


**INVESTIGATING THE IMPACT OF ICT DEVELOPMENTS ON THE ENVIRONMENT IN THE DIGITAL ECONOMY AND GREEN ECONOMY IN SOUTHEAST ASIA**

**Emas Sulisnaningrum<sup>A</sup>, Siti Mutmainah<sup>B</sup>, Suryaning Bawono<sup>C</sup>, Benjamin Drean<sup>D</sup>**



ARTICLE INFO	ABSTRACT
<p><b>Article history:</b></p> <p><b>Received</b> 20 February 2023</p> <p><b>Accepted</b> 11 May 2023</p>	<p><b>Purpose:</b> This study examines information and communication technology's effects on industry revolution 4 on the environment as an effort to develop a digital economy and a green economy in Southeast Asia that is part of the ASEAN organization.</p> <p><b>Design/methodology/approach:</b> We use the variables of growth (GDP), green energy, investment in ICT, and the environmental footprint of Southeast Asia in our study. We use secondary data from the Global Footprint Network and the World Bank with a research period from 1990 to 2020. We apply the ARDL technique to determine the relationship between the variables and their direction of causation.</p> <p><b>Findings:</b> The impact of ICT on environmental sustainability did not have a significant impact, meaning that the development of information and communication technology is very feasible to be developed to support the green economy as well as the digital economy. Where the use of green energy has a significant negative impact on the ecological footprint which is getting better for environmental sustainability as well as trade openness. Technology shows that technological developments during the research period are increasingly friendly to the environment.</p> <p><b>Research, Practical &amp; Social implications:</b> This research provides an overview of the economy and the environment and how to develop a green economy</p> <p><b>Originality/value:</b> This study investigates three interrelated sectors, namely digital, environment and economy</p>
<p><b>Keywords:</b></p> <p>ICT Developments; Environment; Digital Economy; Green Economy; Southeast Asia.</p> <div data-bbox="172 1003 480 1249" style="text-align: center;">  </div>	<p>Doi: <a href="https://doi.org/10.26668/businessreview/2023.v8i5.1052">https://doi.org/10.26668/businessreview/2023.v8i5.1052</a></p>

**INVESTIGANDO O IMPACTO DOS DESENVOLVIMENTOS DAS TIC NO MEIO AMBIENTE NA ECONOMIA DIGITAL E NA ECONOMIA VERDE NO SUDESTE ASIÁTICO**

**RESUMO**

**Objetivo:** Este estudo examina os efeitos da tecnologia da informação e comunicação na revolução da indústria 4 no meio ambiente como um esforço para desenvolver uma economia digital e uma economia verde no Sudeste Asiático que faz parte da organização ASEAN.

**Desenho/metodologia/abordagem:** Usamos as variáveis de crescimento (PIB), energia verde, investimento em TIC e a pegada ambiental do Sudeste Asiático em nosso estudo. Usamos dados secundários da Global Footprint Network e do Banco Mundial com um período de pesquisa de 1990 a 2020. Aplicamos a técnica ARDL para determinar a relação entre as variáveis e sua direção de causalidade.

<sup>A</sup> PhD in Universitas Merdeka Malang. Lecturer of accounting department of STIE Jaya Negara Tamansiswa Malang, Indonesia. E-mail: [emasulisnaningrummalang@gmail.com](mailto:emasulisnaningrummalang@gmail.com)

Orcid: <https://orcid.org/0000-0002-4384-8242>

<sup>B</sup> PhD in Universitas Merdeka Malang. Lecturer of accounting department of STIE Jaya Negara Tamansiswa Malang, Indonesia. E-mail: [sitimutmainahmmalang@gmail.com](mailto:sitimutmainahmmalang@gmail.com) Orcid: <https://orcid.org/0000-0001-6422-9734>

