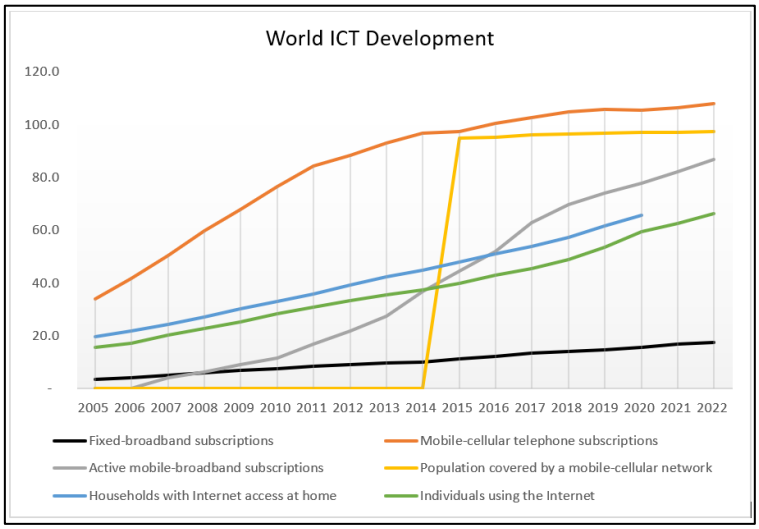
The use of robotization, artificial intelligence (AI), and sericitization of the production process, as well as the growth of online markets and platforms, will lead to the growth of trade, as per the simulations. This is due to the more extensive use of ICT services and the fall in trade costs (WTO, 2021). The COVID-19 pandemic has accelerated the ongoing digital transformation, with the world moving online. Digitalization has enabled remote learning and work, while firms have adopted digital business models to maintain operations and revenue flow, and mobile applications have been developed to track and trace the pandemic. Digitalization also enhances the ability to work remotely or sell without contact, providing a buffer against the pandemic's adverse effects (Copestake et al., 2022).

Governments worldwide are investing in scientific and technological infrastructure to boost value creation and prosperity through the digital economy. Although digital technology is essential to an economy's future well-being, it is not sufficient to maximize competitiveness. To accomplish two important objectives, namely, improving efficiency and enhancing the range and quality of services provided to citizens and businesses, digital technology must not only be implemented but also explored (IMD, 2017). The Organisation for Economic Cooperation and Development (OECD) reports that almost all its member states have a national digital strategy at the highest level of government, with infrastructure construction, digital skills development, and other components. Malaysia, Nigeria, Egypt, and China also regard digitalization as a vital developmental strategy at the national level (Gierten & Molly, 2022).

ICT development is a crucial part for the development of digitalization (Reis et al., 2020), ICT indicators also have been chose as the variables to study on the topic of digitalization (Myovella et al., 2021; Burinskienė & Seržantė, 2022; Khusainov et al., 2022). Figure 1.1 shows the ICT development trends around the world. The ICT

indicators development data has been obtained from the International Telecommunication Union (ITU) databases, measure by every 100 inhabitants from all the countries around the world. As shown in figure 1.1, mobile-cellular telephone subscription and the mobile-cellular network coverage remain at the highest level over the years. However, the active mobile-broadband subscriptions has the highest growth rate among other indicators. Household with internet access and the individual internet user both grow consistently over the years.

Figure 1.1 World ICT Development Trend



Source: (ITU, 2022)

In contemporary times, digital technology is an essential component for economic growth as it covers diverse spheres of economic activities and creates new opportunities for socio-economic development. The global economic system is undergoing radical transformation towards a more sustainable economy development, and digital technologies play a significant role in achieving this objective.

In September 2015, the United Nations General Assembly endorsed the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs). Sustainable development is recognized as the path for future society's development, which meets the present needs without compromising the

ability of future generations to fulfil their own needs. The three main pillars of sustainable development are social, economic, and environmental. Innovative technologies, such as artificial intelligence (AI), machine learning, analytics, and the Internet of things (IoT), offer significant potential for achieving sustainable development goals (Pan & Zhang, 2020). International organizations, including the World Bank, OECD, and ECLAC, consider digitization as a crucial factor in overcoming sustainability challenges, reports produced or commissioned by leading companies and organizations in the Information and Communication Technology (ICT) sector also convey the same message (García Zaballos et al., 2019; Ono et al., 2017).

The United Nations envisages a world in which all countries enjoy sustained, inclusive, and sustainable economic growth, and people have access to decent work (UNCTAD, 2019). This world respects democracy, good governance, and the rule of law and has an enabling environment at national and international levels. It also emphasizes the importance of sustainable consumption and production patterns, climate-sensitive development, and the protection of biodiversity, wildlife, and other living species. The 17 SDGs and targets are ambitious and transformational and aim for a world free of poverty, hunger, disease, and want, where all life can thrive, free of fear and violence. The SDGs also strive for universal access to quality education, health care, social protection, safe drinking water, sanitation, and sustainable energy, among other necessities. In summary, the United Nations' 2030 Agenda calls for transformative change, which moves beyond incrementalism, and aims to create a world in which all people can lead a dignified life with no discrimination and underpinned by social, economic, and environmental justice.

The World Bank was the pioneer in mainstreaming the concept of good governance in the 1990s by including it in its lending policies for underdeveloped nations. "Governance and Development," a report published in 1992, described good governance as "the manner in which authority is exercised to regulate a country's economic and social resources in order to promote that country's economic and social development" (UCLG ASPAC, 2021). Since then, many groups at the national and international levels have adopted the term in an effort to reduce corruption, prioritise the views of marginalised groups, give a platform to those who

have been historically silenced, and better meet the present and future demands of their communities.

When we talk about a country's "governance," it's referring to its established norms and structures for distributing power. The respect of citizens and the state for the institutions that govern economic and social interactions between them, as well as the process by which governments are selected, monitored, and replaced, all play a role in this indicator (World Bank, 2021). According to the United Nations (2006), governance includes all of the processes and institutions that allow individuals and communities to make their voices heard, protect their rights, fulfil their responsibilities, and resolve conflicts. Meanwhile, the International Monetary Fund (IMF) defines governance as "a concept that encompasses the management of a country," which includes economic, policy, and legal facets. The term "governance" is used to describe the system of making decisions and selecting which policies would be put into action.

Corruption, defined as "the abuse of public office for private gain," increases when governance is subpar. The integrity of markets is threatened, competition is distorted, and economic growth is jeopardised when corruption is allowed to flourish. Therefore, bad leadership is bad for business and the economy (IMF, 2022). Because good governance is linked to the political and institutional processes and outcomes required to accomplish development goals, the quality of a country's institutions is crucial. Delivering on civil, cultural, economic, political, and social rights is the actual litmus test of "good" governance.

1.2 Problem Statement

The digital economy plays a crucial role in promoting innovation, competitiveness, and economic growth worldwide. While the digital transformation has been a priority for political and organizational agendas for several years, the fourth industrial revolution has made it a frontline issue. According to a recent study

conducted by Forth et al. (2020), over 80% of high-level executives consider digital transformation to be a top priority. In order to ensure economic growth and promote the use of information and communication technologies (ICT) in the digital economy, it is essential to conduct a detailed study of the impact of factors on the level of digitalization in the world's economies.

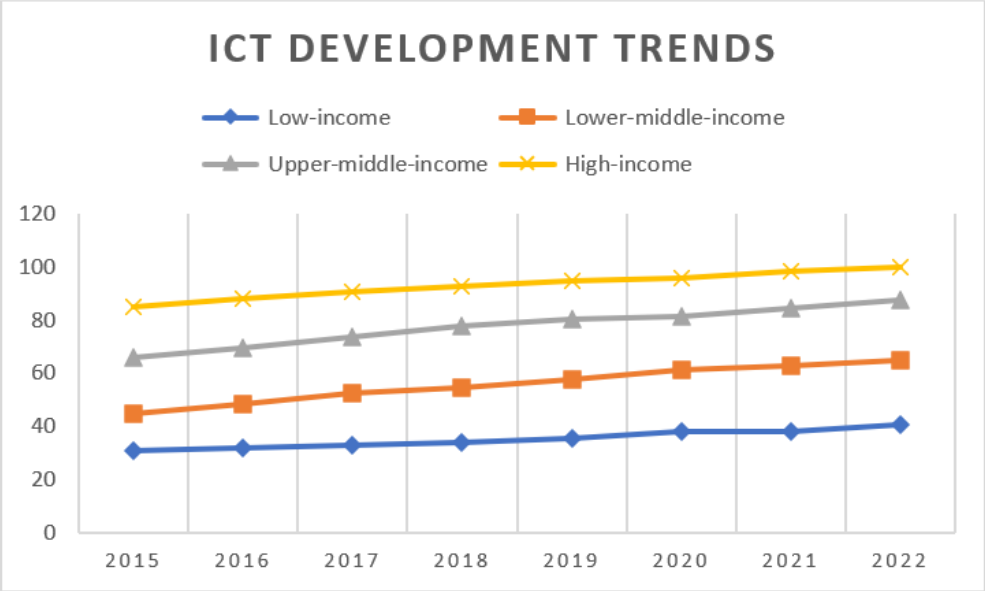
The 17 Sustainable Development Goals (SDGs) announced by the United Nation is now an intent for every country to achieve a better economy. To achieve the better SDGs, it may lead to the adoption of policies and regulations that impact a country's level of digitalization. For instance, governments may implement regulations to ensure that digital technologies are used in a way that is safe, secure, and respects citizens' privacy rights. They may also promote the development of digital technologies that support SDG goals, such as renewable energy systems, smart transportation systems, and sustainable agriculture. The emergence of intelligent systems connected to the internet of things provides a significant potential to address strategically the challenges associated with the United Nations Sustainable Development Goals (SDGs) for the establishment of a fair, ecologically sustainable and healthy society. Achieving the SDGs may require investment in digital infrastructure, such as broadband networks, data centres, and digital platforms, to support the development and deployment of digital technologies, which bring a country to a higher level of digitalization and improve access to digital services and information.

