Asia-Pacific Economic Cooperation

Understanding the economic impact of digitalisation on digital trade

Evidence from APEC economies

APEC Digital Economy Steering Group

December 2024

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Economic Cooperation

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Glossary of terms

ASEAN	Association of Southeast Asian Nations.
Digital intensity	The share of inputs from digital sectors across all intermediate and capital inputs. It is used in this study as an approximation for digitalisation in the production process, therefore it is used interchangeably with digitalisation.
Digital trade	All trade that is digitally ordered and/or digitally delivered. Its measurement is defined in Section 1.1 of the study.
Digitally ordered trade	Goods and services that are purchased but not necessarily delivered through digital means.
Digitally delivered trade	Used interchangeably with digitally deliverable services – Services that can be delivered digitally (e.g., financial or administrative services) but not necessarily ordered via digital platforms or channels.
E-commerce	Sales or purchase of goods or services, conducted over computer networks by methods specifically designed for the purpose of receiving or placing of orders.
FTA	Free Trade Agreement.
GDP	Gross Domestic Product – the monetary or market value of all final goods and services produced and sold within the borders of a given economy in a given period of time.
GVA	Gross value added. This is the value generated by producing goods and services and is measured as the value of output minus the value of intermediate consumption. It is a measure of economic contribution.
IMF	International Monetary Fund.
Inputs	Resources used to create goods and services (e.g., raw materials, financial capital, human capital, etc.).
OECD	Organisation for Economic Co-operation and Development.
WTO	World Trade Organization.
UNCTAD	United Nations Conference on Trade and Development.

Executive Summary

Digitalisation has significantly changed how international trade is conducted, both via the use of digital platforms to facilitate the exchange of non-digital goods and services, as well as through the increase in digitally deliverable exports, including financial and professional services, and mobile apps and content.

The impact of digitalisation of trade is of particular significance to APEC economies which already benefit substantially from cross-border trade. As a bloc, intra-APEC trade in merchandise and commercial services trade grew almost fivefold between 1994 and 2019.[1] In 2022, intra-APEC trade volumes reached USD 30 trillion or almost half (47%) of global trade. An earlier study commissioned by APEC found that in 2018, APEC intra-regional digital trade contributed USD 2.1 trillion to economies in the APEC region, approximately 4.1% of regional GDP.

Governments recognise the enormous opportunity presented by digital trade and have taken steps to create a global rules-based system to harness the opportunity. Past research discussed the overall benefits of digital trade participation to an economy, and the importance of digital trade rules in driving digital trade growth.[2] However, increasing participation in the digital trade ecosystem also depends on the readiness of the domestic business environment, including businesses and consumers. There is already growing recognition of this, as digital economy agreements (e.g., Digital Economy Partnership Agreement (DEPA) are increasingly going beyond digital trade rules which support “at-the-border” trade liberalisation, to look at how economies can work together to strengthen “behind-the-border” capabilities (e.g., strengthening digital infrastructure or skills) to support digital trade).

Past research has generally acknowledged that increased digitalisation is beneficial for digital trade participation, given the link between overall digital adoption and the increased use of digital trade tools as well as the ability to produce digital goods and services.[3] However, the empirical evidence on the strength of this relationship remains limited, largely due to the lack of sufficiently granular data on digital trade flows. Furthermore, past measures of digitalisation have relied on indicators such as Internet use or broadband coverage. Such data has not been consistently available across economies and sectors, and where available, might not be directly comparable due to differences in collection methods.

This study aims to address this gap in the existing body of literature by using a novel methodology to estimate digitalisation levels among APEC economies. This will allow for a closer study on the extent of digitalisation across economies and sectors as well as support a more in-depth examination of the relationship between digitalisation and digital trade. It relies on the following measures for digitalisation and digital trade:

[1] APEC Policy Support Unit (2020), Research Outcomes: Summary of Research Projects and COVID-19 Policy Briefs 2020. Available at: https://www.apec.org/docs/default-source/Publications/2021/7/Research-Outcomes-Summary-of-Research-Projects-and-COVID-19-Policy-Briefs-2020/221_PSU_Research-Outcomes-2020.pdf

[2] APEC Committee on Trade and Investment (CTI) (2023), Economic Impact of Adopting Digital Trade Rules: Evidence from APEC Member Economies. Available at: https://www.apec.org/publications/2023/04/economic-impact-of-adopting-digital-trade-rules-evidence-from-apec-member-economies

[3] See Freund and Weinhold (2004); Choi (2010); Lin (2015); López-González and Ferencz (2018); Herman and Oliver (2022); Benz, Jaax and Yotov (2022); López-González, Sorescu and Kaynak (2023).

(a) Digitalisation

The study relies on digital intensity as an approximation for digitalisation. This can be expressed as the share of inputs from digital sectors across all intermediate and capital inputs. Existing studies typically measure digitalisation through digital connectivity indicators such as the extent of Internet access or usage. This is unable to provide a direct indication of the extent to which the business leverages digital tools to improve or transform the process of producing goods and services. Digital intensity captures a more focused perspective of how digitalisation enters the production process through one of two separate input components used in production: (i) raw materials (intermediate inputs); and (ii) machinery and equipment (capital inputs). This provides a more consistent measure of digitalisation across sectors as well as economies and enables analysis to be conducted at the sector-level compared to connectivity indicators which are typically available only at the economy-level.

It is important to acknowledge that this approach has minor conceptual limitations, which have been noted for transparency and to guide future research. Sectors currently classified as producing 'digital' products also produce non-digital intermediate inputs, albeit in smaller proportions. Additionally, this methodology does not account for differences in the quality of digital products employed as intermediate inputs, nor does it capture the labour contribution for the in-house development of digital assets.

(b) Digital Trade

This study relies on the definition established in the OECD-WTO-IMF Handbook on Measuring Digital Trade (Second Edition) and leverages the same approach from a previous APEC study (also developed by Access Partnership) to provide an estimate of digital trade.[4] Broadly, the methodology recognises that there are two key components that form digital trade.

Component 1 covers goods and services which are digitally ordered but not necessarily delivered through digital means. Examples of such transactions are purchasing a wallet through an e-commerce platform, or booking a hotel stay abroad via an online portal. It also covers digital content such as music, games or mobile applications ordered via digital platform intermediaries. Component 2 covers services that are digitally deliverable but not necessarily digitally ordered. This includes services such as financial services and telecommunications services.

By examining the impact of digitalisation on digital exports for an economy, the research aims to support policymakers in adopting evidence-based approaches to strengthen digital trade participation. It seeks to provide insights into the following areas:

(a) How does digital intensity differ across economies?
(b) How does digital intensity differ across sectors?
(c) What is the impact of digitalisation on digital trade?

[4] APEC Committee on Trade and Investment (CTI) (2023), Economic Impact of Adopting Digital Trade Rules: Evidence from APEC Member Economies. Available at: https://www.apec.org/publications/2023/04/economic-impact-of-adopting-digital-trade-rules-evidence-from-apec-member-economies

A. Differences in digital intensity across economies

High-income economies with advantages in digital infrastructure, human capital as well as more resources to formulate robust digital policy have higher digital intensity. Past research suggests these factors as determinants of the extent of digitalisation in an economy and that high-income economies generally exhibit higher levels of digital infrastructure and human capital development as well as have more resources to put in place robust digital policies and governance frameworks. In 2020, the average digital intensity for high-income economies stood at 8.5%, while the average for non-high-income economies stood at 5.7%. The average digital intensity across APEC economies is 7.2%.

However, non-high-income economies are progressing quickly. Non-high-income economies outpaced high-income economies in progress for digitalisation between 2000 and 2020. Between 2000 and 2020, non-high-income APEC economies outpaced high-income economies in digitalisation progress, with average digital intensity increasing by 46% compared to 41% in high-income economies. Overall, APEC economies saw a 43% rise in digital intensity, from 5.1% in 2000 to 7.2% in 2020. This rapid progress can be attributed to factors such as the leapfrogging effect, where emerging economies adopt newer technologies without the burden of legacy systems, decreasing costs of digital technologies, and proactive governmental policies promoting digital infrastructure and skills training.

B. Differences in digital intensity across sectors

Services sectors have higher digital intensity than non-services sectors and digitalised at a faster pace between 2000 and 2020. In 2020, services sectors across APEC economies exhibited higher levels of digital intensity compared to non-services sectors like manufacturing. The higher level of digital intensity in services is primarily driven by the high levels of digitalisation in the information and telecommunications (ICT) (29.3%) and the financial services (21.0%) sectors. The pace of digitalisation was also faster in commercial services sectors, with the digital intensity of these sectors increasing by 59.6% between 2000 and 2020, compared to a 44.0% increase for non-commercial services sectors and a 12.5% increase for non-services sectors.

There is significant scope for APEC economies to strengthen digital intensity in key economic sectors. Six APEC economies – Brunei Darussalam; Chile; Indonesia; Peru; the Philippines; and Russia – had a lower digital intensity than the APEC average for their three largest sectors measured by gross value added (GVA) to the economy. While manufacturing is one of the most important sectors for APEC economies and of the top three contributors to GVA for the majority of APEC economies, the manufacturing sector lags commercial services sectors in digital intensity. In 2020, commercial services sectors recorded an average of 9.9% in digital intensity compared to 6.8% for the manufacturing sector. In particular, for the 12 APEC economies for which manufacturing is the top GVA contributor, five recorded digital intensity levels which were below the APEC average.

C. Impact of digitalisation on digital trade

Overall, higher digital intensity correlates with higher trade volumes of digitally deliverable services as digitalisation impacts the demand and supply functions for digital trade. The analysis found that digitally deliverable services exports increased by 2.5% ($p < .011$) for APEC economies for every percentage point increase in digital intensity. From the demand-side channel, digitalisation creates more possibilities for the creation of digitally deliverable services and content, increases usage of digital ordering platforms that extends market reach to new consumers, and enhances product and service quality for product differentiation. From the supply-side channel, digitalisation streamlines business processes to reduce production costs, reduces entry barriers to increase number of new participating firms, and reduces cost of replication to scale products and services.

The impact of increasing digital intensity on digitally deliverable services trade does not vary across economies of different levels of development. The analysis found no statistically significant difference between high-income and non-high-income economies in terms of how digital intensity impacted digital trade flows, suggesting that both high-income and non-high-income economies can benefit similarly from increasing digitalisation. Prior research (e.g., Di et al., 2022) found that digital

infrastructure, human capital, and capacity to innovate were important drivers of trade that were also correlated with an economy's level of development. That income levels were not found to have an observable effect on the relationship between digital intensity and digital trade in the analysis suggests that the level of income does not inherently constrain an economy's capacity to benefit from digitalisation. Instead, investments to drive digitalisation will benefit economies of different levels of development.

The impact of digitalisation on digital trade varies depending on the sector, with the ICT sector experiencing the most pronounced effects, followed by the financial services and professional services sectors. The analysis found that a percentage point increase in digital intensity correlates with 2.3% higher exports of ICT services and 1.7% higher exports of financial services and professional services respectively. The difference in impact may stem from fundamental differences in the drivers of demand for their core services. While the cost savings and innovation that digitalisation delivers can induce additional demand for ICT services due to greater price-elasticity, it is likely to have a more modest effect on demand for financial services and professional services, where the core value proposition may be driven by other elements such as human expertise, personalised advice, and trust-based relationships.

Critical areas of collaboration amongst APEC economies

Through the insights above, four key insights from the study that translate into potential action items for APEC policy makers have been identified. These action items include areas for (A) regional collaboration across APEC economies; and (B) development of economy-level and sector-level policy within APEC economies.

Key findings	A. Action items for regional collaboration across APEC economies	B. Action items for economy-level and sector-level policy within APEC economies
1. Increased digitalisation drives increased participation in digitally deliverable trade	APEC policymakers could focus digital trade agreements and regional collaboration efforts on domestic digitalisation ("i.e., behind the border") initiatives	Domestic strategies or frameworks to drive digitalisation could support digital trade growth
2. Increased digitalisation has no significant impact on the volume of digitally ordered exports	Strengthening regional collaboration on e-commerce could support the growth of digitally ordered exports	Support for small and medium enterprises (SMEs) to participate in digital trade could drive inclusive gains from the digital economy
3. Economies with developed digital infrastructure, robust digital policy and strong human capital have higher digitalisation levels	Capacity building efforts to drive digitalisation could focus on digital infrastructure and human capital	Non-high-income economies can reap significant benefits through policies to strengthen investment in digital infrastructure and human capital
4. APEC economies are not capturing the full potential of digitalisation in priority sectors	Regional collaboration to support digitalisation in key sectors such as manufacturing could benefit digital trade growth in APEC	The development of targeted sectoral roadmaps could bridge digitalisation gaps in priority sectors

1. Digital trade and digital intensity trends in APEC

This section provides an overview of the recent developments in digital trade and current state of digitalisation across APEC economies.

1.1. Digital trade developments in APEC

The adoption of digital technologies by businesses and governments in APEC have transformed the way that goods and services are being created and traded. Digital technologies have enabled the proliferation of e-commerce platforms that link small-scale retailers directly to consumers in other markets as well as supported the cross-border procurement and provision of various services such as those in the financial, professional, education and healthcare sectors, which can be delivered digitally.

The impact of digitalisation on trade is of particular significance to APEC economies which already benefit substantially from cross-border trade. As a bloc, intra-APEC trade in merchandise and commercial services trade grew almost fivefold between 1994 and 2019.[5] In 2022, intra-APEC trade volumes reached USD 30 trillion or almost half (47%) of global trade. APEC policymakers recognise the potential benefits of trade digitalisation and the role of digital trade in supporting the development of APEC economies. An earlier study commissioned by APEC found that in 2018, APEC intra-regional digital trade contributed USD 2.1 trillion to economies in the APEC region, approximately 4.1% of regional GDP.[6]

The facilitation of digital trade is already an integral part of APEC's future workplans with APEC Leaders pledging, in 2017, to "work together to realise the potential of the Internet and digital economy" and welcoming the adoption of the APEC Internet and Digital Economy Roadmap (AIDER).[7] The AIDER identifies 11 key focus areas (KFA) and with KFA 11 focusing on the facilitation of e-commerce and advancing cooperation on digital trade. The findings from this study will further support APEC economies in developing evidence-based approaches to facilitate the growth of digital trade in a sustainable and inclusive manner.

1.1.1 Digital trade developments in APEC

The OECD-WTO-IMF Handbook on Measuring Digital Trade (Second Edition) released in 2023 defines digital trade as all trade that is digitally ordered and/or digitally delivered.[8] The Handbook seeks to address at least in part the challenges in estimating digital trade volumes to date due to the lack of globally aligned definitions and approaches. This study relies on the definition established in the Handbook and leverages the same approach from a previous APEC study (also developed by Access Partnership) to provide an estimate of digital trade, against the backdrop of existing data constraints.[9] Broadly, the methodology recognises that there are two key components that form digital trade:

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[5] APEC Policy Support Unit (2020), *Research Outcomes: Summary of Research Projects and COVID-19 Policy Briefs 2020*. Available at: https://www.apec.org/docs/default-source/Publications/2021/7/Research-Outcomes-Summary-of-Research-Projects-and-COVID-19-Policy-Briefs-2020/221_PSU_Research-Outcomes-2020.pdf

[6] Asia-Pacific Economic Cooperation (2023), *Economic Impact of Adopting Digital Trade Rules: Evidence from APEC Member Economies.* Available at: https://www.apec.org/docs/default-source/publications/2023/3/economic-impact-of-adopting-digital-trade-rules-evidence-from-apec-member-economies/223_cti_economic-impact-of-adopting-digital-trade-rules.pdf?sfvrsn=e1021415_2

[7] Asia-Pacific Economic Cooperation (n.d.), "Digital Economy Steering Group". Available at: https://www.apec.org/groups/committee-on-trade-and-investment/digital-economy-steering-group

[8] OECD, WTO and IMF (2023), *Handbook on Measuring Digital Trade, Second Edition*. Available at: https://www.oecd-ilibrary.org/trade/handbook-on-measuring-digital-trade-second-edition_ac99e6d3-en

[9] APEC Committee on Trade and Investment (CTI) (2023), Economic Impact of Adopting Digital Trade Rules: Evidence from APEC Member Economies. Available at: https://www.apec.org/publications/2023/04/economic-impact-of-adopting-digital-trade-rules-evidence-from-apec-member-economies.

