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OPTIMIZING INDONESIA'S DIGITALLY-ENABLED SERVICES FOR ECONOMIC GROWTH AND IMPROVED TRADE BALANCE

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Abstract

This study examines how digital trade in services (DTS) can promote economic growth and improve Indonesia's digital trade balance. Over the past two decades, digital transformation has reshaped global trade, but developing economies such as Indonesia face a dual reality of opportunities and infrastructure constraints. Despite sectoral growth, Indonesia recorded a USD 18.4 billion deficit in DTS in 2024, driven primarily by imports of telecommunications, professional services, and digital content. This trade imbalance underscores the need to optimize Indonesia's digital services exports and reduce dependence on foreign digital products. Using a mixed-methods approach that combines cross-country panel GMM and time-series GMM for Indonesia, the study finds that regulations, digital talent, and digital infrastructure are critical to accelerating economic growth and enhancing the competitiveness of digital service exports. However, strict regulations can hinder exports, particularly in developing countries that face challenges in regulatory and infrastructure capacity. In Indonesia, while improved regulations can support economic growth and reduce the DTS deficit, further development of digital talent and infrastructure is essential to driving growth. The study recommends focusing on developing digital talent, strengthening regulations, and expanding digital infrastructure. These efforts will reduce the DTS deficit and position Indonesia as a competitive player in the global digital economy.

Keywords: Digitally-enabled services, Digital services exports, Digital trade balance, Economic growth, GMM

JEL Classifications: F10, F14, O40, C36

1. Introduction

1.1 Background

The development of Information and Communication Technology (ICT) has triggered a significant transformation in the global economy, making digital trade in services (DTS) a key component of economic growth and international trade. The DTS sector, which includes software development, online professional services, digital content, and platform-based activities, has grown faster than traditional goods and services exports, reflecting the shift toward a knowledge-based economy (Baima et al., 2020; Jiang & Jia, 2022; Sturgeon, 2021). This sector has a significant impact on both developed and developing countries; however, developing countries, such as Indonesia, face challenges in building a competitive DTS sector.

According to data from BPS (2024), Indonesia's economy grew by 5.03% in 2024, with significant contributions from the services sector, particularly ICT (growing by 9.3%), transportation and warehousing (growing by 8.69%), and other services (growing by 9.8%). Despite this notable growth, Indonesia faces a deficit in its DTS balance. Digital exports from Indonesia increased from USD 25.3 billion in 2017 to USD 39.0 billion in 2024, while imports remained higher, resulting in a deficit of USD 18.4 billion in 2024 (UNCTAD, 2024). Regulatory uncertainty related to data protection and data localization policies, along with disparities in infrastructure and human resources across regions, hinder Indonesia's potential in this sector. Furthermore, the dominance of foreign platforms limits the ability of local SMEs to innovate and compete effectively.

On the other hand, countries such as Singapore, the Philippines, and China have successfully strengthened their DTS sectors through supportive policies and investments in innovation and international competitiveness. For example, Singapore promotes digital exports through the Digital Enterprise Blueprint and AI Verify initiative (Kong et al., 2024), while the Philippines strengthens its BPO sector with investments in digital infrastructure (Candelario et al., 2024). These countries have adopted policies that support local capabilities and integration into the global digital economy. Meanwhile, Indonesia's policies and infrastructure development remain fragmented, hindering its ability to compete in the global digital economy and exacerbating the imbalance in the DTS sector.

While literature acknowledges the important role of DTS in economic growth, its impact is not always uniform across countries. Some countries report a positive trade balance in DTS, while many others still experience a trade deficit. DTS can promote economic growth by improving efficiency, expanding market access, and reducing cross-border transaction barriers, thereby lowering transaction costs and increasing productivity (Wen et al., 2023; Zhu et al., 2021). However, regulatory barriers, such as cross-border data restrictions and policy misalignments between countries, can prevent these potential benefits and negatively affect economic growth (Yi et al., 2022; Zhang & Wang, 2022). In developing countries, particularly those dependent on agriculture and manufacturing sectors with limited access to digital infrastructure and skill development, DTS offers an opportunity to access global markets without requiring a physical presence, which can increase income and create jobs, even for groups with low levels of education (Baldwin & Forslid, 2023; Ndubuisi et al., 2021).

However, DTS often leads to an increased trade deficit, as many countries, especially developing ones, become more reliant on importing DTS rather than exporting it. Dependence on foreign service providers in sectors such as cloud computing, software, and data analytics worsens these countries' digital trade balance (Yang et al., 2025). Moreover, regulatory barriers, such as cross-border data restrictions and policy misalignments across countries, can slow DTS exports and

reduce the benefits from this trade (Yi et al., 2022). Nevertheless, DTS continues to have a positive impact on economic growth by improving market efficiency, expanding access to global markets, and opening new opportunities for businesses, especially in developing countries, to compete internationally and drive economic diversification.

Although several normative and conceptual studies have examined the impact of DTS on economic growth, the relationship between the two remains underexplored. This study aims to fill this gap by comparing two different contexts: cross-country studies to understand the global dynamics of DTS and an in-depth analysis of Indonesia as a developing country. Through this approach, the study will expand knowledge on the influence of regulations, digital infrastructure, and digital talent development on economic growth and service exports, as well as the challenges developing countries face in leveraging the potential of DTS.

1.2 Research Objectives

The objectives of this research are as follows:

1. To design evidence-based policies to enhance the productivity of sectors contributing to the growth of digital service exports.
2. To identify policy interventions aimed at reducing Indonesia's trade deficit in digital services and creating a more competitive digital economy.

2. Literature Review

2.1. Digital Trade in Services Concept

The rapid development of digital technologies has transformed global trade, shifting from the exchange of physical goods to the exchange of information, services, and value. Digitalization enables the conversion of various types of information, such as text, images, languages, and data, into binary code for processing, transmission, and storage by computer systems (Lang, 2021). Consequently, digital trade has become a significant part of this shift, driving international exchange in a new phase of digital economic growth (Acs et al., 2021; Jiang et al., 2022). Scholars define digital trade in different ways. Meyer et al. (2023) describe it as the electronic transfer of products and services, while Peters (2023) broadens this to include online commerce, cross-border data flows, and value chain interactions. The OECD-WTO Handbook defines it as "all international trade that is digitally ordered and/or digitally delivered," covering both digitally ordered goods (e.g., cross-border e-commerce) and digitally delivered services (e.g., streaming, software, and online consulting) (IMF et al., 2023).

Digital trade is transforming all sectors of the economy. Technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) support this transformation by reshaping how value is created and how cross-border value is transmitted (Rahman & Rahman, 2022). Sugiyarto et al. (2024) suggest that the core of digital trade lies not only in the goods exchanged but also in the digital infrastructure and platforms that support it, enabling coordination and connectivity across markets. This perspective shows that digital trade is not a separate sector but a mode of transactions that blurs the boundaries of traditional trade by facilitating the exchange of intangible digital products (IMF et al., 2023; OECD & IMF, 2017).

DTS represents one of the most dynamic aspects of this development. It refers to the cross-border exchange of services through digital networks, including digitized traditional services like finance and education, as well as fully digital services such as cloud computing, data analytics, and electronic payment systems (Chang et al., 2024; Sun et al., 2022). These services are characterized by intangibility,

replicability, and low marginal costs, which enable real-time global delivery. Some researchers emphasize that DTS involves cross-border service exchanges facilitated by digital technologies such as the internet. Benz & Rozensteine (2021) and Ferencz (2019) describe DTS as activities that use digital infrastructure to facilitate service trade, including digitized services and technology-based services such as cloud computing and big data. Digitalization allows services that were previously non-tradable to be traded globally at low cost and high efficiency, a view supported by Zhu et al. (2021). On the other hand, Baldwin & Forslid (2023) argue that DTS enables developing countries to enter global markets directly, without first undergoing industrialization.

In this study, DTS refers to services produced, distributed, and delivered via digital networks, primarily the internet. The scope includes both traditional services that have undergone digital transformation and fully digital services such as cloud computing and electronic payment systems. Measurement of DTS across countries commonly uses customs records, bank and card payment data, enterprise and household surveys, value-added tax documentation, and platform-based digital data. Bank Indonesia adopts a more integrated, data-driven approach by combining the International Transactions Reporting System, customs e-commerce records, telecommunications data, marketplace information, and credit and debit card reports. This approach improves the accuracy of identifying digital traders and reduces reliance on survey-based approximations.

2.2. Factors Affecting Digital Trade in Services

The growth of DTS depends on several factors that influence how countries and businesses interact in the global market. These factors include regulation, digital talent, and digital infrastructure, all of which play roles in determining the success of digital trade. Regulation involves actions taken by governments to reduce or prevent the social and economic costs of activities or transactions that could harm society (Wang et al., 2024). Yeerken & Feng (2024) discuss how trade policies create an environment that encourages firms to enter the global digital services market, particularly as service trade liberalization expands. Li et al. (2025) show how policies improve market understanding and improve the performance of the services sector. Liu et al. (2024) find that digital tariff-reduction policies reduce barriers to digital trade and build trust among international trading partners. Jiang et al. (2022) confirm that customs regulations can support trade in both goods and services. Jangam (2023) explain that ease-of-doing-business regulations help create a favorable environment for the development of digital services trade. These findings indicate that more flexible and accessible regulations can promote digital trade in the services sector.

In addition to regulation, digital talent is another factor driving the growth of digital trade. Digital talent refers to individuals with knowledge and expertise in information technology relevant to digital trade (Rabetino et al., 2024). Wen et al. (2023) and Zhang & Wang (2022) explain that digitalization accelerates the acquisition of global talent, which is important for enhancing capabilities in digital trade, especially during the COVID-19 pandemic. Dethine et al. (2020) show that the development of digital skills in sectors that are in demand in the global market can transform digital trade. Di et al. (2022) find that expertise in AI and big data analytics strengthens a company's ability to compete in global markets. Santos et al. (2023) and Sood & Pattinson (2020) report that companies managing digital talent adopt digital trade technologies more effectively. Studies by Di et al. (2022) and Kong et al. (2024) indicate that digital talent influences the efficiency and adaptability of businesses in the global digital services market. Therefore, digital talent supports the growth of digital trade by strengthening global market competitiveness.