<sup>C</sup> Master in Universitas Jember. Lecturer and researcher management department of STIE Jaya Negara Tamansiswa Malang, Indonesia. E-mail: [ninobalmy@gmail.com](mailto:ninobalmy@gmail.com) Orcid: <https://orcid.org/0000-0001-6617-276X>

<sup>D</sup> Master in Lycée George Sand, EPL du Velay. Researcher of School Of Life and Wellness, France. STIE Jaya Negara Tamansiswa Malang, Indonesia. E-mail: [benjamindrean63600@gmail.com](mailto:benjamindrean63600@gmail.com)

Orcid: <https://orcid.org/0000-0001-5887-3259>

**Resultados:** O impacto das TIC na sustentabilidade ambiental não teve um impacto significativo, o que significa que o desenvolvimento da tecnologia da informação e comunicação é muito viável de ser desenvolvido para apoiar a economia verde, bem como a economia digital. Onde o uso de energia verde tem um impacto negativo significativo na pegada ecológica, que está melhorando para a sustentabilidade ambiental e a abertura comercial. A tecnologia mostra que os desenvolvimentos tecnológicos durante o período de pesquisa são cada vez mais amigáveis ao meio ambiente.

**Pesquisa, implicações práticas e sociais:** Esta pesquisa fornece uma visão geral da economia e do meio ambiente e como desenvolver uma economia verde

**Originalidade/valor:** Este estudo investiga três setores inter-relacionados, a saber, digital, meio ambiente e economia

**Palavras-chave:** Desenvolvimentos de TIC, Meio Ambiente, Economia Digital, Economia Verde, Sudeste Asiático.

## INVESTIGACIÓN DEL IMPACTO DE LOS DESARROLLOS DE LAS TIC EN EL MEDIO AMBIENTE EN LA ECONOMÍA DIGITAL Y LA ECONOMÍA VERDE EN EL SUDESTE ASIÁTICO

### RESUMEN

**Propósito:** Este estudio examina los efectos de la tecnología de la información y la comunicación en la revolución industrial 4 en el medio ambiente como un esfuerzo por desarrollar una economía digital y una economía verde en el sudeste asiático que forma parte de la organización ASEAN.

**Diseño/metodología/enfoque:** Usamos variables de crecimiento (PIB), energía verde, inversión en TIC y la huella ambiental del sudeste asiático en nuestro estudio. Utilizamos datos secundarios de Global Footprint Network y el Banco Mundial con un período de búsqueda de 1990 a 2020. Aplicamos la técnica ARDL para determinar la relación entre las variables y su dirección de causalidad.

**Resultados:** El impacto de las TIC en la sostenibilidad ambiental no tuvo un impacto significativo, lo que significa que el desarrollo de las tecnologías de la información y la comunicación es muy viable de desarrollar para apoyar tanto la economía verde como la economía digital. Donde el uso de energía verde tiene un impacto negativo significativo en la huella ecológica, la cual está mejorando para la sostenibilidad ambiental y la apertura al comercio. La tecnología muestra que los desarrollos tecnológicos durante el período de investigación son cada vez más respetuosos con el medio ambiente.

**Investigación, implicaciones prácticas y sociales:** esta investigación proporciona una visión general de la economía y el medio ambiente y cómo desarrollar una economía verde.

**Originalidad/valor:** Este estudio investiga tres sectores interrelacionados, a saber, digital, medio ambiente y economía.

**Palabras clave:** Desarrollo de las TIC, Medio Ambiente, Economía Digital, Economía Verde, Sudeste Asiático.

### INTRODUCTION

IT firms are becoming more and more interested in ecologically friendly technologies, including green energy and other industrial methods. Businesses started using advanced manufacturing models, which became known as advanced manufacturing, to decrease environmentally hazardous emissions (Fernando, Jabbour, & Wah, 2019). Besides, green energy decreases harmful emission (Wu, Kee, Loo, Goh, & Alyanbaawi, 2020). The utilization of innovative safe materials and intelligent technologies, including robotics and wireless sensor networks, characterize this. as a group of linked wireless sensors and information systems that keep track of the condition of equipment, conveyors, assembly machines, and reactors things in an enterprise. These systems communicate with production control components while

processing sensor data in real-time. Such an automatic system reacts to any changes in company indicators, notifies staff of incidents and problematic circumstances, evaluates the effectiveness of equipment use, and determines the degree of environmental pollution and the amount of trash produced (Kumar, Mohammed, Abdulkareem, Damasevicius, Mostafa, Maashi, & Chopra, 2021).