Component 1 covers goods and services which are digitally ordered but not necessarily delivered through digital means. Examples of such transactions are purchasing a wallet through an e-commerce platform, or booking a hotel stay abroad via an online portal. It also covers digital content such as music, games or mobile applications ordered via digital platform intermediaries. Component 2 covers services that are digitally deliverable but not necessarily digitally ordered. This includes services such as financial services and telecommunications services.

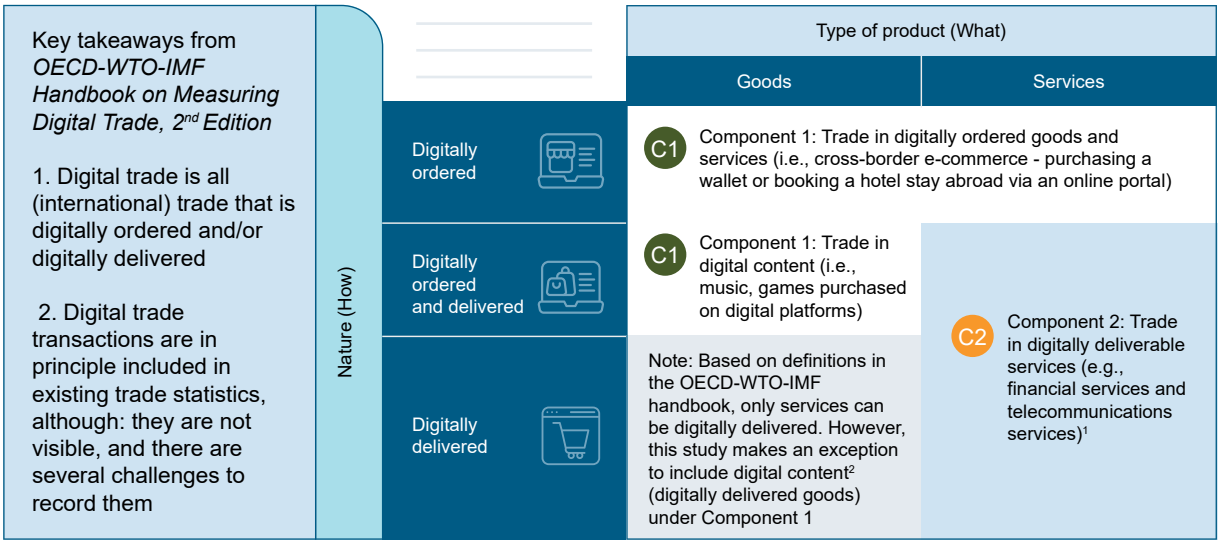
Specific to this study, Component 1 (trade in digitally ordered goods and services) was estimated for only 2016 to 2020 due to a lack of robust e-commerce data before 2016. The previous study had similarly estimated Component 1 for 2016 to 2018. Component 2 was estimated from 2000 to 2020.[10]

Due to the limitations of published trade data, these estimates do not provide the absolute value of all digital trade flows in a given year as they do not encompass all aspects that conceptually comprise digital trade[11]; but are instead useful proxies based on currently available data to show overall trends in digital trade flows, specifically trade in digitally ordered goods and services and trade in digitally deliverable services.

Exhibit 1 shows how these components cover different aspects of digital trade. The detailed methodology to estimate each component is in the Appendix.

EXHIBIT 1

Our methodology to measure digital trade covers the digitally ordered and digitally delivered components of digital trade



Notes:

1. This includes insurance and pension services; financial services; telecommunications, computer, and information services; and other business services.
2. OECD-WTO-IMF (2023). Available at: https://www.oecd-ilibrary.org/trade/handbook-on-measuring-digital-trade-second-edition_ac99e6d3-en

Source: Literature review and Access Partnership analysis

[10] Papua New Guinea was excluded from the dataset due to lack of data.
[11] For instance, components such as non-monetary digital flows are conceptually relevant for digital trade but not measured in domestic accounts nor international goods and services trade statistics and hence excluded. One example is data flows to search engines and social networks, which do not entail a direct monetary transaction but do support them. See OECD, WTO and IMF (2023), Handbook on Measuring Digital Trade, Second Edition. Available at: https://www.oecd-ilibrary.org/trade/handbook-on-measuring-digital-trade-second-edition_ac99e6d3-en

1.1.2 Trends in digital trade in APEC

Trend 1: Intra-regional trade in APEC doubled between 2016 and 2020 with trade in digitally ordered goods and services leading growth

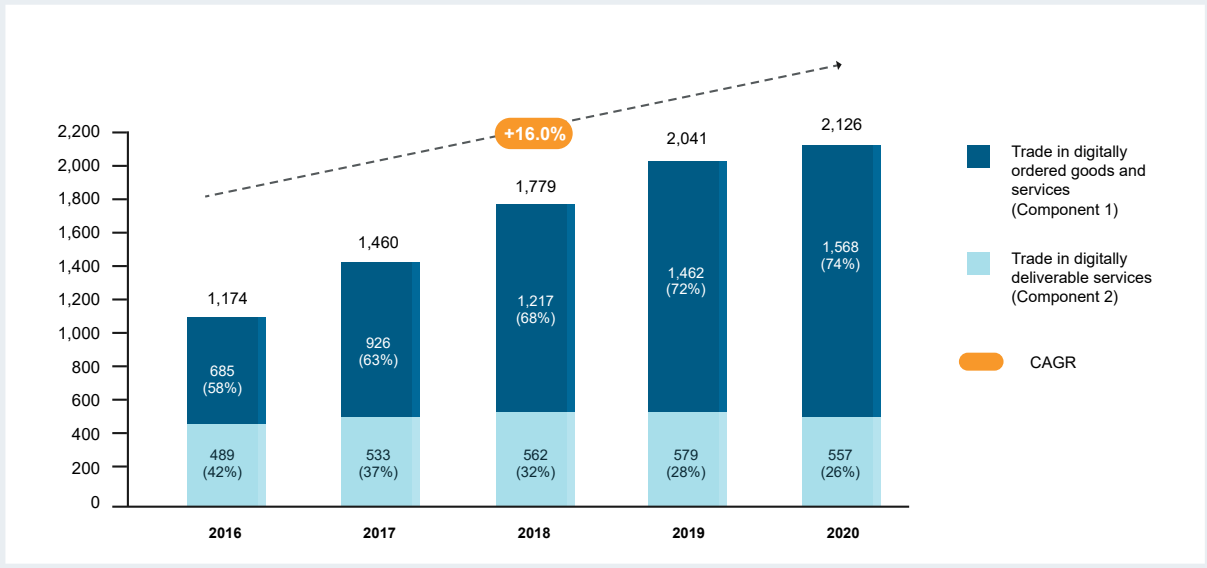
APEC intra-regional digital trade in 2020 was estimated at USD 2.12 trillion (Exhibit 2) and constituted 28% of APEC total intra-regional trade. This is nearly double from USD 1.17 trillion in 2016 at a compound annual growth rate (CAGR) of 16.0%. In 2020, trade in digitally ordered goods and services (e.g., cross-border e-commerce) comprised almost three-quarters (74%) of APEC intra-regional digital trade, with trade in digitally deliverable services (e.g., IT and information services, financial and insurance services) being a relatively smaller (26%) component.

Looking at the growth rates of the two components, trade in digitally ordered goods and services (Component 1) for APEC economies grew at a compound annual growth rate of 23% between 2016 and 2020 (Exhibit 2). In contrast, trade in digitally deliverable services (Component 2) grew at a more moderate CAGR of 3% between 2016 and 2020. The strong growth in trade in digitally ordered goods and services also appears to continue globally post-2020. UNCTAD calculations indicate that e-commerce sales in 2021 increased 15% over pre-pandemic (2019) levels and rose a further 10% in 2022.[12]

EXHIBIT 2

APEC intra-regional trade doubled between 2016 and 2020

Trade in digitally ordered goods and services (Component 1)[1] and trade in digitally deliverable services (Component 2)[2] between APEC economies, 2016 to 2020
Gross export value, USD billion



Notes:

1. Trade in digitally ordered goods and services: Cross-border e-commerce statistics in economies are used to estimate trade in digitally ordered goods and services as well as trade in digital content. This includes bilateral trade between APEC economies, excluding Brunei Darussalam; Chile; Malaysia; New Zealand; Papua New Guinea; Peru; Viet Nam as data is not available for these economies.

2. Trade in digitally deliverable services: This is defined as insurance and pension services; financial services; telecommunications, computer, and information services; and other business services. Trade data includes all bilateral digital trade between APEC economies (excluding Papua New Guinea due to lack of data).

Source: Access Partnership analysis, Euromonitor, Trade in Value Added (TiVA) database, UNCTAD

[12] UNCTAD (2024), Business e-commerce sales and the role of online platforms. Available at: https://unctad.org/system/files/official-document/dtlecde2024d3_en.pdf

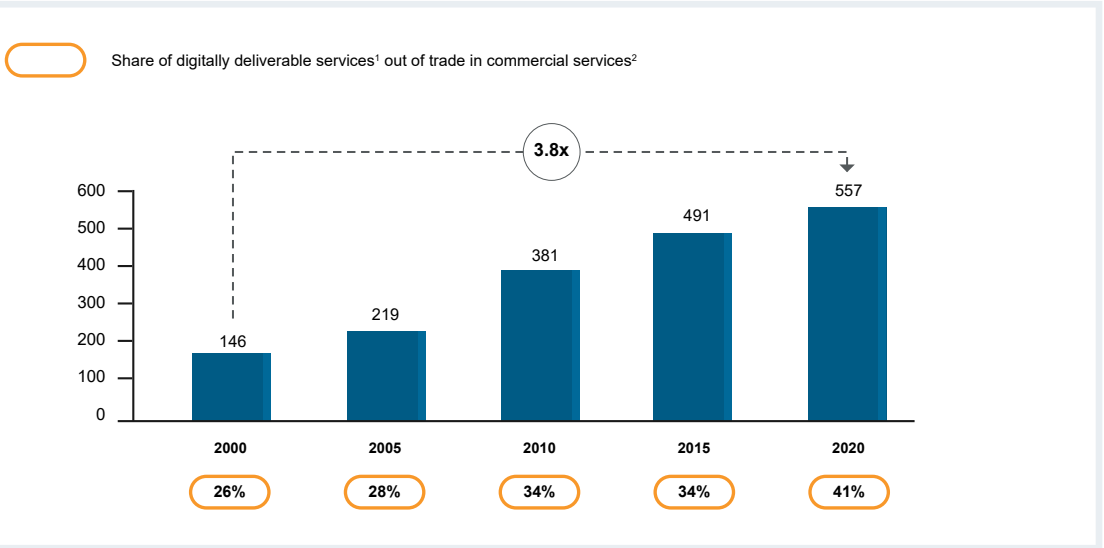
Trend 2: Trade in digitally deliverable services as a share of trade in commercial services grew sharply between 2000 and 2020

Trade in digitally deliverable services more than tripled from USD 146 billion in 2000 to USD 557 billion in 2020 (Exhibit 3). As a share of total trade in commercial services – which includes digitally deliverable services and services that are not digitally deliverable[13] – trade in digitally deliverable services grew sharply from 26% to 41% in the same period. This momentum had been accelerated by the resilience of digitally deliverable services in 2020 even during the COVID-19 pandemic, whereas the delivery and trade of non-digital services such as travel and tourism slumped dramatically and drove a double-digit decline in overall services trade.[14] Even before the pandemic, the growing importance of digitally deliverable services was evident, with their share of commercial services steadily increasing in the years leading up to 2020, reaching 28% in 2005 and hovering at 34% in 2010 and 2015.

EXHIBIT 3

Digitally deliverable services are increasing as a portion of trade in commercial services in APEC

Trade in digitally deliverable services (Component 2) between APEC economies
Gross export value, USD billion



Notes:

1. Digitally deliverable services include publishing, audio-visual, and broadcasting activities (ISIC 58 to 60); telecommunications services (ISIC 61); IT and other information services; (ISIC 62 to 63); financial and insurance activities (ISIC 64 to 66); professional, scientific, and technical activities (ISIC 69 to 75); and administrative and support services (ISIC 77 to 82). Trade data includes all bilateral digital trade within 20 APEC economies (excluding Papua New Guinea due to lack of data).

2. Commercial services include distributive trade, transport, accommodation and food services (ISIC 45 to 56); real estate services (ISIC 68), and digitally deliverable services as defined below. Trade data includes all bilateral digital trade within 20 APEC economies (excluding Papua New Guinea).

Source: Access Partnership analysis, Trade in Value Added (TiVA) database

[13] Commercial services include distributive trade, transport, accommodation, and food services (ISIC 45 to 56); real estate services (ISIC 68); information and communication services (ISC 58 to 53); financial and insurance activities (ISIC 64 to 66); professional, scientific, and technical activities (ISIC 69 to 75); and administrative and support services (ISIC 77 to 82).
[14] OECD (2022), "OECD Policy Responses to Coronavirus (COVID-19): International trade during the COVID-19 pandemic: Big shifts and uncertainty". Available at:
https://www.oecd.org/coronavirus/policy-responses/international-trade-during-the-covid-19-pandemic-big-shifts-and-uncertainty-d1131663/

1.2. Digital trade developments in APEC

Digitalisation refers to the transformation of economies through the integration of digital technology. The ability of an economy to integrate digital technology is expected to be linked at least in part to its ability to participate in digital trade, and increasingly, policymakers are considering the potential of broadening cooperation to strengthen "behind-the-border" capabilities (e.g., strengthening digital infrastructure or skills) to support digital trade. Recent digital economy agreements such as the Digital Economy Partnership Agreement (DEPA) look to address areas such as SME cooperation and digital inclusivity.

There is an extensive body of literature on the impact of digitalisation on trade and growth. This existing research typically measures digitalisation through digital connectivity indicators such as the extent of Internet access or usage.[15] However, such measures can be blunt measures of digitalisation of an economy, as they are unable to provide a clear indicator of the extent digitalisation is integrated into business operations or production activities. In other words, some existing studies consider the extent to which a business uses the Internet, but this measure is not able to identify the extent to which the business leverages digital tools to improve or transform the process of producing goods and services. This is a gap that this research seeks to address.

1.2.1 Estimating digitalisation through digital intensity

This study relies on digital intensity as an approximation for digitalisation.[16] Digital intensity measures the extent to which output within a sector is produced using digital goods and services inputs, including digital technologies. In contrast to past measures of digitalisation that focus on the state of digital connectivity and Internet usage in an economy, which often rely on compiling findings from various surveys, the use of digital intensity provides a more consistent measure of digitalisation across sectors as well as economies. In turn, this provides a more empirically robust dataset for analysis. Importantly, it also addresses a large gap in current research by enabling analysis to be conducted at the sector-level (i.e., the digitalisation levels of different sectors and their impact on digital trade can be broken down and compared), given that digital connectivity and Internet indicators are typically available only at the economy-level.

In constructing the digital intensity measure for each economy, both intermediate and capital digital inputs will be captured. Digitalisation can enter the production process through one of two input components used in production: (i) raw materials (intermediate inputs[17]); and (ii) machinery and equipment (capital inputs). Both types of inputs can be materially equivalent in circumstances where the difference arises from how businesses treat the use of these inputs for financial accounting purposes (i.e., as a capital outlay as compared to an operational expense). Indeed, business models have changed significantly in recent years so that what was previously capitalised (e.g., machinery and equipment, data centres) can now be accessed for service fees (e.g., Cloud Infrastructure as a Service). The detailed methodology used to estimate each component is in the Appendix.