2.3. Digital Trade in Services, Economic Growth, and Digital Services Exports

The study of the impact of DTS on economic growth remains limited. To build the theoretical foundation for this research, a review of studies analyzing the impact of digital trade services, enabled by factors such as regulation, digital infrastructure, and digital talent, on economic growth is used. The existing theoretical and empirical literature examining the relationship between DTS and economic growth generally finds a positive effect of DTS on economic growth. An early study by Sarma & Pais (2011) serves as the foundation for modern empirical research analyzing the link between DTS and economic growth. This research shows that DTS has the potential to increase a country's productivity and competitiveness. More recent studies, such as Wen et al. (2023), further support DTS's role in economic growth.

The potential of DTS as a driver of economic growth has attracted attention. Over time, various studies and models have developed around this topic. While the findings of these studies vary, most empirical research concludes that DTS helps reduce poverty, foster economic growth, and improve total factor productivity by boosting business activity, thereby enhancing aggregate productivity. Several studies have explored the causal relationship between regulation, digital infrastructure, and digital talent and economic growth, highlighting the strong interconnection between these factors (Di et al., 2022; Nikensari et al., 2024; Ugiloy, 2024). Additionally, Jangam (2023) emphasize the need for effective monetary policies to improve a country's development indicators.

Empirical research indicates that DTS has emerged as an innovative solution to enhance economic development in developing countries, contributing to their economic growth (Kan et al., 2022; Okorie et al., 2025; Qiu et al., 2023). The development of digital infrastructure has prompted researchers to investigate its impact on economic growth. Studies report differing effects across economies, yet most have focused on countries with established DTS, such as the United States and Singapore (Brougham & Haar, 2020; Chen & Gao, 2022; Elfaki & Ahmed, 2024). Research analyzing the impact of DTS in countries like Indonesia, which is still in the early stages of this sector's growth, remains limited. This research gap presents an opportunity for this study, which aims to assess whether the current DTS contributes to economic growth in developing countries such as Indonesia.

To analyze the impact of DTS on economic growth, this study applies the theoretical framework of the Solow-Swan growth model (Solow, 1956). According to this theory, economic growth is determined by both exogenous and endogenous factors, including production, capital stock, labor, and technology (Aghion & Howitt, 1998). Many studies have used the Solow-Swan model to examine the effects of digital service trade on economic growth in developing countries, categorizing factors affecting economic growth into internal, external, and technological factors (Amponsah et al., 2021; Okorie et al., 2025; Tajiboevna, 2024). This study follows a similar approach by linking technology-based factors, such as digital infrastructure and digital talent, to economic growth.

In line with the logic of the Solow-Swan model, DTS is expected to promote economic growth. DTS ensures that people across sectors have access to efficient, reliable, and low-cost services, thereby stimulating increased consumption and investment across the economy (Kan et al., 2022; Xi & Wang, 2023). This encourages people to invest and use more services, improving their daily lives (Erkoyuncu et al., 2023). Better resource allocation and inclusive economic policies help businesses and governments leverage digital services to strengthen the economic system (Liu et al., 2024). Several studies suggest that ICT capacity building and human capital strengthening through the development of ICT capabilities are positively related to economic growth (Oliinyk, 2024; Suhendra et al., 2025). Based on these arguments

and the role of DTS in opening new paths to better economic growth, the first hypothesis of this study is as follows:

H1. Digital Trade in Services has a positive effect on economic growth.

Existing literature links service exports to economic growth, where higher service exports reflect greater competitiveness and economic activity (Zhang & Wang, 2022). DTS is seen as a way to reduce economic inequality, which supports growth and underscores the importance of investments in digital infrastructure (Adelekan & Sharmina, 2024; Santos et al., 2023). DTS helps sustain stable economic growth. It lowers trade costs, improves production efficiency, and increases the global competitiveness of service exports (Chen et al., 2023; Ianenko et al., 2019; Kraus et al., 2021; Santos et al., 2023). Several studies show that DTS increases service exports, which drives growth (Jiang et al., 2022). Research suggests that access to quality services supports growth by enabling investment in infrastructure that improves the environment. Easier access to digital services increases demand for goods and services, which boosts consumption and reduces economic inequality (Yi et al., 2022).

However, DTS does not benefit all countries or industries equally. Some studies show that smaller or less advanced countries face difficulties using digital tools to compete internationally due to gaps in digital infrastructure (Di et al., 2025; Elfaki & Ahmed, 2024). Other studies suggest that DTS could increase inequalities between firms or countries, where only those with advanced technology can fully take advantage of digital trade opportunities (Ianenko et al., 2019; Sood & Pattinson, 2020). While DTS improves efficiency, unequal access to digital technology prevents some countries and industries from benefiting fully.

Research on the impact of DTS on economic growth and service exports is still developing. Studies such as Wang et al. (2024) show a relationship between digitalisation and growth, while Wen et al. (2023) find that DTS increases service exports. However, the findings across studies are not consistent. Ferencz (2019) shows that differences in regulation across countries cause the benefits of digital services trade to be uneven. Zhu et al. (2021) also emphasise that the digital divide and differences in statistical recording limit the ability of some countries to expand digital service exports. Mulenga & Mayondi (2022) further show that digital service exports have a positive impact on GDP in developed countries, but a negative or insignificant impact in developing and least developed countries. These differences indicate an imbalance in countries' capacity to benefit from DTS. This suggests the need for further research to understand the conditions under which DTS can effectively promote service exports. Based on this gap, the second hypothesis of this study is formulated as follows:

H2. Digital trade in services has a positive effect on service exports.

3. Methodology

3.1. Panel GMM Analysis of Digital Service Exports Across Countries

To estimate the impact of DTS on economic growth and digital service exports across countries, this study uses panel data from 2017 to 2024. Data for the study's variables are sourced from credible institutions such as the World Bank, UNCTAD, WGI, UNESCO, WIPO, ITU, OECD, and ILO. The digital services export data is sourced from UNCTAD, while economic variables are proxied to GDP per capita from the World Bank. The primary independent variables related to DTS include the regulatory dimension (REG), digital talent (TLN), and digital infrastructure (IFR). The regulatory dimension is proxied by regulatory quality data from the World Governance Indicators (WGI). Meanwhile, digital talent and digital infrastructure are

measured using Principal Component Analysis (PCA), based on the methods of Jiang & Jia (2022) and Yaqin & Safuan (2023), which capture structural factors in digital trade performance.

To address potential biases, the study includes control variables such as FDI, employment, tax revenue, and openness in the DTS model. The analysis covers 24 countries, with 12 having a positive current account balance and 12 with a negative current account balance, representing regions from North America, Europe, Asia, and Africa. This diversity allows for the identification of patterns relevant to policy-making in countries with surplus and deficit accounts. Descriptions of each variable are presented in Table 3.1.

Table 3.1 List of variables for cross-country studies

Variables	Descriptions	Unit of measurement	Sources
Dependent variables:			
GDP	Gross Domestic Product	USD (Million)	World Bank
DS_EXP	The export value of digital services by a country	USD (Million)	UNCTAD
Independent variables:			
DS_IMP	The import value of DTS received by a country	USD (Million)	UNCTAD
REG	Regulatory quality	Index (0-1)	WGI
TLN	The extent of digital talent in a country, as derived from PCA, based on indicators:		
	▪ Human Capital Index (HCI)	Index (0-1)	World Bank
	▪ Average years of schooling (AYS)	Years	UNESCO
	▪ Government expenditure on education (GED)	% of GDP	World Bank
	▪ Patent applications (PTN)	Residents	WIPO
IFR	▪ R&D expenditure (RDE)	% of GDP	UNESCO
	The digital infrastructure of a country, as assessed through PCA, is based on indicators:		
	▪ Individuals using the Internet (INT)	% of population	ITU
	▪ Secure internet servers (SIS)	Number	Netcraft
	▪ Fixed broadband subscriptions (FBS)	Number	ITU
DSTRI	▪ Digital Services Trade Restrictiveness Index (DSTRI)	Index 0-1	OECD
	▪ Fixed telephone subscriptions (FTS)	Number	ITU
Control variables:			
TAX	Tax Revenue	% of GDP	IMF
EMP	Employment to population ratio (15+)	%	ILO
OPN	Trade openness	% of GDP	World Bank
FDI	Foreign direct investment	USD	IMF

The study aims to assess how DTS affects economic growth and digital service exports across countries. DTS has become a significant driver of economic growth in several countries, as noted in previous studies (Mulenga & Mayondi, 2022). To test this relationship, we use the following models:

$$GDP_{it} = \alpha_1 GDP_{it-1} + \gamma_1 Enablers_{it} + \delta_1 Controls_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

$$DS_EXP_{it} = \alpha_2 DS_EXP_{it-1} + \gamma_2 Enablers_{it} + \delta_2 Controls_{it} + \nu_i + \eta_{it} \quad (2)$$

Equations (1) and (2) show that GDP and service exports are the dependent variables for measuring economic growth and service exports, while enablers, which consist of regulatory variables (REG), digital talent (TLN), and digital infrastructure (IFR), serve as proxies for DTS. Control variables include Tax Revenue (TAX), Employment to population ratio (EMP), Trade openness (OPN), and Foreign direct investment (FDI) with the error term (ε_{it}). This approach is consistent with prior research on the impact of DTS on economic growth (Kan et al., 2022; Mulenga & Mayondi, 2022; Wen et al., 2023). Panel data allows for both time and cross-sectional analysis, addressing

heterogeneity and providing more informative and efficient results (Gujarati & Porter, 2009).

