Evaluation of Applying ICT to Develop Digital Agricultural Economy: Perspectives from Direct Indicators

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Abstract. This study measures and investigates the digital economy's expansion in Vietnam's agriculture sector from 2008 to 2018. Input-out (I-O) tables from the OECD statistical database were used to assess the performance of ICT applications in creating Vietnam's digital agriculture sector and compare them to Indonesia's, emphasizing the cross-country relative ranking. The research findings highlight the achievements and challenges of using ICT to develop digital agriculture in Vietnam, with the Vietnamese government playing a leading role. However, the potential for development has yet to be thoroughly realized over a 10-year period because Vietnam's productivity indicators remain low compared to Indonesia. The study also comprehensively provides a thorough picture of ICT application in digital agriculture, recommending some policy implications to encourage practitioners to become more involved in this area. This can strengthen the ICT's critical role in actively promoting Vietnam's digital agriculture, hence driving the digitalization of the sustainable economy in general.

Keywords: Digital agricultural economy, Indonesia, information and communication technologies (ICT), Input-output (I-O) tables, Vietnam.

1 Introduction

Today, the continual advancement of information and communication technologies (ICT) like artificial intelligence (AI), 5G, big data, and the internet of things (IoTs) is not only reshaping business structures, organizational interactions, and people's motivation and organization but also driving the digital economy as a recognized engine for economic growth (Brynjolfsson & Kahin, 2002). The digital economy first introduced by Tapscott in 1996 (Bukht & Heeks, 2017), has gained a lot of attention in the past ten years. This acknowledgment is a result of its significant contribution to socioeconomic change, which is essential for raising the productivity and resilience of the economy, as well as for economic growth.

A recent survey conducted by AlphaBeta in 2021 revealed that 85% of businesses have made minimal or no preparations for adopting digital technologies (AlphaBeta, 2021). According to the General Statistics Office of Vietnam (GSO), most of the Vietnamese people live and work in rural areas (GSO, 2017). As such, agriculture plays

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an important role in the social and economic development of Vietnam (Dao & Nguyen, 2013). The agricultural sector accounts for approximately 12 percent of Vietnam's GDP in 2023 and a significant portion of the country's employment (GSO, 2023). For a country where agriculture remains a strategic pillar of the economy, the rapid development of digital technology offers a unique opportunity to increase productivity and improve sustainability and diversity. Therefore, the application of information and communication technologies (ICT) in agriculture will also be vital. While ICT is acknowledged as a major factor in the expansion and advancement of agriculture, several developing nations have recently placed a greater emphasis on its use.

There are few literature reviews conducted on ICT innovations in developing countries, especially in agricultural practices. While previous studies of (Kaila & Tarp, 2019) found that Internet access is associated with a 6.8% higher volume of total agricultural output in Vietnam. This is similar to (Hoang, 2020) study on the factors that determine the use of mobile phones for fruit marketing by Vietnamese farmers shows that ICT is an effective tool that facilitates farmers to apply ICTs for fruit marketing by using descriptive statistics, inferential statistics and a binary logistic regression were applied to analyze the data. However, the study only focused on fruit, future research could expand to other agricultural products or sectors. Recently, notably, the study by (Vu & Nguyen, 2023) has addressed in detail a practical framework to quantify the digital economy. This was achieved by utilizing data obtained from Input-Output (I–O) tables available in the OECD statistics database, thereby facilitating a quantitative understanding of the digital economy. They showed that the ICT sector, particularly foreign-invested ICT hardware manufacturing when compared with Thailand because Vietnam lags in key indicators of the digital economy, the study said that it is necessary to promote the economy deeply. The study concluded that when compared to Thailand, the ICT sector is falling behind, especially in terms of foreign investment in ICT hardware production. However, the study by (Vu & Nguyen, 2023) has certain limitations. Its scope remains broad, concentrating only on specific facets of the digital economy in other countries or regions. The role of technology development for sustainable agriculture in Vietnam is very important. The dissemination of new ideas, techniques, and information on the efficient use of fertilizers and pesticides, risk, and farm management in agriculture to enhance agricultural production through various sources of information to farmers must be prioritized in Vietnam through the research of Chandio et al. (2024). However, for a more precise understanding, it is imperative to conduct comparative analyses with other nations. The selection of Vietnam as the main focus and Indonesia as a comparative counterpart is based on several convincing reasons. With a population of almost 100 million, Vietnam has embraced the digital revolution and become a shining example of economic progress and global integration (Vu & Austin, 2014). Furthermore, in keeping with the country's centennial of independence, the Vietnamese government is steadfastly committed to utilizing the promise of the digital revolution to achieve its bold goal of becoming high-income by 2045 (National Assembly, 2021).

In contrast, Vietnam's aspirational comparative objective is Indonesia, given its higher GDP per capita and rapid digital evolution. Indonesia is also one of the most

attractive digital investment destinations. The total investment inflow towards the digital sector was $4.5 billion in 2020 and $9.1 billion in 2021 (Google, Temasek, and Bain & Company, 2022). Notably, Indonesia can spur economic growth to new heights with an estimated yearly economic impact of USD 150 billion by 2025 by turning digital (Das, Gryseels, Sudhir, & Tee, 2016).