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[15] Lin, F. (2015), *Estimating the effect of the Internet on international trade*. The Journal of International Trade & Economic Development, Available at: https://www.tandfonline.com/doi/full/10.1080/09638199.2014.881906#:~:text=The%20empirical%20results%20show%20that,and%20controlling%20for%20infrastructure%20measures. Choi, C. (2010), *The effect of the Internet on service trade.* Available at: https://www.sciencedirect.com/science/article/abs/pii/S0165176510002697 https://doi.org/10.1016/j.econlet.2010.08.005. López González, J. and S. Sorescu (2021), "Trade in the time of parcels", OECD Trade Policy Papers, No. 249. Available at: https://www.oecd-ilibrary.org/trade/trade-in-the-time-of-parcels_0faac348-en. González, J. L., Sorescu, S., and Kaynak, P. (2023), Of bytes and trade: Quantifying the impact of digitalisation on trade. Available at: https://www.oecd-ilibrary.org/docserver/11889f2a-en.pdf?expires=1715676312&id=id&accname=guest&checksum=962C5533C76651CBD3F47D113AAB95D6

[16] See Chiappini, R. and Gaglio, C. (2023), *Digital intensity, trade costs and exports' quality upgrading*. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/twec.13448. For alternate measures of digital intensity, see Liu and McDonald-Guimond (2021), *Measuring digital intensity in the Canadian economy.* Available at: https://www150.statcan.gc.ca/n1/pub/36-28-0001/2021002/article/00003-eng.htm; and European Commission (n.d.), "Digital Intensity Index". Available at: https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_dii_esmsip2.htm

[17] The Bureau of Economic Analysis (BEA) defines Intermediate Inputs as "Goods and services that are used in the production process of other goods and services and are not sold in final-demand markets."

1.2.2 Trends in digitalisation across APEC

Trend 1: Economies with advantages in digital infrastructure, human capital as well as the quality of digital policy and governance have higher digital intensity

Past research suggests that critical determinants of digital intensity in an economy include (i) the extent of digital infrastructure development; (ii) the extent of human capital development; and (iii) the quality of digital policy and governance. Table 1 summarises findings on the determinants of digital intensity from existing literature.

TABLE 1 Summary literature of the determinants of digital intensity

Critical determinants of digital intensity	Past research
Extent of digital infrastructure development	Billon et al. (2010) analysed factors affecting digitalisation, identifying digital infrastructure as the most important determinant of digitalisation for economies at lower digitalisation levels.[18] A robust digital infrastructure facilitates more seamless integration of digital inputs into existing processes, amplifying its positive effects on productivity and efficiency.
Extent of human capital development	Maji and Laha (2022) showed that in Asia Pacific economies, education positively and significantly affects digitalisation.[19] A digitally skilled workforce further encourages firms to use more digital inputs in production as they can be certain the technology will be appropriately harnessed by the workers.
Quality of digital policy and governance	Md et al. (2023) found that political stability significantly drives digital usage across the Asia-Pacific region, with stable economies more likely to prioritise investment in digital infrastructure.[20] High quality institutions, such as those in financial and legal services, also attract technology investments and make it easier for businesses to use technology. Comparing digital intensity levels to the findings of the Network Readiness Index 2023 also point to economies with higher governance scores (i.e., a strong capacity to foster a conducive regulatory environment for digital adoption as well as trust and inclusion in the digital economy) being better placed to support digital adoption (see Exhibit 6).

[18] Billon, M., Lera-Lopez, F., and Marco, R. (2010), *Differences in digitalisation levels: A multivariate analysis studying the global digital divide.* Review of World Economics, 146, 39–73.
[19] Maji, S. K., and Laha, A. (2022), *The role of digital skill in mitigating digital divide: evidences from Asia-Pacific region*. Rajagiri Management Journal, Vol. 16 No. 3, pp. 260-271.
[20] Md, A. M., Md, I. H., and Sangwan, S. (2023), *Determinants of digitalisation: Evidence from Asia and the Pacific countries*. Available at: https://www.emerald.com/insight/content/doi/10.1108/DTS-10-2023-0097/full/pdf?title=determinants-of-digitalization-evidence-from-asia-and-the-pacific-countries

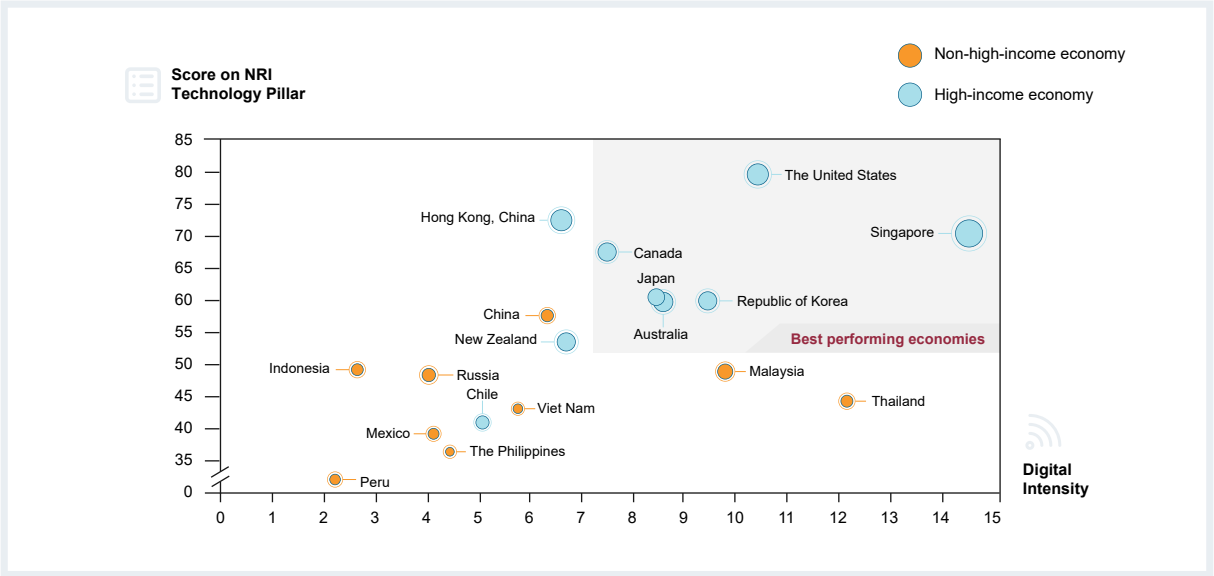
In the absence of strong indicators that demonstrate the combined quality of these determinants and their interaction, it can be broadly assumed that high-income economies generally exhibit higher levels of digital infrastructure and human capital compared to other economies.[21] High-income economies have more resources to invest in digital infrastructure and human capital through connective infrastructure as well as skilling programs. Such economies tend to also have more well-resourced public service sectors and focused institutions and policies to support and facilitate digital adoption amongst businesses and individuals.

Findings from the Network Readiness Index (NRI) 2023 support the link between high-income economies and digital infrastructure, human capital, and the quality of digital policy and governance.[22] Best performing APEC economies (upper-right quadrant), which score well on the technology (corresponding broadly to digital infrastructure), people (corresponding broadly to human capital) and governance (corresponding broadly to the quality of digital policy and governance) pillars of the NRI, are mainly high-income economies (Exhibits 4, 5, and 6). These economies also have a higher digital intensity in 2020.

EXHIBIT 4

High income economies tend to have more developed digital infrastructure and higher digital intensity

Comparison of score on technology pillar of Network Readiness Index (NRI) 2023 against digital intensity, %



Notes:

1. The technology pillar of the NRI measures an economy's digital infrastructure to support technology adoption based on three sub-pillars: access, content, and future technologies. Indicators analysed in the access sub-pillar include mobile tariffs, handset prices, Internet access, coverage, and speed. Indicators analysed in the content sub-pillar include mobile apps development, Internet domain registrations and AI publications. Indicators analysed in the future technologies sub-pillar include investment and adoption in emerging technologies, robot density, and computer software spending.

2. The size of the circle represents the GDP per capita of each economy.

Source: Access Partnership analysis, Portulans Institute

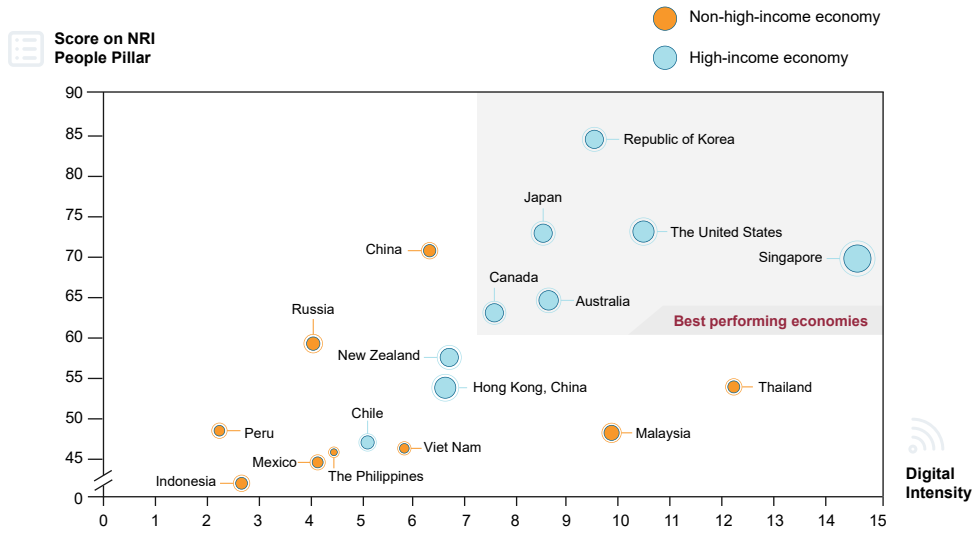
[21] This study classified the economies into two categories: high-income and non-high-income economies. High-income economies are classified as economies with GNI per capita higher than 13,845 based on World Bank's income classification in FY2024. All other economies are classified as non-high-income economies. World Bank (2023), "World Bank Group country classifications by income level for FY24 (July 1, 2023- June 30, 2024)". Available at: https://blogs.worldbank.org/en/opendata/new-world-bank-group-country-classifications-income-level-fy24

[22] Portulans Institute (2023), Network Readiness Index 2023. Available at: https://download.networkreadinessindex.org/reports/nri_2023.pdf

EXHIBIT 5

High income economies tend to have more developed human capital and higher digital intensity

Comparison of score on people pillar of Network Readiness Index (NRI) 2023 against digital intensity, %



Notes:

1. The people pillar of NRI measures an economy's human capital to leverage technologies based on three sub-pillars: individuals, businesses, and governments. Indicators analysed in the individuals sub-pillar include ICT skills in the education system, tertiary enrolment, and AI talent concentration. Indicators analysed in the businesses sub-pillar include businesses with websites, investment in R&D and telecommunication services, and knowledge intensive employment. Indicators analysed in the governments sub-pillar include the quality of a government's delivery of online services, a government's promotion of investment in emerging technologies, and investment in higher education.

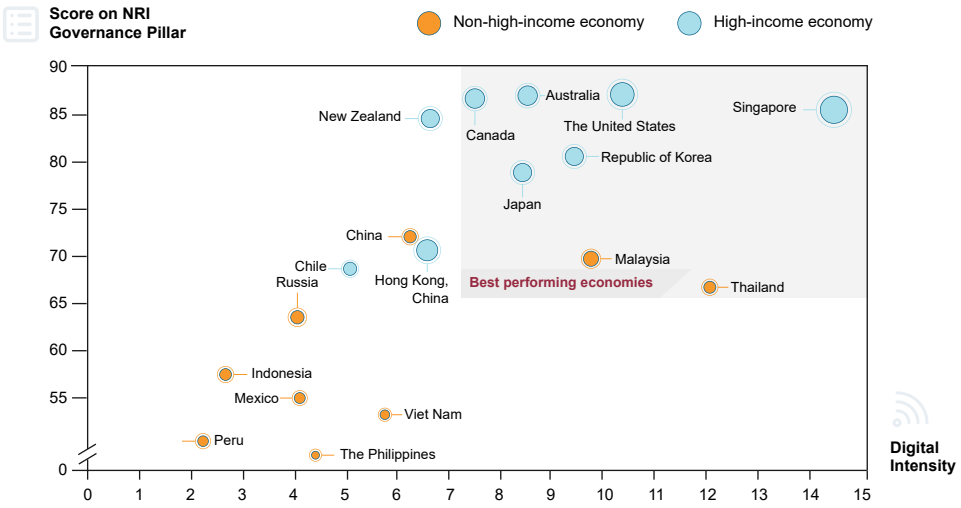
2. The size of the circle represents the GDP per capita of each economy.

Source: Access Partnership analysis, Portulans Institute

EXHIBIT 6

Economies with strong governance frameworks have high digital intensity

Comparison of score on governance pillar of Network Readiness Index (NRI) 2023 against digital intensity, %



Notes:

1. The governance pillar of the NRI measures an ability to support safe and inclusive technology adoption based on three sub-pillars: trust, regulation, and inclusion. Indicators analysed in the trust sub-pillar include secure Internet servers, cybersecurity strength, and online access to financial institutions. Indicators analysed in the regulation sub-pillar include the government's ability to formulate and implement sound digital and privacy policies and regulate ICT and emerging technologies. Indicators analysed in the inclusion sub-pillar include the availability of local online content, and gender, socioeconomic, and geographical gaps in use of Internet and digital payments.

2. The size of the circle represents the GDP per capita of each economy.

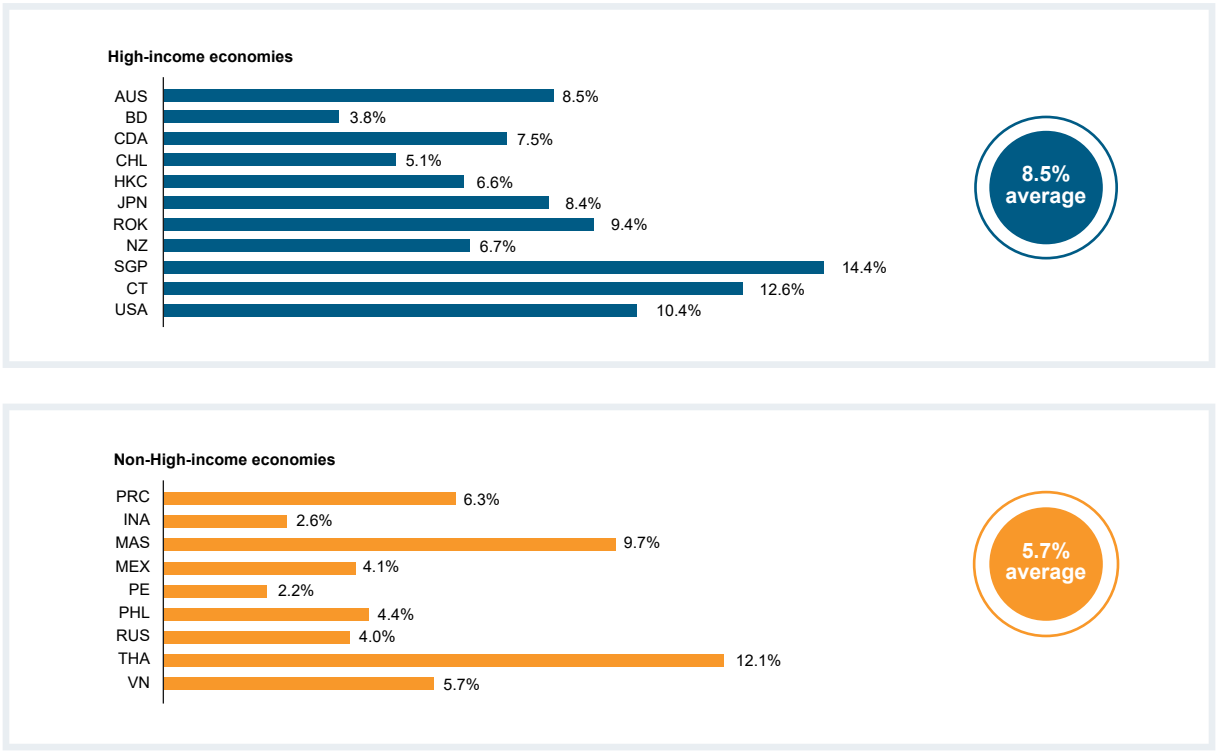
Source: Access Partnership analysis, Portulans Institute

Comparing digital intensity against economies of different income levels, high-income economies have a higher digital intensity compared to non-high-income economies. In 2020, the average digital intensity for high-income economies stood at 8.5%, while the average for non-high-income economies stood at 5.7% (Exhibit 7). The average digital intensity across APEC economies is 7.2%.