The study applies the Generalized Method of Moments (GMM) panel data analysis technique to capture the effect of DTS on economic growth and digital service exports. This method effectively addresses heterogeneity and endogeneity. Equations (1) and (2) assume that DTS is endogenous to economic growth and digital service exports, aligning with previous studies (Jangam, 2023; Kan et al., 2022; Li et al., 2023). The Arellano & Bond (1991) technique is used to analyze the data with the GMM approach, which is suitable for small samples with a large number of cross-section units (N) and a small number of time periods (T), providing robust results free from cross-sectional dependence. Previous studies, such as Wen et al. (2023), have also used this approach. The model's validity is tested using the Sargan test to ensure that instruments are uncorrelated with the error term, and the Arellano-Bond test is performed to check for second-order autocorrelation (AR2).

3.2. GMM for Analyzing Time Series Data from Indonesia

To address the second research question regarding the impact of DTS on economic growth and the current account deficit in digital services trade in Indonesia, this study uses time-series data from the first quarter of 2017 to the fourth quarter of 2024. Data for all research variables are sourced from reputable institutions, including Bank Indonesia, UNCTAD, WGI, UNESCO, WIPO, ITU, OECD, and ILO. Unlike the cross-country case, Indonesia's digital trade data is obtained from statistics developed by the Department of Statistics (DSta) at Bank Indonesia. This approach offers a contribution to the field, as most countries compiling digital trade statistics rely on survey-based methods or transaction-level data from APMK (*Aplikasi Pembayaran dan Kegiatan Transaksi*). For the economic variable, GDP per capita in Indonesia is used as a proxy, sourced from BPS.

The main independent variables driving DTS, and used in this study, include the dimensions of regulation, digital talent, and digital infrastructure. This differs from the cross-country case, which applies PCA only to the dimensions of infrastructure and digital talent. The PCA method is based on the techniques of Jiang & Jia (2022) and Yaqin & Safuan (2023), which facilitate the measurement of digital structural factors. A detailed explanation of these variables is provided in Table 3.2.

Table 3.2 List of variables for the Indonesian case

Variables	Descriptions	Unit of measurement	Sources
Dependent variables:			
GDP	Gross Domestic Product	USD (Million)	BPS
CDS	Current account deficit in digital services	USD (Million)	DSta-Bank Indonesia
Independent variables:			
	Regression dimension:	Index (0-1)	
	▪ Government effectiveness (GOE)	Index (0-10)	World Bank
	▪ Regulatory quality (REQ)	Index (0-10)	World Bank
	▪ Voice and accountability (VAA)	Index (0-10)	World Bank
	▪ Political stability (POL)	Index (0-10)	World Bank
	▪ Rule of law (LAW)	Index (0-10)	World Bank
	Infrastructure dimension:	Index (0-1)	
	▪ Digital services trade restrictiveness index (DSTRI)	Index (0-1)	OECD
	▪ ICT development index (ICT)	Index (0-10)	BPS
	▪ International internet bandwidth (BIT)	bit/s per user	BPS
	▪ Internet user (USER)	per 100 people	ITU
	▪ Internet subscriber (SUBS)	Persons	ITU
	▪ Mobile data costs (COST)	USD per GB	ITU

Variables	Descriptions	Unit of measurement	Sources
	<i>Talent dimension:</i>	Index (0-1)	
	▪ Human capital index (HCI)	Index (0-100)	BPS
TLN	▪ Number of people employed in STEM fields (STEM)	Persons	Sakernas
	▪ Digital skill level within the workforce (ICTS)	Percentage (%)	BPS
	▪ Number of patents (PTN)	Number (units)	BPS
	▪ Average length of schooling (RLS)	Years	BPS
Control variables:			
CRD	Credit growth	Percentage (%)	Bank Indonesia
INF	Inflation rate	Percentage (%)	BPS
OPN	Trade openness	Percentage (%)	World Bank
FDI	Foreign direct investment	USD (Million)	BKPM

To reduce potential bias, this study also includes control variables: credit growth (CRD), inflation (INF), trade openness (OPN), and foreign direct investment (FDI), in the digital trade model for Indonesia. The goal of this study is to explore the impact of DTS on economic growth (GDP) and the current account deficit in digital services (CDS), with DTS considered a driver of economic growth, as shown in prior research (Mayondi & Mulenga, 2022). To test this relationship, the following models are used:

$$GDP_t = \beta_1 GDP_{t-1} + \mu_1 Enablers_t + \vartheta_1 Controls_t + \varepsilon_t \quad (3)$$

$$CDS_t = \beta_2 CDS_{t-1} + \mu_2 Enablers_t + \vartheta_2 Controls_t + \eta_t \quad (4)$$

Equations (3) and (4) identify GDP and the current account deficit in digital services (CDS) as dependent variables to measure economic growth and the digital trade balance in services. The variables driving DTS (regulation, digital talent, and digital infrastructure) are used as proxies for DTS. Additional control variables include CRD, INF, OPN, and FDI, with error terms (ε_t).

This study uses time-series data analysis with the GMM approach to identify the impact of DTS on economic growth and the current account deficit in digital services. CDS are calculated as the difference between digital service exports and imports. This approach handles heterogeneity and endogeneity issues in the data. Equations (3) and (4) assume that DTS affects economic growth and the current account deficit in digital services in an endogenous manner, consistent with the existing literature (Jangam, 2023; Kan et al., 2022; Li et al., 2023). To limit instrument proliferation and maintain robustness in specification tests, instruments are summarized, and the lag depth is restricted, following best practices for GMM implementation in time-series data (Roodman, 2009). Model fit is evaluated using the Hansen J test for over-identification restrictions and the Arellano and Bond test for serial correlation. A model with proper specification shows non-significant J statistics and no AR(2) in differenced equations (Alvarez & Arellano, 2003; Hansen, 1982).

4. Results and Analysis

4.1. Regulation, Infrastructure, and Digital Talent in Indonesia

From 2017 to 2024, Indonesia has made significant progress in enhancing its regulatory environment and digital infrastructure (Figure 4.1 and Figure 4.2). Improvements in governance indicators, such as government effectiveness and regulatory quality, have strengthened institutional capacity and policy stability (Mulenga & Mayondi, 2022; Omar et al., 2017). Advancements in digital

infrastructure have also increased technology access across the country. Although DSTRI showed a slight increase, indicating minor trade barriers (Benz & Rozensteine, 2021), Indonesia has made notable progress in internet connectivity. Increased mobile internet speeds and reduced data costs have made digital services more accessible to the public (Javaid et al., 2024). Internet penetration, for example, increased from 32.34% in 2017 to 77.57% in 2024 (BPS, 2024b), highlighting the rapid digitalization of the country and its growing ability to offer digital services to both local and international markets.

Along with these regulatory and infrastructure improvements, human capital development in Indonesia has also made progress (Figure 4.3). The increase in the HCI from 70.81 in 2017 to 74.20 in 2024 indicates better educational outcomes and skill development (BPS, 2025a). Additionally, the increase in the STEM workforce from 2.49 million in 2017 to 2.95 million in 2024 aligns with global digital skill demands (BPS, 2025b; Gayatri et al., 2023). The percentage of the workforce with ICT skills has also significantly increased from 40.48% to 79.71% (BPS, 2024b; Suhendra et al., 2025). These developments, along with increased patent activity and improvements in education quality, enhance Indonesia's innovation capacity and solidify its role as a competitive force in the global digital economy.

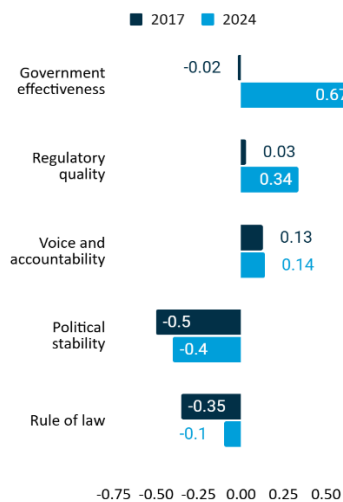


Figure 4.1 Regulatory and Governance Trends in Indonesia

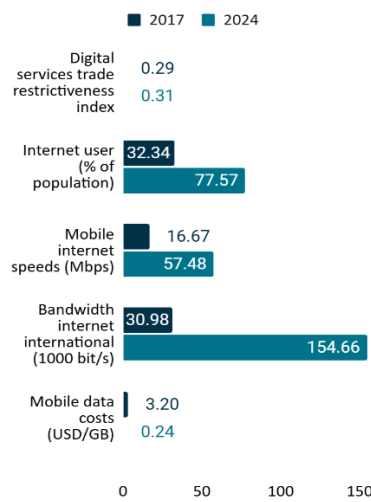


Figure 4.2 Digital Infrastructure Trends in Indonesia

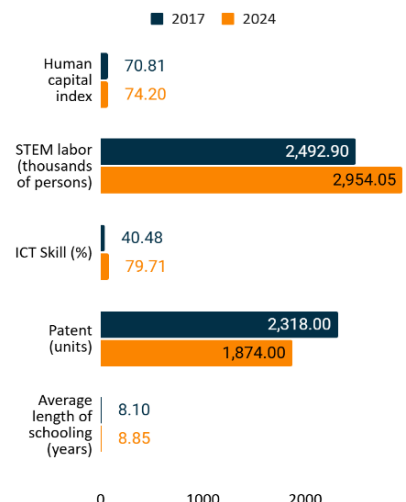


Figure 4.3 Digital Skills and Talent Trends in Indonesia

4.2. Global Development of Digital Trade in Services

Global digital services exports have experienced significant growth in recent years, particularly in the ICT, professional consulting, and financial services sectors. According to data from UNCTAD (2025), between 2017 and 2024, global digital services exports grew substantially, with the ICT sector expanding from USD 544.1 billion in 2017 to USD 1.25 trillion by 2024 (see Figure 4.4). This surge reflects the growing importance of this sector in the global economy, driven by advancements in digital technology. Similarly, professional consulting exports grew from USD 512.8 billion to USD 1.01 trillion over the same period. Financial services also saw significant growth, rising from USD 493.7 billion in 2017 to USD 781.6 billion by 2024. These trends highlight the increasing importance of knowledge-based services in the global economy, with a clear shift towards digitalization and technological innovation. Other sectors, including royalties and licenses, research and

development (R&D), OBS-Miscellaneous, insurance and pensions, architectural and engineering services, and audiovisual services, have also experienced steady growth.