However, both Indonesia and Vietnam face common challenges in pursuing national digital strategies to realize their development ambitions. First, both countries have to deal with the trap of low-middle income. Second, both countries confront the looming shadow of the middle-income trap and the pressing issue of population aging (APO, 2022). Moreover, a significant proportion of their labor force (33.61% in Vietnam and 29.28% in Indonesia) still works in the agricultural sector, where labor productivity lags significantly behind the broader region (World Bank, 2024). Secondly, given the continued discrepancies in results, both nations struggle with the need to strengthen their current digital promotion policies. In a report titled "The Network Readiness Index 2023" which was produced by the Portulans Institute in collaboration with the University of Oxford, Vietnam (VN) and Indonesia (IN) are ranked admirably among 134 economies for both individual readiness (VN: 16th; IN: 29th) and network access (VN: 31st; IN: 18th). However, it shows their ranks noticeably lower for content creation (VN: 51st; IN: 43rd), government preparedness (VN: 81st; IN: 47th), business readiness (VN: 67th; IN: 118th), and regulation (VN: 94th; IN: 72nd). Finally, both countries (VN: 85th; IN: 45th) show only moderate readiness for future technology.

Therefore, this study aims to assess the status of the adoption of the digital economy in Vietnam's agricultural sector. Moreover, it aims to shed light on the hurdles faced in ICT adoption, thereby assisting policymakers in devising investment strategies that encourage more sustainable digital communication in agriculture. To achieve this, we use data derived from I–O tables accessible through the OECD statistics database of the previous study (Vu & Nguyen, 2023). The review of literature on the digital economy along with conducting an in-depth comparative analysis between Vietnam and Indonesia will provide valuable insights into these issues.

To provide a specific illustration, this article employs a comparative approach to assess the evolution of Vietnam's digital economy. It carries out a preliminary comparative analysis between Vietnam and Indonesia, showcasing the method's effectiveness in understanding the performance of the digital economy across diverse economies. The research concentrates on the timeframe from 2008 to 2018, a time for which data is available, and during which the progress of the digital economy in both Vietnam and Indonesia has played a significant role in driving overall economic growth and transformation.

2 Literature Review

2.1 Theoretical basis

The digital economy is defined as a wide range of economic activities such as using digitized information and knowledge as the primary factor of production, modern

information networks as a significant activity space, and the efficient utilization of information and communication technology (ICT) as a major driver of productivity growth and economic structural optimization (G20 Digital Economy Task Force, 2016). The digital economy is defined narrowly, which includes digital goods and services such as software, hardware, e-commerce, business-to-business, cloud services, and other paid digital services. From a broader perspective, the digital economy is defined as "any economic activity reliant on, or significantly enhanced by the use of digital inputs, including digital technologies, digital infrastructure, digital services, and data (BEA (2018, 2020)). It describes all producers and consumers who use these digital inputs in their economic activity, including the government (OECD (2020, p. 5).

Applications of information and communication technology (ICT) may be essential to supplying the world's growing food needs (FAO, 2017). ICT is described as any tool, application, or equipment that enables data interchange or gathering through interaction or transmission and is referred to as information and communication technology (ICT) (George et al., 2011). Current trends in ICT include creative solutions for computers, radios, TVs, and mobile phones, as well as cutting-edge technology like blockchain, AI, cloud computing, Internet of Things (IoT), and big data analytics (OECD, 2017). By increasing efficiency, transparency, and traceability, these disruptive ICT developments have the potential to support sustainable transitions in agriculture (El Bilali & Allahyari, 2018). E-agriculture is the term for the use of modern technologies in agriculture or the application of ICTs in agriculture.

2.2 Previous study of the digital economy in agriculture

ICT and agricultural growth have a substantial association, according to research by Oyewole et al. (2013). (Büyükbay & Gündüz, 2011) findings corroborated this claim, demonstrating a strong correlation between internet and computer use and the social and economic traits of the participants. The conclusion of Oyewole et al. (2013) that ICT has affected agriculture has been supported by the finding of Patel and Patel (2013) in a study conducted to evaluate the application of cloud computing in the agricultural development of rural India. Some have suggested that cloud computing technology has had a favorable impact on the agricultural industry and the services it offers its users. This finding is consistent with (Büyükbay & Gündüz, 2011) analysis of the role that ICT application plays in the rural agricultural growth of Turkey's Tokat Province. Computer and internet technologies to be applied effectively in rural areas, farmers must receive intensive training and ICT infrastructure must be established. However, the primary study constraint is that only thirty percent of the 184 questionnaires that were sent were gathered regarding computer and Internet use, which was insufficient.

Another research by Zewge & Dittrich (2017) conducted a systematic study between 2006 and 2014 and observed the rapid growth of ICT in developing regions as a boon for rural communities. They found that some African nations, like Kenya and Uganda, have successfully adopted ICT innovations in agriculture. Similarly, Klerkx et al. (2019) reviewed the impact of the latest ICT technologies such as big data, the

Internet of things, augmented reality, robotics, AI, and blockchain on social, economic, and institutional dynamics in the agricultural sector's socio-economic dynamics. They identified key thematic clusters such as use and adaptation, farmer identity and skills, power and ethics, knowledge, and economics and management. The conceptualization of digital agriculture from larger social, cyber-physical, and ecological systems, as well as the policy processes of the digitization of agriculture, are among the four subject areas they identified as deficient. Furthermore, Mujeyi et al. (2021) have examined the relationship between the adoption of climate-smart agriculture and the use of personal ICT devices including phones, televisions, and radios. According to their findings, farmers' welfare is positively impacted by the adoption of climate-smart agriculture and by having access to information via radio, TV, and mobile phones. They also suggest that timely information and forecasts be made available as a crucial component of guaranteeing household welfare. Nonetheless, they provided significant "lessons learned" on how to collect baseline data for rural communities in agricultural systems, suggesting that a general problem in the study of innovations is the lack of high-quality, usable data.