Yet, the potential negative effects exist as the cost of implementing the necessary policies and investments to achieve the SDGs. Countries may face challenges in allocating resources and financing the necessary infrastructure development, innovation, and capacity-building required to achieve the SDGs. This may divert resources away from digitalization efforts, particularly in less developed countries where digital infrastructure is still being developed. The potential for increased regulation and oversight of digital technologies in the pursuit of SDGs. While regulations are important to ensure the responsible use of digital technologies, excessive or poorly designed regulations may impede innovation and slow down the pace of digitalization. There is a risk that some SDGs policies may result in

negative impacts on digitalization. The government policies designed to reduce carbon emissions may limit the use of digital technologies, such as cloud computing and data centres, which are energy intensive.

Figure 1.2 shows the ICT development trends among low-income, lower-middle income, upper-middle income, and high-income country. A significant digital divide can be found between different income-level country, with a higher level of income, the ICT development maintain at the higher level.

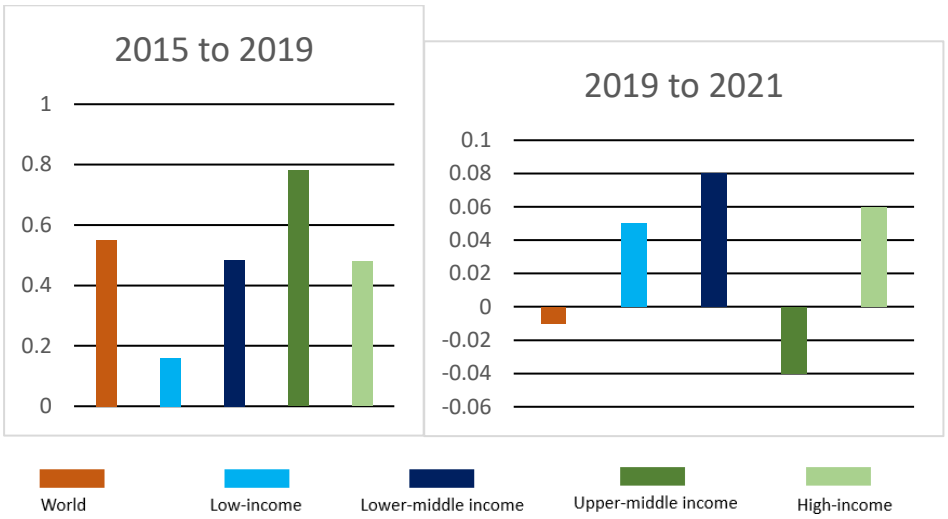
Figure 1.2 Different income-level countries ICT development



Source: (ITU, 2022)

Figure 1.3 show the growth rate of Sustainable Development Goals (SDG) index score for different income group countries, with the data presented by Cambridge University Press (Sachs et al., 2022). From 2015 to 2019 the world progressed on the SDG Index at an average rate of 5.5% a year. The highest growth rate for achieving SDG goals is the upper-middle income country, follow by lower-middle income, high-income, and low-income countries. For the year 2019 to 2021, countries all around the world have been affected by the Covid-19 pandemic, the overall growth rate on SDG index score has been declining, the world is experiencing a negative growth rate on the SDG index score.

Figure 1.3: SDG scores of different income level countries



Source: (United Nations, 2022)

In fact, we should recognize that digital progress is purposeful, a country to achieve sustainable development will need to involve in more technology and innovation, thus leading to a higher digitalization level. While digitalization been known as an important factor to develop a better economy, the world has also pledge to achieve the United Nation Sustainable Development Goals (SDG). However, the level of SDGs score is inconsistent with the digitalization level between high income, middle income and low-income nations. This has brought the research question to this study, will the effort to achieve SDGs be a catalyst or restriction to promote digitalization? Good governance is always an important aspect to social, economy and politics, it is crucial to achieve sustainable development and digitalization because it establishes a framework of principles and guidelines that promote transparency, accountability, and efficiency in the implementation of related policies. What's the role of good governance between the contradiction of sustainable development and digitalization?

1.3 Research Questions

1. Will the effort to achieve SDGs be a catalyst or restriction to promote digitalization?
2. Is upholding a good governance able to promote higher digitalization level?
3. What is the role of good governance between the contradiction of sustainable development and digitalization?

1.4 Research Objectives

1. To investigate the relationship between Sustainable Development and Digitalization.
2. To investigate the relationship between Good Governance and Digitalization.
3. To examine the impact of Good Governance to Sustainable Development and Digitalization relationship nexus.

1.5 Significance of Study

This study brings out a topic that has not been deeply explored by other scholars which investigating the direct effect of achieving Sustainable Development and good governance towards Digitalization, as well as the indirect effect (moderating effect) of good governance in achieving both sustainable development and digitalization. There is no doubt these factors are important for a country development in the aspect of social, economic, and environment.

Unlike the previous studies that focused on correlations between SDGs and Digitalization by using static methods, we apply Quantile Regression Analysis to study different relationships nexus at different digitalization levels. By applying quantile regression on all sample countries, high-income countries, and middle-income countries, we were able to provide a more comprehensive result taking into

consideration of different digitalization levels and the developing status of the country.

1.6 Chapter Layout

The remaining parts of this paper are organized as follows. Chapter 2 will be reviewing related research done by researchers and discussing the linkage between the dependent variable and independent variables. In Chapter 3, the research methods will be discussed, as well as the data collected. Chapter 4 discusses the results that we get from the data analysis. Finally, Chapter 5 will include the discussion on the result findings, a conclusion for the whole study, the implications for policies design, limitations and recommendations for future study.

1.7 Conclusion

In this chapter, we have discussed the research background and problem statement. The research objectives and questions were also being developed at the end of this chapter. Last but not least, the significance of this study is being highlighted. In the next chapter, we are going to look into the relevant research which has been done previous researchers

Chapter 2: Literature Review

2.0 Introduction

Many researchers have investigated the nexus between digitalization, sustainable development, and good governance, but the outcomes of the studies are ambiguous. In Section 2.1, we have a brief introduction of the dependent variable we used in the study, digitalization. In Section 2.2, we explained the main theories of this paper based on, Theory of Externalities and Institutional Economic Theory. In Section 2.3, we looked into the empirical results of literature that study the linkage between sustainable development and digitalization. In Section 2.4, we discussed the results of studies that examined the linkage between good governance, sustainable development, and digitalization. In Section 2.5, to identify the control variables for this study, we looked into the outcomes of research that study other determinants of digitalization. In Section 2.6, the conceptual framework of this study has been proposed. In Section 2.7, we developed the hypothesis of this research. In Section 2.8, we talked about the research gap which this paper set out to fill. Lastly, in section 2.9, we summarise what we learned from the existing literature.

2.1 Digitalization

The term "digitalization" refers to the widespread adoption of digital technologies in all facets of modern life, including business and culture (Lange et al., 2020). Access to essential services and communications, for example, have been profoundly influenced by advances in information and communication technology (ICT) (Sujarwoto & Tampubolon, 2016). Nair et al. (2020) revealed that as economies adopt and implement new ICTs, they become more globally competitive and generate new opportunities for economic growth.

Numerous scholars have conducted extensive research on digitalization, with many of them using the ICT Development Index (IDI) or other indicators of the state of digitalization as proxies (Ben Ali, 2022; Burinskienė & Seržantė, 2022; Gu et al., 2022; Myovella et al., 2021; Petkovski et al., 2022). The revised number of indicators for the ICT Development Index (IDI) is 14. Originally, the IDI was a composite index that took into account 11 separate metrics. It's a tool for keeping tabs on and comparing the state of ICT in different nations and over time (ITU, 2021).

But the essence of digital technology is to upgrade the qualities of traditional technology by transforming it into "smart" systems that are aggressive, efficient, and user-friendly (Coskun-Setirek & Tanrikulu, 2020). To put it another way, the scope of "digitalization" is narrower than "all activities related to digital data" but wider than only the information and communications technology (ICT) industry. The IMD World Digital Competitiveness Ranking ranks countries based on their propensity to accept and investigate digital technology, which in turn transforms government practises, business models, and society at large (IMD, 2017). Knowledge, technology, and future preparation are the three primary characteristics of a country's digitalization as defined by the ranking (score) methodology. The intangible resources required for technological research, understanding, and development are captured by the knowledge dimension. Quantifying the global setting that allows for the growth of digital technologies is what the technology dimension is all about. The future readiness metric analyses how well-prepared a country is to accept and benefit from its ongoing digital transformation.

ICT indicators typically focus on the availability, adoption, and use of digital technologies and infrastructure, such as internet connectivity, mobile phones, computers, and software applications. They provide a snapshot of the level of digitalization in a country, and can be used to track progress over time. Examples of ICT indicators include the percentage of households with internet access, the number of mobile phone subscribers, and the number of secure internet servers. On the other hand, IMD Digital Competitiveness indicators measure the overall competitiveness of a country in the digital economy, based on a broader range of factors that go beyond ICT infrastructure and adoption. These factors include the

quality of digital skills and education, the strength of the digital innovation ecosystem, the degree of digital regulation and policy, and the level of digital trust and security. The IMD Digital Competitiveness ranking is based on a composite score of these different factors and provides a more holistic assessment of a country's readiness and ability to compete in the digital economy.

