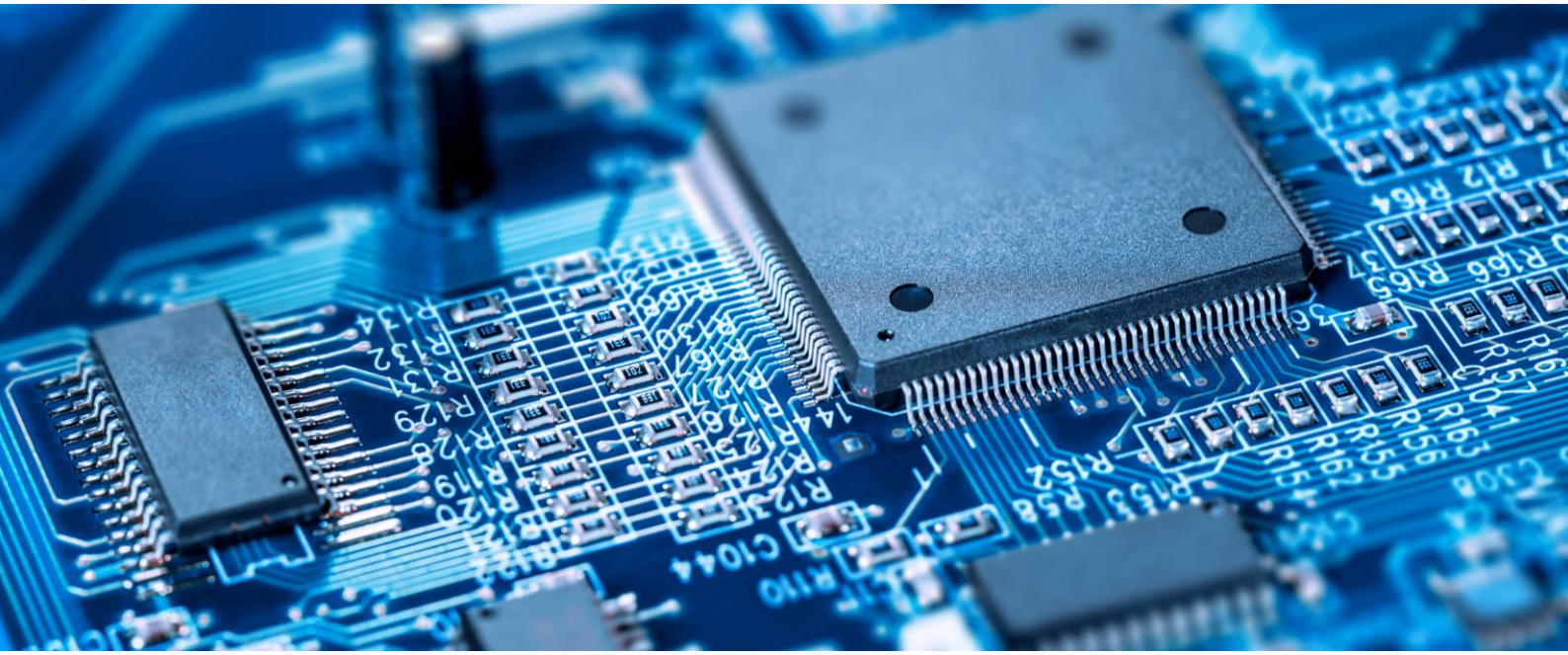
Asia-Pacific
Economic Cooperation



Final Report

Assessing Study on the Impact of Information Technology Agreement (ITA) and Future of ICT Trade

APEC Market Access Group
July 2024

Asia-Pacific
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Glossary and definitions

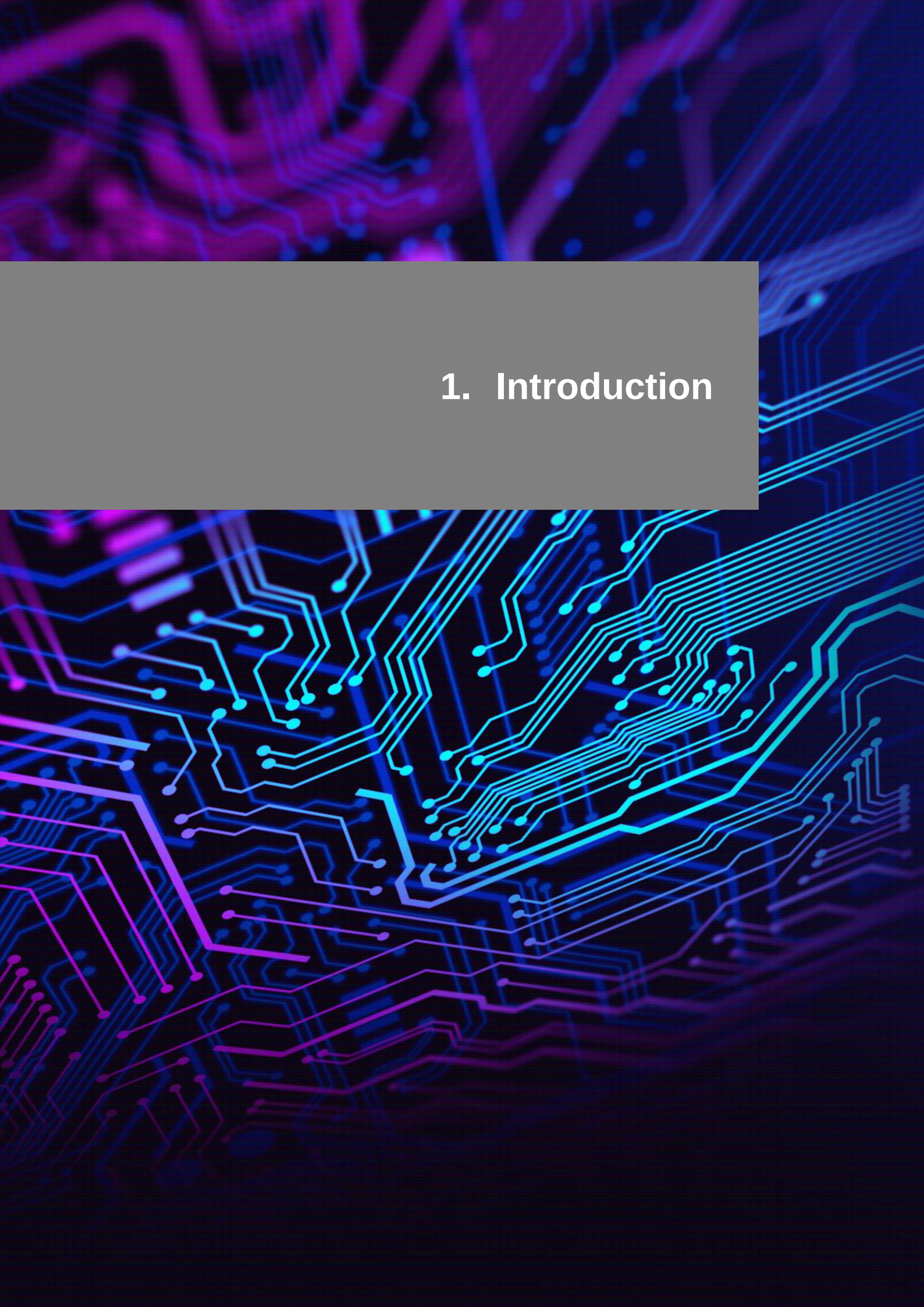
AEO:	Authorized Economic Operator certifications
AES:	Advanced Encryption Standard
AISG:	AI Singapore
ALM:	Additive Layer Manufacturing
APS:	Australian Public Service
AR:	Augmented Reality
ASYCUDA:	Automated System for Customs Data
ASYHUB:	Automated System for Customs Data Hub
ASYPM:	Automated System for Performance Measurement
ASYREC:	Automated System for Relief Consignments
ATIGA:	ASEAN Trade in Goods Agreement
BRII:	Business Research and Innovation Initiative
CAB:	Conformity Assessment Bodies
CAC:	Cyberspace Administration of China
CAGR:	Compound Annual Growth Rate
CCC:	China Compulsory Certification
CCRA:	Common Criteria Recognition Arrangement
CIFAR:	Canadian Institute for Advanced Research
CMCS:	Ceramic Matrix Composites
COFETEL:	Comisión Federal de Telecomunicaciones
CSAP:	Cloud Security Assurance Program (CSAP)
CU:	Custom Unions