EXHIBIT 7

High-income economies have a higher digital intensity compared to non-high-income economies

Digital intensity of of APEC economies in 2020, %



Source: Access Partnership analysis, OECD Inter-Country Input-Output Database, The Conference Board

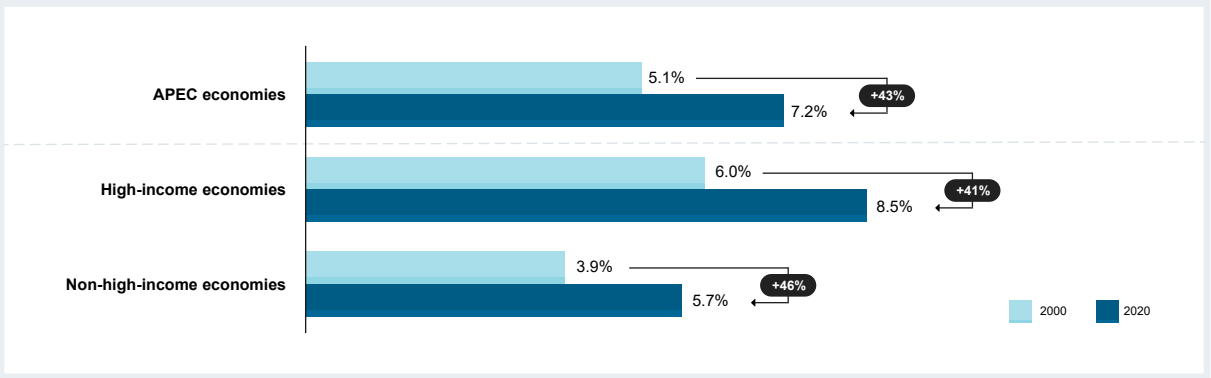
Trend 2: Non-high-income economies outpaced high-income economies in progress for digitalisation between 2000 and 2020

The average digital intensity of APEC economies increased by 43% between 2000 and 2020, increasing from an average digital intensity of 5.1% in 2000 to 7.2% in 2020. During this period, non-high-income economies outpaced high-income ones in digitalisation progress, with digital intensity increasing by 46% in non-high-income economies compared to 41% in high-income economies (Exhibit 8). In particular, Viet Nam (182% increase) and Russia (157% increase) made the most significant progress, more than doubling their digital intensity.

EXHIBIT 8

Between 2000 and 2020, the growth of digital intensity in non-high-income economies outpaced the growth in high-income economies

Digital intensity by APEC economies in 2020, %



SOURCE: Access Partnership analysis, OECD Inter-Country Input-Output Database, The Conference Board

Several factors may explain the relatively more rapid progress on digitalisation among non-high-income economies.

First, non-high-income economies may have leapfrogged high-income economies in adopting newer and better technologies. This theory was initially proposed by Perez and Soete (1998) which suggested that emerging economies are more incentivised to adopt newer and more efficient technologies as they are not burdened by the sunk costs of investments in legacy systems, unlike high-income economies.[23] Several studies, including those by Lee and Lim (2001), and Lee et al. (2005), have confirmed leapfrogging through case studies in East-Asia, where firms in latecomer economies increase their market share by adopting newer technologies.[24]

Second, technologies have become more affordable, enabling firms in non-high-income economies to use more digital inputs in their production. Studies by Spiezia (2016) and Bryne and Corrado (2017) showed that technical progress in technologies have rapidly decreased the input cost over the years.[25] Cheaper technology is particularly crucial for non-high-income economies, which face more adoption barriers than high-income economies.

Third, over this period, the governments of many non-high-income economies have recognised the importance of digitalisation and actively implemented policies and programs to promote it. These initiatives include investments in digital infrastructure, incentives to promote technological innovation and increased support for digital skills training. For example, Viet Nam, the economy with the fastest growing digital intensity, established several policies that encouraged more digitalisation. Its domestic policy announced in 2010 prioritised digital skills training for workers and promoted technology use among various other goals.[26]

[23] Perez, C. and Soete, L. (1988), Catching-Up in Technology: Entry Barriers and Windows of Opportunity. Available at: https://downloads.unido.org/ot/16/41/16414872/WP_17_FINAL.pdf
[24] Sources include: Lee, K., and Lim, C. (2001), "Technological Regimes, Catching-up and Leapfrogging: Findings from the Korean Industries", Research Policy, 30/3, 459–83; and Lee, K., Lim, C., and Song, W. (2005), "Emerging Digital Technology as a Window of Opportunity and Technological Leapfrogging", International Journal of Technology Management, 29/1–2, 40–63.
[25] Sources include: Spiezia, V. (2016), Working Party on Measurement and Analysis of the Digital Economy. Available at: https://one.oecd.org/document/DSTI/ICCP/IIS(2016)1/FINAL/En/pdf; and Bryne, D., and Corrado, C. (2017), ICT Prices and ICT Services: What do they tell us about Productivity and Technology? Available at: https://www.federalreserve.gov/econresdata/feds/2017/files/2017015pap.pdf
[26] Ministry of Planning and Investment Vietnam (2018), "Policies to boost investment in the digital economy in Vietnam". Available at: https://fia.mpi.gov.vn/en/Detail/CatID/1c9dee34-6455-4d73-8b8c-71a35a99b8ae/NewsID/7b43899c-437c-4b56-b4a5-64c3af97c1fe

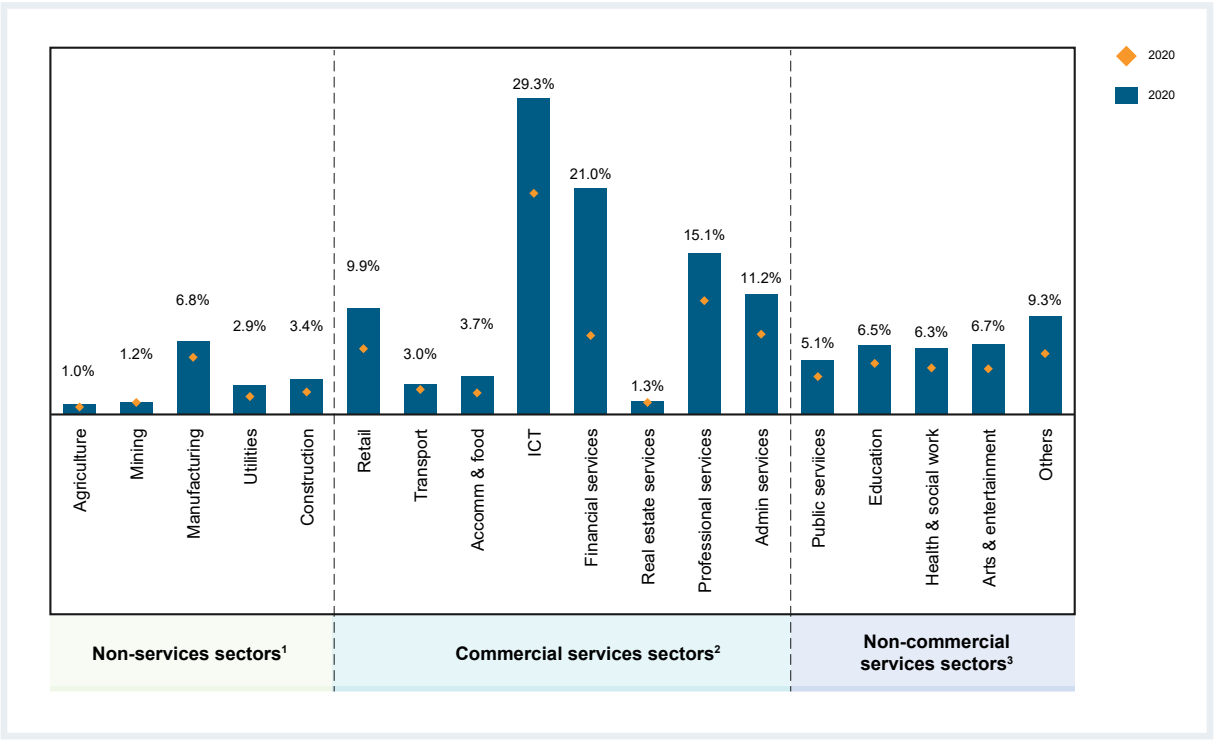
Trend 3: Services sectors have higher digital intensity than non-services sectors and digitalised at a faster pace between 2000 and 2020

In 2020, services sectors across APEC economies exhibited higher levels of digital intensity compared to non-services sectors like manufacturing. The higher level of digital intensity in services is primarily driven by the high levels of digitalisation in the ICT (29.3%) and the financial services (21.0%) sectors (Exhibit 9).

EXHIBIT 9

Across the APEC economies, the ICT, financial services and professional services sectors had the highest digital intensity in 2020

Digital intensity by sectors in 2000 and 2020, %



Notes:

1. Non-services sectors include agriculture, forestry and fishing (ISIC 01 to 03); mining and quarrying (ISIC 05 to 09); manufacturing (sector ISIC 10 to 33); utilities (ISIC 35 to 39); and construction (ISIC 40 to 43).
2. Commercial services include distributive trade, transport, accommodation, and food services (ISIC 45 to 56); real estate services (ISIC 68); information and communication services (ISC 58 to 53); financial and insurance activities (ISIC 64 to 66); professional, scientific, and technical activities (ISIC 69 to 75); and administrative and support services (ISIC 77 to 82).
3. Non-commercial services sectors include public services (ISIC 84); education (ISIC 85); human health and social work (ISIC 86 to 88); arts, entertainment and recreation (ISIC 90 to 93); and other services activities (ISIC 94 to 96).

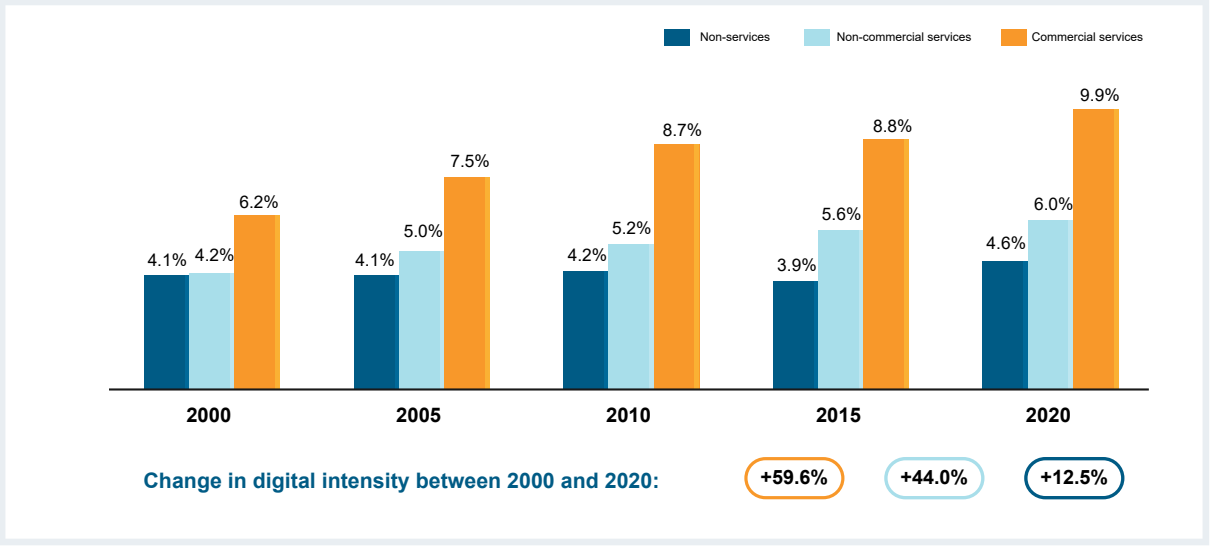
Source: : Access Partnership analysis, OECD Inter-Country Input-Output Database, The Conference Board

Except for the mining sector, all other sectors experienced a growth in digital intensity between 2000 and 2020. The pace of digitalisation was also faster in commercial services sectors, with the digital intensity of these sectors increasing by 59.6% between 2000 and 2020, compared to a 44.0% increase for non-commercial services sectors and a 12.5% increase for non-services sectors (Exhibit 10).

EXHIBIT 10

Between 2000 and 2020, digital intensity of commercial services sectors grew faster than non-commercial services and non-services sectors

Digital intensity by sectors, 2000 to 2020, %



SOURCE: Access Partnership analysis, OECD Inter-Country Input-Output Database, The Conference Board

Our findings align with conclusions made by Chiappini and Gaglio (2023) and Calvino et al. (2018) that commercial services sectors consume more digital inputs in production than manufacturing sectors.[27] Chiappini and Gaglio (2023) explain that the rapid pace of digitalisation of commercial services could be due to the expansion of online platforms.

Online platforms have progressively permeated various sectors, such as transport and logistics (e.g., ride sharing and delivery platforms), retail (e.g., e-commerce), media (e.g., streaming platforms), and travel bookings (e.g., online travel agencies). From ride sharing platforms like Uber and Grab, to online accommodation agencies like Airbnb, the delivery of services is rapidly being digitalised and becoming a permanent fixture. Online platforms lower the entry barrier for more offline firms to connect with online users and leverage digital opportunities. For example, in Southeast Asia, the number of users on these platforms increased by 54%, while the value of transactions increased by 228% between 2015 and 2020.[28] The increased online activity highlights greater use of digital platforms for many firms in the region.

Calvino et al. (2018) find that commercial services sectors, particularly the ICT and financial services sectors, have a higher share of ICT investments, ICT inputs consumed in production, ICT specialists in the workforce and ICT task intensity which explains the higher digital intensity observed.[29] Moreover, commercial service sectors may also be more prepared for digitalisation. These sectors are often knowledge-based, relying heavily on efficient communication, collaboration, and information sharing. The proliferation of digital tools like video conferencing, project management software, and online collaboration platforms significantly enhance the efficiency and productivity of knowledge work.

[27] Chiappini, R. and Gaglio, C. (2023), Digital intensity, trade costs and exports' quality upgrading. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/twec.13448
[28] Google (2020), e-Conomy SEA 2020. Available at: https://storage.googleapis.com/gweb-economy-sea.appspot.com/assets/pdf/e-Conomy_SEA_2020_Report.pdf
[29] Calvino, F., Criscuolo, C., Marcolin, L., and Squicciarini, M. (2018), A taxonomy of digital intensive sectors. Available at: https://www.oecd-ilibrary.org/docserver/f404736a-en.pdf?expires=1720154092&id=id&accname=guest&checksum=D1A8CF58D7F730641E20756170B6B58E

Trend 4: In many APEC economies, the largest sectors have digital intensity below the APEC average

Six APEC economies – Brunei Darussalam; Chile; Indonesia; Peru; the Philippines; and Russia – had a lower digital intensity than the APEC average for all of their three largest sectors measured by gross value added to the economy (Exhibit 11). Meanwhile, Australia; China; Malaysia; Singapore; Chinese Taipei; and Thailand were the only APEC economies with all three sectors having a higher digital intensity than the APEC average. This provides additional insight to our findings in Exhibit 7, where China; Malaysia; and Thailand had the highest digital intensity among the non-high-income economies, as their largest sectors are highly intensive in digital inputs.

EXHIBIT 11

The largest sectors in many APEC economies have digital intensity below the APEC average

Digital intensity of top three largest sectors, % and relative to APEC average[1,2]

At or above average | Below average

Economy	Assessment of top three largest sectors' digital intensity					
	#1		#2		#3	
Australia	Real estate	2.9%	Mining	2.1%	Retail	11.1%
Brunei Darussalam	Mining	0.6%	Public services	4.1%	Manufacturing	0.5%
Canada	Real estate	3.7%	Retail	9.8%	Manufacturing	2.9%
Chile	Mining	0.7%	Retail	8.7%	Manufacturing	2.4%
China	Manufacturing	7.5%	Retail	10.5%	Financial services	27.7%
Hong Kong, China	Retail	9.2%	Financial services	15.1%	Real estate	1.9%
Indonesia	Manufacturing	2.0%	Agriculture	0.2%	Retail	5.8%
Japan	Manufacturing	3.1%	Retail	14.3%	Real estate	1.4%
Republic of Korea	Manufacturing	9.9%	Retail	12.4%	Real estate	1.1%
Malaysia	Manufacturing	13.1%	Retail	13.9%	Other services	12.5%
Mexico	Retail	5.0%	Manufacturing	7.4%	Real estate	0.5%
New Zealand	Real estate	1.7%	Manufacturing	3.5%	Retail	11.3%
Peru	Manufacturing	0.8%	Retail	2.8%	Mining	0.3%
The Philippines	Manufacturing	6.6%	Retail	7.6%	Agriculture	0.6%
Russia	Manufacturing	2.7%	Retail	6.7%	Real estate	0.5%
Singapore	Manufacturing	17.1%	Retail	11.9%	Financial services	24.4%
Chinese Taipei	Manufacturing	18.3%	Retail	14.3%	Real estate	1.3%
Thailand	Manufacturing	14.5%	Retail	18.5%	Agriculture	1.5%
United States	Real estate	1.5%	Manufacturing	4.6%	Retail	13.7%
Viet Nam	Manufacturing	13.1%	Agriculture	0.4%	Retail	3.3%

SOURCE: Access Partnership analysis, OECD Inter-Country Input-Output Database, The Conference Board

Notes:

1. The top three sectors are determined by sectoral contribution to GVA.
2. Sectoral digital intensity for each economy's sector is assessed relative to the simple average across all APEC economies for that particular sector and are either rated as "at or above average" (green) or "below average ("red").