Recently, IMD digital competitiveness ranking has gained more and more attention from academic studies, which researchers use to select their sample countries (Borisova et al., 2021; Hrosul et al., 2022; Kravchenko et al., 2019). Due to the comprehensiveness of IMD Digital Competitiveness in interpreting the level of digitalization, scaled from “low” to “high” (0 to 100), we use it as the proxy of the digitalization level in our study to achieve a more reliable outcome, following previous studies (Ahmadova et al., 2022; Gurieva et al., 2021; Kushnir et al., 2021; Salakhova et al., 2021).

2.2 Theories

2.2.1 Theory of Externalities

Externalities present significant challenges for economic policymakers, as they occur when individuals, households, and firms fail to consider the indirect costs or benefits of their economic transactions. This failure to internalize these costs and benefits can lead to market outcomes that are inefficient (Helbling, 2010). More illustratively, this theory states that the actions of one person or entity can have positive or negative effects on others who are not involved in the transaction. This theory can be used to evaluate trade-offs between two important goals by considering the external costs and benefits associated with each goal. Externalities theory can be applied to situations that investigate the potential positive or negative externalities resulting on digitalization while achieving SDGs. While digitalization has been said a mechanism to develop a better economy, but it has been found that digitalization has negative correlation with some SDGs. Thus, the positive externalities can refer to the benefits that achieving SDGs can have on digitalization,

such as increased investment in energy-efficient buildings, smart transportation systems, and digital public services in order to achieve sustainable cities and communities (SDG 11). On the other hand, negative externalities can also arise, such as when governments divert resources away from digitalization to focus on achieving SDGs, for instance, mass increasing subsidies on reducing poverty (SDG 1) which may slow down the pace of digitalization. Additionally, environmental regulations aimed at achieving SDGs can also create negative externalities by increasing the costs of production and reducing the competitiveness of firms in the digital sector.

2.2.2 Institutional Economic Theory

Institutional economics means rules that impact the economy's overall behavior, it was first be introduced by Hamilton (1919) in the paper "The Institutional Approach to Economic Theory." Institutional economics theory determines the factors that influence the economy, focuses on the role of institutions in shaping economic behavior and outcomes. It can be formal and informal rules, norms, and practices that govern economic and social interactions (Wallstreetmojo, n.d.).

Institutional quality is important for digitalization because it provides a stable and predictable environment for businesses to operate in, which in turn encourages investment and innovation. When institutions such as government agencies, legal systems, and regulatory bodies are transparent, efficient, and effective, they create an environment that is conducive to the growth of the digital economy. Good governance, which refers to the effective and efficient use of power to manage a country's economic and social resources, is a crucial element of institutional economics.

2.3 Sustainable Development and Digitalization

According to research conducted by Burinskienė & Seržantė (2022), who looked at how SDGs portrayed the connection between digitalization and sustainability using correlation matrix and linear regression method, a number of ICT variables and sustainability indicators were found to have exceptionally strong correlations. By comparing the top 10 developed and top 10 developing nations, Popkova et al. (2022) provide useful evidence between the SGDs with digitalization using correlation analysis. Findings from this study reveal that progress in digital technology is well-suited to tackling the grand challenges of sustainable development because they give a novel analysis of the links between SDGs and digital technologies to establish their exact interdependencies.

According to research Ionescu-Feleagă et al. (2023), a positive and negative correlation exists between the Digital Economy Society Index (DESI) and the Sustainable Development Goals (SDG) Index for member states of the European Union (EU). The analysis of statistical correlations between digitalization and sustainable development indicators that Pérez-Martínez et al. (2023) provide is exhaustive and methodical on a country level. Consistent with previous research, this finding supports the idea that digitalization (as measured by the IDI Development Index), sustainability (as measured by the SDG Index), and economic growth (as measured by the GCI and GDP) are all strongly correlated. However, a more nuanced picture emerges from the examination of sub-indicators, with 2 of the SDGs and 22% of the SDG indicators showing negative associations with digitalization. It would appear that trade-offs occur in environmental protection areas like climate change, depletion of natural resources, and waste generation due to their negative associations with existing economic development models, while synergies are generated in areas related to economic and social sustainability. While Ahmadova et al. (2022) find that digitalization has an inverted U-shaped relationship on environmental performance, Wang et al. (2022) find the opposite to be true: that digitalization has a significant positive effect on environmental performance in China.

Using data in year 2020, Kushnir et al. (2021) examine the link between sustainable development indicators and digitalization indicators in a sample of nations consisting of the top three performers on each indicator by approaching statistical analysis. It was found that a favorable relationship exists between digitization and sustainable development (more than 60% of the metrics) when the stated results of digitalizing the economy have already been realized. But it is difficult to pinpoint a single year as the starting point for digitization because some nations have already achieved notable triumphs while others are just beginning to implement national digital modernization programs.

To ascertain the Pareto Optimality for both rich and emerging nations, Gurieva et al. (2021) utilized modernization (digitalization) aspects as criteria for long-term economic growth by approaching regression and scenario analysis. The study includes the top 8 developed and developing countries that have the highest digitalization level in the IMD digital competitiveness rating in the year 2019. It was found that advanced economies can meet all criteria for economic sustainability at once, albeit doing so calls for a slower rate of modernization, or moderate digitalization. With this, the identified Pareto-optimal is difficult to put into practice since it puts the goals of sustainable development in direct conflict with the interests of economic growth and global competitiveness. Since the identified Pareto optimality reduces the average value of sustainability indicators, optimization is unnecessary in developing countries where it is impossible to simultaneously meet all the criteria for economic sustainability. In the same breath, common sense suggests developing nations speed up their own digitalization of the economy in order to keep up with the rest of the world.

2.4 Good Governance, Sustainable Development, and Digitalization

According to the Worldwide Governance Indicators (WGI), a country's governance consists of its established norms and structures for exercising power. In this context, "good governance" refers to the respect that citizens and the state have for the

institutions that control their economic and social interactions, as well as the process by which governments are elected, monitored, and changed. Omri & Ben Mabrouk (2020) research objective is to determine if excellent governance helps in attaining sustainable development by guaranteeing the compatibility of economic growth, environmental protection, and human development. By using GMM method analysis, the finding demonstrates the moderating role of good governance in reducing the adverse effects of carbon emissions on economic growth and human development while also mitigating the beneficial effects of economic expansion on emission increases. Digitalization also exhibits a moderating effect. Ben Ali (2022) found that while ICT can help a country's finances when corruption is limited, it has no effect when corruption is widespread. By bolstering governments' governance capacities, the digital economy encourages the shift to renewable energy (Shahbaz et al., 2022).

Besides, a good governance is important on digital development, no matter on the perspective of corporate or country. As the digital development involve of policies and strategy implemented, which need good monitoring on it as to ensure it can perform well. Political and institutional instability is taken by previous literature contributions as an important digital development determinant, especially those highly digitalized country (Billon et al., 2010; Chinn & Fairlie, 2007). Recent study conducted by Myovella et al. (2021) indicate that regulatory efficiency is one of the main factor that affecting the digital divide among Sub-Saharan African economies. A supportive findings from Pyroh et al. (2021) stated the further implementation of information and communication technologies and improving legislation in the digital economy, which will ensure the implementation of effective digital policy. By highlighting the necessity of both institutional stability and infrastructure development, Skaletsky et al. (2016) show that there is a way out of the apparent dead end. The study applies TreeNet Algorithm, gives out an important message, which institutional quality is less important than all of the measures of infrastructure, demographic characteristics, education, and income when the country is at a lower level of digitalization. But a country cannot achieve a higher level of digitalization unless it develops its institutional quality.

2.5 Other Factors and Digitalization

Broadband policies are examined from multiple angles by Falch & Henten (2018). These angles include infrastructure vs. service competition, regulatory vs. developmental policies, and networks vs. content prioritisation. According to the study's findings, GDP is a significant factor in determining the extent of the digital divide. Nishijima et al. (2016) use valuable nationally representative survey data from 2005, 2008, 2011, and 2013 to conduct an empirical analysis on the evolution of the digital divide among Brazilian citizens, including its primary causes. According to the findings, bridging the digital gap is hindered by factors such as a lack of disposable income, the high cost of mobile phones, and potential challenges with smartphone applications. The number of mobile phones, internet users, and broadband subscribers in China makes it the largest ICT market in the world, but there is significant digital disparity within and between provinces, prefectural cities, and counties. In order to better understand digital divides across China's prefectural cities, Song et al. (2020) conducted a cluster analysis of spatial agglomeration and used a geographically weighted regression (GWR) model to investigate the most influential correlations. The researchers concluded that the digital divide is largely driven by differences in household wealth between urban and rural areas.

Foreign direct investment (FDI) is an important channel for technology dissemination across OECD countries, as shown by research conducted by Hejazi & Safarian (1999) on the spill over effect of FDI as an additional channel of technological spill overs in six of the G7 countries. From 2000 to 2014, Latif et al. (2018) analyse the interplay between information and communication technologies (ICT), FDI, economic growth with trade and globalisation, and the five BRICS economies. The relationship between commerce and economic expansion appears to be causal in both directions. Furthermore, a unidirectional causality from trade to FDI is observed. ICT infrastructure is determined to be a granger cause of trade and FDI. The relationship between commerce and ICT infrastructure has been found to have causality in both directions. Chinn & Fairlie (2007) applied a panel of 161 countries to data from 1999-2001 to investigate what factors contribute to

regional differences in personal computer (PC) and Internet usage. According to the findings, the global digital divide is driven less by differences in trade openness and more by differences in per capita income and regulatory quality. Using annual data from 2000-2018, Rath et al. (2022) analyse the convergence of ICT development for 27 EMEs. The results demonstrate that factors like per capita income and FDI significantly affect ICT development.