DAA:	Detect and Avoid
DIMSs:	Disaster Information Management Systems
DOE:	Department of Energy (The United States)
DOT:	Department of Transportation
EAEU:	Eurasian Economic Union
ECITES:	Electronic Convention on International Trade in Endangered Species of Wild Fauna and Flora System
EDA:	Electronic Design Automation
EIA:	Economic Integration Agreement
EMC:	Electromagnetic Compatibility
EMDG:	Export Market Development Grant
EPSR:	Electrical Products (Safety) Regulation
ESCAP:	Economic and Social Commission for Asia and the Pacific
EWSs:	Early Warning Systems
FCC:	Federal Communications Commission
FINL:	Foreign Investment Negative List
FTAs:	Free Trade Agreements
GMPs:	Good Manufacturing Practices
HDD:	Hard-Disk Drives
HKPC:	Hong Kong Productivity Council (Hong Kong, China)
HS:	Harmonized System
ICNIRP:	International Commission on Non-Ionizing Radiation Protection
ICT:	Information and Communication Technologies
ICTS:	Information and Communications Technology and Services

IDB:	Inter-American Development Bank
IEC:	International Electrotechnical Commission
IMDA:	Infocomm Media Development Authority
ISPs:	Internet Service Providers
ITI:	Information Technology Industry Council
ITU:	International Telecommunication Union
JCET:	Jiangsu Changjiang Electronics Technology
JEITA:	Japan Electronics and Information Technology Industries Association
JSWIFT:	Jamaica Single Window for Trade
LEDs:	Light-Emitting Diodes
MBIE:	Ministry of Business, Innovation and Employment
MCO:	Multi-Component Integrated Circuits
MIC:	Ministry of Communications
MFN:	Most-Favored Nation
MSIT:	Ministry of Science and ICT
MNOs:	Mobile Network Operators
MOSTI:	Ministry of Science, Technology, and Innovation
MVNOs:	Mobile Virtual Network Operators
MRA:	Mutual Recognition Arrangement
NFTs:	Non-Fungible Tokens
NTB:	Non-Tariff Barriers
NTM:	Non-Tariff Measures
OAN:	Open Access Network
OTT:	Over-the-Top Services

OSAT:	Outsourced Semiconductor Assembly and Test
PCB:	Printed Circuit Boards
PSA:	Partial Scope Agreement
QIH:	Quantum Technology Innovation Hubs
Q-STAR:	Quantum STrategic industry Alliance for Revolution
R&D:	Research and Development
RDS:	Robotics Domain Specific
RECT:	Robotics Enabling Capacity Technology
RFID:	Radio Frequency Identification
RIE 2020:	Research Innovation Enterprise Plan
RTA:	Regional Trade Agreement
SDGs:	Sustainable Development Goals
SES:	Security Evaluation Scheme
SISAM:	Customs Selection System through Machine Learning
Smart Nation:	An Initiative by the Government of Singapore to Harness Infocom Technologies, Networks, and Big Data to Create Tech-Enabled Solutions
SMEs:	Small and Medium Enterprises
SNSP:	Smart Nation Sensor Platform
STEM:	Science, Technology, Engineering and Mathematics
TBA:	Telecommunications Business Act
TBT:	Technical Barriers to Trade
TCF:	Telecenter Foundation
TCW:	Telecenter Women Program
TEL:	Telecommunications and Information Working Group

TOT:	Telephone Organization of Thailand
TTE:	Telecommunications Terminal Equipment
UNCTAD:	United Nations Conference on Trade and Development
VET:	Vocational Education and Training
VR:	Virtual Reality
WSIS:	World Summit on the Information Society
WTO:	World Trade Organization



1. Introduction

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This report emphasizes the crucial role of Information and Communication Technology (ICT) in global trade and society. More than 25 years have passed since the Information Technology Agreement (ITA) was reached, but digital technologies and industries continue to develop and expand. New ICT products have grown in trade volume in recent years, especially those that did not exist when the current agreement was concluded. This APEC project aims to provide an update on key advancements in ICT products in the APEC region, analyze the trade of ICT products within the ITA and ITA expansion (ITA2), and anticipate the effects of new and emerging ICT products on the future global trade in ICT products. Note that this report was prepared between July to October 2023, and any data and information are reflective of that period.