2. Understanding impact of digitalisation on digital trade

This section considers the economic impact of digitalisation on digital trade.

2.1. The link between digitalisation and digital trade

The expected impact of digitalisation on digital trade is analysed based on a supply-demand framework.30 Digitalisation impacts both the demand and supply functions for digital trade.

2.1.1 Demand-side channel

Increased digitalisation across sectors creates more possibilities for the creation of digitally deliverable services and content. This expansion of consumer choice31 helps to accommodate a wider range of consumer preferences with regard to product type and delivery, leading to an outward shift in the demand curve for these products by increasing market reach and overall consumer demand. For example, the rise of mobile apps for fitness tracking, language learning, and entertainment streaming services like Netflix have realised demand for new formats of digital content and services that had been delivered in physical ways or had not previously existed.

In addition, digitalisation increases the provision and therefore consumer usage of digital ordering platforms. Digital ordering platforms have made markets more efficient (Bakos, 1997), reducing friction between buyers and sellers.32 As investments in digital technologies increased, these online marketplace platforms have incorporated advanced technologies to facilitate geographical expansion and enable consumers' cross-border purchase and delivery of goods. Important marketplace technologies include global electronic payment gateways (e.g., PayPal), international logistics and shipping offerings (e.g., AfterShip), translation and localisation tools (e.g., Transifex), and scalable cloud computing infrastructure (e.g., Amazon Web Services). These enhancements driven by digitalisation have further increased market access, reducing search costs, and exposing consumers to a wider array of products, increasing demand for digital trade.

Digitalisation also enables advanced digital technologies to be applied to product differentiation, often resulting in improved product quality and enhanced customer experiences. For instance, e-commerce platforms like Amazon use recommendation engines to personalise product suggestions, while chatbots provide instant customer support, enhancing the overall customer experience and driving demand. Such product differentiation and personalisation can reduce friction for the buyer and create more attractive offerings, increasing demand and even supporting higher prices.33

These features of digitalisation collectively contribute to pushing out the demand curve for digital trade (Exhibit 12). This creates a situation where, at the initial price level, the quantity demanded exceeds the quantity supplied for digitally ordered goods and services and digitally deliverable services. This shortage and potential for additional profit signals to new and existing providers to expand their capacity to meet the shortage. The digital production and ordering of these goods and services, with low marginal costs of production and distribution, makes it easier to rapidly scale up supply and reach a new market equilibrium. This increase in quantity supplied to meet quantity demanded not only resolves the initial shortage but also leads to a substantial increase in the overall quantity of digital trade transacted.

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[30] Supply and production are terms which are often used interchangeably.
[31] United Nations Conference on Trade and Development (2022), Digitalisation of Services: What Does It Imply To Trade And Development? Available at: https://unctad.org/system/files/information-document/tsce-myem2022-Digital-Services_en_.pdf
[32] Bakos, J. Y. (1997), Reducing buyer search costs: Implications for electronic marketplaces. Management Science, 43(12), 1676-1692. Available at: https://pubsonline.informs.org/doi/10.1287/mnsc.43.12.1676
[33] Porter, M. E. (1985), Competitive advantage: Creating and sustaining superior performance. Free Press; Collier Macmillan.

EXHIBIT 12

Digitalisation increases the demand, and therefore, quantity, for digital trade, all other things held constant

How digitalisation increases demand…

1

Creates more possibilities for the creation of digitally deliverable services and content

This realises demand for new formats of digital content and services (e.g., Netflix) that had been delivering physical ways or had not previously existed.

2

Increases consumer usage of digital ordering platforms

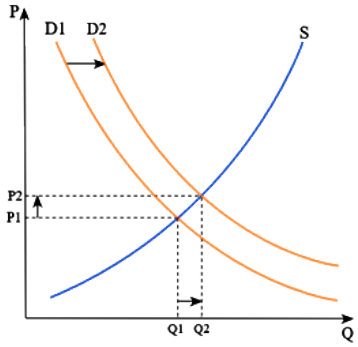
Enhancements driven by digitalisation, such as e-payments (e.g., PayPal), international logistics, and global cloud computing, have enabled platforms to go global, increasing market access and demand.

3

Enables advanced digital technologies to be applied to product differentiation

Such product differentiation and personalisation (AI chatbots) can reduce buyer friction and create more attractive offerings, increasing demand.

… and quantity of digital trade



- The increase in demand (from D_1 to D_2) causes a shortage at the initial price level P_1 where quantity demanded on demand curve D_2 exceeds quantity supplied on the supply curve S.
- This creates a signal for producers to expand capacity at increasingly higher prices (movement along the supply curve S). Consumers also reduce their quantity demanded at higher prices (movement along the demand curve D_2). A new market equilibrium is reached at Q_2 where quantity supplied equals quantity demanded.
- Quantity of digital trade transacted increases from Q_1 to Q_2.

SOURCE: Literature review, Access Partnership analysis

2.1.2. Supply-side channel

Digitalisation streamlines business processes and improves efficiency, reducing production costs (Bartel, Ichniowski and Shaw, 2007; Brynjolfsson et al., 2008; Akerman, Gaarder and Mogstad, 2013).[34] For example, cloud computing and software automation tools streamline production processes and reduce labour costs. Digital tools and platforms also help firms access online resources, such as training and government services, and attract a wide range of qualified workers with reduced recruitment time and hiring costs (Miroudot & Cadestin, 2017). Due to such changes in the cost of production, firms respond by either expanding production capacity for a given price, or offering more competitive prices for the same unit, which represents an outward shift of the supply curve.

Lower barriers to entry facilitated by the presence of more digital platforms attract new providers, fostering competition. For example, online marketplace platforms such as Amazon, Alibaba, and eBay simplify setting up online stores, enabling firms of all sizes to participate in the global market and reach out to potential customers and suppliers worldwide (ITC, 2018; UNCTAD 2015, 2017). With a greater number of firms in the sector and a more diversified range of available products and services, this also has the impact of shifting the supply curve outward.

[34] Bartel, A., C. Ichniowski and K. Shaw (2007), How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills, The Quarterly Journal of Economics, Vol. 122/4, pp. 1721-1758. Available at: https://www.jstor.org/stable/pdf/25098887. Brynjolfsson, E. et al. (2008), Scale without Mass: Business Process Replication and Industry Dynamics, Harvard Business School Technology & Operations Mgt. Unit Research Paper, No. 07-016. Available at: http://ssrn.com/abstract=980568. Akerman, A., I. Gaarder and M. Mogstad (2013), The Skill Complementarity of Broadband Internet, Discussion Paper, No. 7762, IZA Institute for the Study of Labor, Bonn, Available at: http://ftp.iza.org/dp7762.pdf

Information economies are also characterised by high initial production costs but low marginal costs of reproduction (Goldfarb and Tucker, 2018).[35] Once the first copy has been created, it can be easily replicated and distributed at a minimal cost, providing more scope for producers to increase sales volumes across a wider variety of prices and allowing for massive scalability without substantial additional investments (Lambrecht et. al, 2014).[36]

These features of digitalisation collectively contribute to pushing out the supply curve for digital trade (Exhibit 13). This creates a situation where, at the initial price level, the quantity supplied exceeds the quantity demanded for digitally ordered goods and services and digitally deliverable services. This surplus triggers a market-clearing process, where sellers will need to lower prices to attract more buyers. As prices decrease, the quantity demanded increases, reducing the surplus until a new equilibrium price and output is reached where the quantity supplied matches the quantity demanded. Digital ordering platforms make it easier for consumers to observe such price changes and respond by purchasing, causing equilibrium to be reached more quickly. This increase in quantity demanded to meet quantity supplied not only resolves the initial surplus but also leads to a substantial increase in the overall quantity of digital trade transacted.

EXHIBIT 13

Digitalisation increases the supply, and therefore, quantity, for digital trade, all other things held constant

How digitalisation increases supply…

1 Streamlines business processes and improves efficiency

This reduces operational and labour costs, while digital tools and platforms help firms access resources and attract talent with lower recruitment and hiring costs. Changes in cost of production increase supply

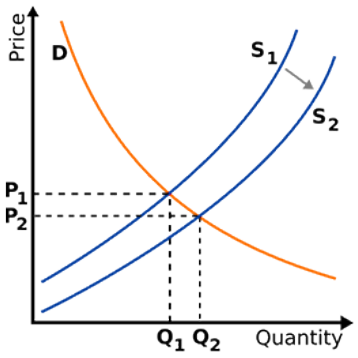
2 Lowers barriers to entry for digital trade participation

Online market platforms (e.g., Amazon) simplify setting up online stores, enabling firms of all sizes to participate in the global market. This increases the number of firms in the industry and increasing supply.

3 Allows for scalability of production without substantial additional investments

Information economies are also characterised by high initial production costs but low marginal costs of reproduction. Producers of digital goods and content can expand supply and rapidly increase sales in response to changing demand.

… and quantity of digital trade



- The increase in supply (from S_1 to S_2) causes a surplus at the initial price level P1 where quantity supplied on the supply curve S_2 exceeds quantity demanded on the demand curve D.
- Sellers will need to lower prices (movement along the supply curve S_2) to attract more buyers. As prices decrease, the quantity demanded (movement along the demand curve D) increases, until the surplus is eliminated at market equilibrium Q_2, where quantity demanded equals quantity supplied.
- Quantity of digital trade transacted increases from Q_1 to Q_2.

SOURCE: Literature review, Access Partnership analysis

The combined effect of the demand and supply shifts caused by digitalisation is expected to result in a significant increase in the quantity of digital trade.

[35] Goldfarb and Tucker (2017), Digital economics. National Bureau of Economic Research. Available at: https://conference.nber.org/confer/2019/DTs19/GoldfarbTucker.pdf
[36] Lambrecht et al. (2014), How do firms make money selling digital goods online? Available at: https://link.springer.com/article/10.1007/s11002-014-9310-5

2.2. Impact of digitalisation on digital trade flows in APEC economies

To confirm the hypothesis established in Section 2.1 – that digitalisation is expected to increase the quantity of digital trade – as well as to understand the extent to which the adoption of digital inputs in production will lead to increased digital trade flows, an econometric analysis was conducted. The analysis relies on digital intensity as an approximation for digitalisation.

The econometric model used in this study is based on a structural gravity model, adapted from Anderson and van Wincoop (2003).[37] The structural gravity model is widely used to study and quantify the effects of various determinants of international trade and is seen as a critical tool for the analysis of consumption of digital inputs in production. The specifications of the structural gravity model used can be found in the Appendix. The analysis seeks to answer the following research questions and key findings from the analysis are in Exhibit 14:

1. Does the share of digital inputs used in production affect digital trade flows?
2. How does the impact of digital intensity on digital trade flows differ between high-income and non-high-income economies?
3. Does digital intensity affect digital trade flows differently in different sectors?

EXHIBIT 14

Summary findings for research questions

Research question	Key findings	Impact on digitally deliverable services	Impact on digitally ordered goods and services
1	A percentage point increase in digital intensity correlates with 2.5% increase in digitally deliverable services exports for APEC economies.	2.5%	
2	No statistical significance difference between the impact of digital intensity on digital trade for high-income and non-high-income economies.	✖	✖
3	A percentage point increase in digital intensity correlates with: • 2.3% increase in ICT exports • 1.7% increase in financial services exports • 1.7% increase in professional services exports • Insignificant effect on administrative and support services exports	2.3% 1.7% ✔ ✖	*Findings were not statistically significant*

Impact: **A%** Strong statistical significance *(p<.05)* ✔ Weak statistical significance *(p<.10)* ✖ No statistical significance

Source: Access Partnership analysis

[37] Anderson, J. E. and van Wincoop, E. (2003), Gravity with Gravitas: A Solution to the Border Puzzle. Available at: http://fmwww.bc.edu/EC-P/wp485.pdf

2.2.1. Does the share of digital inputs used in production affect digital trade flows?

Higher digital intensity correlates with higher export volumes for digitally deliverable services but there is no significant relationship with export volumes of digitally ordered goods and services.

An aggregate-level analysis found that, between 2000 and 2020, there was a significant positive relationship ($p = .011$) between an economy's level of digital intensity and its digitally deliverable services exports. On average, a percentage point increase in digital intensity correlates with a 2.5% increase in digitally deliverable services exports for APEC economies. This finding is reasonably aligned with recent literature on the impact of digitalisation on trade; González, Sorescu, and Kaynak (2023) find that a 1% increase in bilateral digital connectivity increases international trade by 1.5%, across economies at all levels of development, including lower-income economies, while Chiappini and Gaglio (2023) find that a percentage point increase in digital intensity increases services sectors exports by 1.04%.

However, the analysis did not find a significant relationship between an economy's level of digital intensity and its digitally ordered goods and services exports ($p = .796$).

This could be due to the different impact of digitalisation on a firm's ability to export digitally deliverable services and digitally ordered goods and services. As discussed in Section 2.1.2, greater use of digital inputs enables firms to improve service quality, create new solutions, and efficiently scale production, thus increasing both the supply and demand of digitally deliverable services. Firms with higher digitalisation also better understand and use digital delivery channels, enhancing their reach and service delivery, leading to higher exports.

On the other hand, for digitally ordered goods and services, the increased use of digital inputs have a less significant effect. In part, the reason for this may be that the biggest driver of exports for these firms has been the introduction and use of online platforms. While digitalisation will improve production efficiency and reduce costs, online marketplace platforms have significantly lowered the barriers to exporting – it has reduced the cost for firms to reach new and larger markets with just an Internet connection and basic digital skills. Providing support to firms to more effectively use online platforms would likely have a greater impact on the export decision than other initiatives to digitalise their production processes.

2.2.2. How does the impact of digital intensity on digital trade flows differ between high-income and non-high-income economies?

The impact of digital intensity on digitally deliverable services trade does not vary across economies of different levels of development.

The study found no significant difference ($p = .360$) between high-income and non-high-income economies in terms of how digital intensity impacted digitally deliverable trade. This suggests that increasing digitalisation can benefit both groups similarly in digitally deliverable trade.

This result has important implications for understanding how digital trade is enabled. Prior research (e.g., Di et al., 2022)[40] has emphasised factors like digital infrastructure, human capital, and innovation capacity as critical drivers for trade that were also correlated with an economy's level of development (Box 1). However, our findings indicate that income levels were not found to have an observable effect

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[38] González, J. L., Sorescu, S., and Kaynak, P. (2023), *Of bytes and trade: Quantifying the impact of digitalisation on trade*. Available at: https://www.oecd-ilibrary.org/docserver/11889f2a-en.pdf?expires=1715676312&id=id&accname=guest&checksum=962C5533C76651CBD3F47D113AAB95D6

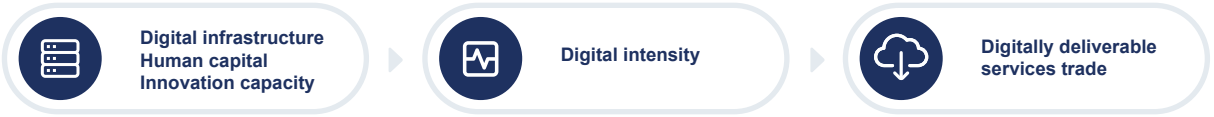
[39] Chiappini, R. and Gaglio, C. (2023), *Digital intensity, trade costs and exports' quality upgrading*. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/twec.13448. This study builds on the existing digital intensity estimated by Chiappini and Gaglio by incorporating capital inputs with intermediate inputs to account for capital investments in ICT assets by firms in the digital intensity measure.