In a similar vein, Bhujabal & Sethi (2020) analyse the interplay between foreign direct investment (FDI), information and communication technology (ICT), trade, and per capita gross domestic product growth in SAARC developing nations from 2000 to 2017. They find that FDI has a unidirectional causal relationship with ICT, while trade has a bidirectional causal relationship with ICT. Furthermore, a one-way causality is seen when comparing trade to FDI and when comparing GDP per capita to FDI. These results corroborate the research conducted by Caselli & Coleman (2001), who compiled extensive data on computer equipment imports for nearly every country in the world beginning in 1970. Using panel data analysis, they investigate what factors lead to increased computer imports from one country to another. They conclude that trade openness is most strongly correlated with computer adoption in OECD nations.

There is a two-way causation at work in the correlation between digitalization and national income or GDP (Myovella et al., 2021). There may be less of a digital divide and more penetration of ICT services in high-income nations, as suggested by the research of Czernich et al. (2011).

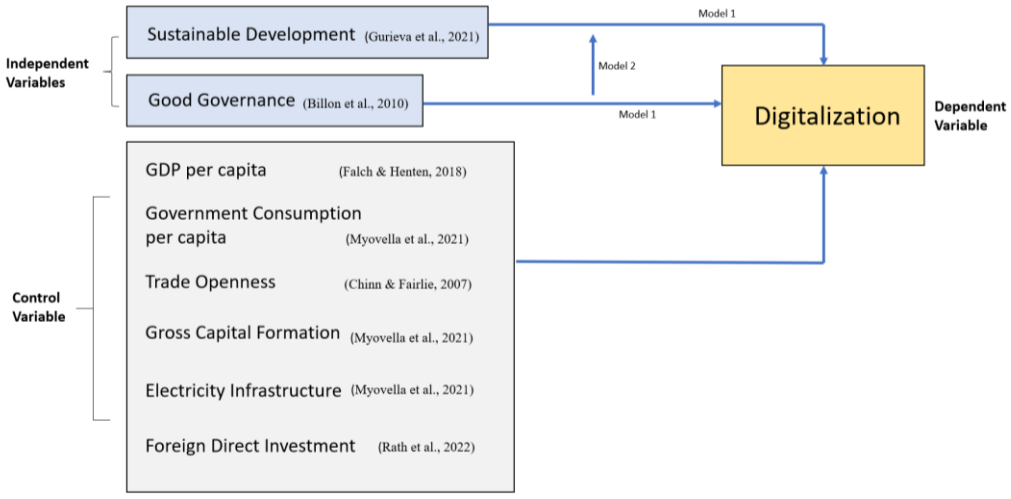
Disparities in infrastructure, especially in telecommunications, can contribute to the digital divide. Ghobadi & Ghobadi (2013) investigate the factors that have contributed to the development of Iran's digital divide. They argue that effective access to ICT is of utmost importance because new technologies appear constantly. Sujarwoto & Tampubolon (2016) uses information gathered from the Indonesian national socio-economic survey for the years 2010–2012, which includes a total of 3.3 million people, 750,000 households, and 292 districts, to investigate the relationship between spatial inequality and the Internet divide in Indonesia, a developing country that is rapidly expanding its use of ICT. Differences in

telecommunications infrastructure between districts are a major contributor to the digital divide.

Determinants of the digital gap in Sub-Saharan African economies are the subject of a new study by Myovella et al. (2021). This research takes into account a wide range of socioeconomic, demographic, institutional, and geographical elements that have been shown to have a significant impact on a country's level of digitalization and digital divide in the past. The study found that the digital gap is strongly related to factors including GDP per capita, gross capital formation, political stability, regulatory effectiveness, and power infrastructure. The level of the digital divide is also affected by other factors through spill over effect, such as GDP per capita, government consumption, trade openness, and power infrastructure.

2.6 Conceptual Framework

Figure 2.1 Conceptual Framework



2.7 Hypothesis Development

H1: There is a positive and negative relationship between sustainable development and digitalization.

H2: There is a positive relationship between good governance and digitalization.

H3: There is a positive moderating effect of good governance on sustainable development.

2.8 Research Gap

The linkage between sustainable development and digitalization is ambiguous. Previous studies have stated that to achieve sustainable development, different digitalization level is required for different developing status of country. The study on whether achieving sustainable development will slowing down or promoting digitalization is remain unclear. At the same time, good governance is found as an important factor to moderate the negative effect of both sustainable development and digitalization, but there is lack of study focus on mediating role of good governance on sustainable development towards digitalization. We believe that the externalities of achieving sustainable development will differ on different digitalization level of a country. To fill this research gap, this paper set to validate the nexus between sustainable development, good governance, and digitalization by approaching quantile regression, on different income-level countries. The main objective of this study is to answer whether achieving sustainable development will have a positive or negative effect on digitalization level, and the moderating role of the good governance between the relationship.

2.9 Conclusion

The purpose of this review was to inspect studies of other control variables and the relationship between sustainable development, good governance, and digitalization. Different outcomes have been discovered in different sampling areas by applying

different methods. This field of study is important due to the higher concerns gaining from on sustainable development and digitalization. Hence, more research is required to gain a deeper understanding of the influence between these variables so to give a clearer picture for policy makers on making better decisions.

Chapter 3: Methodology

3.0 Introduction

The research methodology of this research will be described respectively in this chapter. In section 3.1, we stated the information of our collected data, including the variables description and the sources. Next, we provide a summary and a correlation analysis of our data to have a better understanding of the data in section 3.2. Further, we describe the construction of our research model that will be used in this study in section 3.3. Lastly, we wrap up this chapter in section 3.4.

3.1 Data

This research analyses the annual data from 2013 to 2020 for a panel of 50 countries that are included in the studies of the IMD World Competitiveness Centre, namely: Argentina, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Korea Rep., Latvia, Lithuania, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, United Arab Emirates, Ukraine, United Kingdom, and United States. The reason for the data sample starting with 2013 is due to the earliest available data on IMD Digital Competitiveness. On the other hand, the year 2020 provides the latest data for most of the variables. Among the all the sample countries, there are 36 of them are high-income countries, 14 of them are middle-income countries, according to the world bank classification.

Referring to table 3.1, the dependent variable employed in this study is DS (Digitalization Score), use to capture the digitalization of the country, which proxy by the IMD Digital Competitiveness Score. The two independent variables are

SDGI (SDGs index) use to capture the country effort on achieving sustainable development and WGI (World Governance Index) use to capture good governance level. In addition, we also include control variables to strengthen our result findings, which are GDPPC (GDP per capita, PPP), TO (Trade Openness), GC (Government Consumption per capita), GCF (Gross Capital Formation per capita), ATE (Access to Electricity), and FDI (Foreign Direct Investment). The data for DS was collected from IMD World Competitiveness Centre (IMD, 2022). The data for SDGI was obtained from Sustainable Development Solutions Network, a global initiative for United Nations (UNSDSN, 2022). The data for WGI was collected from Worldwide Governance Indicators (World Bank, 2022c). The data for GDPPC, TO, GC, GCF, ATE, and FDI were derived from World Development Indicators (World Bank, 2022b).

Table 3.1: Data Description

Variables	Variables Description	Sources
DS	IMD Digital Competitiveness Score (0 to100)	IMD World Competitiveness Centre
SDGI	Sustainable Development Index (0 to100)	Sustainable Development Solutions Network
WGI	Worldwide Governance Indicators (-2.5 to 2.5)	Worldwide Governance Indicators
GDPPC	Natural log of Gross Domestic Products per capita (current international $)	World Development Indicators
TO	Trade Openness (% of GDP)	World Development Indicators
GC	Natural log of Government Consumption per capita (constant LCU)	World Development Indicators
GCF	Gross Capital Formation per capita (constant 2015 US dollar)	World Development Indicators

ATE	Access to Electricity (% of population)	World Development Indicators
FDI	Natural log of Foreign Direct Investment, net inflows (% of GDP)	World Development Indicators

This study utilizes two independent variables. 1) To measure the direct effect of sustainable development has on digitalization, we use Sustainable Development Goals Index (SDGI) to capture the effort of a country on achieving sustainable development. The SDGI is an assessment of each country's overall performance on the 17 SDGs, giving equal weight to each Goal. The score signifies a country's position between the worst possible outcome (score of 0) and the target (score of 100), with the data obtained from Sustainable Development Solutions Network (2022).

2) To measure the direct and indirect effect of good governance has on digitalization, we use Worldwide Governance Indicators (WGI) to capture a country institutional quality, with the data obtained from World Bank (2022c). The Worldwide Governance Indicators project reports aggregate and individual governance indicators for more than 200 countries over the period 1996–2021, including six dimensions of governance: Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption. We use the average value of the 6 dimensions included as the proxy of WGI.

3.2 Data Estimation

3.2.1 Descriptive Analysis

First, we will conduct a descriptive analysis of the raw data we collected before taking any further statistical analyses. A descriptive analysis is an obligate important first step, it provides an overview of the data's distribution, makes it easier to detect any outliers or typos, and allows the researchers to identify the correlations among the variables. By running a descriptive analysis, the measures

of central tendency, including the mean, median, and mode, can be acquired. The information provided by descriptive analysis will help the researchers have a better understanding of the data.