In recent years, Vietnam's digital economy has developed more. Using a panel dataset from 2008–2012, the study of Kaila & Tarp (2019) adds to the growing literature on the connection between Internet availability and agricultural output in rural Vietnam. During this time, there was a significant growth in the number of people with access to the Internet and the emergence of both government-run and private websites that offered agricultural information. This finding showed that the Internet is linked to a 6.8% increase in total agricultural output. According to research (Hoang, 2020) on the elements that influence Vietnamese farmers' usage of mobile phones for fruit marketing, ICT is a useful instrument that makes it easier for farmers to use ICTs for fruit marketing. In order to analyze the data, the research used binary logistic regression, inferential statistics, and descriptive statistics. Nevertheless, this study's data was limited to citrus fruits. Further research could be conducted to assess determinants of farmers' ICT adoption with other agricultural produce including livestock and fishery. Khuong & Vu (2023) succinctly present a practical framework for quantifying the digital economy, based on concepts and techniques from previous studies, particularly those of OECD (2020) and ADB (2021). The framework uses data from I–O tables available in the OECD statistics database to provide quantitative insights into the digital economy. The study includes a direct comparison between Vietnam and Thailand, illuminating their relative positions. The findings indicate that the ICT sector, particularly in the production of ICT hardware with foreign investment, contributes about 50% to Vietnam's digital economy, while backward linkages and digital transformation contribute 20-30% each to the respective sectors. Compared to Thailand, Vietnam lags in key digital economic indicators. The value-added ratio of Thailand/Vietnam in 2018 was 3.9 for the total digital economy, 3.2 for the ICT sector, 3.1 for contributions from backward linkages, and 6.4 for digital transformation in the non-ICT sector, while the GDP ratio was 2.1. These results highlight investments in digital infrastructure, internet adoption promotion, and attracting FDI to ICT hardware manufacturing are crucial but not sufficient for the rapid advancement needed in Vietnam's digital economy. However, this research has some limitations due to its

general scope, suggesting that future research could focus on specific aspects of the digital economy in other countries or regions. A recent study by Chandio et al. (2024) evaluated the impact of technological advancements on sustainable agriculture in Vietnam. The study emphasized the importance of disseminating new ideas, techniques, and information about the effective use of fertilizers and pesticides, risk, and farm management in the agricultural sector to increase agricultural production via different sources of communication to farmers must give priorities in Vietnam. Agricultural production can be improved by using cost-effective agricultural technologies such as biopesticides or natural methods, and new and effective agricultural tools, techniques, and methods. However, the study has certain limitations. Firstly, it only focuses on Vietnam. Secondly, it only considers variables such as climate change, fertilizer consumption, pesticide use, cultivated area, and energy consumption, while overlooking the impacts of other variables on agricultural production. Agricultural credit, ICT, carbon dioxide (CO2) emissions, methane (CH4) emissions, carbon emissions, and timely irrigation, which play important roles in determining agricultural production, were not considered in the study. Finally, due to the lack of data on these variables, the scope of the study's experimentation is somewhat limited.

2.3 Current situation of the digital economy in agriculture in Vietnam

The agricultural sector has long affirmed its important position as the backbone of the Vietnamese economy, ensuring food security, making an important contribution to economic balance, and playing a crucial role in macroeconomic stability. In 2023, it continued to contribute to the country's overall achievements with a growth rate of 3.83%, the highest in recent years, contributing positively to the overall economic growth of 5.05% (Ministry of Agriculture and Rural Development, 2024). With unified awareness and action, an effective transformation from production-oriented thinking to agricultural economic thinking, from precision agriculture to digital agriculture, contributed to this result.

Due to the novelty and development of the digital agriculture concept, no clear policy has yet been established. However, the process of transitioning to digital agricultural services innovation has witnessed remarkable commitment from government agencies and stakeholders in creating effective policies and incentives. As Government ministries, the Ministry of Agriculture and Rural Development (MARD) has played a key role in developing agricultural policies, along with the Ministry of Natural Resources and Environment. Additionally, under the Ministry of Agriculture and Rural Development, the Institute of Policy and Strategy, the Plant Protection Department, and the National Agricultural Extension Center were established to advise state agencies on research and policy effectiveness. The Prime Minister has also proactively attracted financial resources to support the industry with the Ministry of Planning and Investment (Burra et al., 2021).

In 2008, the National Agricultural Extension Center (NAEC) was established by merging different ministries, serving as a national agricultural extension organization for the agriculture, forestry, and fishery fields (Qamar, 2012). Furthermore, the vision for land information system reform was also given, since land reform is considered a

core part of the gradual market reform ("Đổi Mới") by the Vietnamese government (George, 2011). Digital solutions, including land information systems, have been integrated into the national reform agenda by the Vietnam Land Administration Project since 2008, aiming to enhance the efficiency and transparency of the administrative service (World Bank, 2015). In 2010, Vietnam's Gender Strategy for Agriculture and Rural Development aimed to strengthen sustainability, agricultural extension services, and women's research, production, and training participation. As part of the agriculture 4.0 model, Vietnam prioritizes integrating new technologies to improve efficiency and environmentally friendly practices (FAO, 2024).

Vietnam has recently taken steps to create a more favorable environment for digital agriculture through infrastructure development and financial support. As of 2015, Law No. 86/2015/QH13 on Information Security Law was passed by the National Assembly, The first step towards a comprehensive set of laws aimed at protecting users' personal information and supporting cloud technologies and data-driven approaches (VCCI, 2015; Burra et al. 2021). Decision No. 575/QD-TTg targets increasing agricultural production value by 500%. This goal has been realized by strengthening large-scale farm automation and establishing high-tech agricultural zones and 500 digital agricultural cooperatives by 2020. The Prime Minister has committed to investing more in agribusinesses developing digital agricultural solutions and establishing at least 200 enterprises within Vietnam's borders. The Ministry of Agriculture also promotes digital solutions to improve information access and multi-dimensional communication through Directive 6524/CT-BNN-KHCN (General Department of Vietnam Customs, 2017).