Technology nowadays may assist produce efficient environmental protection instruments in addition to serving the interests of consumers and businesses (Butt, Zulqarnain, & Butt, 2021; Rafael & Lopes, 2020). The use of ICT solutions can reduce cumulative greenhouse gas emissions. Increasing business turnover, publicity and growing brand influence put such companies in front of certain responsibilities not only to their customers, but also to the environment. However, it should be noted that the environmental impact of the ICT sector is one of the lowest in the global economic structure (Lahcen et al., 2020).

Alternative energy is a crucial component of "green" technology. Projects involving "green" technology aid in promoting the technology and make it more fashionable and attractive to other markets, which will eventually lead to the widespread of the idea of "smart" production (Xia, Zhang, Yu, & Tu, 2019). Another approach to get bonus points is by using green technologies. Consumers' use of energy-saving, environmentally friendly items increases brand loyalty while reducing the amount of money IT businesses must spend maintaining these devices. This approach allows companies to reduce costs for producers and consumers. It seems that supporting "green" technology is both popular and financially advantageous (Zhang & Liu, 2022).

Business social responsibility is a real tool for building staff, customer, partner, and country loyalty. Any business, including IT firms, thinks in terms of profit. It is no secret that lower energy prices and, in certain circumstances, total independence in resource use from suppliers justify major corporations' "green" initiatives' endeavors, particularly when it comes to locating alternative energy sources. Meanwhile, such "green" practices should not only involve businesses but also consumers themselves (Chen McCain, Lolli, Liu, & Jen, 2019 ; Novianto & ,Prabowo, 2021).

People need to realize that this entire narrative about conserving energy and lowering CO2 emissions is more than just empty rhetoric. The monthly expenditures for heat, electricity and other expenses must demonstrate significant financial gains. You should be aware of when to expect a return on your investment when installing eco-friendly equipment at home (Hsu, Quang-Thanh, Chien, & Mohsin, 2021). But the introduction of green technologies is not yet

in great demand. Of course, the fact that the earth today has a lot of hydrocarbons and energy prices are lower than in other countries does not contribute to the development of energy efficiency and renewable energy technologies (Berrada & Laasmi, 2021).

The state should join the active spread of "green" activities. Reducing CO2 emissions is a global problem. Therefore, if the initiative has government support, then it can create certain business opportunities. Adopting eco-friendly practices in smart manufacturing and facilities increases profits and protects the future of our planet. In connection to industrial processes and the fourth industrial revolution, this is particularly true. This study investigates how the Industrial Revolution 4 was affected by information and communication technologies on the environment as an effort to develop a digital economy and a green economy in Southeast Asia that are members of the ASEAN organization.

## LITERATURE REVIEW

Efficiency may be greatly improved by the utilization of information and communication technology (ICT) tools in a variety of corporate settings and indirect industry applications (Priyanto Widarni, & Bawono, 2022; Tandoh, Duffour, Essandoh, & Amoako, 2022). Governments and business associations have developed and implemented various ICT programs and initiatives to address environmental issues and global warming (Kumar Prakash, & Khan, 2020). These programs and initiatives are aimed at reducing energy costs and using them more efficiently, which will no doubt have a positive impact on the global economy and society as a whole (Neves, Marques, & Patrício, 2020).