[40] Di, Y., Zhi, R., Song, H., and Zhang, L. (2022), Development and Influencing Factors of International Trade in Digitally Deliverable Services. Available at: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.908420/full

on the relationship between digital intensity and digital trade. This suggests that the level of income does not inherently constrain an economy's capacity to benefit from digitalisation. Instead, these factors increase digital trade by enhancing overall digital intensity, rather than directly mediating the relationship between digital intensity and digital trade (Exhibit 15). Importantly, this means that investments to drive digitalisation will benefit economies regardless of their level of development.

EXHIBIT 15

These factors may be boosting digitally deliverable services trade through enhancing digital intensity



Source: Access Partnership analysis

BOX 1 Summary findings for research questions

Digital infrastructure
Digital infrastructure acts as the foundation for utilising digital technology and significantly impacts digital trade. At the basic level, this could constitute reliable Internet connectivity, while more advanced infrastructure could include secure data centres and e-payment systems that enable smoother transactions and effective use of digital inputs. Robust digital infrastructure creates an environment conducive to using digital inputs and maximises the benefits of these inputs.

Abeliansky and Hilbert (2017) showed that higher quality digital infrastructure significantly boosts trade, especially in emerging economies.[41] They argued that emerging economies are disadvantaged in trade because they are far from the technological communication frontier in terms of data speed. Various studies, including Choi (2009) and Kang et al. (2021), have also reached similar conclusions for Asia Pacific economies.[42]

Human capital and innovation capacity
Digitally deliverable services are knowledge-intensive, making education essential. Without a trained workforce, businesses cannot maintain adequate output or effectively utilise digital inputs. Non-high-income economies have fewer resources to invest in education and training, particularly digital skilling, to develop human capital critical to fully harness the benefits of digital inputs.

Ma et al. (2022) found that human capital significantly improves the quality, quantity and development of services sectors.[43] The authors suggest that skilled labour can not only boost productivity, but also quickly adapt to technological changes to push the advancements in the services sectors. Di et al. (2022), found that enhancing human capital has a larger impact on digitally deliverable services trade in non-high-income economies, suggesting these economies should focus on developing their workforce to boost digital trade.[44]

[41] Abeliansky, A. L. and Hilbert, M. (2017), *Digital technology and international trade: Is it the quantity of subscriptions or the quality of data speed that matters?* Available at: https://www.sciencedirect.com/science/article/abs/pii/S0308596116302026?via%3Dihub
[42] Choi, C. (2009), *The Effect of the Internet on Service Trade*. Economics Letters. 109 (2010). pp. 102–104. Kang, J. W., Avendano, R., Crivelli, P., Sy, D. H., and Cho, W. H. (2021), *Factors affecting the competitiveness of digital services trade*. Available at: https://www.adb.org/sites/default/files/publication/842321/digital-services-trade-asia-pacific.pdf
[43] Ma, H., Sun, Y., Yang, L., Li, X., Zhang, Y., and Zhang, F. (2022), Advanced Human Capital Structure, Industrial Intelligence and Service Industry Structure Upgrade ——Experience from China's Developments. Emerging Markets Finance and Trade, 59(5), 1372–1389.
[44] Di, Y., Zhi, R., Song, H., and Zhang, L. (2022), *Development and Influencing Factors of International Trade in Digitally Deliverable Services*. Available at: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.908420/full

2.2.3. Does digital intensity affect digital trade flows differently in different sectors?

The impact of digitalisation on digital trade varies across digitally deliverable services sectors, with the ICT sector experiencing a more pronounced effect.

The analysis found that a percentage point increase in digital intensity correlates with 2.3% higher exports of ICT services ($p < .001$), 1.7% higher exports of financial services ($p = .004$) and professional services ($p = .072$) but was not statistically significant for administrative and support services ($p = .107$). This divergence in impact may stem from fundamental differences in the drivers of demand for their core services.

In the ICT services sector, a percentage point increase in digitalisation translates to a substantial boost in exports. The cost savings and innovation that digitalisation delivers to ICT services can enable firms to gain a competitive edge, increase market share, and expand their market. For example, telecommunications, hardware and software services providers which employ a larger proportion of digital inputs in production and support may be able to lower costs and deliver keener pricing relative to less digitised ICT services providers, which may provide an edge in capturing export demand. Furthermore, various industry studies (e.g., McKinsey & Company, 2024) also assert that high-tech companies in particular stand to benefit most from integrating new technologies like automation and artificial intelligence, even more than financial services.[45]

Digitalisation yields a smaller effect on exports for financial services and professional services, as demand for these services may be determined by exogenous factors which are unrelated to digitalisation. While technology does play a role in making certain financial services and professional services more efficient, it is likely to have a more modest effect on demand, as the core value proposition of these services may be more predicated on other elements such as human expertise, personalised advice, and trust-based relationships. These elements are not easily replicated or enhanced through digital inputs alone. For instance, legal consultancies may utilise digital tools for research and communication, but their primary value lies in their lawyers' experience, their nuanced understanding of complex legal frameworks, and their ability to represent the client in negotiations. Regulatory and compliance safeguards to ensure consumer safety, common in financial services, may also serve to limit the effect of digitalisation on exports.

BOX 2 Explaining differential impacts on digitally deliverable services sectors with the supply-demand framework

A stylised supply-demand framework may help explain the differing results by sector. For the reasons above, the demand for ICT services may be characterised as having greater price-elasticity (more sensitive to changes in price) as opposed to that of financial services and professional services.

From a cost reduction perspective, that means that for a given increase in supply of digitally deliverable services driven by digitalisation's impact on reducing cost of production, can lead to lower prices in a competitive market. For ICT services, this leads to a greater increase in quantity demanded of such services, as compared to financial services and professional services (Exhibit 16).

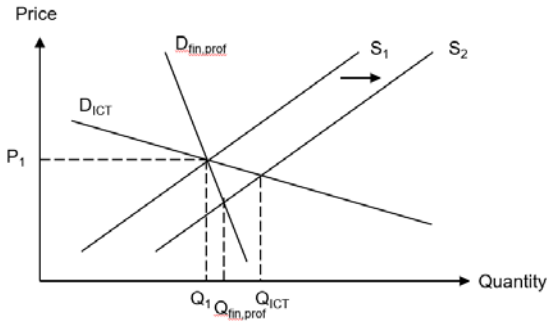
Alternatively, from an innovation perspective, the demand increases more for ICT services compared to financial services and professional services, which similarly results in a more pronounced increase in digital trade (Exhibit 16).

[45] Accenture (2019), "Workforce 2025: Financial Services skills and roles". Available at: https://www.accenture.com/us-en/insights/financial-services/workforce-2025-skills-roles-future. McKinsey & Company (2023), "The Economic Potential of Generative AI". Available at: https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-ai-the-next-productivity-frontier#introduction

EXHIBIT 16

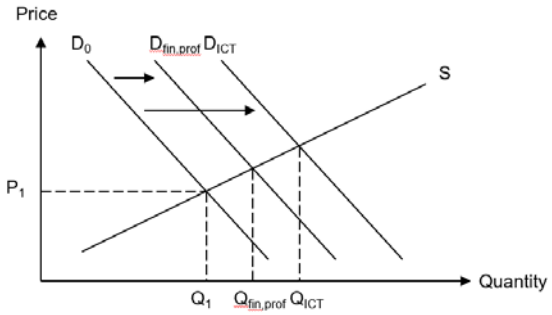
Digitalisation's impact on cost and innovation both increase trade in ICT services more than financial services and professional services

Cost-reduction impacts on digital trade



- The demand for ICT (D^{ICT}) is assumed to be more price-elastic than the demand for financial services and professional services ($D_{fin,prof}$)
- A decrease in cost of production due to digitalisation causes an increase in supply from S_1 to S_2, and a surplus at the initial price level P_1 where quantity supplied on the supply curve S_2 exceeds quantity demanded on both demand curves DICT and Dfin,prof. Sellers will need to lower prices (movement along the supply curve S_2) to attract more buyers. As demand is more elastic for ICT services, more consumers increase their quantity demanded in response to the lower prices.
- This results in a greater market equilibrium output traded for ICT services (Q_{ICT}) compared to financial services and professional services ($Q_{fin,prof}$)

Innovation impacts on digital trade



- Due to innovation from digitalisation, demand for ICT services increased more (D_0 to D_{ICT}) compared to professional services ($D_{fin,prof}$), as demand for financial services and professional services depends on other exogenous factors unrelated to digitalisation.
- This causes a shortage at the initial price level P_1 where quantity demanded exceeds quantity supplied, which is greater for ICT services due to the larger demand change. This creates a signal for producers to expand capacity at increasingly higher prices (movement along the supply curve S). Consumers also reduce their quantity demanded at higher prices (movement along the demand curve D_2). A new market equilibrium is reached at $Q_{fin,prof}$ and Q_{ICT} respectively where quantity supplied equals quantity demanded.
- This results in a greater market equilibrium output traded for ICT services (Q_{ICT}) compared to professional services ($Q_{fin,prof}$)

SOURCE: Literature review, Access Partnership analysis

In conclusion, while the impact of digitalisation on exports is significant for ICT services, its effect on financial services and professional services is less pronounced. This highlights the importance of considering sectoral nuances when analysing the relationship between digitalisation and export performance.

3. Unlocking digital trade through digitalisation

Through a stronger understanding of digitalisation trends and the impact of digitalisation on digital trade exports, policymakers can develop better policies to reap the benefits of digital trade. Four key insights from the study that translate into potential action items for APEC policymakers have been identified. These action items include areas for (A) regional collaboration across APEC economies; and (B) development of economy-level and sector-level policy within APEC economies (Table 2).

TABLE 2 **Summary of takeaways and potential action areas**

Key findings		A. Action items for regional collaboration across APEC economies	B. Action items for economy-level and sector-level policy within APEC economies
1	Increased digitalisation drives increased participation in digitally deliverable trade	APEC policymakers could focus digital trade agreements and regional collaboration efforts on domestic digitalisation ("i.e., behind the border") initiatives	Domestic strategies or frameworks to drive digitalisation could support digital trade growth
2	Increased digitalisation has no significant impact on the volume of digitally ordered exports	Strengthening regional collaboration on e-commerce could support the growth of digitally ordered exports	Support for SMEs to participate in digital trade could drive inclusive gains from the digital economy
3	Economies with developed digital infrastructure, robust digital policy and strong human capital have higher digitalisation levels	Capacity building efforts to drive digitalisation could focus on digital infrastructure and human capital	Non-high-income economies can reap significant benefits through policies to strengthen investment in digital infrastructure and human capital
4	Economies with developed digital infrastructure, robust digital policy and strong human capital have higher digitalisation levels	Regional collaboration to support digitalisation in key sectors such as manufacturing could benefit digital trade growth in APEC	The development of targeted sectoral roadmaps could bridge digitalisation gaps in priority sectors

Finding 1: Increased digitalisation drives increased participation in digitally deliverable trade

The study found that higher digitalisation is correlated with greater digital trade participation with a percentage point increase in digital intensity correlating with a 2.5% ($p = .011$) increase in digitally deliverable services exports for APEC economies. For an individual economy, an increased level of digitalisation translates into more digitally deliverable services exports. At the APEC-level, growing digitalisation across the group will translate into a more vibrant digital trade landscape for digitally

deliverable trade. Both regional and economy-level initiatives can help to support the growth of digitalisation in APEC economies to harness higher digital export volumes:

A. APEC policymakers could focus digital trade agreements and regional collaboration efforts on domestic digitalisation ("i.e., behind the border") initiatives

Stronger collaboration between APEC economies to increase digital intensity levels in APEC economies could facilitate the development of a vibrant digital trade network in the region. Such collaboration could potentially take place through the APEC regional collaboration initiatives or the conclusion of Digital Economy Agreements (DEAs) that consider behind-the-border measures such as digital inclusion and SME empowerment in their scope (see Box 3).

BOX 3 Strengthening regional digitalisation levels through Digital Economy Agreements

A Digital Economy Agreement (DEA) establishes digital trade rules and digital economy collaborations between two or more economies. Unlike conventional trade agreements, the DEAs are centred around collaboration in digital economy and trade issues. DEAs amongst APEC economies are increasingly recognising the importance of greater collaboration in the digitalisation efforts of partners to growing digital trade.

The Digital Economy Partnership Agreement (DEPA) was signed between Chile; New Zealand; and Singapore in June 2020, with the intention of complementing WTO negotiations on e-commerce and building on work related to the digital economy underway in APEC as well as other international forums.[46] The DEPA is a living agreement and membership is open to WTO members able to meet its standards. Modules under the DEPA cover a range of digital economy issues, including the adoption and use of technology to facilitate trade (e.g., paperless trading, growth of e-payments, prohibition of customs duties on electronic transmission) as well as data issues. Beyond cross-border issues, the DEPA also seeks to strengthen collaboration between signatories on efforts to increase digital collaboration and reduce barriers in accessing digital trade opportunities. It also commits signatories to greater cooperation to enhance trade and investment opportunities for small and medium enterprises (SMEs) in the digital economy as well as for the promotion of ethical AI governance frameworks.

Similarly, the Australia-Singapore Digital Economy Agreement (DEA) signed in August 2020 provides a range of new trade rules and comprehensive framework for bilateral cooperation to reduce digital trade barriers and enable business and consumers in both Australia and Singapore to capitalise on the digital economy.[47]

The DEA seeks to support digitalisation efforts in Australia and Singapore through strengthening collaboration on AI governance frameworks, data innovation and support for SMEs to harness the benefits of the digital economy.

B. Domestic strategies or frameworks to drive digitalisation could support digital trade growth

The potential of increased digital exports creates strong impetus for economies to put in place strategies to drive digitalisation. Past research points to economies with stronger capacity to foster a conducive regulatory environment for digital adoption having higher digitalisation levels.[48] Within APEC, Thailand (12.1%) and Malaysia (9.7%) have digital intensity levels significantly higher than the APEC average of 7.2%. Both economies have put in place specific strategies to drive digital adoption (Box 4).

[46] New Zealand Ministry of Foreign Affairs and Trade (n.d.), "Digital Economy Partnership Agreement". Available at: https://www.mfat.govt.nz/en/trade/free-trade-agreements/free-trade-agreements-in-force/digital-economy-partnership-agreement-depa/
[47] Australian Department of Foreign Affairs and Trade (2020), "Australia-Singapore Digital Economy Agreement." Available at: https://www.dfat.gov.au/trade/services-and-digital-trade/australia-and-singapore-digital-economy-agreement
[48] Portulans Institute (2023), Network Readiness Index 2023. Available at: https://download.networkreadinessindex.org/reports/nri_2023.pdf

BOX 4 Policies to support digital adoption in Malaysia and Thailand

For instance, Thailand 4.0, announced in 2016, outlines the Thai government's strategies to develop and invest in 10 digital intensive industries.[49] Additionally, Thailand's financial services sector – which contributes to a sizeable share of total economic activity – is rapidly digitalising. Policies like the Financial Sector Master Plan Phase III and National e-Payment Master Plan encouraged financial institutions to integrate technologies into their services. The success of these policies is evident as non-bank e-payment providers more than doubled and e-payments volume increased by 3.7 times between 2010 and 2017.[51]

Similarly, Malaysia' Multimedia Super Corridor, established in 1996, aimed to accelerate the digital economy by creating a special economic zone to support ICT sector growth and innovation.[52] In 2006, more than 900 ICT companies were operational, and by 2020, this number had nearly tripled to 2,800.[53] More recently, the National Policy on Industry 4.0 was launched to enhance manufacturing sector competitiveness through funding, infrastructure development, and talent upskilling, aiming to increase the sector's use of digital inputs.[54]

Finding 2: Increased digitalisation has no significant impact on the volume of digitally ordered exports

While an increase in digital intensity correlates with higher digitally deliverable services exports for APEC economies, the analysis did not find a significant relationship between an economy's level of digital intensity and its digitally ordered exports. In part, the absence of an observable relationship may be due to the presence of online e-commerce platforms which have already significantly lowered the barriers for businesses to export and reduced the cost of scaling their export sales. These platforms are designed to be simple for users and often require only an Internet connection and basic digital skills for businesses to start selling online. As such, prioritising support for businesses to better use online platforms more effectively and safely would likely yield a significant effect on digitally ordered goods and services trade and APEC economies can unlock the benefits of digitally ordered trade through supporting and facilitating e-commerce.