Table 3.2: Descriptive Statistic

VARIABLES	Obs.	Mean	Std. Dev.	Min	Max
DS	400	69.12	17.75	31.91	100
SDGI	400	75.67	5.836	55.14	86.420
WGI	400	0.758	0.739	-0.841	1.859
GDPPC	400	10.34	0.636	8.480	11.680
TO	400	99.93	71.06	22.49	442.60
GC	400	9.942	2.127	7.446	15.630
GCF	400	8.383	0.974	5.577	10.590
ATE	400	99.15	2.906	82	100
FDI	400	3.795	0.351	0.000	5.198

Table 3.2 displays a summary of the variables. In total, there are 400 observations from 50 countries with 8 years of sample period. From the table above, we can observe that there are big differences between the maximum and minimum in DS, indicating that the gap on digitalization between the sample countries is big, thus using quantile regression able to provide more specific relationship with other variables at different levels of DS. For GDPPC, GC, GCF, ATE, and FDI, the natural log has been computed on the original data as coefficients on the natural-log scale are directly interpretable as approximate proportional differences. The original data collected for TO and ATE are already calculated as percentages, so no mathematical method has been taken on it.

3.2.2 Correlation Analysis

Next, correlation analysis will be conducted on the data. Correlation analysis is able to examine the depth of the relationship between the quantitative variables. The

correlation coefficient, also known as “r”, varies from -1 to +1, it denotes the strength and the direction of the relationship between the two variables. A high correlation means that the variables are having a strong relationship with each other; on the flip side, a low correlation denotes that the variables are barely related. The positive sign (+) indicates a positive relationship, and the negative sign (-) indicates a negative relationship between the variables.

Table 3.3: Correlation Analysis

	DS	**SDGI**	**WGI**	**GDPPC**	**TO**	**GC**	**GCF**	**ATE**	**FDI**
DS	1								
SDGI	0.5955	1							
WGI	0.8254	0.7346	1						
GDPPC	0.7892	0.7368	0.7912	1					
TO	0.1211	0.1956	0.2565	0.3731	1				
GC	0.0643	-0.0161	0.0159	0.0067	-0.0372	1			
GCF	0.8449	0.6955	0.8735	0.9316	0.2639	0.1029	1		
ATE	0.3562	0.6346	0.3398	0.6672	0.1951	0.0288	0.4728	1	
FDI	0.0024	0.0168	0.0584	0.1029	0.3272	-0.0015	0.0711	0.0391	1

From table 3.3, we can observe that WGI, GDPPC, and GCF are having a high positive correlation with DS, while SGDI is having a moderate correlation with DS. Besides that, ATE is a having low positive correlation with DS, while TO, GC, and FDI is having an almost negligible relationship with DS. Importantly, WGI is also having a high positive correlation with SDGI, there is no any negative correlation found between other variables and the dependent variable (Y). While GCF has been found to highly correlated with other variable, causing a multicollinearity problem, thus we decide to drop the variable after checking the VIF value.

3.3 Model Construction

This research employed quantile regression to study the relationship of sustainable development and good governance towards digitalization, by utilizing the advantages of quantile regression with bootstrap replications to analyse different relationships nexus in different digitalization level. The results provided by quantile regression gives a clearer picture of the relationship than classical linear regression. According to Binder & Coad (2011)the standard regression technique only provides summary point estimation for the average results of the whole distribution. By just focusing on the mean results, not only will it over-or underestimates the coefficients, but it will also fail to recognize the strong association between variables. Hence, to avoid the issues above, we employ Quantile Regression proposed by Koenker & Bassett (1978) which is more accurate and thus provides more reliable predictions, as it allows us to include a wide spectrum of conditional quantile functions. The quantile regression method is suitable for our study, which able to capture the relationship between SDGI and WGI towards at different DS level.

The written equations for quantile regression using in this study are shown at below. In quantile regression, the β (τ) represents the coefficient at the individual quantile τ level and βi is the unobserved individual effects. DS_{it} represents country i's digitalization level in year t.

$$DS,_t(\tau|X_{i,t}) = \beta_0 + \beta_{1,\tau}\, SDGI_{i,t} + \beta_{2,\tau}\, WGI_{i,t} + \beta_{3,\tau}\, GDPPC_{i,t} + \beta_{4,\tau}\, TO_{i,t} + \beta_{5,\tau} GC_{i,t} + \beta_{6,\tau}\, GCF_{i,t} + \beta_{7,\tau}\, ATE_{i,t} + \beta_{5,\tau}\, FDI_{i,t} + \varepsilon i$$

Eq. (1)

$$DS,_t(\tau|X_{i,t}) = \beta_0 + \beta_{1,\tau}\, SDGI_{i,t} + \beta_{2,\tau}\, (WGI*SDG)_{i,t} + \beta_{3,\tau}\, GDPPC_{i,t} + \beta_{4,\tau}\, TO_{i,t} + \beta_{5,\tau} GC_{i,t} + \beta_{6,\tau}\, GCF_{i,t} + \beta_{7,\tau}\, ATE_{i,t} + \beta_{5,\tau}\, FDI_{i,t} + \varepsilon i$$

Eq. (2)

The Eq. (1) of the study is being constructed with the aim to estimate the results for hypothesis 1 and 2, the direct effect of SDGI and WGI towards DS. Secondly, Eq.

(2) is designed to estimate the result for hypothesis 3, the variable SDGI and WGI*SDG is constructed to check the moderating effect of WGI on SDG, examines the direct effect of SDGI and indirect effect of WGI towards DS.

The data sample will separate the countries data into three categories to do the analysis using quantile regression, which are all countries, high-income countries, upper and lower-middle income countries. By applying equation (1) and (2) on three sample countries dataset, we will have 6 regression result outcome, which will be presented in Chapter 4.

3.4 Conclusion

The data employed in this study are being described clearly early in this chapter. Further, we have adopted descriptive and correlation analysis on the data, it helps us to have a better understanding of the data we collected. Later in this chapter, we discussed how we construct the model for this study. We have constructed two equations to examine the direct and indirect effect of independent variables (SDGI & WGI) towards dependent variable (DS). Last but not least, we have discussed the Quantile Regression, which we are going to conduct the study based on.

Chapter 4: Data Analysis

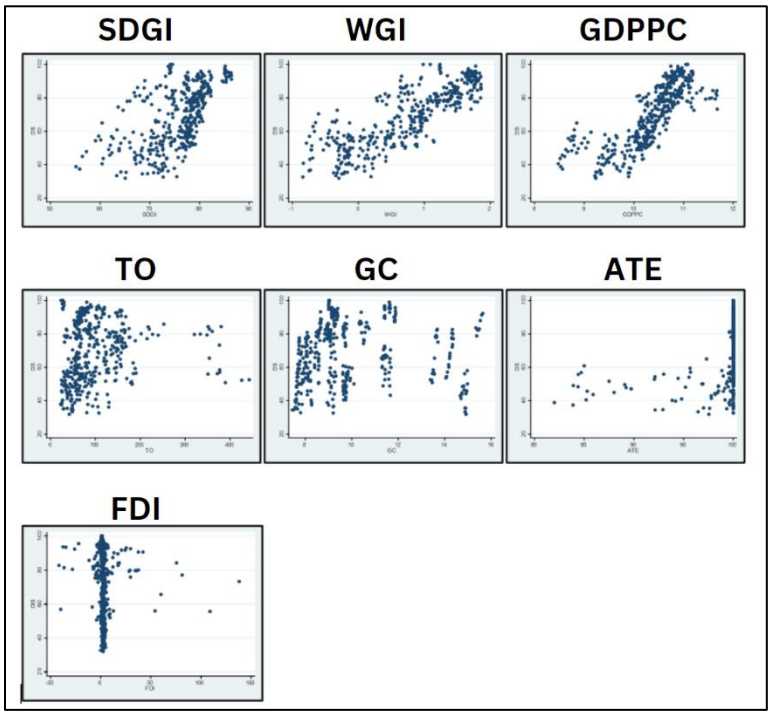
4.0 Introduction

In this chapter, we will explain the results of our data analysis through the research model that we have proposed in Chapter 3. Section 4.1 shows the scatter plot result of the dependent variable against independent variables and other control variables. Section 4.2 and 4.3 shows the result of quantile regression analysis on all sample countries, by applying equation 1 and 2 respectively. Section 4.4 and 4.5 shows the result of quantile regression analysis on high-income countries only, by applying equations 1 and 2 respectively. Section 4.6 and 4.7 shows the result of quantile regression analysis on middle-income countries only, by applying equation 1 and 2 respectively.

4.1 Scatter Plot

Figure 4.1 shows the scatter plots of the dependent variable (DS) (on the Y-axis) against the independent variables and control variables (X-axis). Graphically, SDGI, WGI, and GDPPC has a positive relationship with DS. Clustering patterns are not obvious, yet scatter points are relatively more saturated in higher DS quantiles, giving partial justification for using the quantile regression method. The abnormal scatter points on other variable may implies that the data is not normally distributed, thus, quantile regression is suggested to apply in this study.

Figure 4.1: Scatter Plot of DS against other variables



4.2 Result of Model 1 investigates on all sample countries

Table 4.1 shows the quantile regression result for all the sample countries, investigating the direct effect of SDGI and WGI have on DS. SDGI has significant negative relationship with DS at 75th and 95th quantiles, at 1% significance level. The coefficient values getting bigger from lower quantile to higher quantile, turns negative at 50th, 75th, and 95th quantiles. WGI has significant positive relationship with DS at all quantiles, at 1% significance level. The importance is inconsistent at different quantiles, which the coefficient value increase at 25th and 75th quantiles, decrease at 50th and 95th quantiles.