Although ICTs are still directly responsible for only a fraction of the world's current greenhouse gas emissions, however, there is growing concern about the impact of ICTs on the environment (Gössling, 2020). This concern is driven by the strong growth in demand for ICT equipment and data centers across all sectors. At the same time, there is a growing awareness that the use of ICT can significantly reduce the environmental impact in sectors such as smart networking, smart home, smart logistics, smart mobility, and smart transportation (Porru, Misso, Pani, & Repetto, 2020). This is especially possible by optimizing or incorporating completely new and more energy-efficient processes. The energy saved is estimated to be several times greater than the total energy consumption of modern ICT equipment. ICT can help reduce global CO2 emissions by reducing their own energy consumption and by using IT solutions to reduce the overall energy consumption of facilities, buildings, and production (Bastida, Cohen, Kollmann, Moya, & Reichl, 2019).

The ever-increasing popularity of the Internet of Things concept and the increasing number of web applications in the industry prompted a sharp rise in the volume of data centers (Albreem, Sheikh, Alsharif, Jusoh, & Yasin, 2021). Businesses are installing more servers or expanding their capabilities as demand for electronic data continues to increase and each of these servers requires more power than the previous model (Sun, Zhou, Sun, Yu, & Vasilakos, 2020). Most of it falls on installing lots of new servers for business purposes. In addition, the worldwide, data center operating costs continue to increase steadily, along with rising energy costs. But regardless of the size and nature of the company, the largest contribution to overall levels of harmful emissions is not made by data centers (Pärssinen, Wahlroos, Manner, & Syri, 2019).

There are now many opportunities available to replace outdated IT equipment (workstations, personal computers, servers) with green embedded ICTs, most of which can not only reduce overall energy consumption but also reduce cooling requirements and free up value-added production areas. Financially, replacing IT equipment before it has fully depreciated may seem unwise (Antoni, Jie, & Abareshi, 2020). However, the latest generation of embedded industrial computing technology can offer much greater benefits in terms of lower power consumption, high-cost efficiency, and space-saving required for equipment installation (Nguyen & Chapman, 2021).

Another proven way to increase enterprise energy efficiency is virtualization, a technology designed to allow multiple application workflows to run on a single computer (Xu, Ma, Shea, Wang, & Liu, 2018). Managers of data centers now have total control over power optimization thanks to new power management technologies. This is accomplished by enabling you to consider real power usage and trend information for a single physical system or a collection of systems as a whole (Benlahbib, Bouarroudj, Mekhilef, Abdeldjalil, Abdelkrim, & Bouchafaa, 2020).

Data center performance in terms of energy consumption can be improved through the use of new energy-efficient hardware, improved airflow management in forced cooling systems to reduce overall cooling requirements, investment in energy management software, and introduction of environmentally friendly solutions to data center equipment and take additional measures to limit their overall energy consumption (Bose, Roy, Mondal, Chowdhury, & Chakraborty, 2021; Vafamehr & Khodayar, 2018).

A wide range of compact and space-saving models with highly scalable computing platforms can fully meet the needs related to information technology servers and industrial

computers in intelligent manufacturing. To ensure the stability of a particular device, remote control software is used that actively monitors device temperature, fan speed, voltage level, hard drive status, and other hardware components. Such active management can prevent serious accidents and device damage or save on expensive maintenance work, effectively reducing the overall system maintenance costs. The control system can remotely turn on or off a specific device or group of devices according to the requirements and workload of the "smart" production facility or its data center. In addition, some of these systems can protect information and devices by performing timely data backups. It is only natural that a computer that meets the updated specifications will reduce energy use overall in all operating modes (Shirmarz & Ghaffari, 2020).

There are new guidelines for idle mode on PCs because all previous standards only set requirements for sleep and standby. Most operator panels and the HMI (Human-Machine Interface) in a company or facility remain functional even when not in use. It consumes a large amount of electricity. These gadgets also need to be cooled since they produce heat, which increases total energy usage and increases company costs. The energy cost savings for one operator panel may not seem like much, but if we talk about a hundred computers, for a company this is already a significant amount. Thus, by meeting proper requirements for environmental cleanliness, companies can save on financial costs and, therefore, increase profit margins, which, in turn, means competitive advantage (Naim, A. (2021).