However, financial support is mainly for large-scale farms and businesses; On the contrary, smallholders have long struggled to access this service. Institutions often provide small-scale producers with unaffordable interest rates (Burra et al., 2021). Consequently, these manufacturers tend to have limited innovation capabilities. Most notably, The biggest obstacle hindering the effective implementation of digital solutions by relevant parties is the low level of digital literacy. People with better access to smart devices are more likely to be digitally skilled, such as younger farmers and higher-income consumers. Similarly, manufacturers require increasingly complex levels of knowledge and information to make informed decisions and identify deviations from traditional environmental conditions; however, to access this information, sufficient digital skills are needed. This underscores the reason why digital literacy is certainly the first step to take in the digital transformation process, as it facilitates or hinders the effective and successful implementation of most digital interventions.

In summary, aiming to improve capacity to access the 4th Industrial Revolution, Over the past two decades, Vietnam has enacted broader legal frameworks to support digital agriculture, albeit through still fragmented policies and agencies. It is necessary to develop the digital agricultural economy in the direction of promoting its potential and strengths. Besides, it is also needed to find solutions to help small-scale producers access better financial support services; and more importantly, improve the knowledge of those involved in the digital transformation process.

3 Methodology

3.1 Input-Output model

The Input-Output Table (IOT) serves as a crucial tool for depicting a comprehensive picture of an economy's production activities. It provides detailed insights into the interconnectedness among various economic sectors, enabling the assessment of one sector's impact on others and the evaluation of economic policies' influence on the overall economy.

The input-output model by W. Leontief originated from the ideas of K. Marx and Leon Waras, based on the supply-demand relationships within the entire economy. W. Leontief assumed to simplify the model that each production technology is a linear relationship between the quantity of products produced and the products or services used as inputs. This relationship is represented by a system of linear equations with coefficients determined by the technological process.

The main equations describing the flows between n productive sectors in the IO model are:

Where:

- X_i represents the total output of the i-th economic sector,
- X_{ij} is the output of the i-th sector used as an intermediate input by the j-th sector,
- Y_i represents the final consumer demand for the products of sector i.

Technical coefficient (It represents the ratio of the product of sector i that is required by sector j to produce one unit of its own product):

The equation can be rewritten in matrix form as follows:

$$X = AX + Y \tag{1}$$

Where: X = the column vector of outputs; Y = the column vector of final demands and A is the square n-by-n matrix of technical coefficients, called the technology matrix. With I is the n-by-n identity matrix, is:

In the economy, the structural changes of industries are closely interrelated. Some industries are highly dependent on others, while some industries only depend on a few remaining ones. As a result, the changes in certain industries will have a greater impact on the economy than others. Input-output analysis often relies on backward linkages and forward linkages as tools to measure the interrelationships of an industry with other industries, in terms of being an input user or an input supplier.

3.2 The coefficient of dispersion for Industry A with respect to Industry B

To calculate the coefficient of dispersion for industry A with respect to industry B in the Leontief matrix, we need to sum the elements along the column related to industry B in the Leontief matrix and divide it by the total output of industry B.

Coefficient of dispersion for industry A with respect to industry B:

$$(\Sigma A_{ij})/X_j \tag{2}$$

Where:

- A_{ij} is the element in the Leontief matrix related to industry A and industry B,
- X_j is the total output of industry B.

This coefficient of dispersion provides information on the importance of industry A for industry B, indicating the extent to which industry A relies on the products of industry B as inputs.

3.3 The value-added coefficient (VAC)

The ratio of value added to total output in the Input-Output Table (IOT) is an important measure of efficiency and economic productivity in a specific industry or the entire economy. Usually expressed as a percentage, this ratio is called the value-added coefficient (VAC) or output-input ratio.

$$VAC = Value\ added/Total\ output \tag{3}$$

An industry or sector with a high VAC indicates that it generates more value-added relative to the amount of input used. In other words, production efficiency is high, and the value-added created per unit of input is high.

An industry or sector with a low VAC indicates that it generates less value-added relative to the amount of input used. In other words, production efficiency is low, and the value-added created per unit of input is low.

4 Results and Discussions

In terms of total value, ICT used as an input in the agricultural sector of both countries increased over time. Additionally, Vietnam has a much higher increase and the total value of ICT used as an input in agriculture compared to Indonesia. This indicates that the agricultural sector in Vietnam applies ICT more than in Indonesia. Since 2008, the Vietnamese government has set a strategic direction to modernize and informatize agriculture (Vietnam Government Portal, 2008).