Indonesia's performance in the digital services sector has also shown significant progress, with exports growing by 11.3% in 2024, following an impressive 35.4% increase in 2023 (Figure 4.5). This growth rate positions Indonesia as an emerging player in the global digital services market, surpassing other major economies such as the U.S., Singapore, the U.K., China, and Malaysia. Despite this impressive growth, Indonesia's digital services export structure remains dominated by professional consulting and digital management services, which have already seen significant development. However, there is still substantial untapped potential in the ICT sector. The growth in digital services exports reflects the increasing digital capabilities of Indonesia. This underscores the potential for broader market engagement and the need to further develop ICT services to strengthen the country's position in the global digital economy.

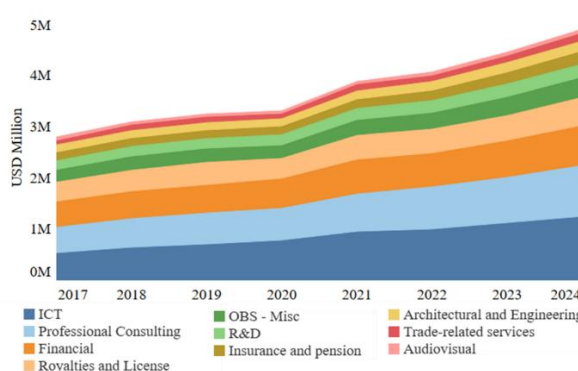


Figure 4.4 Global Digital Services Exports by Sector (2017-2024)
Source: UNCTAD (2025)

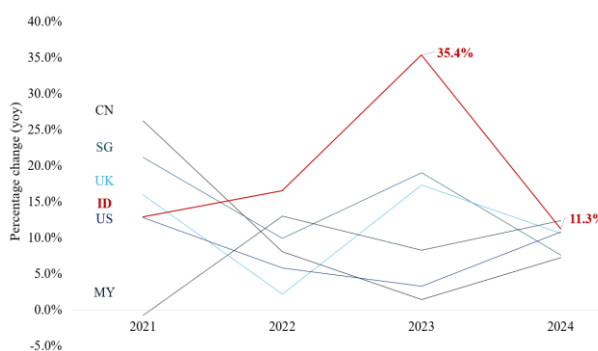


Figure 4.5 Digital Services Export Growth Across Countries
Source: UNCTAD (2025)

4.3. Digital Trade in Services in Indonesia

Indonesia recorded sustained increases in both digital services exports and imports from 2017 to 2024 (Figure 4.6). However, the trade balance remained in deficit, as import values consistently exceeded export values. Digital services exports increased from USD 25.3 billion in 2017 to USD 39.0 billion in 2024. However, imports of digital services grew even faster, from USD 32.7 billion to USD 57.5 billion during the same period, widening the deficit from USD 7.4 billion to USD 18.5 billion. This persistent gap indicates that Indonesia's participation in the digital economy remains consumption-oriented, heavily relying on foreign providers for services such as cloud computing, software development, and data analytics (Yang et al., 2025).

The widening deficit also reflects the dual nature of Indonesia's digital transformation. On the one hand, it shows progress in adopting advanced technologies and integrating them into domestic economic activities (Purnamasari et al., 2025). On the other hand, it reveals structural challenges that limit the country's ability to capture value from this transformation. The surge in digital imports between 2020 and 2022 coincided with the pandemic, when many companies and institutions relied on global platforms to maintain operations (Thorbecke, 2023). Although exports rebounded after 2022, especially in ICT and business-related services, their growth has not been sufficient to cover the deficit. Limitations in digital talent, uneven infrastructure, and fragmented regulations continue to restrict Indonesia's competitiveness in producing digital services (Elfaki & Ahmed, 2024).

Indonesia's digital services trade in 2024 increasingly shifted toward digital and knowledge-based activities, though traditional segments still shape the overall profile. Figure 4.7 shows that on the export side, professional and management consulting led with USD 4.30 billion, followed by ICT services at USD 3.76 billion, with additional contributions from financial services at USD 1.62 billion and research and development at USD 0.81 billion. Smaller segments, such as royalties and licenses at USD 0.19 billion, insurance and pension services at USD 0.18 billion, and audiovisual and related services at USD 0.12 billion, indicate that capabilities in high-value intangible products are still in the consolidation phase. This pattern aligns with comparative evidence on the growth of services in middle-income countries.

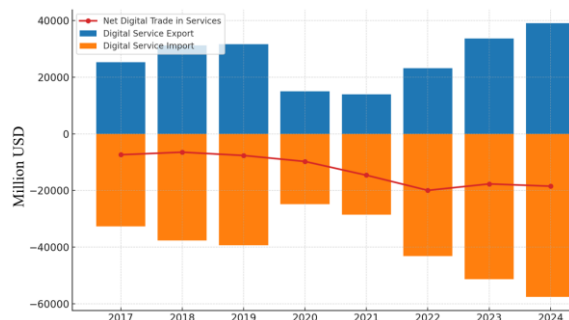


Figure 4.6 Indonesia's Digital Trade in Services (Million USD)
Source: UNCTAD (2025)

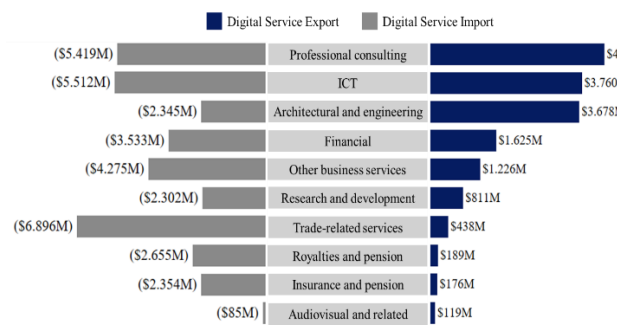


Figure 4.7 Composition of Indonesia's Service Exports and Imports, 2024
Source: UNCTAD (2025)

On the demand side, the import structure shows that Indonesia lacks capacity in certain sectors. ICT services were recorded at USD 5.51 billion, professional and management consulting at USD 5.42 billion, and high demand was seen in financial services (USD 3.53 billion), royalties and licenses (USD 2.65 billion), insurance and pensions (USD 2.35 billion), research and development (USD 2.30 billion), and audiovisual services (USD 0.09 billion). Therefore, policy priorities should focus on improving human capital quality, expanding and strengthening digital infrastructure, and implementing adaptive regulations. This will enhance competitiveness, data governance, and drive innovation, in line with international assessments and Indonesia's digital transformation agenda.

4.4. Impact of Digital Trade in Services on Economic Growth and Exports Across Countries

4.4.1 PCA for Infrastructure and Talent Dimensions

This study uses PCA to reduce the complexity of datasets, focusing on two key dimensions that influence the development of DTS, infrastructure, and talent. The infrastructure dimension includes variables such as internet user penetration, secure internet servers, broadband subscriptions, the digital services restrictiveness index, and fixed telephone subscriptions. The talent dimension includes variables such as the human capital index, average years of schooling, government spending on education, patent applications, and R&D expenditure. Table 4.1 indicates that the data are appropriate for PCA, with Kaiser–Meyer–Olkin (KMO) values of 0.7621 for infrastructure and 0.7278 for talent, both above the usual 0.50 threshold. These KMO values indicate that the data have adequate correlations for factor extraction, supporting the identification of underlying variables (Jiang & Jia, 2022).

Table 4.2 shows the PCA results for the infrastructure and talent areas. In the infrastructure area, the Digital Services Restrictiveness Index (17.64%) and fixed

broadband subscriptions (17.23%) contribute the most, emphasizing how access and service growth boost digital connectivity. Other factors like internet user penetration (16.03%) and secure internet servers (15.42%) also highlight the importance of strong infrastructure for inclusive connectivity. In the talent area, R&D spending (19.79%) and the Human Capital Index (19.76%) are the main contributors, underlining the value of skilled human capital in turning digital infrastructure into productive economic results. These PCA results show that the components for both infrastructure and talent are strong and can be used as combined indices to track progress in digital service development (Johnstone & Paul, 2018). By capturing key aspects of digital infrastructure and human skills, these components offer a clear framework for assessing and monitoring the evolution of digital transformation in the economy. This approach helps guide strategic decisions to promote inclusive digital growth and broader socio-economic progress.

Table 4.1 KMO Test in the First Stage of PCA Across Countries

Infrastructure Dimensions		Talent Dimensions	
Variable	KMO	Variable	KMO
Individuals using the Internet	0.8237	Human Capital Index	0.7461
Secure internet servers	0.6502	Average years of schooling	0.6148
Fixed broadband subscriptions	0.7769	Government expenditure on education	0.8286
Digital Services Restrictiveness Index	0.7915	Patent applications	0.7904
Fixed telephone subscriptions	0.7343	R&D expenditure	0.6793
KMO total	0.7621	KMO total	0.7278

Source: Author's calculations.

Table 4.2 PCA Estimation in the First Stage Across Countries

Infrastructure Dimensions			
Variable	PC1	Norm Weight	Weight (%)
Individuals using the Internet	0.4532	0.1602	16.03
Secure internet servers	0.4384	0.1543	15.42
Fixed broadband subscriptions	0.4859	0.1723	17.23
Digital Services Restrictiveness Index	0.4972	0.1764	17.64
Fixed telephone subscriptions	0.4705	0.1670	16.70
Eigenvalues (PC1)	4.1507		
PC1 variance (%)			74.83
Talent Dimensions			
Variable	PC1	Norm Weight	Weight (%)
Human Capital Index	0.4821	0.1976	19.76
Average years of schooling	0.4653	0.1893	19.93
Government expenditure on education	0.4487	0.1844	18.44
Patent applications	0.4962	0.1614	16.14
R&D expenditure	0.5125	0.1979	19.79
Eigenvalues (PC1)	4.4107		
PC1 variance (%)			79.03

Source: Author's calculations.