Green Panel PCs can be programmed to turn off power automatically and enter a power-saving state when idle. In this case, the remote on/off control system can measure power consumption and report how much power each Panel PC or HMI is drawing from the mains. The network administrator can enable/disable it remotely and even a group of devices, or wake the PC in question to update its software, for maintenance or backup (Assefa & Özkasap, 2019). Another approach to reducing power consumption is to use thin client technology. Instead of a Panel PC or HMI device, a thin client will consume about one-fifth of the power of a typical Panel PC (Manglani, Hodge, & Oxenham, 2019).

Green Ethernet is a symmetrical protocol that allows network ports to switch from a stronger power mode (data transfer mode) to a lower power mode (LPI mode) depending on whether data transfer has occurred (active state) or not (idle or standby state). This technology is called LPI (Low Power Idle), which actually defines a low power consumption state that can be used during periods when there is no line usage (Wu, Chen, & Wang, 2022).

Every device that implements a physical model of data transfer (network port switch, network card, etc.) asserts its ability to support the EEE (Energy-Efficient Ethernet) protocol during auto-negotiation when establishing a connection. If the devices on both sides of the communication channel support the EEE protocol, they are operating in the EEE protocol mode. But if at least one of these devices doesn't support EEE technology, they work normally. When there is no data transfer, EEE-compliant devices can use a modified static logic design to go beyond Low Power Idle (LPI) mode. In addition, the use of the EEE protocol to achieve power savings does not result in a transition to a lower bandwidth mode, and backward compatibility with existing interfaces that do not support this standard, although it does save energy, allows enterprises and organizations to upgrade their networks incrementally, without equipment downtime (Jiang, Liao, Yan, Cheng, Zhang, & Wang, 2021).

## RESEARCH METHOD

This empirical study tries to evaluate the connection between Southeast Asia's environmental impact, investment in ICT, and economic growth (GDP). We use secondary data from the Global Footprint Network and the World Bank with a research period from 1990 to 2020. The variables we measure are described in table 1.

Table 1. Description Of Variables

Variable	Description	Source
EFP	Ecological footprint	Global footprint network
GDP	Economic Growth	World Bank
GE	Green economics or Renewable energy consumption	World Bank
TTO	Technology trade openness	World Bank
ICT	Information and Communication Technology, a composite indicator made up of four components that is fixed telephone subscriptions, mobile cellular subscriptions, Fixed broadband subscriptions, and Internet users	World Bank

Table 2 presents descriptive statistics on economic growth (GDP), green energy (GE), technology trade openness (TTO), as well as ICT.

Table 2. Descriptive Statistics

Variable	Mean	Max	Min	Std.Dev	Kurtosis
EFP	0.493	0.725	0.181	0.185	1.814
GDP	4.561	5.702	3.381	0.425	3.195
GE	1.264	1.889	0.789	0.352	1.737
TTO	1.341	1.681	1.072	0.371	1.368
ICT	1.765	2.226	1.241	0.955	1.761

With regard to time series analysis, we examined the stationarity status of the series using the ADF test and PP test null hypothesis which is nonstationary. The cointegration condition between variables will then be tested, we used the Engle and Granger test, Johansen Test, and the ARDL-bound testing methodology. Eventually, we use the ARDL approach to establish the causal relationship between the variables in question.