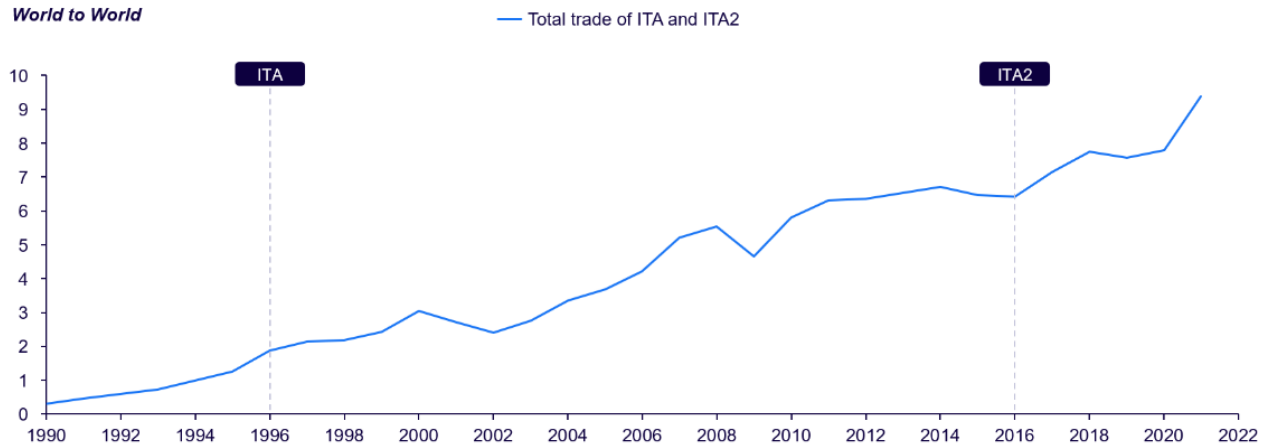
1.1 The importance of ICT

ICT plays an indispensable role in global trade and societal dimensions. Global trade and domestic productivity benefit from the ICT. According to the United Nations Conference on Trade and Development (UNCTAD), global trade in ICT goods and services amounted to approximately USD4.8 trillion[1] in 2020. ICT has emerged as a catalyst for enhancing global trade dynamics, spurred by internet access and new technology advancements. The use of ICT has aided economies in optimizing their supply chains, expediting trade processes, and increasing the efficiency of trade operation activities. Emerging ICT trends and technologies have helped economies reduce costs and logistical barriers and enabled seamless real-time information data exchange. ICT has also increased the productivity of industries and workers, spurring the economy's growth. ICT has increased accessibility to public services and improved the quality of education, healthcare, and governance across multiple economies.

1.2 Current ICT landscape

The current global ICT landscape is marked by vibrant economic and technological developments. ICT adoption has surged in recent years because of robust investments in ICT infrastructure leading to higher internet penetration. The growing middle class and its spending power across many economies have also contributed to ICT adoption. Research by the International Telecommunication Union (ITU) indicates that a 10 percent increase in broadband penetration can result in 1.4 percent growth in GDP for low- and middle-income economies[2]. ICT maturity levels vary among economies, with some having high dependence on the state of local digital infrastructure. In some economies, emerging ICT has been the backbone of everyday life. Technology innovations such as 5G, artificial intelligence (AI) and the Internet of Things (IoT) have transformed industries and societies. Governments and businesses have myriad of opportunities, including the use of advanced tools to boost productivity and enhance economic prosperity for citizens. Nonetheless, governments are also faced with the challenge of addressing potential risks to economic prosperity, such as cybersecurity threats and the digital divide.

1.3 How ITA impacts trade



Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Figure 1: Overall ITA and ITA2 trade (World to world) from 1990 to 2021, in Trillion USD

The ITA has had a profound impact on the volume of trade flows. The total trade of ITA and ITA2 products grew from USD0.3 trillion to USD9.3 trillion from 1990 to 2021 (Figure 1). Since July 1997, the ITA has spurred greater trade activity among member economies by reducing or eliminating tariffs on an extensive range of ICT goods, namely, semiconductors, computers, smartphones, and other technology products. One key achievement is the expansion of global supply chains in the ICT sector. Businesses are sourcing ICT components across different economies and integrating them into final products. They are also investing in research and development and manufacturing infrastructure to produce high-tech goods. The removal of tariffs has fostered competitive pricing for ICT products across businesses and economies. As a result, trade value within the ICT value chain across multiple economies has grown substantially, which has enhanced global economic interdependence.

1.4 Report coverage

The objective of this report is to evaluate the impact of the ITA, which covers both ITA and ITA2, as well as its implications on the future of ICT trade across APEC economies. This report outlines a comprehensive analysis of trade flow and the ICT environment, considering factors such as the digital divide, the associated costs related to communication networks and IT equipment, and the digitalization of trade and customs clearance processes. The analysis delves into how ICT has helped support sustainable development goals (SDGs), the convergence of emerging ICT and Industry 4.0 technologies, their trade dynamics, and the potential outcomes of reduced tariffs on these emerging ICT products. The study offers insights into ICT policies and features in each APEC economy, explores the involvement of APEC economies in global supply chains and examines non-tariff measures that impact ICT trade.

2. Executive summary

2. Executive summary

This report has been developed to increase knowledge about the latest trends of ICT products and technologies, especially in Asia-Pacific, and build awareness of the future of ICT trade for APEC economies. This report underscores the vital role of ICT in both global trade and societal advancement. It highlights the continued evolution of ICT since the establishment of the ITA more than two decades ago.

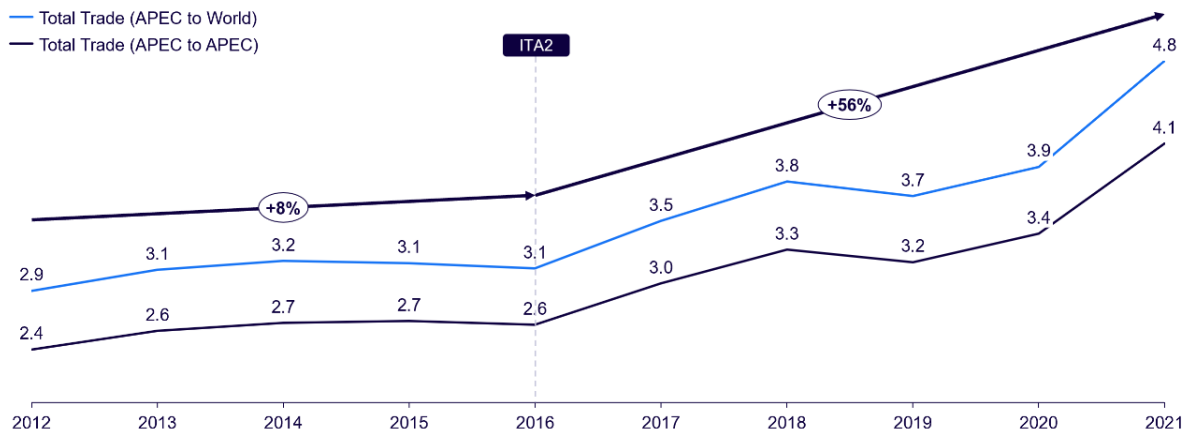
The primary objective is to assess the changes in trade dynamics of ICT products across APEC economies over the years, including how non-tariff measures affect ICT trade, and provide an updated perspective on emerging ICT technologies, namely, key trends, trade, and policies within APEC economies. The report also analyzes the ICT environment, including assessing the digital divide and changes in costs of communication networks and devices. APEC economies' involvement in the supply chain of major ICT equipment was also analyzed.

Summary of results and findings

This study sought to increase awareness of the future of ICT trade within the APEC region across nine areas:

1. ICT trade flow analysis

The ITA has played a key role in broadening global access to advanced technology products such as computers, mobile phones and semiconductors. Its primary goals are to foster the worldwide spread of information technology and contribute to global economic growth through completely eliminating tariffs on ICT products covered by the Agreement. ITA has significant influence on the expansion of ICT trade around the world.



Source: United Nations Conference on Trade and Development (UNCTAD), The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Figure 2: Overall ICT products trade value across APEC and World from 2012 to 2021, in trillion USD

Since the implementation of ITA2 in 2016, trade in ICT products has accelerated, increasing APEC's trade with the rest of the world by 56 percent, from USD3.1 trillion to USD4.8 trillion between 2016 and 2021. Intra-APEC ICT trade accounted for approximately 85 percent of world trade during the same period.