A. Strengthening regional collaboration on e-commerce could support the growth of digitally ordered exports

At the regional level, this finding provides impetus to APEC economies to accelerate and strengthen existing collaboration in the promotion of e-commerce. The AIDER's KFA 11 calls for APEC economies to collaborate in the development of transparent and consistent regulatory environments for e-commerce, including through supporting the use of electronic means such as paperless customs clearance, electronic transaction documents, digital authentication, and electronic and online payments.[55]

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[49] Kohpaiboon, A. (2020), *Industry 4.0 policies in Thailand*. Available at: https://www.iseas.edu.sg/wp-content/uploads/pdfs/ISEAS_EWP_2020-2_Archanun.pdf
[50] Thonglim, S. (2022), *Productivity growth and technology adoption in banking sector of Thailand.* Available at: https://ethesisarchive.library.tu.ac.th/thesis/2022/TU_2022_6204040031_16362_27407.pdf. Bank of Thailand (n.d.), *Financial Sector Master Plan Phase III (2016-2020).* Available at: https://www.bot.or.th/en/our-roles/financial-institutions/financial-sector-master-plan/financial-institution-master-plan-phase3.html
[51] Chucherd, T., et al. (2019), *Digitalisation of Financial Services and Implications for Monetary Policy in Thailand*. Available at: https://www.bot.or.th/content/dam/bot/documents/th/research-and-publications/research/discussion-paper-and-policy-paper/paper_eng_DigitalisationFinancialServicesThailand.pdf
[52] Malaysian Investment Development Authority (n.d.), *MSC Malaysia Status.* Available at: https://www.mida.gov.my/industries/services/other-services/other-services-multimedia-super-corridor-ms
[53] UNCTAD (2006), *Information Economy Report 2006.* Available at: https://unctad.org/system/files/official-document/sdteecb20061ch2_en.pdf. Ministry of Communications (2024), "MSC Companies to Transition to Malaysia Digital Status". Available at: https://www.kkd.gov.my/en/public/news/22137-msc-companies-to-transition-to-malaysia-digital-status
[54] Lee, C. (2022), *Strategic Policies for Digital Economic Transformation: The Case of Malaysia.* Available at: https://www.iseas.edu.sg/wp-content/uploads/2022/10/ISEAS_EWP_2022-6_Lee.pdf
[55] Asia-Pacific Economic Cooperation (n.d.,), "Digital Economy Steering Group". Available at: https://www.apec.org/groups/committee-on-trade-and-investment/digital-economy-steering-group

Various actions have been taken to facilitate and promote e-commerce in line with the objectives of the AIDER. For instance, the Survey on E-Commerce Regulations in APEC provides a public database that summarises domestic approaches, measures, and polices that are related to e-commerce in APEC economies with the objective of facilitating transparent and predictable legal and regulatory approaches to e-commerce across APEC.[56] The findings of the study emphasise the need to continue and accelerate these actions to support e-commerce development across APEC.

B. Support for SMEs to participate in digital trade could drive inclusive gains from the digital economy

At the economy-level, the findings of the study suggest that APEC economies can reap the benefits of digital trade by providing more support to businesses, including SMEs, to use online platforms more effectively. As basic digital skills are needed to use online platforms, this could support inclusive gains from the digital economy as smaller retailers or businesses are able to expand their customer pools easily.

In Malaysia, an economy-wide strategy has been developed to drive e-commerce development. The National E-Commerce Strategic Roadmap (NESR) sets out plans to intensify e-commerce adoption amongst enterprises through capability building and market access support, greater support for innovation and the development of e-commerce – conducive policies and regulatory frameworks, amongst other areas.[57]

Finding 3: Economies with developed digital infrastructure, robust digital policy and strong human capital have higher digitalisation levels

The findings of the study suggest that while all economies, regardless of income level, stand to benefit equally from higher digital trade if digitalisation increases, high-income economies currently have higher digitalisation levels. Non-high-income economies currently lag high-income economies in digital intensity with an average digital intensity of 8.5% for high-income economies and an average of 5.7% for non-high-income economies.

The secondary research established the importance of the extent of development of human capital and digital infrastructure in supporting economies in capturing the gains from digitalisation. High-income APEC economies generally have more resources to invest in human capital (including innovative capacity) and digital infrastructure development as well as formulate robust digital policy. These factors are critical in driving digitalisation.

A. Capacity building efforts to drive digitalisation could focus on digital infrastructure and human capital

APEC economies already recognise the importance of collaboration in strengthening digital infrastructure and human capital. Under the AIDER framework, KFA 1 focuses on the development of digital infrastructure in APEC while KFA 10 covers human capital development through its focus on a sustainable and inclusive digital economy.[58] The findings of the study create impetus for APEC to ensure that implementation of KFA 1 and KFA 10 remain on-track. APEC could also consider looking to programmes or initiatives undertaken by other regional groupings as references to drive stronger collaboration in these areas. The European Union's (EU) DigComp Framework which supports development of digital competencies in EU members is an example (see Box 5).

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[56] APEC (2022), "Survey on E-Commerce Regulations in APEC". Available at: https://tr.apec.org/wp-content/uploads/2023/02/Survey-on-E-Commerce-Regulations-as-of-5-Sep-2022-clean.pdf
[57] MDEC (n.d.), "National E-Commerce Strategic Roadmap (NESR)". Available at: https://mdec.my/nesr
[58] Asia-Pacific Economic Cooperation (n.d.), "Digital Economy Steering Group". Available at: https://www.apec.org/groups/committee-on-trade-and-investment/digital-economy-steering-group

BOX 5 Regional collaboration to strengthen digital competencies in the EU

The EU DigComp Framework is an EU-wide tool to improve citizens' digital competence by supporting policymakers in formulating policies that support digital competence building, and in planning education and training initiatives to improve the digital competence of specific target groups. It provides a structure to identify and describe the key areas of digital competence.[59]

The DigComp defines digital competence as involving the "confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society" and a combination of "knowledge, skills and attitudes." The framework identifies the key components of digital competence in five areas, namely, (i) information and data literacy; (ii) communication and collaboration; (iii) digital content creation; (iv) safety; and (v) problem solving.[60]

Alongside the DigComp, the EU has produced various guides for its usage and implementation, outlining how it can be used to assess digital competence levels, strengths and weaknesses of an individual or target population; design training measures; as well as evaluate, and certify learning achievements and enhanced competence.[61]

A. Non-high-income economies can reap significant benefits through policies to strengthen investment in digital infrastructure and human capital

Growth in digital intensity for non-high-income economies has outpaced high-income economies between 2000 and 2020 and policies to strengthen investments in digital infrastructure and human capital can support further digital adoption critical for non-high-income economies to reap the benefits of digital trade. Initiatives by the Australian and the Philippine governments provide useful reference for APEC economies to strengthen digital infrastructure and human capital (Box 6).

BOX 6 Policies to strengthen digital infrastructure and human capital in Australia and the Philippines

Australia's Better Connectivity Plan can provide a useful case study for other APEC economies to boost digital infrastructure.[62] The plan is a key initiative by the Australian Government to boost network connectivity in rural and regional communities. It will conduct an independent audit of mobile coverage to identify black spots and guide investment priorities. Significant resources will be dedicated to improving mobile coverage in under-served regions and increasing the resilience of communications services. Furthermore, local farmers will be guided to take advantage of the connectivity through the adoption of connected machinery and sensor technology.

The Philippine Digital Workforce Competitiveness Act provides useful reference for other APEC economies to strengthen human capital.[63] The Act aims to upskill, reskill, and train the Philippine workforce, equipping them with digital tools and knowledge. It ensures equitable access to digital skills and competencies aligned with global standards and encourages digital innovations and entrepreneurship. Specifically, the Act calls for the establishment of the Inter-Agency Council, which will serve as the primary body for promoting and enhancing the competitiveness of the Philippine digital workforce.

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[59] EU Erasmus+ (2022), "DigComp 2.2: The Digital Competence Framework for Citizens - with new examples of knowledge, skills and attitudes". Available at: https://www.schooleducationgateway.eu/en/pub/resources/publications/digcomp-22.htm

[60] EU (n.d.), "DigiComp Framework". Available at: https://joint-research-centre.ec.europa.eu/digcomp/digcomp-framework_en#definition-of-digital-competence

[61] EU (n.d.), "DigiComp Implementation Guides". Available at: https://joint-research-centre.ec.europa.eu/digcomp/digcomp-implementation-guides_en

[62] Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts (2023), "Better Connectivity Plan for Regional and Rural Australia". Available at: https://www.infrastructure.gov.au/media-communications-arts/better-connectivity-plan-regional-and-rural-australia

[63] National Economic and Development Authority (2023), "Neda Releases IRR of PH Digital Workforce Competitiveness Act". Available at: https://neda.gov.ph/neda-releases-irr-of-ph-digital-workforce-competitiveness-act/

Finding 4: APEC economies are not capturing the full potential of digitalisation in priority sectors

Across APEC economies, significant gaps were observed in the digital intensity of key economic sectors (i.e., top three sectors contributing to GVA). Key economic sectors for the APEC economies include manufacturing, retail services, and real estate services sectors. A number of economies recorded digital intensity levels below the APEC sectoral average in their top three sectors. Meanwhile, only six economies had all three key sectors recording a higher digital intensity than the APEC average.

A. Regional collaboration to support digitalisation in key sectors such as manufacturing could benefit digital trade growth in APEC

Manufacturing is one of the most important sectors for APEC economies and one of the top three contributors to GVA for the majority of APEC economies. In terms of digitalisation however, the manufacturing sector lags commercial services sectors in digital intensity. In 2020, commercial services sectors recorded an average of 9.9% in digital intensity compared to 6.8% for the manufacturing sector. In particular, five of the 12 APEC economies with manufacturing as the top GVA contributor recorded digital intensity levels for manufacturing which were below the APEC average.

Given the significant role that the manufacturing sector plays in APEC, stronger regional collaboration for the adoption of digital technologies in the manufacturing sector could create substantial benefits and drive digital trade. The Roadmap and Action Plan to Promote Smart Manufacturing Development in ASEAN provides useful guidance for such collaboration.[64] It sets out concrete recommendations for ASEAN members to harmonise standards for smart manufacturing in the region and to participate in the development of international standards on smart manufacturing as well as collaborate in the promotion of smart manufacturing technologies to enterprises amongst other areas.

B. The development of targeted sectoral roadmaps could bridge digitalisation gaps in priority sectors

At an economy-level, the adoption of target industry roadmaps for digital adoption could potentially support APEC economies to overcome the challenges faced in digital adoption for specific sectors. Singapore's Industry Transformation Roadmap and Industry Digital Plans provide a useful reference (see Box 7). Exhibit 11 in Section 1.2.2 provides further insight on the specific sectors that each economy could potentially focus on.

[64] ASEAN (2020), Roadmap and Action Plan to Promote Smart Manufacturing Development in ASEAN. Available at: https://asean.org/wp-content/uploads/Roadmap-and-Action-Plan-to-Promote-Smart-Manufacturing-Development-in-ASEAN.pdf

BOX 7 Targeted sectoral roadmaps to support digital adoption in Singapore

The Industry Transformation Maps (ITMs) developed by the Singapore government provide a useful model. Industry-specific ITMs have been developed for 23 industries, drawing together the inputs from private and public stakeholders in each industry, including trade associations and key firms.

Each ITM charts out the overall growth direction for the industry under different pillars of transformation, such as jobs and skills, productivity, innovation, and internationalisation. For example, the Electronics ITM sets out Singapore's vision of becoming a critical node globally for advanced electronics manufacturing and innovation.[65] The productivity pillar sets out the goals of adopting automation and Internet of Things (IoT) technologies in the industry, while the jobs and skills pillar sets out the objective of upskilling and reskilling existing and displaced workers. Policies and programmes can take guidance from the ITM to help the industry achieve these objectives.

Aligned with the ITMs for each sector, Industry Digital Plans (IDPs) targeted at MSMEs provide a step-by-step guide to assess their digital adoption readiness and identify suitable digital solutions and training programmes to equip employees with the right skillsets at each stage of their digitalisation journey.[66] The food manufacturing IDP for example provides firms with an overview of suitable technologies across the manufacturing process and the benefits of each technology as well as the new job roles required for digitalisation.

The IDPs and ITMs are complemented by various grants to support the costs of procuring digital solutions as well as the costs for worker training.

[65] Ministry of Trade and Industry (n.d.), "Electronics". Available at: https://www.mti.gov.sg/ITMs/Manufacturing/Electronics
[66] IMDA (n.d.), "Industry Digital Plans for SMEs". Available at: https://services2.imda.gov.sg/CTOaaS/IndustryDigitalPlans

4. Appendix

This section describes the detailed methodology and sources used for the research. There are three main parts in this section:

a. Methodology and data sources to approximate digital trade in Section 1.1
b. Methodology and data sources to approximate digitalisation in Section 1.2
c. Specifications of structural gravity model and detailed results of quantitative analysis in Section 2.2

4.1. The link between digitalisation and digital trade

This study estimates intra-APEC digital trade flows by quantifying two primary components: trade in digitally ordered goods and services, and trade in digitally deliverable services. This approach aligns with the definition of digital trade established by the OECD, WTO, and IMF as "all international trade in goods and services that is digitally ordered and/or delivered."

4.1.1. Trade in digitally ordered goods and services

To measure trade in digitally ordered goods and services (i.e., cross-border e-commerce), a three-step process is employed. First, estimates of cross-border business-to-consumer (B2C) e-commerce goods and services imports are obtained for each economy using data purchased from Euromonitor.[67] These estimates are then scaled up to include business-to-business (B2B) transactions using UNCTAD ratios. Finally, the imports are broken down by source at the bilateral level using Trade in Value-Added (TiVA) data on the export composition of gross imports of final and intermediate products, excluding sectors where e-commerce is less prevalent.[68] The estimates are cross-checked for reliability against UNCTAD e-commerce estimates.[69]

4.1.2. Trade in digitally deliverable services

Trade in digitally deliverable services is estimated using gross export values obtained from the Trade in Value Added (TiVA) database. Aligning to the convention adopted by the Handbook that goods cannot be delivered digitally, we focused on digitally deliverable services in sizing digitally delivered trade.[70] Digitally deliverable services in this study are defined as the following: information and telecommunications services (ISIC sector J), financial and insurance services (ISIC sector K), professional services (ISIC sector M), and administrative and support services (ISIC sector N).

4.2. Methodology and data sources to approximate digitalisation

The estimation of digital intensity within each economy involves capturing digital inputs in both intermediate inputs and capital inputs as part of distinct inputs contributing to the production process.

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[67] Data is available for the following economies: Australia; Canada; People's Republic of China; Hong Kong, China; Indonesia; Japan; Republic of Korea; Mexico; the Philippines; Russia; Singapore; Chinese Taipei; Thailand; the United States.

[68] These include agriculture, hunting, forestry and fishing; food products, beverages and tobacco; and mining and quarrying.

[69] Sources include UNCTAD (2021), Estimates of Global E-commerce 2019 and Preliminary Assessment of COVID-19 Impact on Online Retail 2020. Available at: https://unctad.org/system/files/official-document/tn_unctad_ict4d18_en.pdf; UNCTAD (2020), UNCTAD Estimates of Global E-commerce 2018. Available at: https://unctad.org/system/files/official-document/tn_unctad_ict4d15_en.pdf; and UNCTAD (2019), "Global e-commerce sales surged to $29 trillion". Available at: https://unctad.org/news/global-e-commerce-sales-surged-29-trillion#:~:text=Global%20e%2Dcommerce%20sales%20grew,quarter%20of%20the%20world's%20population.