GDPPC has significant positive impact on DS at all quantiles, at 1% significance level. The importance reduce when moving from lower to higher quantile. TO has significant negative impact on DS at all quantiles, at 1% significance level. The coefficient value decrease at 25th and 50th quantiles, increase at 75th and 95th quantiles. GC is found positive significant at 75th quantile only, at 1% significance level. ATE has significant negative relationship with DS at15th and 25th quantiles,

at 1% significance level. A significant negative relationship at 50th quantile, 5% significance level. FDI has no significant relationship with DS.

Table 4.1: Result of Eq. (1) on all countries

VARIABLES	q.15	q.25	q.50	q.75	q.95
SDGI	**0.0883**	**0.1434**	**-0.1274**	**-0.6866*** **	**-0.7642*** **
	(0.2662)	**(0.2444)**	**(0.2622)**	**(0.2299)**	**(0.2167)**
WGI	**11.5853*** **	**11.6107*** **	**11.5493*** **	**14.7485*** **	**13.0187*** **
	(2.2246)	**(1.8501)**	**(2.1386)**	**(2.1688)**	**(2.2242)**
GDPPC	19.7027***	19.2969***	17.7197***	14.6938***	13.2301***
	(2.5449)	(2.5271)	(3.0287)	(2.4564)	(2.6153)
TO	-0.0585***	-0.0488***	-0.0427***	-0.0563***	-0.0563***
	(0.0117)	(0.0117)	(0.0110)	(0.0064)	(0.0129)
GC	0.3923	0.2885	0.1550	0.9709***	0.3045
	(0.3404)	(0.2638)	(0.4107)	(0.2761)	(0.4141)
ATE	-1.5416***	-1.4593***	-0.9312**	-0.2419	0.5193
	(0.3287)	(0.3088)	(0.4203)	(0.3606)	(0.3599)
FDI	-0.3295	0.4550	-0.8194	0.2832	1.0156
	(1.8136)	(1.9554)	(1.9016)	(1.3410)	(1.8679)
Constant	-2.8967	-11.4987	-15.5213	-16.7473	-59.2140***
	(20.8242)	(15.7561)	(23.4126)	(20.0459)	(17.9479)
Pseudo R2	0.5535	0.5598	0.5654	0.5259	0.4714

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.3 Result of Model 2 investigates on all sample countries

Table 4.2 shows the quantile regression result for all the sample countries, investigating the direct effect of SDGI and indirect effect of WGI have on DS. SDGI has significant negative relationship with DS at 75th and 95th quantiles, at 1% significance level. The coefficient values getting bigger from lower quantile to

higher quantile. WSDG has significant positive relationship with DS at all quantiles, at 1% significance level. The importance is inconsistent at different quantiles, which the coefficient value increase at 25th and 75th quantiles, decrease at 50th and 95th quantiles.

GDPPC has significant positive impact on DS at all quantiles, at 1% significance level. The importance reduce when moving from lower to higher quantile. TO has significant negative impact on DS at all quantiles, at 1% significance level. The coefficient value decrease at 25th and 50th quantiles, increase at 75th and 95th quantiles. GC is found positive significant at 75th quantile only, at 1% significance level. ATE has significant negative relationship with DS at15th and 25th quantiles, at 1% significance level. FDI has no significant relationship with DS.

Table 4.2: Result of Eq. (2) on all countries

VARIABLES	**q.15**	**q.25**	**q.50**	**q.75**	**q.95**
SDGI	**-0.0169**	**0.0974**	**-0.3220**	**-0.8362*** **	**-1.0515*** **
	(0.2763)	**(0.2563)**	**(0.2948)**	**(0.2479)**	**(0.2327)**
WSDG	**0.1562*** **	**0.1581*** **	**0.1626*** **	**0.1952*** **	**0.1741*** **
	(0.0308)	**(0.0260)**	**(0.0315)**	**(0.0251)**	**(0.0276)**
GDPPC	19.7068***	17.7681***	16.6419***	14.9508***	14.5046***
	(2.9948)	(2.6847)	(3.2014)	(2.2293)	(2.5387)
TO	-0.0570***	-0.0423***	-0.0403***	-0.0536***	-0.0532***
	(0.0132)	(0.0116)	(0.0099)	(0.0063)	(0.0112)
GC	0.2513	0.2019	0.0466	0.9541***	0.4077
	(0.3424)	(0.3140)	(0.3387)	(0.2721)	(0.3551)
ATE	-1.3929***	-1.2869***	-0.7142	-0.0866	0.5794
	(0.3516)	(0.3797)	(0.4866)	(0.3997)	(0.3961)
FDI	-0.3025	0.3844	-1.3505	0.2918	1.1570
	(1.7760)	(1.8646)	(1.9258)	(1.2563)	(1.9996)
Constant	-9.2612	-9.3044	-9.2696	-24.3002	-59.3853**
	(21.1676)	(20.4122)	(24.3744)	(21.8420)	(23.2378)
Pseudo R2	0.5597	0.5659	0.5721	0.5346	0.4835

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.4 Result of Model 1 investigates on high-income countries

Table 4.3 shows the quantile regression result for high-income countries only, investigating the direct effect of SDGI and WGI have on DS. SDGI has significant positive relationship with DS at 15^{th} and 25^{th} quantiles, at 5% and at least 10% significance level respectively. It has been found to have a significant negative relationship with DS at 75^{th} and 95^{th} quantiles at 5% and 1% significance level respectively. The coefficient value getting smaller at lower and medium quantiles (15^{th} to 25^{th} and 50^{th}) but getting bigger at higher quantile (75^{th} and 95^{th}). WGI has significant positive relationship with DS at all quantiles, at 1% significance level. The importance is consistent at all quantiles.

GDPPC has significant positive impact on DS at all quantiles, at 1% significance level. The importance reduce when moving from lower to higher quantile (15^{th} to 25^{th}, 50^{th}, and 95^{th}), but increased in 75^{th} quantile. TO has significant negative impact on DS at all quantiles, at 1% significance level. The coefficient value decrease at 25^{th} and 50^{th} quantiles, increase at 75^{th} and 95^{th} quantiles. GC is found positive significant at 75^{th} and 95^{th} quantiles, at 1% significance level, the coefficient value getting bigger at higher quantile (75^{th} and 95^{th}). ATE has significant positive relationship with DS at 50^{th} and 75^{th} quantiles, at 5% significance level respectively. A significant positive relationship at 95^{th} quantile, at 1% significance level. The coefficient value getting bigger when moving towards higher quantile. FDI has no significant relationship with DS.

Table 4.3: Result of Eq. (1) on high-income countries

VARIABLES	q.15	q.25	q.50	q.75	q.95

SDGI	**0.8368****	**0.6581***	**0.1349**	**-0.4053****	**-0.7037*****
	(0.3702)	**(0.3497)**	**(0.2865)**	**(0.2026)**	**(0.1956)**
WGI	**15.3101*****	**15.2837*****	**15.9889*****	**15.0586*****	**15.9790*****
	(2.2825)	**(1.7381)**	**(1.9761)**	**(2.3552)**	**(2.9724)**
GDPPC	19.2597***	17.6812***	15.9920***	20.3718***	14.2645***
	(3.4133)	(3.0723)	(3.4282)	(4.2812)	(2.7886)
TO	-0.0528***	-0.0520***	-0.0344**	-0.0491***	-0.0723***
	(0.0157)	(0.0135)	(0.0145)	(0.0091)	(0.0081)
GC	-0.4826	-0.5050	0.4645	1.2386***	1.4769***
	(0.3419)	(0.3296)	(0.4462)	(0.2736)	(0.3811)
ATE	0.7312	10.6239	36.3703**	37.0576**	73.9863***
	(11.2770)	(11.5110)	(16.4518)	(16.5560)	(13.9575)
FDI	-0.6263	-0.2163	-0.2537	0.5381	0.2149
	(1.2548)	(1.4916)	(2.2786)	(1.5087)	(1.2872)
Constant	-279.2019	-1,236.7285	-3,760.0391**	-3,835.0381**	-7,433.9693***
	(1,119.2436)	(1,141.6996)	(1,630.4578)	(1,625.9302)	(1,379.5413)
Pseudo R2	0.5862	0.5851	0.5217	0.4899	0.4535

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.5 Result of Model 2 investigates on high-income countries

Table 4.4 shows the quantile regression result for high-income countries, investigating the direct effect of SDGI and indirect effect of WGI have on DS. SDGI has positive relationship with DS at 15^{th} quantile, at least 10% significance level. Significant negative relationship with DS at 75^{th} and 95^{th} quantiles, at 1% significance level. The coefficient value getting smaller at lower and medium quantiles (15^{th} to 25^{th} and 50^{th}) but getting bigger at higher quantile (75^{th} and 95^{th}). WSDG has significant positive relationship with DS at all quantiles, at 1%

significance level. The coefficient value increase at lower and medium quantiles (15^{th} to 25^{th} and 50^{th}), but reduce at higher quantiles (75^{th} and 95^{th}).