As shown from the analysis of the highest-traded ICT products by HS codes in 2021, the top three traded HS codes comprised various electronic and integrated circuits (semiconductors). The top 10 highest-traded HS codes comprised five that were included in ITA2, such as electronic integrated circuits, telephone sets for transmission or reception of data, and communication apparatuses. The remaining five HS codes were products included in the ITA, such as telephones for cellular networks, automatic data processing machines, and machinery.

2. ICT environment analysis

This section conducts a comprehensive assessment of mobile telecommunications connectivity within APEC economies to highlight progress in reducing the digital divide. It also examines the costs of communication networks and equipment. It incorporates case studies that emphasize the benefits of ICT in enabling digitalization of customs clearance procedures to increase the efficiency of trade in APEC economies.

Analysis of the APEC digital divide shows that between 2014 and 2022 the digital divide improved by 1.27 times across APEC economies. The costs of communication networks have become more affordable, and trade in communication equipment has increased.

Furthermore, many economies have transformed their customs procedures through digitalization, which has helped increase efficiency and reduce costs in customs operations. This is evident from case studies such as:

- The Automated System for Customs Data (ASYCUDA), developed by UNCTAD, which modernizes customs operations and has been adopted by many developing economies, improving processes, and increasing customs and excise revenue
- The potential of AI and blockchain technologies to enhance trade operations

3. Emerging ICT and 4.0 technologies

This section focuses on identifying emerging ICT that has strong potential to mature into developed technologies and could be deployed at scale by 2030. The top 10 emerging ICT that we identified in this study can be found in Table 1.

Table 1: Top 10 emerging ICT developments and their respective trends
Source: Arthur D. Little analysis

Emerging ICT	Trends (non-exhaustive)
Artificial Intelligence	• Generative AI is creating a virtuous cycle of innovation, paving the way for new business models and applications • Generative AI speeds up product development, enhances customer experience and improves employee productivity • The cost of AI training is decreasing, while performance is rapidly improving
Big Data	• The big data market is already expanding quickly, particularly in developed economies, and will continue to add economic value as its uptake across industries drives impressive efficiency improvements in data analytics
Blockchain	• Blockchain applications have expanded to include financial transactions, the IoT, healthcare and supply chain management
Drones (Unmanned Aircraft)	• Technological improvement in cameras, mapping software, multidimensional mapping, and sensory applications is driving growth and application of drones in sectors such as infrastructure and domestic security
Immersive Media	• Metaverse applications are fast becoming the next form of the internet (Web 3.0), aided by advancement of wearable technologies such as AR/VR headsets and glasses • In the same way smartphones shifted the digital economy from personal computers to mobile phones, increasingly sophisticated AR/VR headsets and glasses could drive a shift in the digital economy from mobile phone screens to more immersive environments created by such wearable technologies • The industrial metaverse may become the future of the metaverse for businesses and has the potential to transform business productivity. The industrial metaverse is defined as a connected digital twin of a real system of physical infrastructure, such as cities, buildings, or other commercial or industrial facilities. The industrial metaverse has functionalities to interact with the real system in its actual environment, thus allowing its users to better understand the past and forecast the future of real systems

Internet of Things	• IoT market growth is driven largely by advances in semiconductor technology that enables development of lower-cost, lightweight, and more efficient devices • Demand for advanced consumer electronics in many economies is also driving IoT market growth, and the integration of AI and the IoT is expected to provide meaningful and timely insights into diverse domains and use cases such as agriculture, energy, manufacturing, public services, and transportation
Mobile Networks	• Innovation, investment, and standardization have driven the enormous and rapid deployment of 5G globally • Focus is shifting to the radio access network (i.e., OpenRAN) • 5G will transform traditional broadband access networks and technologies
Quantum Computing	• Increasing demand to solve complex computational problems at high speeds is driving the growth of this market • Interest and investment in quantum computing technology are growing among government, universities, and private companies
Robotics	• Costs of production in robotics have decreased, thus reducing prices – average robotics costs have seen more than a 50 percent drop since 1990
3D Printing	• Growth is contributed by increasing the variety of materials that can be 3D printed, production speed/resolution/accuracy, and the size of printable objects, while decreasing development cost and time • Industry demand mainly comes from healthcare, consumer electronics, automotive, dental, food, fashion, and jewelry

4. Trade of new and emerging ICT products

More than 25 years have passed since the ITA was reached, and ICT developments and industries continue to grow and expand rapidly, with a significant ability to continue shaping the future dynamics of global commerce.

Highly traded new and emerging ICT products were identified and analyzed on two levels:
- Baseline list – The HS codes in the future ICT products list were used as a baseline list (Table 32)
- Complementary list – The top seven highest-traded emerging ICT HS codes (Table 31) from the complementary list that could be directly linked to the shortlist of top 10 emerging ICT in Table 1, which includes industrial robots, parts of 3D printers and unmanned aircraft

5. Impact of reduced tariffs on emerging ICT products

The ITA implemented in 1997, as well as its expansion in 2016, reduced tariffs on ICT products and led to an increase in imports and economic growth within participating economies. This section aims to analyze the impact of tariff savings for APEC economies on emerging ICT products and how it contributes to the growth of emerging ICT product imports in APEC economies.

Through our analysis, individual APEC economies' tariff savings were estimated by multiplying their import value of HS codes by their respective most favored nation (MFN) tariff rates. Next, total tariff savings in APEC were calculated by summing up individual APEC economies' tariff savings.

The section analyzed the APEC tariff savings and APEC growth in emerging ICT HS codes imports:
- APEC tariff savings
  - Tariff savings of the top 40 emerging HS codes from the future ICT products list – USD13.9 billion
  - Tariff savings of the top 7 HS codes from emerging ICT technologies – USD25.6 million
- APEC growth in emerging HS code imports
  - Top 40 emerging HS codes from the future ICT products list – USD10.4 billion to USD16 billion
  - Top 7 HS codes from emerging ICT products – USD19.2 million to USD29.4 million

However, while the top 7 emerging ICT products HS codes represent a relatively small amount of tariff savings and growth in imports, they may still have potential for robust growth in the future due to other factors such as government incentives through policy-making decisions.

6. ICT policies and features in APEC

This section delves into APEC economies' emerging ICT policies and features, summarizing their strategies and investments in shaping the growth of emerging ICT within their economies.

Through analyzing strategy documents on APEC economies prioritized emerging ICT focus areas, emerging ICT policies were found to be centered around AI, quantum technologies, and the IoT.