[70] OECD, WTO and IMF (2023). Handbook on Measuring Digital Trade, Second Edition. Available at: https://www.oecd-ilibrary.org/trade/handbook-on-measuring-digital-trade-second-edition_ac99e6d3-en

4.2.1. Digital intensity (intermediate inputs)

For intermediate inputs, digital intensity is defined as the proportion of digital inputs to the total intermediate inputs within a given sector, or as follows:

$$DI_{ikt}^{m} = \frac{IC_{ikt}^{\omega}}{IC_{ikt}^{\Omega}},$$

$$where\ \omega\ and\ \Omega\ refer\ to\ the\ digital\ and\ total\ intermediate\ inputs, respectively$$

Referencing the OECD's proposed definition of the digital sector, this study identifies digital inputs as follows: digital goods refer to the manufacture of computer, electronic, and optical products (division 26 of sector C from ISIC, revision 4), while digital services include publishing, programming, and broadcasting activities (divisions 58-60 of sector J), telecommunications (division 61 of sector J), computer programming, consultancy, and related activities, and information service activities (divisions 62-63 of sector J). The construction of the digital intensity measure for intermediate inputs uses data from the OECD Inter-Country Input-Output (ICIO) tables to estimate the ratio of intermediate inputs to sector outputs that are provided by digital industries.[71]

The digital intensity measure aims to capture how extensively sectors use intermediate inputs that are digital in nature. For this analysis, "digital" intermediate inputs are those from sectors producing digital products (e.g., software publishing and ICT goods). Calculating digital intensity based on a sector's share of intermediate inputs from these sectors is expected to capture deliberate changes to the digital intensity of production within a sector (i.e., decisions to pursue digitalisation by businesses). This contrasts with an alternative approach of accounting for the amount of digital content embedded in intermediate inputs from either digital or non-digital sectors,[72] which would instead effectively define digital intensity as "the share of intermediate inputs which are produced using digital inputs", a step removed from the sector's own production process.

It is important to acknowledge that this analysis has minor conceptual limitations, which have been noted for transparency and to guide future research. Sectors currently classified as producing 'digital' products also produce non-digital intermediate inputs, albeit in smaller proportions. This exerts an impact on the estimation of digital intensity. Additionally, this methodology does not account for differences in the quality of digital products employed as intermediate inputs.

4.2.2. Digital intensity (capital inputs)

Digital intensity for capital inputs is defined as the share of capital services attributed to digital capital (more commonly known as ICT capital).[73] Measures of capital services are typically based on productive capital stocks derived using the perpetual inventory method (PIM), resting on the idea that stocks constitute cumulated flows of investment, corrected for retirement and efficiency loss. While theoretically sound, severe data limitations exist for investment flows by asset and sector since 2000, making comparable capital services computations difficult. As such, this analysis utilises a proxy: the share of capital compensation[74] that is attributable to ICT capital owners.

$$DI_{ikt}^{c} = \frac{u_{ikt}^{\omega}}{u_{ikt}^{\Omega}},$$

$$where\ \omega\ and\ \Omega\ refer\ to\ the\ digital\ and\ total\ capital\ compensation, respectively$$

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[71] OECD (2023), "OECD Inter-Country Input-Output Database". Available at: http://oe.cd/icio

[72] That is, while Industry C may purchase 'digital' goods or services from 'digital' industries, Industries A and B; Industry B may also purchase 'digital' intermediate inputs from Industry A (or vice-versa). Therefore, 'digital' intermediate inputs from Industries A or B may be indirectly embedded in Industry C's purchases. This indirect transmission of 'digital' inputs may even occur through direct purchases by Industry C from a 'non-digital' industry (Industry D).

[73] Capital services is considered to be an appropriate measure of capital input in production analysis. OECD (2021), *OECD Productivity Statistics Database: Methodological Notes*. Available at: https://www.oecd.org/sdd/productivity-stats/OECD-Productivity-Statistics-Methodological-note.pdf

[74] The capital compensation of a specific industry is equal to the value added of the industry in question minus the wage share (i.e. labour compensation).

Aligning with EU KLEMS[75], the ICT share of capital compensation serves as a reasonable proxy for the ICT share of capital services due to its direct link to the productive contribution of ICT assets. This share reflects the proportion of income attributed to ICT capital within the broader context of capital income, thus encapsulating the relative value derived from its utilisation compared to other forms of capital. As ICT assets are employed to enhance productivity and generate goods and services, their share of income can be considered a reasonable indicator of their contribution to overall capital services.

Acknowledging the assumptions inherent in this approach, its practicality and availability in domestic accounts make it valuable for cross-economy comparisons and sheds light on the role of digitalisation in capital inputs. Although this proxy relies on certain assumptions for best approximation, such as perfect competition, homogeneous capital, constant returns to scale, full asset utilisation, and the absence of externalities, the trade-off between theoretical precision and practicality is reasonable, allowing for meaningful insights into the role of digital intensity in capital inputs. Furthermore, as the focus is on the relative share of ICT capital rather than absolute capital quantities, potential distortions arising from these assumptions are likely to be less significant.

This digital intensity measure leverages the OECD's breakdown of fixed capital assets into ICT and non-ICT assets according to the 2008 System of National Accounts.[76] By this definition, ICT assets encompass Computer hardware, Telecommunication equipment, and Computer software and databases. At the economy level, the construction of the digital intensity measure for capital uses data from sources with harmonised and comparable capital compensation data – such as the World KLEMS databases[77] and The Conference Board.[78] However, data at the sector level is not available for many of the APEC economies. In the absence of such data, this study approximates sector-level digital and non-digital capital compensation by using the relative composition of Gross Fixed Capital Formation (GFCF) for each sector to break down economy-level digital and non-digital capital compensation into sectoral components.[79]

A limitation of this study's digital intensity measure is its inability to fully capture the value of in-house developed digital assets such as websites, booking systems, or financial models. While traditional inputs, including hardware and software, are essential components, their value is often magnified through in-house development processes. These processes, driven by digitally skilled labour, transform raw inputs into highly valuable digital assets.

While we recognise the significance of digitally skilled labour in creating in-house digital capital, data constraints prevented us from incorporating it into our digital intensity measure.[80] Consequently, the digital intensity measure may underestimate the true level of digitalisation, particularly in economies with strong in-house development capabilities.

However, the current measure still provides a valuable comparative analysis of digital intensity across economies. Economies with high digital intensity, based on our measure, also tend to have a higher share of digitally skilled labour, which will contribute to a higher digital intensity. This suggests that while the absolute magnitude of digital intensity might be underestimated, the relative ranking of economies is likely to remain consistent.

4.2.2. Accounting for price effects

To ensure analytical accuracy, changes in digital intensity over time are disaggregated into price and volume effects. This involves deflating intermediate inputs using sector-specific output deflators and capital inputs using asset-specific deflators, both obtained from OECD datasets.[81] Adjusting for price

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[75] Koszerek et. al (2007), *An overview of the EU KLEMS Growth and Productivity Accounts.* Available at: https://ec.europa.eu/economy_finance/publications/pages/publication9467_en.pdf

[76] OECD (2021), *OECD Compendium of Productivity Indicators 2021: Investment by asset type.* Available at: https://www.oecd-ilibrary.org/sites/f42002ac-en/index.html?itemId=/content/component/f42002ac-en

[77] World KLEMS (n.d.,). "Productivity and growth accounting". Available at: https://www.worldklems.net/wkdata

[78] The Conference Board (n.d.), "Total economy database – growth accounting and total factor productivity". Available at: https://data-central.conference-board.org/

[79] The assumption is that capital assets in each sector and economy share the same rate of return and depreciation profile, hence, resulting in the same composition for capital compensation as GFCF at the sector level. Data for GFCF at the sector level is either be referenced from the OECD dataset, or where unavailable, from domestic statistics.

[80] Existing literature typically measures the skills of an economy's workforce through its expected years of schooling, but this does not accurately capture the level of digital skills in the workforce as digital skills are not often taught in school curriculum and the acquisition of such skills typically happens in formal work or training settings.

[81] OECD (n.d.), "Annual GDP and components – output approach". Available at: https://data-explorer.oecd.org/

fluctuations isolates the impact of digitalisation, measured by the volume of digital inputs as a share of total inputs, on digital trade. While acknowledging limitations, such as the inclusion of non-digital inputs within 'digital' sectors and the exclusion of quality differences in digital products, this methodology provides a comprehensive and consistent estimate of digital intensity by capturing both intermediate and capital digital inputs and adjusting for price effects.

4.3. Structural gravity model: Specification and results

The structural gravity model in this analysis employs the Armington-Constant Elasticity of Substitution (CES) version of the structural gravity model (Anderson and van Wincoop, 2003), estimated via the Poisson Pseudo-Maximum Likelihood (PPML) estimator. This estimates the gravity model in its multiplicative form. In this way, the PPML estimator is justified on several grounds: in particular, it accounts for heteroscedasticity and is consistent with and without the inclusion of zero-trade observations.[82] The analysis excluded Papua New Guinea due as data was not available for both components used to estimate digital trade.

Pair fixed effects were used for the analysis.[83] Exporter-time and importer-time fixed effects as defined in Baier and Bergstrand (2007) were also included, which can be seen as accounting for all sources of unobserved heterogeneity that are constant for a given importer across all exporters.[84] We include domestic trade flows in line with the proposed approach by Heid, Larch, and Yotov (2015).[85] Interacting the digital intensity variable (the variable of interest) with the border dummy creates a bilateral digital intensity variable and allows the identification of the digital intensity impact which would otherwise have been collinear with exporter-time fixed effects. The PPML equation is laid out as follows:

$$X_{ijt} = \exp\left[b_0 + b_1 FTA_{ijt} * Bi_{ij} + b_2 DI_{it} * Bi_{ij} + \mu_{it} + \gamma_{jt} + \lambda_{ij} + \varepsilon_{ijt} \right] (1)$$

where X_{ijt} is the bilateral trade flows (digitally ordered goods and services or digitally deliverable services), from exporter economy i to importer economy j in year t and includes the domestic trade flows X_{iit}. FTA_{ijt} is a dummy variable equal to unity if there are any free trade agreements (FTAs) between economies *i* and *j* in year *t*, DI_{it} is the digital intensity of exporter economy *i* in year *t*, and Bi_{ij} is a dummy variable equal to 1 for international trade and 0 for domestic trade. μ_{it} are the exporter-time fixed effects, γ_{jt} are the importer-time fixed effects, λ_{ij} are the pair fixed effects and ε_{ijt} is the error term.

The coefficient of interest, b_2, measures the effect of a percentage point change in digital intensity on digital trade flows, after controlling for other trade costs arising from various geographic and trade policy variables.

To estimate the relationship between digital intensity and digital trade flows for economies of different levels of development, we interacted a dummy term, INC_i, that equals to 1 if the exporter economy *i* is a high-income economy in 2024 and 0 otherwise, with the digital intensity measure and added it to equation (2):

$$X_{ijt} = \exp\left[b_0 + b_1 FTA_{ijt} * Bi_{ij} + b_2 DI_{it} * Bi_{ij} + b_3 DI_{it} * Bi_{ij} * INC_i + \mu_{it} + \gamma_{jt} + \lambda_{ij} + \varepsilon_{ijt} \right] (2)$$

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[82] WTO (2016), *An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model*. Available at: https://unctad.org/system/files/official-document/gds2016d3_en.pdf

[83] Standard errors were clustered by importer-time for digitally ordered goods and services trade, and exporter-importer pair level for digitally deliverables services trade. Existing literature has typically clustered the standard errors by trading pair in order to account for any intra-cluster correlations at the trading pair level. However, in this study, as the dataset for digitally ordered goods and services was constructed based on trade flows in importer economy, it was more appropriate to cluster the standard errors to account for any correlations at the importer-time level.

[84] Baier, S. L., and Bergstrand, J. H. (2007), *Do free trade agreements actually increase members' international trade?* Journal of International Economics, Elsevier, vol. 71(1), pp 72-95.

[85] Heid, B., Larch, M., and Yotov, Y. V. (2015), *A Simple Method to Estimate the Effects of Non-discriminatory Trade Policy within Structural Gravity Models*. Available at: https://www.etsg.org/ETSG2015/Papers/439.pdf

A sectoral analysis was also carried out for the four digitally deliverable services sector identified: information and telecommunication, financial services, professional services, and administrative and support services sectors. Adopting the suggestion by Shepherd, Doytchinova, and Kravchenko (2019), this study runs separate models for each sector with a full set of exporter-time, importer-time and pair fixed effects as in the aggregate trade version in equation (1). This allows for multilateral resistance and the elasticity of substitution to vary accordingly. The sectoral model is estimated as follows:

$$X_{ijt}^{k} = \exp\left[b_0 + b_1 FTA_{ijt} * Bi_{ij} + b_2 DI_{it}^{k} * Bi_{ij} + \mu_{it} + \gamma_{jt} + \lambda_{ij} + \varepsilon_{ijt} \right] \quad (3)$$

where X^{k}_{ijt} is the bilateral trade flows (trade in digitally ordered goods and services or trade in digitally deliverable services) of sector *k* in exporter economy *i* to importer economy *j* in year *t*, DI^{k}_{it} is the digital intensity of sector k in exporter economy i in year t, and all other variables are the same as in equation (1). In taking this approach, we recognise that the model does not consider the inter-relations that might exist between the different sectors.

Table A1 presents the results from a series of PPML estimations examining the relationship between the digital intensity and the dependent variable, in this case digitally ordered trade (Component 1). Column (1) reflects a baseline model that includes the FTA measure only. The effect of the FTA measure on digitally ordered trade is insignificant. Column (2) introduces the digital intensity measure, and the effect on digitally ordered trade is insignificant. Column (3) introduces the binary term for income-level interaction with digital intensity, but the effect of all three variables is still insignificant.

TABLE A1 **Gravity model estimates of the effects of digital intensity on digitally ordered trade (Component 1)**

	(1)	(2)	(3)
FTA	0.249	0.260	0.255
	(0.236)	(0.233)	(0.227)
Digital intensity		-0.019	0.425
		(0.072)	(0.284)
Digital Intensity * High income			-0.507
			(0.309)
Num.Obs.	1367	1367	1367
RMSE	5602.54	5595.33	5470.38

Notes:

1. Exporter-time, importer-time and pair fixed effects were included in all specifications but not reported for brevity. Standard errors are clustered by importer-time and are reported in parentheses. The p-values read as follows:
   * $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$.

Table A2 examines the relationship between digital intensity and digitally deliverable services trade (Component 2). Column (1)-(3) follows the model in Table A1, but with trade in digitally deliverable services (Component 2) as the dependent variable. In column (2), the effect of digital intensity on digitally deliverable services trade is found to be positive and significant. In column (3), this effect increases, but the interaction term with income is insignificant, suggesting that income levels do not impact digitally deliverable services trade for APEC economies.

TABLE A2 **Gravity model estimates of the effects of digital intensity on digitally deliverable (trade (Component 2**

	(1)	(2)	(3)
FTA	0.161***	0.064	0.065
	(0.044)	(0.042)	(0.042)
Digital intensity		0.025**	0.036**
		(0.010)	(0.009)
Digital Intensity * High income			-0.014
			(0.015)
Num.Obs.	8319	8319	8319
RMSE	3206.69	3205.77	3189.44

Notes:

1. Exporter-time, importer-time and pair fixed effects were included in all specifications but not reported for brevity. Standard errors are clustered by economy pair and are reported in parentheses. The p-values read as follows:
* $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$.

Table A3 examines the relationship between digital intensity and trade for the information and telecommunication, financial services, professional services, and administrative and support services sectors. The digital intensity of ICT, financial services, and professional services sectors have a positive and significant effect on its own sector's trade. Digital intensity of administrative and support services does not have a significant impact on its own trade.

TABLE A3 **Gravity model estimates of the effects of digital intensity on digitally deliverable trade for each service sector**

	J_ICT	K_Fin	M_Prof	N_Admin
FTA	0.149***	0.087*	0.090**	0.090**
	(0.036)	(0.046)	(0.044)	(0.050)
Digital intensity	0.023***	0.017***	0.017*	-0.014
	(0.007)	(0.006)	(0.010)	(0.009)
Num.Obs.	8319	8319	8319	8319
RMSE	1449.97	671.40	518.57	585.32

Notes:

1. Notes: Exporter-time, importer-time and pair fixed effects were included in all specifications but not reported for brevity. Standard errors are clustered by economy pair and are reported in parentheses. The p-values read as follows:
* $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$.