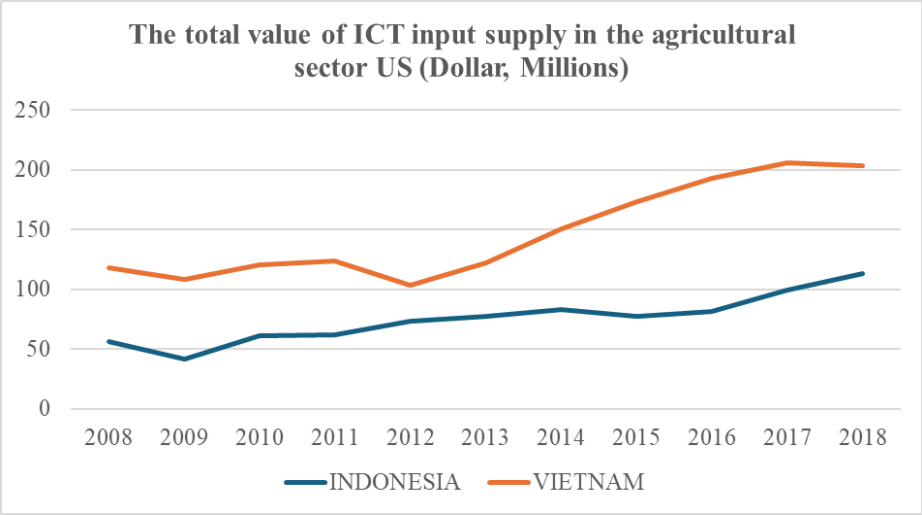

Fig. 1. The total value of ICT input supply in the agricultural sector US (Dollar, Millions)

Source: Authors' calculations, 2024

Comparing the Backward Dispersion Coefficient (Agriculture with respect to ICT) (%) (2008 - 2018) evaluates the importance of ICT in the agricultural sector, showing that both Indonesia and Vietnam use very little input from the ICT sector. Specifically, this ratio fluctuates between 0.18% and 0.34% in Vietnam and there have been signs of a decline in recent years. In Indonesia, it only fluctuates between 0.04% and 0.07%. Despite the increase in total ICT value in both countries, the ratio of ICT use on the total scale of the agricultural sector remains very low and almost negligible, indicating that both countries have not adequately invested or paid attention to the application of ICT in agriculture. Furthermore, this rate has been trending down in Vietnam recently.

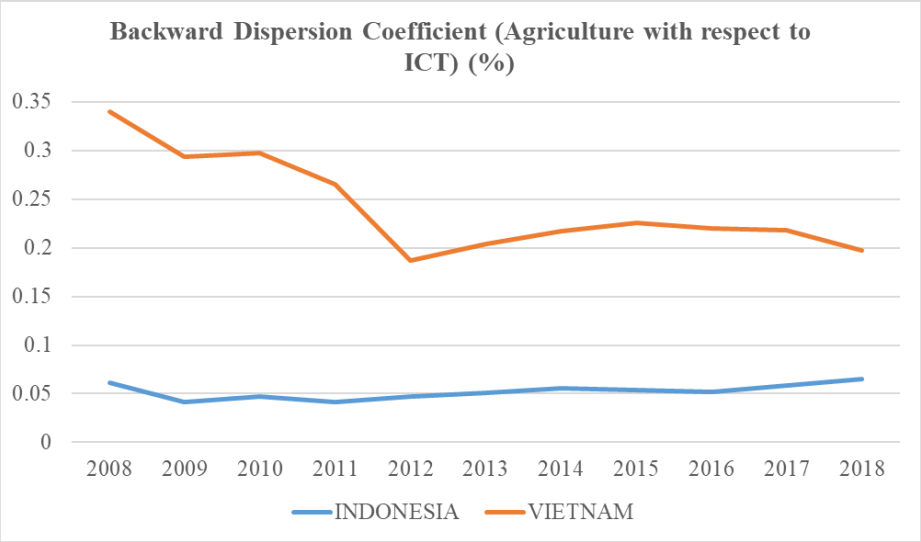

Fig. 2. Backward Dispersion Coefficient (Agriculture with respect to ICT) (%)

Source: Authors' calculations, 2024

The relative proportions among the industry groups within ICT used in agriculture when comparing 2008 and 2018 have changed significantly. Regarding scale, Telecommunications was the most used in the agricultural sector in both countries in 2018. Computer, electronic, and optical equipment have decreased in the total ICT share in both countries. Vietnam decreased from 35% in 2008 to 23% in 2018, and from 13% to 10% in Indonesia. The Vietnamese government has demonstrated early awareness of the importance of information technology in the agricultural sector through policies and development directions since the year 2008 (Vietnam Government Portal, 2008). Both countries are interested in the development of telecommunications.

In terms of IT and other information services, there has been a growing interest in Vietnam in recent years, with more usage of this industry group in the agricultural sector, increasing from 2% in 2008 to 5% in 2018. Meanwhile, this rate decreased sharply in Indonesia from 51% in 2008 to 16% in 2018.