Some APEC economies have adopted AI strategies or comparable guiding policies to set strategic directions and initiatives so they can leverage the benefits of these ICT developments. These include AI-related priorities and goals and, in some cases, a detailed roadmap for achieving them. Many APEC economies see AI as a growth and innovation priority for their economy. Several common themes emerge when synthesizing the intent of these strategies as a whole:

- **Development of AI through R&D** – Some APEC economies have a major focus on catalyzing economic development through R&D funding in AI
- **AI ethics-centered policies** – Most strategies also include provisions to ensure AI systems are designed and implemented ethically and securely
- **Move to commercialization** – Strategies have been put into place to set up the right infrastructure, such as education programs, research institutes, and incentives to promote the development and integration of AI

In addition, APEC economies, ranging from advanced technology leaders to emerging economies, are harnessing the power of the IoT to drive innovation, increase efficiency, and improve the quality of life of their citizens. In this aspect, there is a focus on:

- **Innovation through R&D** – Strategies have included policies to boost innovation and economies
- **Improving quality of life** – Strategies have also been centered around developing economic prosperity for citizens or achieving economic growth

Similarly, APEC economies are increasingly recognizing the potential of quantum technologies to revolutionize various sectors, from computing to security and defense. The majority of economies are focused on:

- **Integration into critical industries** – Quantum technologies are revolutionizing advancements in security and defense applications such as cryptography, cybersecurity, and enhanced sensors
- **Development of quantum technology infrastructure** – Economies have shaped their policies surrounding collaboration, R&D, and development of a workforce that understands and leverages the benefits of quantum technology

7. Achievement and possibilities of ICT to solve global issues

ICT has emerged as a powerful tool for addressing and mitigating a wide range of global challenges, from poverty alleviation to access to quality healthcare and education. This section explores how ICT has already made an impact on such global challenges and contributed to achieving SDGs. Based on our analysis, ICT has the largest impact on eight SDGs, as seen in Table 2.

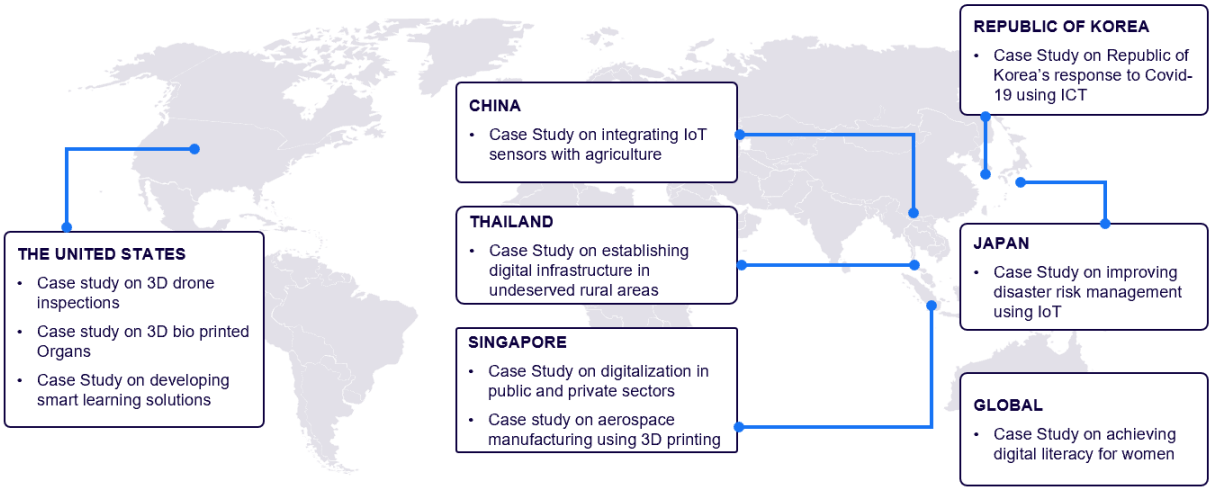
Table 2: Main SDGs impacted and their respective descriptions

Source: United Nations, International Telecommunication Union (ITU), Arthur D. Little analysis

Main SDGs impacted	Description
3 GOOD HEALTH AND WELL-BEING	Ensure healthy lives and promote well-being for all at all ages
4 QUALITY EDUCATION	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
5 GENDER EQUALITY	Achieve gender equality and empower all women and girls
8 DECENT WORK AND ECONOMIC GROWTH	Promote sustained, inclusive, and sustainable economic growth; full and productive employment; and decent work for all

9 INDUSTRY, INNOVATION & INFRASTRUCTURE	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
10 REDUCED INEQUALITIES	Reduce inequality within and among economies
11 SUSTAINABLE CITIES AND COMMUNITIES	Make cities and human settlements inclusive, safe, resilient, and sustainable
17 PARTNERSHIPS FOR THE GOALS	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Selected case studies (Figure 3) highlight the impact of ICT in addressing global challenges related to SDG 3, 4, 5, 8, 9, 10, 11, and 17.



Source: Secondary research, Arthur D. Little analysis

Figure 3: Selected case studies across different APEC economies

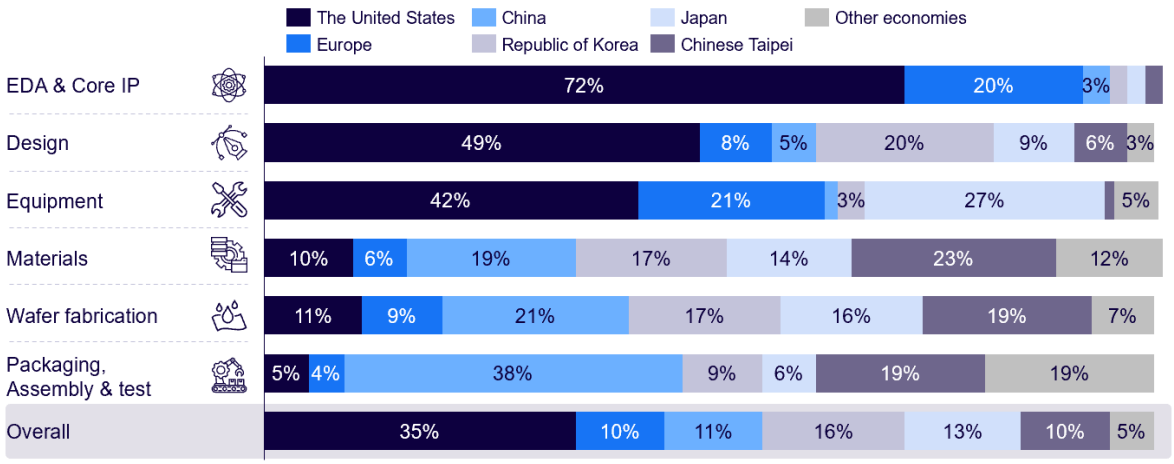
This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by APEC or Arthur D. Little.

8. APEC economies' involvement in the supply chain

The ICT industry relies on a global ecosystem of actors for the sourcing, manufacturing and distribution of technology products and services. This includes a complex supply chain involving third-party vendors, suppliers, service providers, and contractors. The section's objective is to analyze APEC economies' involvement in the ICT supply chain, focusing on the most traded ICT equipment.

The analysis identified that semiconductors should be the focus of ICT supply chain analysis. Semiconductors are an essential component of many ICT products. All of the top 30 technology equipment companies ranked by market capitalization are suppliers, consumers, or both, in the semiconductor industry.