4.4.2 Descriptive Statistics of Variables Across Countries

The descriptive statistics and correlations between the variables in this study are presented in Appendix A.1 and A.2. The descriptive statistics for the relevant variables show that both the dependent variables (GDP and DS_EXP) and the independent variables have positive mean, median, and standard deviation values.

This indicates a meaningful peak distribution and the potential for significant changes in GDP, DS_EXP, and the independent variables. The value of 186.4 billion USD for digital service exports (DS_EXP) and 33.3 trillion USD for GDP indicates strong performance in the digital service export sector. However, the 167.1 billion USD for digital service imports highlights a significant deficit in DTS. The dimensions of regulatory quality (REG), digital talent (TLN), and digital infrastructure (IFR) show moderate variation across countries, indicating that these factors differ in their influence on the development of digital services. The relatively lower average for digital infrastructure (IFR) of 0.42 reflects underdeveloped infrastructure in many countries, limiting their ability to engage in DTS fully.

The results from the correlation matrix (Appendix A.3) indicate that the variables used in our econometric model do not exhibit multicollinearity, as further confirmed by an additional test using the Variance Inflation Factor (VIF). The VIF test results, reported in Appendix A.4, indicate that there are no serious multicollinearity issues, as the VIF values are below the threshold (>10).

4.4.3 Econometric Results of Panel-GMM Estimations Across Countries

This study aims to analyze the impact of DTS on economic growth and digital services exports in 24 countries through empirical hypotheses (H1 & H2). However, before proceeding to the main findings, it is important to explore whether there is cross-sectional dependence among the variables and to address the issue of heterogeneity. We adopted the Driscoll & Kraay (1998) approach and found that cross-sectional dependence does not exist. The results of cross-sectional dependence are reported in Appendix A.4. To verify whether our model is free from heterogeneity issues, we conducted a slope heterogeneity test (Appendix A.5). The coefficient values for each cross-sector are identical, which allows us to use different GMM models to obtain results from the variables under investigation. We developed two GMM models to analyze the impact of DTS on GDP and digital services exports. The GMM estimation results are presented in Table 4.3.

It should be noted that in both models, the proxy for Ln_DS_IMP shows a negative relationship with GDP and digital services exports. Specifically, the coefficient for GDP of -0.0316 indicates that an increase in digital services imports tends to be followed by a decrease in GDP, although the impact is relatively small. Meanwhile, the coefficient for digital services exports of -0.0336 suggests that this negative relationship also occurs in the export sector, with a slightly stronger trend, indicating that an increase in digital services imports has the potential to reduce Indonesia's digital services exports. This indicates a negative impact of imports on economic performance, both in terms of GDP growth and the digital sector's exports. Erkoyuncu et al. (2023) and Murthy et al. (2021) also suggest that this pattern occurs when consumer-oriented imports, such as streaming services or e-commerce, replace domestic offerings, thereby reducing local value-added and slightly weakening economic performance.

Based on the estimation results from both models, the dimensions of regulation (REG), digital talent (TLN), and digital infrastructure (IFR) have a significant impact on GDP (Ln_GDP) and digital services exports (Ln_DS_EXP). In Model (1), the coefficient for REG of -0.0459 shows a significant negative relationship with GDP at the 1% significance level. This indicates that an increase in regulation tends to hinder economic growth, which could reflect the negative effects of stricter regulations or policy changes that do not support growth. This aligns with Nikensari et al. (2024), which argues that strict regulations and limitations in the digital services sector tend to hinder international competitiveness and reduce digital export potential.

Table 4.3 Panel GMM regression estimation (The determinants of GDP and digital service exports across countries)

Dependent variable	Model (1) Ln_GDP	Model (2) Ln_DS_EXP
Lagged dependent variables	-0.2352*** (0.0428)	0.0302*** (0.0608)
Ln_DS_IMP	-0.0316* (0.0058)	-0.0336* (0.0242)
REG	-0.0459*** (0.0125)	-0.0057 (0.0036)
TLN	0.0201*** (0.0455)	0.0083** (0.0096)
IFR	-0.5063* (0.0531)	-0.4396* (0.0140)
TAX	0.0636* (0.0371)	0.0351* (0.0434)
EMP	0.0453*** (0.0369)	0.1209*** (0.0159)
OPN	0.0212* (0.0123)	0.0100*** (0.0178)
Ln FDI	0.0109* (0.0078)	0.0280* (0.0349)
Annual effect	Yes	Yes
AR(1) <i>p</i> values	-2.15(0.08)	-2.35(0.05)
AR(2) <i>p</i> values	-0.37(0.02)	-1.78(0.07)
Hansen test's <i>p</i> values	0.1533	0.1027
Obs.	168	168

Sources and notes: Authors' calculations. *** indicates statistical significance at the 1% level, while ** and * indicate statistical significance at the 5% and 10% levels, respectively.

Interestingly, the variable REG shows an insignificant negative impact on digital services exports, which slightly differs from the findings in Model (1). A logical explanation for this result might be that the percentage of digital services regulated or subject to strict regulations in these countries is still low compared to developed countries, so it does not significantly contribute to digital services exports. This is consistent with research suggesting that despite regulations, the digital sector in developing countries is often not fully affected by stringent regulatory policies or is still in its development phase in international markets. Study by Oloyede et al. (2023) also found that the digital sector in developing countries tends to be less affected by strict regulations compared to developed countries, which already have more mature regulatory frameworks.

Regarding digital talent (TLN), in Model (1), the coefficient of 0.0201 shows a significant positive relationship with GDP at the 1% significance level. This indicates that an increase in the quality and quantity of digital talent can strengthen economic growth, as digital talent plays a key role in improving productivity and innovation across various sectors. In Model (2), the coefficient of 0.0083 shows that an increase in digital talent is also positively related to digital services exports at the 5% significance level, indicating that the development of digital talent can enhance the competitiveness of Indonesia's digital services export sector. Di et al. (2022) and Kan et al. (2022) argue that substantial human capital enables technology adoption, facilitates the creation of high-value digital services, and drives innovation across sectors. These findings confirm that improving human capital and developing infrastructure should remain a focus for advancing Indonesia's digital economy and supporting long-term growth. This confirms that H1 and H2 are supported.

For digital infrastructure (IFR), in Model (1), the coefficient of -0.5063 shows a significant negative relationship with GDP at the 10% significance level. This reflects that inadequate digital infrastructure is related to a decrease in GDP, underscoring the importance of enhancing digital infrastructure to support economic growth. In Model (2), the coefficient of -0.4396 shows a significant negative relationship with digital services exports at the 10% significance level, suggesting that strengthening digital infrastructure could enhance Indonesia's digital services exports. Digital infrastructure improves access to various financial services for the population, especially those in underdeveloped areas, and benefits financial institutions by increasing their contribution to economic growth (Xi & Wang, 2023). Santos et al., 2023 and Wang et al. (2025) explain that well-developed digital infrastructure helps reduce transaction costs, fosters innovation, and boosts productivity.

These findings suggest that DTS can worsen the digital services export issue in developing countries that still face limitations in regulation, digital talent, and infrastructure compared to developed countries. These findings are consistent with studies that show that countries with more advanced digital infrastructure and better-prepared regulations are more capable of accelerating digital services exports (Ndubuisi et al., 2021). Digital infrastructure enhances consumer and business access to financial services and products, allowing them to conduct digital transactions, accelerating economic transformation. This increases economic activity, driving economic growth, which ultimately supports digital services exports. Digital infrastructure empowers consumers to easily access digital products, which creates higher demand for digital services (Jiang & Jia, 2022).

During the estimation of the impact of DTS on GDP and digital services exports, the control variable FDI shows a significant positive trend in both Model 1 and Model 2. These findings suggest that an increase in foreign direct investment can drive the development of infrastructure and digital capacity, which in turn enhances productivity and economic competitiveness. This result is relevant and justifiable because foreign direct investment brings new technologies and boosts innovation, which is essential for expanding the digital services export sector (Suntsova, 2024; Szalavetz, 2020). Other findings to note include the variables EMP, OPN, and TAX, which show a significant positive impact on GDP and digital services exports, leading to the conclusion that employment, trade openness, and tax policies play an important role in supporting economic growth and expanding digital services export markets in these countries.

The robustness of findings is reconfirmed by employing additional measures. The scope, which previously included 24 countries, was changed to focus on six ASEAN countries: Singapore, the Philippines, Indonesia, Vietnam, Malaysia, and Thailand. We reperformed the GMM regression to estimate the impact of DTS on GDP and digital services exports. The results of the robustness check are presented in Table 4.4. It is noteworthy that the enabler of DTS, namely TLN, has a significant (moderate) positive impact on GDP and digital services exports, while other DTS enablers, REG and IFR, have a significant (moderate) negative impact on digital services exports. These results are consistent with our findings in Table 4.4, which demonstrate the robustness of this study. Interestingly, The FDI variable exhibits an insignificant negative impact on GDP and digital services exports, which slightly deviates from the findings in Table 4.4. This could be attributed to the greater emphasis placed by ASEAN countries on domestic investment in physical infrastructure and traditional industries, which have more immediate effects on GDP.