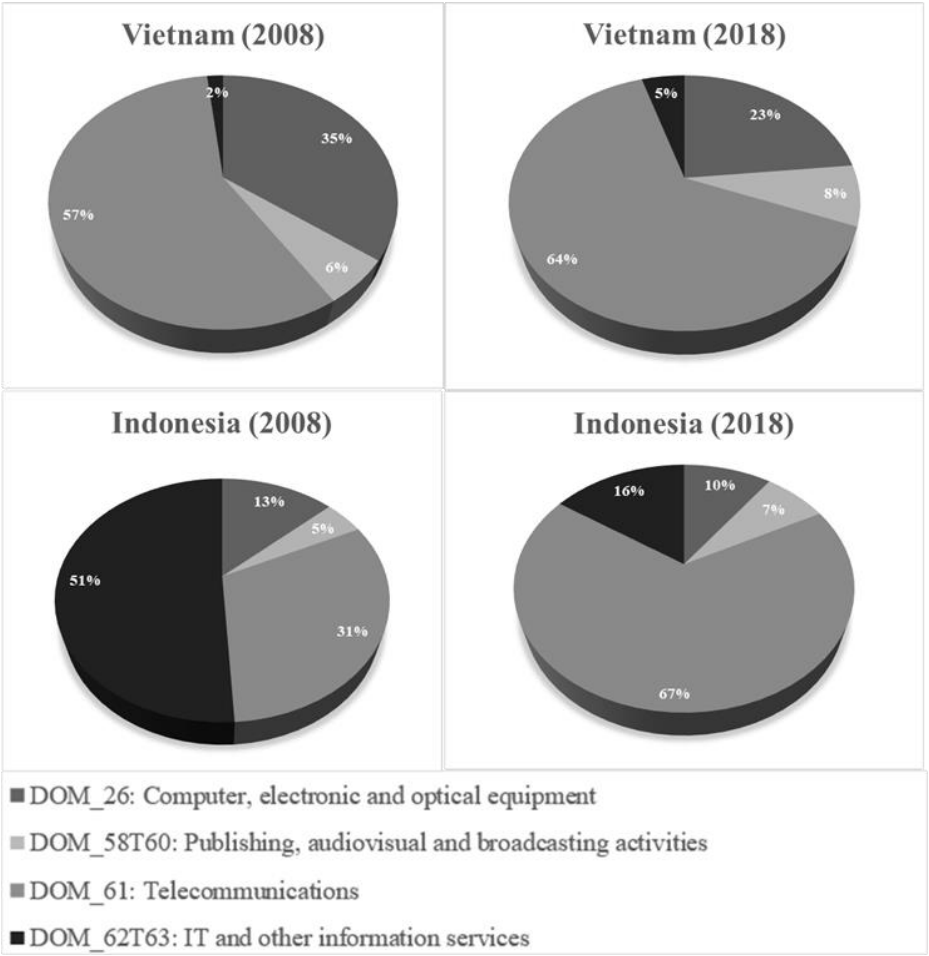

Fig. 3. The value share of ICT sectors providing inputs to agriculture

Source: Authors' calculations, 2024

The results indicate a common trend in both countries, which is a decreasing proportion of Computer, electronic, and optical equipment in agriculture and a shift toward digitalization. In Vietnam, the proportion of Computer, electronic, and optical equipment in agriculture decreased from 35% in 2008 to 23% in 2018. In Indonesia, it decreased from 13% in 2008 to 10% in 2018. These trends indicate a shift away from reliance on such equipment in the agricultural sector in both countries, possibly due to a greater emphasis on digital solutions and technologies in agricultural practices.

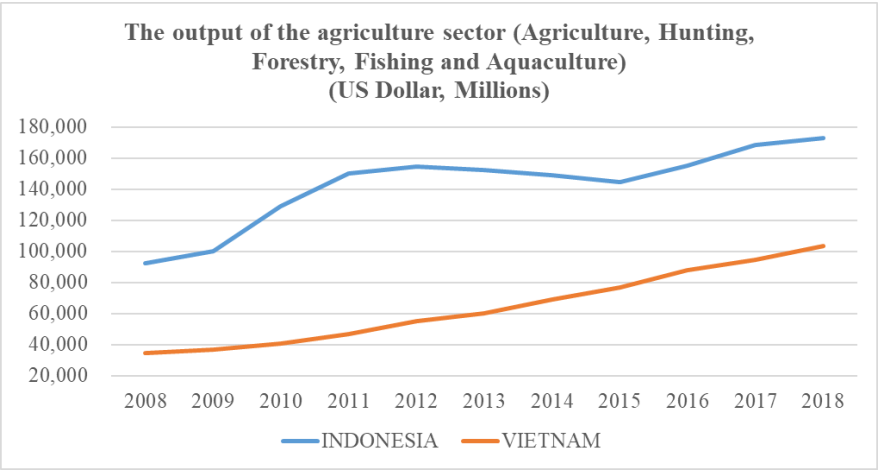

Fig. 4. The output of the agriculture sector (Agriculture, Hunting, Forestry, Fishing, and Aquaculture) (US Dollar, Millions)

Source: Authors' calculations, 2024

Regarding the output scale of the agricultural sector, Indonesia has a larger scale than Vietnam. The comparison results between Vietnam and Indonesia in the period from 2008 to 2018 in the Input-Output Table indicate that the VAC in Indonesia fluctuated between 77% and 81%, this ratio in Vietnam only ranged from 34% to 44%. The high VAC in Indonesia states that the agricultural sector is relatively more efficient and productive than in Vietnam, as it generates more value-added per output unit. This demonstrates that the agricultural sector in Indonesia is effectively utilizing resources and minimizing waste compared to Vietnam.

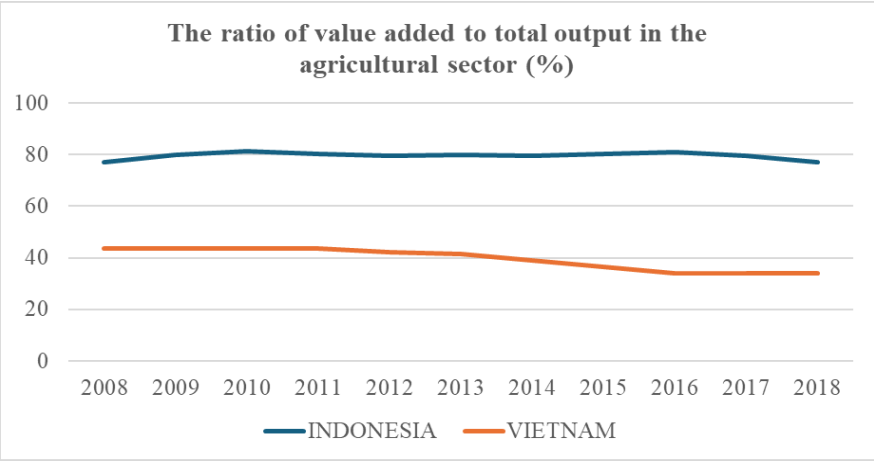

Fig. 5. The ratio of value added to total output in the agricultural sector (%)

Source: Authors' calculations, 2024

Similar to Vu & Nguyen's 2023 study, this study looks at the role of ICT in the digital economy using input-output tables. Both investigations underscore the significance of the digital economy and the crucial role of ICT within it. However, while Vu & Nguyen's research explored 45 GDP areas in the economic sector, our study concentrates on a detailed analysis of ICT's impact on the agricultural sector, an aspect not covered in previous studies.