The total global semiconductors market value was USD556 billion in 2021, and its sales are largely driven by end-consumer demand for communication devices and personal computers such as smartphones and laptops. Increasingly, consumer demand for it is driven in emerging economies within and outside APEC.



Source: Semiconductor Industry Association (SIA), Arthur D. Little analysis

Figure 4: Semiconductor industry value added by activity and economy 2021 in %

Additionally, Figure 4 identified that the semiconductor value chain is very globalized. APEC economies are major players who specialize in different segments of this global supply chain. Within APEC, China; Japan; Republic of Korea; Chinese Taipei; the United States were identified to be major economies, while economies outside of APEC, such as the EU, were also major players.

Additionally, investments into the semiconductor industry have seen an inflow in several other APEC economies that are seeking to strengthen their position in the global semiconductor supply chain. Economies such as Indonesia; Malaysia; Mexico; The Philippines; Singapore; Thailand; Viet Nam are playing an increasingly larger role in the semiconductor supply chain.

9. Non-tariff measures affecting IT and ICT trade

Non-tariff measures (NTMs), which encompass subsidies and trade restrictions on both imports and exports, are significant in influencing trade patterns for ICT products and services worldwide. This section seeks to assess the impact of NTMs within APEC economies, providing more in-depth insight into global ICT trade dynamics. A selection of these NTM developments is presented in an anonymized format.

NTMs serve as primary tools for economies to achieve various public policy objectives, addressing potential market imperfections and non-economic goals such as public health. While NTMs primarily serve public policy objectives, they can also result in trade barriers. In the context of ICT trade, NTMs have significantly impacted the trade of ICT products due to their complex supply chains, continuous evolution, and diverse applications. In the ICT realm, 67 NTMs were identified. The common use of NTMs were as Technical Barriers to Trade (TBT), import/export restrictions, government procurement, and the adoption of measures such as local content requirements and data localization mandates within APEC economies

3. ICT trade flow analysis

3. ICT trade flow analysis

The ITA has significantly expanded global access to high-tech goods such as computers, mobile phones, and semiconductors. Its primary objectives include promoting increased trade, global diffusion of information technology, and enhancing global economic growth and welfare through trade. Analyzing ICT trade flows is crucial, as it offers a comprehensive view of the ITA's impact on ICT trade growth.

3.1 Methodology

To analyze the ICT trade flows in APEC and individual economies, a three-step process was undertaken, encompassing data extraction, data processing and validation, and synthesis.

Firstly, for data extraction, data on ICT trade flows was extracted by Harmonized System (HS) code on a HS6 level. HS codes serve as a standardized numerical classification system for traded goods and are commonly employed throughout the trade process. The scope of ICT HS codes to be extracted for analysis was determined by the UNCTAD, which identified 96 specific ICT HS codes (Table 12).

Trade data (imports and exports) from 2012 to 2021 was extracted for 96 ICT HS codes from the UNComtrade database, with APEC economies as reporters (importers), and data for partners (exporters) was collected at two levels: World and APEC economies. The analysis covered the years 2012 to 2021 and had a geographical focus on trade within APEC (APEC to APEC) and trade between APEC and the rest of the world (APEC to World). The 96 ICT HS codes were subsequently categorized in two distinct ways.

The first categorization is by ITA categories, which is determined through the ITA (Table 14) and ITA2 list (Table 15). This separates the 96 ICT HS codes into three categories (Table 12):

- ITA – 31 HS codes
- ITA2 – 41 HS codes
- Non-ITA – 24 HS codes

The second categorization is by ICT categories, which breaks down the 96 ICT HS codes into five categories provided by UNCTAD, which include (Table 12):

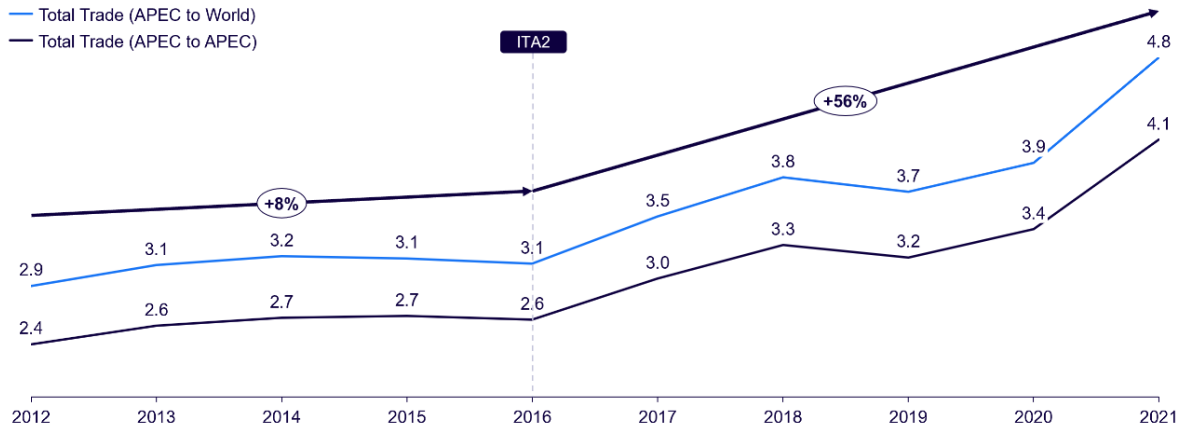
- ICT01 – Computers and peripheral equipment (17 HS codes)
- ICT02 – Communication equipment (10 HS codes)
- ICT03 – Consumer electronic equipment (34 HS codes)
- ICT04 – Electronic components (29 HS codes)
- ICT05 – Miscellaneous (6 HS codes)

Secondly, for data processing and validation, the data undergoes validation in three ways to ensure data integrity, accuracy, and structure. The trade values for 96 ICT HS codes, categorized into ITA (31 HS codes) and ITA2 (41 HS codes), are compared to the entire trade values of ITA (Table 14) and ITA2 (Table 15), respectively. This comparison ensures that the 96 ICT HS codes represent the majority of the trade when compared to that of ITA and ITA2 HS codes. The 31 ITA ICT HS codes (19 percent of ITA HS codes) and 41 ITA2 HS codes (22 percent of ITA2 HS codes) within the 96 ICT HS codes account for 68 percent and 58 percent of the total ITA and ITA2 trade value in 2021, respectively. This shows the significance of the 96 ICT HS codes for analysis. On top of that, the data processing and validation step also revealed four items that are excluded from the analysis (Figure 50). A total of 1 million rows of trade value data points were processed and validated during this study.

3.2 Impact of ITA and ITA2 on ICT trade flow

After the processing and validation of data, the final step involves the synthesis of outputs, which provides insights into APEC ICT trade flows across five main areas.