This study attempts to investigate the relationship between the EFP in the KSA economy on the economic growth (GDP), green energy (GE), technology trade openness (TTO), and ICT. As a result, our model displays as follows:

$$\text{LnEFP}_t = \beta_0 + \beta_1 \text{LnGDP}_{t1} + \beta_2 \text{LnGE}_{t2} + \beta_3 \text{LnTTO}_{t3} + \beta_4 \text{LnICT}_{t4} + e_t$$

where the ecological footprint is measured by EFP as the dependent variable. GDP is the growth of the gross domestic product. GE stands for renewable energy consumption. ICT is information and communication technology. TTO refers to the openness of technology trade. The parameter  $\beta$  represents the long-run elasticity, and  $e$  is the error term,  $t$  is the time series. We use the ARDL model to test the cointegration relationships between the variable. Here's the vector equation we used in the ARDL model :

$$\Delta \bar{y}_t = \sigma + \sum_{k=1}^{n-1} Y_1 \Delta \bar{y}_{t-1} + \epsilon \bar{y}_{t-1} + e_t$$

With  $\bar{y}_t$  are column vectors of  $n$ , variables  $\sigma$  are vectors of constant terms,  $y$  and  $\epsilon$  are coefficient matrices,  $\Delta$  is a variation operator,  $N(0, \Sigma)$   $e$  is error term,  $t$  is time series,  $i$  is number of country. Statistics about the long-term associations are included in the coefficient matrix  $y$ , also known as the effect matrix.

## RESULTS AND DISCUSSION

Before examining the relationship between variables where to test the relationship between variables required stationary data, The results of a unit root test to examine the series' stationarity were then performed using the ADF test and PP test, as well as they are shown in Table 3.



Table 3. Unit Root Test

Variable	ADF test		PP test	
	Level	First difference	Level	First difference
EFP	2.676	5.796*	2.676	5.995
GDP	1.537	5.452*	0.482	10.232
GE	2.676	5.796*	2.676	3.913
TTO	1.519	6.912*	1.329	7.029
ICT	1.280	4.751*	1.280	4.751

The \* sign represents a significantly different coefficient at the 1% level from zero.

Based on table 3 all stationary variables in the first difference are stationary. So it may be concluded that these indicators meet the requirements for cointegration. The Johansen cointegration test is employed and the outcomes are shown in Table 4 below this.

Table 4. Johansen cointegration test

Maximum rank	Eigenvalue	Trace	5% critical value
0	0.665	82,857	68.41
1	0.412	43.877	47.10
2	0.249	24.590	15.30
3	0.210	13.359	3.65
4	0.011	3.319	-
5	0.665	-	-

At maximum rank 1, there is a cointegration relationship between variables with a critical value of 5% higher than the trace value, so in this study, we use the ARDL model presented in table 5.

Table 5. ARDL Result

$\Delta \ln$ Variable	Coefficient	Std. Err	Pvalue
$\Delta \ln$ EFP			
$\Delta \ln$ GDP	0.283*	0.041	0.000
$\Delta \ln$ GE	-1.049*	0.346	0.000
$\Delta \ln$ TTO	-4.083*	0.751	0.000
$\Delta \ln$ ICT	0.041	0.055	0.429

Coefficients at the 1% and 5% levels are indicated by \* and \*\*, successively.

According to table 5's findings, economic growth significantly improves the ecological footprint at the expense of environmental sustainability. The ecological footprint is significantly impacted negatively by the usage of green energy which is getting better for environmental sustainability as well as Technology trade openness which indicates that technological developments in the research period are increasingly friendly to the environment, although the development of ICT has a positive impact on the ecological foot print but is not significant.

## CONCLUSION

The impact of ICT on environmental sustainability does not have a significant impact, which means that the development of information and communication technology is very feasible to be developed to support the green economy as well as the digital economy. Where The use of green energy has a significant negative impact on the ecological footprint which is getting better for environmental sustainability as well as Technology trade openness which indicates that technological developments in the research period are increasing friendly to the environment. Although economic growth in ASEAN member nations in Southeast Asia still contributes adds much to a significant ecological footprint, the development of a green and digital economy in Southeast Asia is a good step to maintain economic growth while preserving the environment by developing environmentally friendly technologies and renewable green energy.