Table 4.4 Robustness Check Results: GMM Estimation of GDP and Digital Service Exports Determinants in ASEAN

Dependent variable	Model (3) Ln_GDP	Model (4) Ln_DS_EXP
Lagged dependent variables	0.0995*** (0.0122)	0.0929*** (0.0332)
Ln DS_IMP	-0.0177*** (0.0083)	-0.0618** (0.0309)
REG	-0.0602* (0.0672)	-0.0106* (0.0016)
TLN	0.0515* (0.0127)	0.0402* (0.0421)
IFR	-0.1067* (0.0811)	-0.1102* (0.0281)
TAX	0.0271 (0.0917)	0.0552 (0.0422)
EMP	0.0945** (0.0795)	0.0282* (0.0293)
OPN	0.0212*** (0.0108)	0.0392** (0.0379)
Ln FDI	-0.0073 (0.0007)	-0.0033 (0.0230)
Annual effect	Yes	Yes
AR(1) <i>p</i> values	-2.59(0.09)	-2.86(0.05)
AR(2) <i>p</i> values	-0.17(0.01)	-1.74(0.06)
Hansen test's <i>p</i> values	0.2153	0.1719
Obs.	42	42

Sources and notes: Authors' calculations. *** indicates statistical significance at the 1% level, while ** and * indicate statistical significance at the 5% and 10% levels, respectively.

4.5. Impact of Digital Trade in Services on Economic Growth and Exports in The Indonesian Case

4.5.1 PCA for Regulation, Infrastructure, and Talent Dimensions

This study employs PCA to reduce the number of variables while preserving the information structure and reveals three principal dimensions of DTS, namely regulation, digital talent, and infrastructure. The regulation dimension includes Government Effectiveness, Regulatory Quality, Voice and Accountability, Political Stability, and Rule of Law; the talent dimension comprises the Human Capital Index, STEM labor, ICT skills, patents, and average years of schooling; while the infrastructure dimension covers the DSTRI, mobile internet speed, internet usage, international bandwidth per user, mobile data cost, and mobile phone subscriptions. The KMO test results, presented in Table 4.5, confirm the suitability of the data for PCA, with values of 0.6013 (REG), 0.8061 (TLN), and 0.6344 (INF), all exceeding the 0.5 threshold (Johnstone & Paul, 2018). The high KMO for the talent dimension indicates strong intercorrelation, whereas the other dimensions, though slightly lower, remain adequate for factor extraction and latent variable identification.

The PCA estimation results in Table 4.6 show how the three dimensions of regulation, infrastructure, and talent shape the development of digital services. In the regulation dimension, Government Effectiveness (17.60%) and Regulatory Quality (16.45%) have the strongest influence, reflecting the importance of strong governance and effective regulations in supporting digital transformation. Political

Stability (13.77%) and Rule of Law (15.70%) contribute to creating a secure and predictable policy environment that supports innovation. In the talent dimension, ICT skills (12.69%) and the Human Capital Index (12.48%) are the main contributors, highlighting the role of a skilled workforce in turning digital infrastructure into real productivity gains. Meanwhile, In the infrastructure dimension, internet user penetration (14.36%) and mobile internet speeds (13.25%) are the main drivers, underscoring the importance of reliable connectivity for improving digital accessibility and inclusion. Overall, these findings emphasize the interdependence between infrastructure development and talent cultivation in supporting inclusive digital growth and aiding broader socio-economic advancement.

Table 4.5 KMO Test in The First Stage of PCA on The Indonesian Case

Regulations Dimension		Talent Dimensions		Infrastructure Dimensions	
Variable	KMO	Variable	KMO	Variable	KMO
Government effectiveness	0.5218	HCI	0.8289	DSTRI	0.5074
Regulatory quality	0.5096	STEM Labor	0.9758	Internet user	0.6059
Voice and accountability	0.5307	ICT Skill	0.7762	Mobile internet speeds	0.5362
Political stability	0.9102	Patent	0.8711	Bandwidth internet international	0.7110
Rule of law	0.5343	RLS	0.7078	Mobile data costs	0.8113
	0.6013		0.8061		0.6344

Source: Author's calculations.

Table 4.6 PCA Estimation in the First Stage on The Indonesian Case

Regulations dimension			
Variable	PC1	Norm Weight	Weight (%)
Government effectiveness	0.555625	0.17602326	17.60
Regulatory quality	0.519113	0.16445641	16.45
Voice and accountability	-0.056703	-0.0179635	-1.80
Political stability	0.415833	0.1317369	13.17
Rule of law	0.495652	0.1570237	15.70
Eigenvalues (PC1)	3.1565405		
PC1 variance (%)			63.13
Talent Dimensions			
Variable	PC1	Norm Weight	Weight (%)
HCI	0.49264	0.12482661	12.48
STEM Labor	0.467037	0.11833919	11.83
ICT Skill	0.501025	0.12695124	12.70
Patent	-0.187345	-0.0474701	-4.75
RLS	0.503049	0.12746413	12.75
Eigenvalues (PC1)	3.946593		
PC1 variance (%)			78.93
Infrastructure Dimensions			
Variable	PC1	Norm Weight	Weight (%)
DSTRI	0.443891	0.06761459	6.76
Internet user	0.517878	0.14357262	14.36
Mobile internet speeds	0.477978	0.13251111	13.25
Bandwidth internet international	0.460964	0.12779414	12.78
Mobile data costs	-0.481008	-0.1333511	-13.34
Eigenvalues (PC1)	3.6070802		
PC1 variance (%)			72.14

Source: Author's calculations.

4.5.2 Descriptive Statistics of Variables in the Indonesian Case

The descriptive statistics for the variables used in this analysis are shown in Appendix A.6 and are based on quarterly data, with some variables extrapolated from quarterly or annual datasets. The variable representing the CDS displays a significant negative mean and experiences notable fluctuations over the period, indicating considerable volatility in DTS. Similarly, GDP shows substantial variability, reflecting the dynamic nature of economic performance during the study period. Trade data for digital services (DS_EXP and DS_IMP) reveals a persistent trade deficit, with imports consistently exceeding exports, highlighting an ongoing imbalance in the sector's trade relations.

Variables REG, IFR, and TLN dimensions were created using PCA, combining these factors into composite indices. These dimensions, which reflect key economic conditions, show limited variability, likely because of their binary nature. Other variables, such as TAX, EMP, OPN, and FDI, exhibit moderate variation, attributable to changing economic conditions. The correlation matrix indicates no significant multicollinearity among the independent variables, confirming the robustness of the econometric model.

In Appendix A.7, we present the correlation structure among the study variables. The CDS shows a strong negative correlation with GDP and digital services imports, indicating an inverse relationship between the trade balance and economic output. Similar to the findings of Mulenga & Mayondi (2022), this pattern suggests that higher economic activity is often accompanied by larger deficits in services, reflecting increased demand for imported digital services in emerging economies. The dimensions derived from PCA, including regulation, infrastructure, and skills, show strong correlations, indicating that these factors are closely interconnected and jointly influence the development of digital services trade.

In contrast, inflation and credit expansion show weaker correlations with other variables, indicating limited direct influence on the digital services sector. As noted by Jiang & Jia (2022), macroeconomic variables such as these tend to have a stronger impact on traditional goods markets compared to digital services activities. Overall, the correlation structure reveals that the main dimensions of DTS are highly interconnected, while conventional macroeconomic indicators have only a moderate impact. The reliability of the empirical model is further supported by Hansen-J and AR(2) tests, which show no statistically significant results, confirming the strength and validity of the econometric specification.

4.5.3 Econometric Results of Time-Series GMM Estimations for the Indonesian Case

This study aims to analyze the impact of DTS on economic growth and the current account deficit in digital trade services (Ln_DS_EXP) in Indonesia. Quarterly data from Q1-2017 to Q4-2024 is used to estimate the results using the GMM. Two GMM models are developed to analyze the relationship between DTS, GDP, and CDS. The estimation results are presented in Table 4.7. Normality tests using the J-B statistic indicate that, for Model 5, the J-B statistic is 4.69 with a p-value of 0.09%, suggesting that the residual series for this model is normally distributed. For Model 4, the J-B statistic of 1.174, with a p-value of 0.57%, also indicates a normal distribution. The results of Model 6 indicate that the model exhibits no apparent inconsistencies, as presented in Appendix A.8.

The estimation results from both models indicate that factors supporting DTS, such as regulation, digital talent, and digital infrastructure, significantly affect economic growth (Ln_GDP) and the current account deficit (Ln_CDS). Specifically, in Model 5, which focuses on GDP, the REG variable has a positive coefficient of 0.0171

with a 10% significance level. This indicates that better regulation contributes positively to economic growth. This finding aligns with the results of Hao et al. (2023) and Yi et al. (2022), who argue that stronger regulatory policies can enhance a country's competitiveness, accelerate investment flows, and improve market efficiency. This finding reflects that improved regulation tends to enhance the business climate, attract investment, and support economic expansion, consistent with several previous studies that highlight the importance of regulatory policies in facilitating economic growth.

Similarly, the results from Model 6 suggest that to reduce the DTS deficit, more integrated and comprehensive regulatory policies are required. This is evident from the significant negative relationship between regulation and Ln_CDS, indicating that better regulation can reduce the digital trade deficit, strengthening the competitiveness of Indonesia's digital services exports in the global market. Improvements in the regulatory environment, such as greater transparency, stricter rule of law, and reduced trade restrictions, tend to accelerate import growth compared to domestic exports. This finding aligns with Yi et al. (2022), which notes that regulatory liberalization can lead to rapid import penetration before domestic industries can compete effectively.

Table 4.7 GMM Estimation Results for the Determinants of GDP and CDS in the Indonesian Case

Dependent variable	Model (5) Ln_GDP	Model (6) Ln_CDS
Lagged of dependent variables	0.7213** (0.6270)	-0.4009* (0.3821)
REG	0.0371* (0.0104)	-1.4459*** (0.3558)
TLN	0.0461* (0.0235)	-0.1474* (0.0669)
IFR	0.0501* (0.0277)	0.4958** (0.2427)
CRD	0.0037** (0.0012)	-0.8059*** (0.2853)
INF	-0.0374*** (0.0051)	0.0822*** (0.0335)
OPN	0.0973*** (0.0132)	-0.5345* (0.2417)
Ln FDI	-0.0251* (0.0044)	0.2035*** (0.0432)
Constant	4.5694* (0.0281)	0.0613* (0.0609)
R-squared	0.95	0.86
Adj. R-squared	0.92	0.79
D-W	1.89	1.91
Obs.	32	32

Source and Notes: Authors' calculations. *** indicates statistical significance at the 1% level, while ** and * indicate statistical significance at the 5% and 10% levels, respectively.