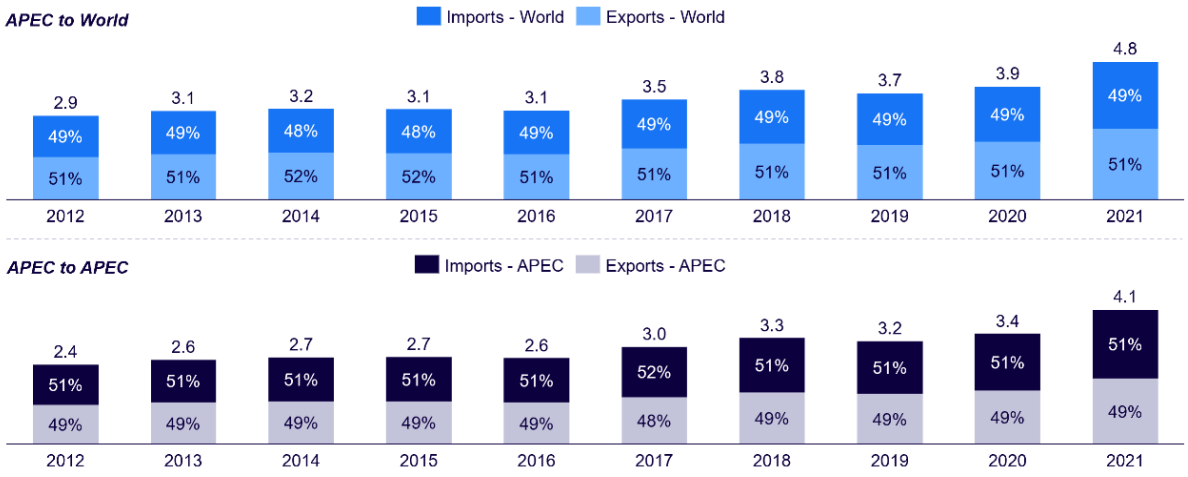
3.2.1 Overall ICT trade value by imports and exports across APEC and World



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 5: Overall ICT products trade value across APEC and World from 2012 to 2021, in trillion USD

Since the implementation of ITA2 in 2016, the trade in ICT products has accelerated, with its value increasing by 56 percent for APEC's trade with the rest of the world, from USD3.1 trillion to USD4.8 trillion between 2016 and 2021. Before the implementation of ITA2, only modest growth was observed from 2012 to 2016, with the trade in ICT products growing by 8 percent, from USD2.9 trillion to USD3.1 trillion. When analyzing trade patterns between APEC economies, it becomes evident that the majority of APEC trade occurs within APEC itself, with intra-APEC trade accounting for approximately 85 percent of world trade from 2012 to 2021.

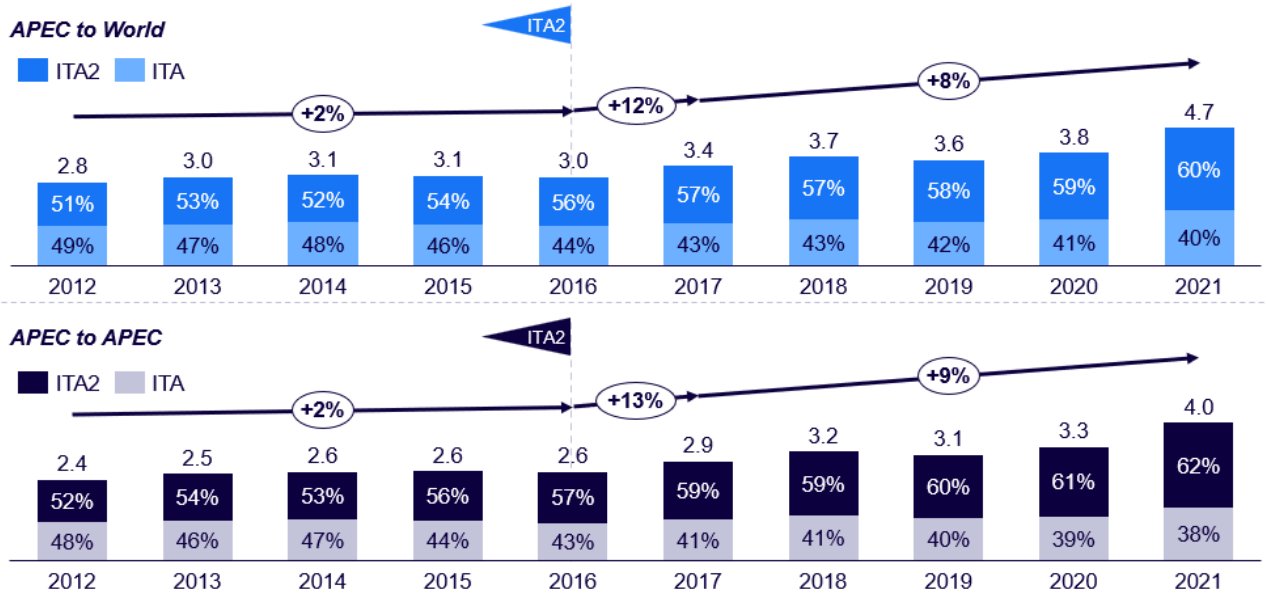


Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 6: Total ICT trade by exports and imports from 2012 to 2021, in trillion USD

Lastly, upon breaking down trade value into imports and exports, it was observed that imports and exports are largely balanced in proportions. Imports and exports are approximately 50 percent of total trade for both trade between APEC and the rest of the world and trade between APEC economies.

3.2.2 Overall ICT trade value split by ITA and UNCTAD ICT category across APEC and World

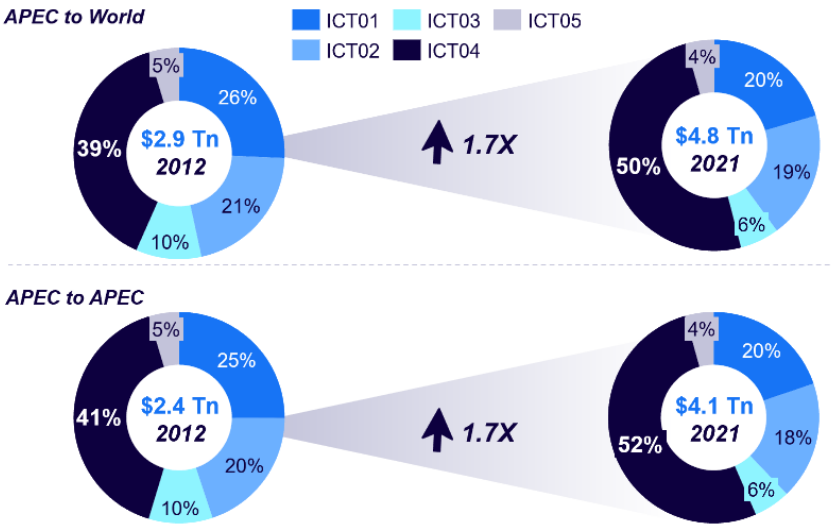


Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 7: Total ICT trade by ITA and ITA2 from 2012 to 2021, in trillion USD

Before the implementation of ITA2 in 2016, the analysis of ICT trade value indicated that the trade in ICT products among APEC economies had experienced flat growth, with a compound annual growth rate (CAGR) of approximately 2 percent from 2012 to 2016 (Figure 7). However, one year after ITA2 took effect, trade between APEC and the rest of the world surged by 12 percent, rising from USD3 trillion to USD3.4 trillion between 2016 and 2017. Similarly, intra-APEC trade also saw a notable increase of 13 percent, going from USD2.6 trillion to USD2.9 trillion.