## REFERENCES

- Albreem, M. A., Sheikh, A. M., Alsharif, M. H., Jusoh, M., & Yasin, M. N. M. (2021). Green Internet of Things (GIoT): applications, practices, awareness, and challenges. *IEEE Access*, 9, 38833-38858.
- Antoni, D., Jie, F., & Abareshi, A. (2020). Critical factors in information technology capability for enhancing firm's environmental performance: case of Indonesian ICT sector. *International Journal of Agile Systems and Management*, 13(2), 159-181.
- Assefa, B. G., & Özkasap, Ö. (2019). A survey of energy efficiency in SDN: Software-based methods and optimization models. *Journal of Network and Computer Applications*, 137(1), 127-143.
- Bastida, L., Cohen, J. J., Kollmann, A., Moya, A., & Reichl, J. (2019). Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming. *Renewable and Sustainable Energy Reviews*, 103, 455-462.
- Benlahbib, B., Bouarroudj, N., Mekhilef, S., Abdeldjalil, D., Abdelkrim, T., & Bouchafaa, F. (2020). Experimental investigation of power management and control of a PV/wind/fuel cell/battery hybrid energy system microgrid. *International Journal of Hydrogen Energy*, 45(53), 29110-29122.
- Berrada, A., & Laasmi, M. A. (2021). Technical-economic and socio-political assessment of hydrogen production from solar energy. *Journal of Energy Storage*, 44(1), 103448.
- Bose, R., Roy, S., Mondal, H., Chowdhury, D. R., & Chakraborty, S. (2021). Energy-efficient approach to lower the carbon emissions of data centers. *Computing*, 103(8), 1703-1721.

Butt, O. M., Zulqarnain, M., & Butt, T. M. (2021). Recent advancement in smart grid technology: Future prospects in the electrical power network. *Ain Shams Engineering Journal*, 12(1), 687-695.

Chen McCain, S. L., Lolli, J. C., Liu, E., & Jen, E. (2019). The relationship between casino corporate social responsibility and casino customer loyalty. *Tourism Economics*, 25(4), 569-592.

Fernando, Y., Jabbour, C. J. C., & Wah, W. X. (2019). Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: does service capability matter?. *Resources, Conservation and Recycling*, 141, 8-20.

Gössling, S. (2020). Technology, ICT and tourism: From big data to the big picture. *Journal of Sustainable Tourism*, 29(5), 849-858.

Hsu, C. C., Quang-Thanh, N., Chien, F., Li, L., & Mohsin, M. (2021). Evaluating green innovation and performance of financial development: mediating concerns of environmental regulation. *Environmental Science and Pollution Research*, 28(40), 57386-57397.

Jiang, W., Liao, K., Yan, Y., Cheng, W., Zhang, L., & Wang, J. (2021). Modeling and Analysis of Latency Distribution in the 40-100Gbps Dual-Mode Energy Efficient Ethernet. *IEEE Transactions on Green Communications and Networking*, 5(3), 1426-1437.

Kumar, N. M., Mohammed, M. A., Abdulkareem, K. H., Damasevicius, R., Mostafa, S. A., Maashi, M. S., & Chopra, S. S. (2021). Artificial intelligence-based solution for sorting COVID related medical waste streams and supporting data-driven decisions for smart circular economy practice. *Process Safety and Environmental Protection*, 152, 482-494.

Kumar, K., Prakash, A., & Khan, W. (2020). Integrating the notion of sustainable development in banking: Analysing historical and conceptual framework. *Indian Journal of Economics and Development*, 16(3), 449-458.

Lahcen, B., Brusselaers, J., Vrancken, K., Dams, Y., Da Silva Paes, C., Eyckmans, J., & Rousseau, S. (2020). Green recovery policies for the COVID-19 crisis: modelling the Impact on the economy and greenhouse gas emissions. *Environmental and Resource Economics*, 76(4), 731-750.

Manglani, H., Hodge, G. L., & Oxenham, W. (2019). Application of the internet of things in the textile industry. *Textile Progress*, 51(3), 225-297.