For TLN (digital talent), the coefficient of 0.0261 in Model 5 shows a significant positive impact on GDP at the 10% significance level. This suggests that the availability of skilled digital talent is critical to driving economic growth, consistent with the increasing role of human capital in the digital economy. This finding corroborates prior research emphasizing the importance of a skilled workforce in

accelerating the adoption and expansion of digital services, thereby enhancing economic productivity (Elfaki & Ahmed, 2024; Santos et al., 2023).

Moreover, the IFR (digital infrastructure) variable shows a significant positive coefficient of 0.0501 at the 10% significance level in Model 5, indicating that improvements in digital infrastructure have a substantial positive impact on GDP. This result supports the view that strong digital infrastructure serves as the foundation for digital trade and services, enhancing efficiency and enabling new economic activities. This is also consistent with the findings of Mulenga and Mayondi (2022), which emphasize that digital infrastructure is a key prerequisite for driving technology-based economic transformation. In Model 6, although the relationships between IFR and TLN with the digital trade deficit (Ln_CDS) show negative signs, only IFR exhibits a significantly positive coefficient at the 5% level (0.4958). This suggests that strengthening digital infrastructure could worsen the digital trade deficit, as better infrastructure increases dependence on imported digital services. To mitigate this deficit, policies should promote domestic digital service exports and reduce reliance on imports.

The control variables INF and FDI show significant negative trends in Model 5 for GDP and significant positive trends in Model 6 for the current account deficit in digital trade services. These findings suggest that higher inflation can reduce economic competitiveness by decreasing purchasing power and increasing production costs, which in turn could worsen the digital trade deficit. This result is relevant because high inflation reduces Indonesia's attractiveness as an investment destination and hinders the expansion of sectors that support digital exports, which are crucial to the growth of the digital services export sector.

Another noteworthy finding relates to the CRD (credit growth) and OPN (global economic integration) variables, which show significant positive impacts on GDP and the current account deficit in digital trade services. This leads to the conclusion that stable credit growth and greater global economic integration can strengthen economic growth and improve the digital trade deficit by increasing investment flows and expanding export markets for digital services.

Table 4.8 Robustness Check Results: GMM Estimation of GDP and CDS Determinants in The Indonesian Case

Dependent variable	Model (7) Ln_CDS
Lagged of dependent variables	0.7081** (0.1939)
REG	-1.8908*** (1.1856)
TLN	-0.1721* (0.0884)
IFR	-0.9599* (0.0969)
CRD	0.5165* (0.1604)
INF	-0.2031** (0.0321)
OPN	0.1529 (0.0374)
Ln FDI	0.1338* (0.0608)
Constant	1.2560* (0.2415)
R-squared	0.75

Dependent variable	Model (7) Ln_CDS
Adj. R-squared	0.74
D-W	2.13
Obs.	32

Source and notes: Authors' calculations. *** indicates statistical significance at the 1% level, while ** and * indicate statistical significance at the 5% and 10% levels, respectively.

The robustness of these findings is reconfirmed by using different measures of DTS. In the previous Model 6, DTS was sourced from Bank Indonesia data. We reperformed the GMM regression using DTS data sourced from UNCTAD. The robustness test results are presented in Table 4.8. Notably, the DTS enabler, REG, has a significant negative impact on the current account deficit in digital trade services (Ln_CDS), while other DTS enablers, TLN and IFR, have a significant negative impact on the digital trade deficit (Ln_CDS), although with a lower significance level. These findings are consistent with those presented in Table 4.7, with the exception of IFR, which shows a significant positive impact in Model 6. This aligns with the hypothesis that to reduce the digital trade deficit in services, digital infrastructure must be strengthened. Improved digital infrastructure can accelerate technology adoption and expand access to digital services, which in turn can reduce reliance on imports and boost digital service exports. Interestingly, the OPN variable shows an insignificant positive impact on the digital trade deficit (Ln_CDS), which slightly differs from the findings in Table 4.8. A logical explanation for this could be that while economic openness affects the trade sector in general, its influence on digital trade could be more limited.

4.6. Discussion

Digital transformation has significantly reshaped the global economy, altering how production, consumption, and trade are organized. Over the past decade, DTS, including software, data analytics, professional consulting, and financial technology, has grown rapidly. For Indonesia, this shift presents an opportunity to diversify its exports and increase productivity. However, despite rapid technological adoption and infrastructure growth, Indonesia's DTS balance has worsened, with a deficit reaching USD 18.4 billion in 2024. The primary challenge lies in transforming digitalization into sustainable growth while improving the external balance.

The export potential of Indonesia's digital services is concentrated in the ICT and financial services sectors. Specifically, cloud computing, gaming, and software development exhibit strong export prospects, supported by the growing digital workforce and expanding data center capacity. However, insights from our Focus Group Discussion (FGD) highlight gaps in Indonesia's creative products, such as animated films, architectural designs, 3D modeling, and music. These areas present untapped potential that could be explored to further boost Indonesia's digital service exports and reduce the widening trade deficit.

To address this challenge, the study employs a mixed-methods approach, combining cross-country panel GMM and time-series GMM for Indonesia. Evidence from the 24-country estimation shows that factors such as regulation, digital talent, and digital infrastructure play important roles. Strengthening digital infrastructure and improving the quality of digital talent can drive economic growth and enhance the competitiveness of digital service exports. However, stringent regulations could hinder digital exports, particularly in developing countries that continue to face regulatory and infrastructure challenges. In Indonesia, good regulations support economic growth and reduce the digital trade deficit. Digital talent drives innovation

and productivity, while robust digital infrastructure is essential for growth, although it can increase reliance on imports.

Digital talent drives innovation and productivity, while digital infrastructure is important for growth, though it can increase reliance on imports. These three enablers of DTS, regulation, digital talent, and digital infrastructure, are involved in the development of DTS. Digital talent has emerged as a driver in reducing the deficit. At the same time, a paradox of "short-term openness" arises, whereby improvements in regulatory quality and openness are associated with larger deficits. This pattern suggests that the main issue is not openness per se but a gap in domestic capabilities.

Without a sufficient base of competitive local companies, openness could increase the presence of foreign providers and widen the imbalance. These findings have implications for the sequencing of policy implementation. Liberalization and regulatory reforms should be carried out alongside the development of domestic capabilities. Priority areas include talent development, support for innovation ecosystems, and broader financing for domestic firms. Empirical results also indicate that credit limits the deficit, suggesting that many firms face financing constraints.

More suitable financial instruments for digital startups and SMEs, such as recognition of intangible assets as collateral, would support the growth and competitiveness of domestic players. Evidence from FGDs with ministries, local governments, universities, and industry players reveals several structural challenges, including fragmented coordination, overlapping mandates, and a heavy reliance on private investment for infrastructure and innovation development. Several regions in Indonesia, focusing on data center development, AI, and animation, show strong potential. However, issues such as uneven connectivity, limited cybersecurity capacity, and talent shortages remain significant barriers.

Universities and vocational schools have made efforts to update their AI and digital design programs; however, ongoing updates are necessary to keep pace with global standards. At the regional level, several city and district governments are integrating digital services with the tourism and creative economy sectors. They support digital nomads and freelancers through coworking spaces, community networks, and AI-based ecosystems for SMEs. However, these efforts remain incomplete, with challenges including mismatches in taxation, visa policies, labor frameworks, and insufficient data on digital service providers, as well as inconsistent public service standards, particularly in network capacity, cybersecurity, and data governance across regions.

To address these gaps, it is important to improve digital infrastructure across Indonesia to ensure more equitable access. Stronger communication between the ministry, local governments, and Digital Economic Zones will also accelerate infrastructure development. Furthermore, facilitating cross-border digital trade through international agreements can provide wider market access for Indonesian businesses and expand cross-border digital payment networks. Developing digital talent through large-scale upskilling and reskilling programs, such as those implemented at vocational education institutions, will equip the workforce to compete in the digital economy.

5. Implication / Policy Recommendation

Based on the results and analysis, to optimize the digital trade sector in Indonesia, there are three main areas that need focus: the development of digital skills, the establishment of adaptive policies, and the improvement of infrastructure and market access. The first priority area is building a foundation of digital skills. The shortage of qualified professionals, such as AI experts, data scientists, and

cybersecurity specialists, is a major barrier to the growth of this sector. Therefore, it is recommended to establish a body that can coordinate the development of digital skills in a structured way between government agencies and related institutions. This body could also manage training funds more efficiently and avoid duplication. Furthermore, there needs to be a reform in the educational curriculum that focuses on globally recognized industry certifications, so that graduates are better prepared to meet the evolving demands of the job market. Strengthening digital skill training is also crucial given the high demand for professionals in AI and other digital technologies. This training will help create a skilled workforce that will support this sector in the long term.

The second area is creating responsive and adaptive policies to address challenges related to market openness that could hinder the growth of this sector. Indonesia needs to adopt more flexible data governance policies, classifying data based on its sensitivity. Highly sensitive data should be processed and stored domestically, while less critical data can be processed internationally. This approach will allow domestic companies to be more competitive in the global market, without being hindered by overly strict regulations. The introduction of a digital nomad visa could also attract global talent and facilitate knowledge transfer. By offering incentives such as tax exemptions, Indonesia can attract skilled professionals who will contribute to the local economy and help develop a more dynamic technology ecosystem. This, in turn, will accelerate economic growth through the influx of talent and technological spillovers.

The third area is enhancing digital infrastructure and market access to support the growth of digital trade. Adequate infrastructure, such as efficient payment systems, is crucial for smooth digital transactions. One measure that can be taken is to accelerate the expansion of QR-based payment systems to enable low-cost transactions between Indonesia and other countries. This could provide a cheaper payment channel for Indonesian digital exporters, such as game developers or freelancers, who often face high transaction fees. Promoting the use of local currencies in international transactions is also necessary to reduce exchange-rate fluctuations that could harm exporters of digital services.