Data in these figures indicate a shift in Vietnam from traditional to digital agriculture. In 2008, Vietnam invested over $100 million in ICT for agriculture, which increased to over $200 million by 2018. This demonstrates the Vietnamese government's recognition that digital transformation in agriculture is necessary. Vietnam's WTO membership in 2007 facilitated telecommunications development, enabling machine-to-machine and human-machine connections (Lee, 2011). The Ministry of Agriculture and Rural Development, and the Ministry of Natural Resources and Environment have been instrumental in formulating policies for digital technology adoption and implementation. The 2010 Gender Strategy for Agriculture and Rural Development aimed to integrate public services with new technologies to enhance sustainability and agricultural extension services (Ministry of Agriculture and Rural Development, 2010). Prime Minister Nguyen Tan Dung approved Decision No. 879/QD-TTg in 2014, prioritizing advanced technologies and communication in agriculture, focusing on digital services, telephones, and software development through 2025 to vision toward 2035. Recently, Vietnam has taken steps to foster digital agriculture through developing infrastructure and supporting finance. By 2018, Vietnam's digital economy constituted 7.9% of its GDP, equivalent to USD 17,458.

5 Conclusion

The article's purpose is to evaluate the ICT application in Vietnam's digital agricultural development, thereby identifying this process's opportunities and challenges. Building on concepts and techniques from previous research, this measurement framework utilizes data extracted from input-output (I-O) tables accessible through the OECD statistical database to obtain valuable quantitative insights into the digital agricultural economy. This method assesses the importance of digital agriculture in a particular country by calculating four key components: (1) the total value of ICT inputs; (2) the backward dispersion coefficient; (3) the total output of the agricultural sector; and (4) the ratio of value added to total agricultural output. The utilization of the measurement framework in the context of Vietnam and the initial comparative analysis with Indonesia also yield valuable findings and profound insights into policies.

Understanding the potential magnitude of ICT application, the Vietnamese government has taken action to encourage this process through policies and incentives from the early stage. Hence, from 2008 to 2018, Vietnam has moved gradually from the traditional agriculture approach to the digital one, also, telecommunications appli-

cations have played a crucial role in the agriculture economy's growth, which are both similar to Indonesia. However, both countries have not been adequately invested in ICT since the input value and the backward dispersion coefficient have remained low during the period of 10 years. Nevertheless, compared to Indonesia, Vietnam's agriculture has been relatively less productive due to the higher input for ICT but the lower VAC ratio. This underscores Vietnam's lag in integrating digital agriculture into the overall agriculture sector, highlighting the urgent situation that Vietnam should undertake significant reform and coordination efforts to promote all elements of the national digital agriculture's growth.

This paper's findings further give some key policy insights needed to promote digital agriculture buildout. First, to successfully transition to digital agriculture, in addition to policies, the State needs to accompany and support farmers in applying digital technology to production. This is because farmers play a key role in the digital transformation process in agriculture, the group that needs the most attention. Therefore, it is necessary to encourage them to use modern electronic devices, participate in discussions on utilizing high technology, and invite farmers who have successfully digitized to share their experiences. Second, as the economic efficiency of ICT is still low with high input but low output, it is needed to enhance added value from the ICT sector. This requires investing in skilled labor and strategic incentives for higher value-added activities. Additionally, as a key to the resilience and the growth of digital agriculture, the interconnectedness between ICT and non-ICT sectors needs to be strengthened. it is crucial to understand the fundamental factors that cause certain industries to significantly lag behind their counterparts in the country being compared regarding digital transformation. The result implies that Vietnam's challenges lie in resource management, which is key to the development of a digital agricultural economy.

Despite valuable results, the research still has some limitations due to the limited sources of reliable data regarding indicators and time; therefore, other significant components of digital agriculture are inaccessible. Hence, further studies could take into consideration combining different methods and expanding the period to assess Vietnam's digital agriculture more accurately, from there proposing more valuable implications, towards the more sustainable economic development generally.

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References

1. Burra, D. D., Hildebrand, J., Giles, J., Nguyen, T., Hasiner, E., Schroeder, K., … Jarvis, A.: *Digital agriculture profile: Vietnam.* Food and Agriculture Organization of the United Nations (2021), https://cgspace.cgiar.org/items/77524a19-14ea-47c5-ba03-4f5d44d449ed, last accessed 2024/05/01
2. Büyükbay, E. O., & Gündüz, O.: An investigation on computer and internet use for agricultural development in rural areas: A case study for Tokat Province in Turkey. African Journal of Biotechnology **10**(56), 11879–11886 (2011)