Naim, A. (2021). New Trends in Business Process Management: Applications of Green Information Technologies. *British Journal of Environmental Studies*, 1(1), 12-23.

Neves, S. A., Marques, A. C., & Patrício, M. (2020). Determinants of CO2 emissions in European Union countries: does environmental regulation reduce environmental pollution?. *Economic Analysis and Policy*, 68(1), 114-125.

Nguyen, D. H., & Chapman, A. (2021). The potential contributions of universal and ubiquitous wireless power transfer systems towards sustainability. *International Journal of Sustainable Engineering*, 14(6), 1780-1790.

Novianto, I. K., Prabowo, B. H. (2021). Green Human Resource Management, Employment and Social Corporate Responsibility in Asia. *Splash Magz*, 1(2), 17-20.

Pärssinen, M., Wahlroos, M., Manner, J., & Syri, S. (2019). Waste heat from data centers: An investment analysis. *Sustainable Cities and Society*, 44, 428-444.

Porru, S., Misso, F. E., Pani, F. E., & Repetto, C. (2020). Smart mobility and public transport: Opportunities and challenges in rural and urban areas. *Journal of traffic and transportation engineering (English edition)*, 7(1), 88-97.

Priyanto, E., Widarni, E. L., & Bawono, S. (2022). The Effect of Internet Inclusion on Financial Inclusion in P2P Lending in Indonesia Based on Human Capital Point of View. In *Modeling Economic Growth in Contemporary Indonesia* (pp. 107-121). Emerald Publishing Limited.

Rafael, D. N., & Lopes, E. L. (2020). Reverse Innovation: What kinds of companies drive efficiency to developed economies?. *International Journal of Professional Business Review*, 5(1), 01–16. <https://doi.org/10.26668/businessreview/2020.v5i1.152>

Shirmarz, A., & Ghaffari, A. (2020). Performance issues and solutions in SDN-based data center: a survey. *The Journal of Supercomputing*, 76(10), 7545-7593.

Sun, G., Zhou, R., Sun, J., Yu, H., & Vasilakos, A. V. (2020). Energy-efficient provisioning for service function chains to support delay-sensitive applications in network function virtualization. *IEEE Internet of Things Journal*, 7(7), 6116-6131.

Tandoh, I. ., Duffour, K. A., Essandoh, M. ., & Amoako, R. N. . (2022). Corporate Governance, Corporate Social Responsibility, and Corporate Sustainability: The Moderating Role of Top Management Commitment. *International Journal of Professional Business Review*, 7(2), e0309. <https://doi.org/10.26668/businessreview/2022.v7i2.309>

Vafamehr, A., & Khodayar, M. E. (2018). Energy-aware cloud computing. *The Electricity Journal*, 31(2), 40-49.

Wu, M., Chen, Q., & Wang, J. (2022). Toward low CPU usage and efficient DPDK communication in a cluster. *The Journal of Supercomputing*, 78(2), 1852-1884.

Wu, M. Z. Y., Kee, D. M. H., Loo, Y. K., Goh, S. J., & Alyanbaawi, H. J. (2020). Increase financial capital of top glove in order to improve environment and sustainability: The case of Top Glove. *International Journal of Accounting & Finance in Asia Pasific*, 3(1), 32-40.

Xia, D., Zhang, M., Yu, Q., & Tu, Y. (2019). Developing a framework to identify barriers of Green technology adoption for enterprises. *Resources, Conservation and Recycling*, 143, 99-110.

Xu, C., Ma, X., Shea, R., Wang, H., & Liu, J. (2018). Enhancing performance and energy efficiency for hybrid workloads in virtualized cloud environment. *IEEE Transactions on Cloud Computing*, 9(1), 168-181.

Zhang, W., & Liu, L. (2022). How consumers' adopting intentions towards eco-friendly smart home services are shaped? An extended technology acceptance model. *The Annals of Regional Science*, 68(2), 307-330.