Through the implementation of these policies, Indonesia is expected to strengthen its digital trade sector, reduce the digital trade deficit, and enhance its global competitiveness in the digital economy. These policies will also open up opportunities for Indonesia to become a key player in the global digital market and foster more inclusive and sustainable economic growth.

6. Conclusion and Further Research

Indonesia's digital economy is growing, but it still faces challenges related to the gap in domestic capacity, which is reflected in the worsening DTS deficit. In 2024, this deficit was recorded at USD 18.4 billion (UNCTAD, 2025), showing that Indonesia struggles to utilize the potential of the DTS sector. The ICT sector, including cloud computing, gaming, and software development, holds export potential. However, creative industries such as animated films, architectural design, 3D modeling, and music are not developing as expected, despite offering opportunities that could help reduce Indonesia's digital trade deficit.

To address this challenge, this study uses a mixed-methods approach, combining cross-country panel GMM analysis and time-series GMM for Indonesia. The results from 24 countries indicate that regulations, digital talent, and digital infrastructure play roles in accelerating economic growth and enhancing the competitiveness of digital service exports. However, strict regulations can hinder exports, particularly in developing countries that face challenges in regulatory and

infrastructure capacity. In Indonesia, while good regulations can support economic growth and reduce the digital trade deficit, further development of digital talent and infrastructure is needed to drive growth.

The three enablers of DTS, which are regulation, digital talent, and digital infrastructure, are important for the development of DTS. While regulatory improvements and increased market openness can create opportunities, a "short-term openness paradox" emerges, as they are often associated with larger deficits. This occurs because, without a strong domestic industry, market openness tends to benefit large foreign digital service providers. Without a base of competitive local companies, Indonesia's digital services sector struggles to capture market opportunities. Therefore, developing skilled and competitive domestic digital talent is important to ensure that local companies can compete in the global market.

Further analysis, using both cross-country and Indonesia-specific data, confirms that successful digital export sectors rely on three main pillars: regulatory quality, digital talent, and digital infrastructure. However, the most important factor in driving digital exports is digital talent. A skilled workforce impacts the digital services sector and contributes to economic performance. The relationship between digital talent development and GDP growth, as well as the reduction of the DTS deficit, shows the importance of investing in workforce development that meets the needs of the digital market.

Additionally, our qualitative research highlights the "death valley" as a barrier for local innovators. At this stage, between the successful creation of prototypes and the development of marketable products, challenges include limited access to growth capital, difficulty attracting senior talent, technical debt, and high infrastructure costs. Although public innovation support frameworks and regulatory sandboxes have supported early-stage technological experimentation, the lack of a well-defined pathway for scaling limits the commercialization of local innovations. Therefore, more focused efforts to enhance talent quality, develop infrastructure, and facilitate access to growth capital are necessary for enabling local innovations to grow and contribute to Indonesia's digital economy.

Further research could build on these findings by exploring firm-level dynamics within the digital services sector to better understand how talent composition, financing structures, and innovation strategies influence export performance. Future studies may also examine the long-term effects of regulatory reforms and market openness on domestic digital firms using micro-level data, including startup and platform-level information. Additionally, incorporating comparative case studies across emerging economies could provide deeper insights into effective policy sequencing to strengthen domestic digital capacity and reduce persistent digital trade deficits.

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APPENDIX

A.1 Summary statistics for variables used in the analysis of digital service exports across countries

Variables	Description	N	Mean	Std.	Min.	Max.
GDP	Gross Domestic Product (USD Million)	168	33,296,950	262,018,200	1,907,043	107,316,300
DS_EXP	The export value of digital services by a country (USD Million)	168	186,404.1	210,238.5	30,673	1,152,747
DS_IMP	The import value of DTS received by a country (USD Million)	168	167,148.0	172,388.4	11,308.2	840,877
REG	Regulatory quality (Index 0-1)	168	0.59	0.32	0.26	1.00
TLN	The extent of digital talent in a country (Index 0-1)	168	0.65	0.30	0.20	0.87
IFR	The digital infrastructure of a country (Index 0-1)	168	0.42	0.23	0.23	0.86
TAX	Tax Revenue (% of GDP)	168	15.44	6.54	0.06	27.43
EMP	Employment to population ratio (15+) (%)	168	6.19	6.07	0.69	34.01
OPN	Trade openness (% of GDP)	168	103.69	90.41	23.08	402.46
FDI	Foreign direct investment (USD Million)	168	55,644.710	82,784.32	- 139,972.3	475,805.1

Source: Author's calculations.

A.2 Correlation matrix for variables used in the analysis of digital service exports across countries

	DS_EXP	DS_IMP	GDP	REG	TLN	IFR	TAX	EMP	OPN	FDI
DS_EXP	1									
DS_IMP	0.5258	1								
GDP	0.4312	0.4969	1							
REG	0.3369	0.2676	0.4505	1						
TLN	0.3178	0.2381	0.4190	0.4938	1					
IFR	-0.0910	-0.1100	-0.2660	-0.3195	-0.3543	1				
TAX	0.0701	-0.1339	0.1372	0.2564	0.2527	-0.1024	1			
EMP	0.1722	-0.2069	-0.2118	-0.2592	-0.2492	-0.0751	0.3393	1		
OPN	0.4623	0.4431	0.2818	0.1469	0.1236	-0.0719	0.2609	0.1034	1	
FDI	0.0890	-0.0735	0.3987	0.3206	0.2931	0.1119	0.3500	0.2264	0.0172	1

Source: Author's calculations.

A.3 VIF test results for variables used in the analysis of digital service exports across countries

Variables	VIF	1/VIF	Variables	VIF	1/VIF
DS_EXP	1.26	0.283	IFR	1.39	0.535
DS_IMP	2.28	0.318	TAX	1.87	0.463
GDP	1.65	0.562	EMP	1.76	0.436

Variables	VIF	1/VIF	Variables	VIF	1/VIF
REG	1.81	0.404	OPN	1.17	0.514
TLN	3.14	0.479	FDI	3.46	0.372

Source: Author's calculations.

A.4 Results of slope heterogeneity for variables used in the analysis of digital service exports across countries

Models	Statistics	1/VIF	<i>p</i>
Ln GDP	Slope	0.796	0.356
	Adjusted slope	1.117	0.537
Ln EXP DS	Slope	1.215	0.683
	Adjusted slope	0.975	0.439

Source: Author's calculations.

A.5 Results of cross-sectional dependence on variables used in the analysis of digital service exports across countries

	Ln GDP	Ln IMP DS	REG	TLN	IFR	TAX	EMP	OPN	Ln FDI
Cross-sectional independence	0.723	0.854	0.376	0.966	0.796	0.375	0.254	0.818	0.864
Off-diagonal elements	0.463	0.529	0.192	0.513	0.471	0.117	0.237	0.329	0.517
	Ln EXP DS	Ln IMP DS	REG	TLN	IFR	TAX	EMP	OPN	Ln FDI
Cross-sectional independence	1.121	1.259	0.914	0.927	0.995	0.667	0.862	0.325	1.171
Off-diagonal elements	0.617	1.523	0.481	0.473	0.518	0.245	0.549	0.117	0.589

Source: Author's calculations.

A.6 Summary Statistics for Variables Used in the Indonesia Case Analysis of Digital Services

Variables	Description	N	Mean	Std.	Min.	Max.
CDS	Deficit in the current account for digital services (USD Million)	32	-1,508,413	625,284	-2,632,550	-443,825,100
GDP	Gross Domestic Product (USD Million)	32	2,811,100,000	240,067,500	2,378,146,000	3,279,510,000
DS_EXP	Exports of digital services (USD Million)	32	694,925	491,715	223,016	2,765,462
DS_IMP	Imports of digital services (USD Million)	32	2,201,677	951,232	1,041,867	5,071,036
REG	Regulatory quality (USD Million)	32	0.56	0.19	0.30	0.88
IFR	Digital infrastructure quality (Index 0-1)	32	0.62	0.19	0.29	0.90
TLN	Digital skills and talent quality (Index 0-1)	32	0.64	0.20	0.30	0.90
CRD	Credit growth (%)	32	7.66	4.43	-4.13	12.69
INF	Inflation rate (%)	32	2.96	1.18	1.33	5.95

Variables	Description	N	Mean	Std.	Min.	Max.
OPN	Trade openness	32	40.04	3.13	32.97	45.47
FDI	Foreign direct investment (USD Million)	32	258,92	88,60	165,80	446,90

Source: Author's calculations.

A.7 Correlation Structure for Variables Used in the Indonesia Case Analysis of Digital Services

	CDS	GDP	DST_EXP	DST_IMP	REG	IFR	TLN	CRD	INF	OPN	INV
CDS	1										
GDP	-0.5793	1									
DST_EXP	-0.4586	0.6947	1								
DST_IMP	-0.5920	0.5685	0.5108	1							
REG	-0.5505	0.5458	0.5130	0.5589	1						
IFR	-0.5286	0.5331	0.6748	0.5250	0.5805	1					
TLN	-0.5782	0.5159	0.6546	0.5475	0.5569	0.5718	1				
CRD	-0.0657	0.2896	0.2379	0.1654	0.1216	0.0411	-0.0037	1			
INF	-0.0685	-0.0610	-0.1342	-0.0222	-0.1531	-0.1815	-0.2079	0.5673	1		
OPN	-0.5589	0.3763	0.3056	0.5243	0.2147	0.1563	0.2919	0.4477	0.3761	1	
FDI	-0.5647	0.5500	0.5724	0.5981	0.5448	0.5959	0.5824	0.3397	-0.0160	0.4002	1

Source: Author's calculations.

A.8 Residual diagnostic test for GMM estimations

Residual Diagnostics		
Normality Test Results		
Estimates Models	J-B	Prob.
Model 3	0.3369	0.2676
Model 4	0.3178	0.2381

Source: Author's calculations.