GDPPC has significant positive impact on DS at all quantiles, at 1% significance level. The coefficient value decrease at 25^{th}, 50^{th}, and 95^{th} quantiles, increased at 75^{th} quantile. TO has significant negative impact on DS at all quantiles, at 1% significance level, 5% significance level at 50^{th} quantile. The coefficient value increase at 25^{th}, 75^{th}, and 95^{th} quantiles, decrease at 50^{th} quantile. GC is found positive significant at 75^{th} and 95^{th} quantiles, at 1% significance level. ATE has significant positive relationship with DS at 50^{th} and 75^{th} quantiles, at 5% significance level. A significant positive relationship at 95^{th} quantile, at 1% significance level. The coefficient value is getting bigger when moving from lower quantile to higher quantile. FDI has no significant relationship with DS.

Table 4.4: Result of Eq. (2) on high-income countries

VARIABLES	q.15	q.25	q.50	q.75	q.95
SDGI	**0.6995***	**0.4194**	**-0.1555**	**-0.6699*****	**-0.8976*****
	(0.3874)	**(0.3432)**	**(0.2863)**	**(0.2207)**	**(0.2247)**
WSDG	**0.1878*****	**0.1949*****	**0.2097*****	**0.2009*****	**0.1892*****
	(0.0263)	**(0.0214)**	**(0.0260)**	**(0.0289)**	**(0.0351)**
GDPPC	19.1707***	17.4196***	15.8643***	18.4931***	15.0031***
	(3.5286)	(3.4273)	(3.7479)	(4.0332)	(2.5952)
TO	-0.0461***	-0.0509***	-0.0331**	-0.0520***	-0.0678***
	(0.0166)	(0.0146)	(0.0155)	(0.0084)	(0.0083)
GC	-0.2922	-0.5255	0.4040	1.2507***	1.1326***
	(0.3571)	(0.3612)	(0.4940)	(0.2612)	(0.3401)
ATE	0.5691	10.7980	35.5932**	40.9587**	66.1727***
	(10.3238)	(11.1135)	(16.9518)	(16.8184)	(14.4715)
FDI	-0.5678	-0.2946	-0.1169	0.1576	0.1139
	(1.3154)	(1.5963)	(2.3016)	(1.5506)	(1.0662)
Constant	-253.7602	-1,232.2724	-3,658.9198**	-4,183.5909**	-6,641.1522***
	(1,022.0481)	(1,099.8695)	(1,680.9901)	(1,652.6764)	(1,435.0770)

Pseudo R2	0.5875	0.5879	0.5273	0.4949	0.4651

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.6 Result of Model 1 investigates on middle-income countries

Table 4.5 shows the quantile regression result for middle-income countries only, investigating the direct effect of SDGI and WGI have on DS. SDGI has negative relationship with DS at 75th and 95th quantiles, at least 10% significance The relationship is positive at lower quantiles, but negative at medium and higher quantiles. The coefficient value decrease at 25th, 75th and 90th quantiles, increase at 50th quantile. WGI has positive relationship with DS at all quantiles, but only significant at 25th quantile, at least 10% significance. The coefficient increase at 25th and 75th quantiles, decrease at 50th and 95th quantiles.

GDPPC has significant positive impact on DS at all quantiles, at 5% (15th) and 1% (25th, 50th, 75th, 95th) significance level. The coefficient value reduce at 25th and 75th quantiles, increased at 50th and 95th quantiles. TO has significant positive impact on DS at 15th, 25th, 50th, and 75th quantiles, at 5% significance level. The coefficient value decrease at 25th and 75th quantiles, increase at 50th quantile. GC is found positive significant at 25th and 50th quantiles, at 5% significance level. ATE has significant negative relationship with DS at 15th quantile, at 5% significance level. A negative relationship at 25th quantile, at least 10% significance level. FDI has no significant relationship with DS.

Table 4.5: Result of Eq. (1) on middle-income countries

VARIABLES	**q.15**	**q.25**	**q.50**	**q.75**	**q.95**
SDGI	**0.8375**	**0.3562**	**-1.3426**	**-1.1830***	**-1.1025***
	(0.8099)	**(0.7986)**	**(0.8764)**	**(0.6080)**	**(0.6384)**
WGI	**4.8410**	**8.3475***	**6.5720**	**7.2642**	**2.4834**

	(7.6286)	(4.9593)	(5.5652)	(4.6525)	(7.7119)
GDPPC	23.1366**	21.8975***	23.7479***	15.8250***	18.8311***
	(10.8547)	(6.7184)	(6.8014)	(4.8253)	(5.9808)
TO	0.1281**	0.1057**	0.1176**	0.1060**	0.0730
	(0.0594)	(0.0498)	(0.0542)	(0.0456)	(0.0459)
GC	1.5584**	1.5414**	0.1423	-0.1039	-0.4431
	(0.7541)	(0.5946)	(0.6266)	(0.7226)	(1.3814)
ATE	-2.3519**	-1.6688*	-0.4946	0.1947	-0.2486
	(0.9918)	(0.9238)	(1.0008)	(0.5569)	(0.4762)
FDI	-11.8741	-39.6557	-66.0102	-18.5392	-64.9365
	(45.4542)	(39.0090)	(45.0078)	(35.5352)	(45.6651)
Constant	13.9251	103.7772	208.6735	36.0530	231.9528
	(169.1217)	(142.6529)	(165.0283)	(129.2247)	(168.2927)
Pseudo R2	0.1667	0.2003	0.2117	0.3501	0.5327

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.7 Result of Model 2 investigates on middle-income countries

Table 4.6 shows the quantile regression result for middle-income countries only, investigating the direct effect of SDGI and indirect effect of WGI have on DS. SDGI has significant negative relationship with DS at 75^{th} quantile, at 5% significance level. A negative relationship with DS at 95^{th} quantile, at least 10% significance. The relationship is positive at lower quantiles, negative at medium and higher quantiles. The coefficient value decrease at 25^{th}, 75^{th} and 90^{th} quantiles, increase at 50^{th} quantile. WSDG has no significant relationship with DS.

GDPPC has significant positive impact on DS at all quantiles, at 5% (15^{th}) and 1% (25^{th}, 50^{th}, 75^{th}, 95^{th}) significance level. The coefficient value reduce at 25^{th} and 75^{th} quantiles, increased at 50^{th} quantile.TO has significant positive impact on DS at 15^{th}, 25^{th}, 50^{th}, and 75^{th} quantiles, at 5% significance level. The coefficient value decrease at 25^{th} and 75^{th} quantiles, increase at 50^{th} quantile.GC is found positive

significant at and 50th quantile, at 5% significance level, at least 10% significance at 15th quantile. ATE has significant negative relationship with DS at 15thquantiles, at 5% significance level. A negative relationship at 25th quantile, at least 10% significance level. FDI has no significant relationship with DS.

Table 4.6: Result of Eq. (2) on middle-income countries

VARIABLES	q.15	q.25	q.50	q.75	q.95
SDGI	**0.8808**	**0.4229**	**-1.3249**	**-1.2953****	**-1.0794***
	(0.8044)	**(0.8860)**	**(0.8421)**	**(0.6295)**	**(0.5778)**
WSDG	**0.0695**	**0.1205**	**0.0921**	**0.0645**	**0.0355**
	(0.1126)	**(0.0808)**	**(0.0766)**	**(0.0655)**	**(0.0875)**
GDPPC	23.0618**	21.7406***	23.7346***	16.6183***	18.8338***
	(11.2104)	(7.8916)	(7.2614)	(5.2682)	(4.7506)
TO	0.1276**	0.1050**	0.1181**	0.1152**	0.0734
	(0.0577)	(0.0515)	(0.0521)	(0.0467)	(0.0470)
GC	1.5781*	1.5773**	0.1484	-0.6142	-0.4351
	(0.8074)	(0.6819)	(0.6469)	(0.8527)	(0.9555)
ATE	-2.3649**	-1.6922*	-0.4947	0.2342	-0.2618
	(1.0471)	(0.9695)	(0.9611)	(0.5566)	(0.4211)
FDI	-13.4335	-40.9661	-67.7175	-22.8259	-64.9493
	(46.0384)	(42.7090)	(43.8693)	(39.7178)	(42.7746)
Constant	18.6713	107.5516	213.9648	52.2793	231.5481
	(172.3407)	(156.4993)	(161.2760)	(144.5345)	(156.4697)
Pseudo R2	0.1641	0.1963	0.2093	0.3481	0.5320

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Chapter 5 Discussion, Implication, and Conclusion

5.0 Introduction

In this chapter, we will discuss and conclude the study outcome of this research. In Section 5.1, we will discuss the results found from quantile regression analysis in chapter 4. In section 5.2, we discuss the implication provided of the research outcome. In section 5.3, we will discuss the limitations we faced while conducting this study in and the recommendations for future study will covered in Section 5.4. Lastly, the overall conclusion will include in section 5.5.

5.1 Discussion

5.1.1 Overall

The quantile regression results with all countries included are as expected, which show that sustainable development and good governance are having a significant relationship with digitalization. Sustainable development is having an insignificant positive impact when digitalization level is low, but it turns to be significant negative impact when digitalization level is high. The importance is getting higher when digitalization is moving to a higher level.

The results of this study are supported by Pérez-Martínez et al. (2023), stated that at low digitalization level, a steeper positive correlation has on sustainable development and digitalization, with higher digitalization, the correlation line turns flatter. Kushnir et al. (2021) stated that when the expressed results of digitalization of the economy have already been achieved, there is a positive connection between digitalization and sustainable development, but not 100%. These scenarios have explained that achieving sustainable development does not promote a country's

digitalization all the time, the complementary relationship seems to be weakened at higher digitalization level.