3. Chandio, A. A., Zhang, H., Akram, W., Sethi, N., & Ahmad, F.: Climate change and crop production nexus: assessing the role of technological development for sustainable agriculture in Vietnam. International Journal of Climate Change Strategies and Management (2024)
4. Das, K., Gryseels, M., Sudhir, P., & Tee, K.: *Unlocking Indonesia's Digital Opportunity* (2016), https://www.mckinsey.com/~/media/McKinsey/Locations/Asia/Indonesia/Our%20Insights/Unlocking%20Indonesias%20digital%20opportunity/Unlocking_Indonesias_digital_opportunity.ashx, last accessed 2024/04/28
5. Dutta, S., & Lanvin, B.: *Network Readiness Index 2023* (2023), https://download.networkreadinessindex.org/reports/nri_2023.pdf, last accessed 2024/04/28
6. El Bilali, H., & Allahyari, M. S.: Transition towards sustainability in agriculture and food systems: Role of information and communication technologies. Information Processing in Agriculture **5**(4), 456–464 (2018)
7. FAO.: *Information and Communication Technology (ICT) in Agriculture A Report to the G20 Agricultural Deputies* (2017), https://www.fao.org/3/i7961e/i7961e.pdf, last accessed 2024/04/25
8. Freeman, R. L.: Fundamentals of Telecommunications. John Wiley & Sons (2005)
9. General Department of Vietnam Customs.: Chỉ thị số 6524/CT-BNN-KHCN ngày 07/8/2017 của Bộ Nông nghiệp và phát triển nông thôn về tăng cường năng lực tiếp cận cuộc cách mạng công nghiệp lần thứ tư (2017), https://www.customs.gov.vn/index.jsp?pageId=3&id=10164&cid=1294, last accessed 2024/04/28
10. George, T., Bagazonzya, H. K., Ballantyne, P. G., Belden, C., Birner, R., R. del Castello, … McLaren, R.: ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. World Bank (2011)
11. Hoang, H. G.: Determinants of the adoption of mobile phones for fruit marketing by Vietnamese farmers. World Development Perspectives, 100178 (2020)
12. Kaila, H., & Tarp, F.: Can the Internet improve agricultural production? Evidence from Viet Nam. Agricultural Economics **50**(6), 675–691 (2019)
13. Lee, R. C.: *Telecommunications in Viet Nam* (2011). from https://mddb.apec.org/Documents/·2011/SOM/SYM/11_som_sym1_012.pdf, last accessed 2024/04/04
14. Ministry of Agriculture and Rural Development.: *Tài liệu Hội nghị Tổng kết năm 2020 và triển khai kế hoạch năm 2021 ngành Nông nghiệp và Phát triển nông thôn ngày 24/12/2020* (2020), https://www.mard.gov.vn/Pages/tai-lieu-hoi-nghi-tong-ket-nam-2020-va-trien-khai-ke-hoach-nam-2021-nganh-nong-nghiep-va-phat--.aspx, last accessed 2024/04/01
15. Ministry of Agriculture and Rural Development.: *The Agriculture sector needs to innovate thinking, promote digital transformation, and embrace green conversion* (2024), https://www.mard.gov.vn/en/Pages/the-agriculture-sector-needs-to-innovate-thinking-promote-digital-transformation-and-embrace-green-conversion-.aspx, last accessed 2024/04/28
16. OECD.: *A ROADMAP TOWARD A COMMON FRAMEWORK FOR MEASURING THE DIGITAL ECONOMY* (2020), https://www.oecd.org/sti/roadmap-toward-a-common-framework-for-measuring-the-digital-economy.pdf, last accessed 2024/04/28
17. Oyewole, O. J., Ige, A. S., & Oyetunde, O. S.: Contributions of ICTs towards Agricultural Development Among Agricultural Researchers in Ibadan North West Local Government,

Oyo State, Nigeria. Asian Journal of Agriculture and Rural Development **3**(11), 829–835 (2013)
18. Qamar, M. K.: *Viet Nam - Major institutions providing extension/advisory services* (2012), https://www.g-fras.org/en/world-wide-extension-study/94-world-wide-extension-study/asia/south-eastern-asia/329-vietnam.html#title-extension-providers, last accessed 2024/04/24
19. Reardon, T., & Peter, T. C.: The economics of the food system revolution. Annu. Rev. Resour. Econ., **4**, 225–264 (2012)
20. Statista.: *Venezuela - Inflation rate 2022 | Statistic* (2022), https://www.statista.com/statistics/371895/inflation-rate-in-venezuela/, last accessed 2024/04/25
21. Thắng, V. T., Tân, V. N., Dũng, T. H., Hiền, N. T. B., & Lan, N. H.: Chuyển đổi số trong nông nghiệp ở Việt Nam (2021), http://digital.lib.ueh.edu.vn/handle/UEH/62508, last accessed 2024/04/21
22. UNFPA.: *Ageing* (2021), https://vietnam.unfpa.org/en/topics/ageing-4#:~:text=Viet%20Nam%20is%20one%20of, last accessed 2024/04/21
23. VIR, V. I. R. -.: *Digital transformation is the way forward for agriculture* (2023), https://vir.com.vn/digital-transformation-is-the-way-forward-for-agriculture-106764.html, last accessed 2024/04/21
24. Vu, K., & Nguyen, T.: Exploring the contributors to the digital economy: Insights from Vietnam with comparisons to Thailand. Telecommunications Policy, 102664–102664 (2023)
25. World Bank.: Vietnam - Land Administration Project (2015), https://documents.worldbank.org/en/publication/documents-reports/documentdetail/895771467994681236/vietnam-land-administration-project, last accessed 2024/04/27
26. Zewge, A., & Dittrich, Y.: Systematic Mapping Study of Information Technology for Development in Agriculture (The Case of Developing Countries). The Electronic Journal of Information Systems in Developing Countries **82**(1), 1–25 (2023)