The further study of Pérez-Martínez et al. (2023) has found negative relationship between digitalization with 2 of the sustainability goals and 22 % of the sustainability indicators included in the SDG index, mostly occurred in areas of environmental. While Wang et al. (2022) revealed that environment sustainability through digitalization, Ahmadova et al. (2022) argue that digitalization will improve environmental performance and reduce after a tipping point, thus an inverted U-shape relationship between environmental performance and digitalization. This has explained that at a low digitalization level, achieving sustainable development will promote the country to a higher digitalization level. At a high digitalization level, further achieving sustainable development require a slowing down or reduction on the digitalization level of the country, in order to reduce the environmental issue of the country.

Good governance has been found as important determinant of digitalization, the result remain highly significant at all quantiles, supported by Myovella et al. (2021). A more illustrative findings on the indirect effect of good governance has found, which able to moderate the negative impact of achieving sustainable development has on digitalization. With the significant results found at all quantiles, upholding a good governance on achieving sustainable development is important for a country to achieve both sustainable development and digitalization at the same time, regardless the current digitalization level of the country. This finding is supported by Omri & Ben Mabrouk (2020), which stated that with good governance, country is able to moderate the negative impact of achieving sustainable development, while Shahbaz et al. (2022) has confirmed the mediating role of good governance on digitalization and energy transition. As the use of digital technologies continues to grow, so too does its environmental footprint, which can have negative consequences on the planet. Therefore, good governance practices that prioritize sustainable development, environmental protection, and the use of digital technology are needed to reduce the conflict between achieving sustainable development and digitalization.

In this study, GDP per capita is found as an important determent of country's digitalization level, supported by (Falch & Henten, 2018; Nishijima et al., 2017). Countries with higher GDP per capita generally have more resources available to invest in digitalization initiatives, such as building broadband networks, funding research and development of new technologies, and expanding digital literacy programs. While trade openness has been found negatively affect digitalization at all quantiles, but the coefficient value shows that its importance is low. This result is in conflict with previous studies, in fact, higher trade openness might increase country's reliance on foreign technology and products, it can hinder a country's efforts to develop its own digital infrastructure and technologies.

5.1.2 High-income Countries

The results on good governance as expected, which highly significant in promoting digitalization in high-income country at all quantiles. In high-income countries, sustainable development has a significant incentive for digitalization when a country's digitalization level is relatively low (15th quantile). As country moving toward a higher digitalization level, the positive influence tends to be smaller, and turns to negative impact when the country has achieved a high digitalization level (75^{th} and 95^{th} quantile). This explains that, when high-income country is at a high level of digitalization, further achieving sustainable development will bring down the country's digitalization level. This result is in line with the finding of Gurieva et al. (2021) which stated that digitalization is need to slow down in order to achieve sustainable development simultaneously in developed countries. However, our study results found that the moderating effect of good governance in high-income countries is highly positive significant at all quantile, we argue that with good governance, developed country is able to achieve both sustainable development and digitalization at the same time. Governance plays an important role to ensure the policy design and its effectiveness in order to reduce the conflict between sustainable development and digitalization, while the focus needed to pay more on the improvement sustainable environmental performance through digitalization.

GDP per capita is an important determinant of digitalization. positively affect digitalization at all quantiles in high-income countries, while trade openness is negatively affect digitalization with a relatively low importance. The percentage of country's population access to electricity is positively affect digitalization at a higher quantiles in high-income countries, this result is in line with previous study, when country has achieve a high digitalization level, government needs to ensure more peoples able to access to electricity use, in order to fully utilize the benefit to going digital. While government consumption is said to be positively affect digitalization at higher quantiles, the spending direction of government is important in order to achieve higher digitalization level.

5.1.3 Middle-income Countries

In middle-income countries, there is no significant relationship found between sustainable development, good governance, and digitalization. This result is conflicting with previous studies, which stated the strong correlation between sustainable development and digitalization in less developed countries (Pérez-Martínez et al., 2023), and good governance as an important factor to achieve digitalization and its moderating effect. The possible reason for this outcome is due to the small sample size on middle-income countries, which not able to provide a comprehensive result for the study. In fact, Skaletsky et al. (2016) has stated that good governance is less important than other determinants of digitalization, but it needs to develop its institutional quality as to move into the higher digitalization level. When sustainable development and good governance have found no significant relationship with digitalization, GDP per capita has been found as an important determinant of digitalization in middle-income country. Trade openness has significant positive impact on digitalization except of 95^{th} quantile, and government consumption have been found affecting digitalization when country is at a low digitalization level.

5.2 Implication

Sustainable development is crucial for a country to achieve because it seeks to balance economic growth with environmental protection and social well-being, ensuring that present and future generations can meet their needs. Digitalization has been identified as the core factor to drive the industrial revolution 4.0, fostering innovation, improving productivity, and improving public services by making them more efficient, accessible, and effective. With both these two goals are important for country to achieve, the effort of government to ensure they can both improve complementarily has been a main concern.

Our study has confirmed that sustainable development and digitalization can be achieved simultaneously, and good governance plays an important role to ensure that the negative externalities of achieving sustainable development on digitalization can be moderated. Previous studies have identified that environmental issue is the main aspect that has negative association with digitalization, an inverted U-shape relationship occurred between it. In high-income countries, achieving sustainable development will complementarily improve digitalization at the same time, but when digitalization moving to a higher level, good governance is needed to ensure that achieving sustainable able to promote digitalization at the same time,

It is crucial for government to promote policy coherence and coordination between different sectors and stakeholders, to ensure that sustainable development policies and digitalization strategies are aligned and mutually reinforcing, focusing on environmental related policies. Government can implement regulations and standards that promote sustainable development, including policies that encourage the use of renewable energy sources and the reduction of electronic waste. At the same time, promoting transparency and accountability, ensuring the negative impact of digitalization on the environment is minimized. This can include establishing clear guidelines and regulations for the disposal of electronic waste, as well as promoting ethical and responsible manufacturing practices. Upholding a good governance in policy design to avoid conflicts or trade-offs between sustainable development and digitalization and ensuring its effectiveness and

efficiency, thus maximizing synergies and opportunities for innovation and collaboration.

In middle-income countries, we found that sustainable development and good governance has no significant relationship with digitalization at all quantiles. But other variables but other variables have show significant relationship with digitalization at all quantiles. Referring to previous literature, our study outcome on the overall and high-income countries, we found strong evidence that good governance is important for country to achieve higher digitalization level.

5.3 Limitation

There are several limitation in this study. First of all, the dependent variable (DS) and independent variables (SDGI, WGI) are compounded from several components and different indicators. In our study, we are using the aggregate average value of all components and indicators for those three variables. Thus, the results that we found can only show the overall relationship of between sustainable development, good governance, and digitalization. Secondly, to ensure the data for all the included variables are available in all the sample period, we have the limitation on small countries sample and periods, which might cause the results are not comprehensively enough, especially for middle-income countries.

5.4 Recommendation for Future Research

For future studies, researchers who intend to study the similar topic may include all sub-components and indicators that use to compound the SDGs index, Good Governance Indicators, and IMD digital competitiveness score. This may provide a clearer result on which parts of the sustainable development and good governance would have the significant relationship with specific parts of the country digitalization, providing more specific targets for governments to achieve on their

policy design. Besides that, researchers may also conduct the study using time series data focus on one country rather than using panel data that conducted on several sample countries. This will provide useful insights for specific country for their policies design on both achieving sustainable development and digitalization.

5.5 Conclusion

Currently, the world is pledged to achieve the United Nations Sustainable Development Goals, to balance economic growth, social development, and environmental protection in order to create a more equitable and sustainable world. At the same time, digitalization has been said as an important tool to achieve better economy development, it has the potential to transform economies and societies, enabling greater access to information, services, and opportunities, as well as promoting connectivity and collaboration across borders.

It is important for country to ensure that both sustainable development and digitalization can be improved from time to time. Thus, this research aims to study whether achieving sustainable development is good or bad for country to achieve higher digitalization level, as well as the moderating effect of good governance to reduce the negative externalities of achieving sustainable development. By employing quantile regression analysis on different income-level countries, we able to capture the nexus at different digitalization level on different developing status countries.

The results of this research show that while sustainable development and digitalization have been important goals to develop a better economy, the trade-off between these two goals occurred when country is already at a high level of digitalization. However, we also proved that good governance plays an important role in mitigating the negative externalities of pursuing sustainable development, it is important for country to seek for the balance on achieving both sustainable development and digitalization through a better governance.

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Appendix

Summary of Literature Review

Sustainable Development & Digitalization		
Author	**Methodology**	**Result**
(Gurieva et al., 2021)	Regression & Scenario Analysis	Achieve Sustainable Development, Slowing down Digitalization
(Pérez-Martínez et al., 2023)	Statistical Analysis	Positive & Negative Relationship
(Ionescu-Feleagă et al., 2023)	Correlation Analysis	Positive & Negative Relationship
(Kushnir et al., 2021)	Statistical Analysis	Positive & Negative Relationship
(Burinskienė & Seržantė, 2022)	Correlation Matrix & Linear Regression	Positive & Negative Relationship

Good Governance, Sustainable Development, and Digitalization		
Author	**Methodology**	**Result**
(Chinn & Fairlie, 2007)	Blinder-Oaxaca Decomposition Technique	Significant Positive Relationship
(Billon et al., 2010)	Multiple Regression Analysis, Canonical Correlation Analysis	Significant Positive Relationship
(Shahbaz et al., 2022)	SYS-GMM Method	Significant Positive Relationship
(Myovella et al., 2021)	Spatial Panel Analysis	Significant Positive Relationship
(Omri & Ben Mabrouk, 2020)	GMM Method	Significant Moderating Role
(Skaletsky et al., 2016)	TreeNet Algorithm	Significant Moderating Role