Following the implementation of ITA2 in 2016, APEC's trade with the world experienced an accelerated growth rate of 8 percent CAGR from 2017 to 2021, resulting in an increase in trade volume from USD 3 trillion to USD4.7 trillion between 2016 and 2021. During the same period, intra-APEC trade also experienced a noteworthy growth rate of 9 percent CAGR, with total trade increasing from USD2.6 trillion to USD4 trillion from 2016 to 2021. Furthermore, the proportion of ITA2 in ICT trade grew from 56 percent to 60 percent between 2012 and 2021 for trade between APEC and the world, while intra-APEC trade saw an increase from 57 percent to 62 percent during the same period. This highlights the significance of ITA2 in driving the growth of ICT trade.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 8: Total trade by ICT category from 2012 to 2021, in trillion USD

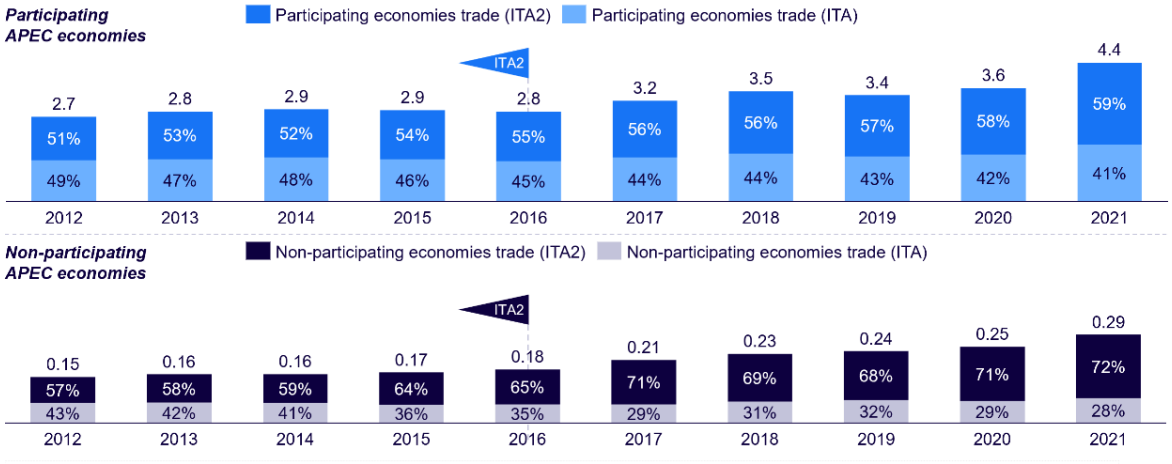
The analysis of the overall ICT trade value, split by UNCTAD ICT categories across APEC and the world, divides total trade into five categories (Table 12): ICT01 (computers and peripheral equipment), ICT02 (communication equipment), ICT03 (consumer electronic equipment), ICT04 (electronic components), and ICT05 (miscellaneous). The ICT04 category experienced significant growth, increasing by 11 percentage points from 2012 to 2021, primarily because of the expansion in integrated circuits (semiconductors), and it remains the largest traded category. This growth in ICT04, compared to ICT01 and ICT02, indicates a rising trend in trade for semi-finished versus finished ICT products.

The top three traded HS codes (854231, 854239, and 854232) within ICT04, which cover electronic integrated circuits, account for the majority of the growth in this category. These top three traded HS codes represent 81 percent of total ICT04 trade in 2021, and experienced higher growth in CAGR, ranging from 8 percent to 14 percent from 2012 to 2021, compared to the average ICT04 CAGR of 8 percent. Although the proportion of ICT01 and ICT02 has been decreasing, the CAGR for these two categories increased by 3 percent and 4 percent, respectively, from 2012 to 2021. The growth in ICT01 is attributed to finished products such as portable automatic data processing machines (laptops), storage units, and parts and accessories used for automatic data processing machines. Conversely, the growth in ICT02 is attributed to phones and other communication apparatuses.

3.2.3 ICT trade value (imports and exports) of participating and non-participating APEC economies

Participation in the ITA has resulted in reduced tariffs, making ICT products more affordable for businesses and consumers. Expanding the ITA to include more economies could foster significant economic growth.

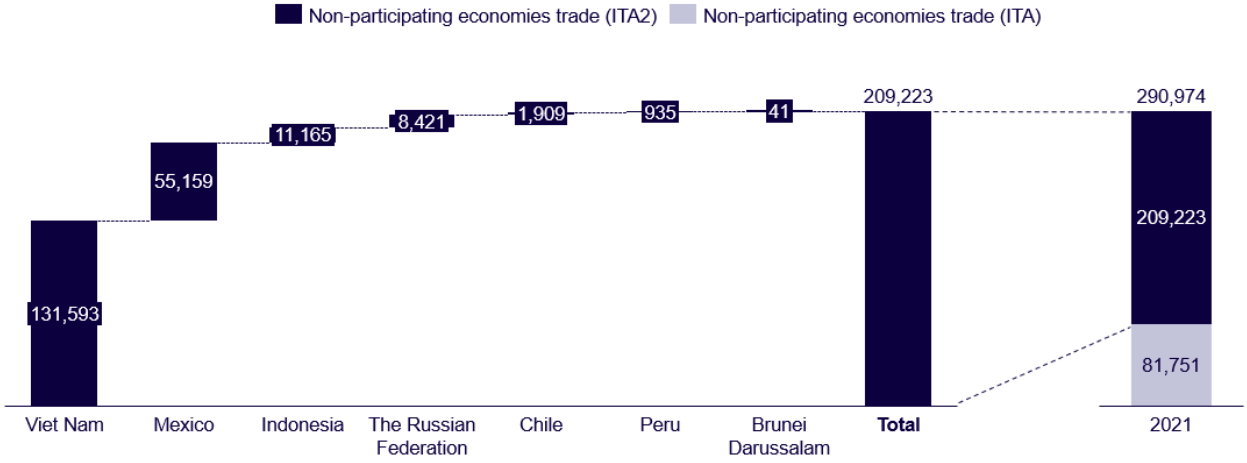
The list of participating and non-participating economies for ITA and ITA2 can be found in Table 16.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 9: ICT trade value of participating and non-participating APEC economies from 2012 to 2021 (ITA and ITA2), in trillion USD

Analysis of the ICT trade value in both participating and non-participating APEC economies reveals that even though non-participating economies in ITA and ITA2 constitute only 6 percent of the total trade, their impact on ICT trade amounts to USD290 billion in 2021. Among participating economies, the proportion of ITA2 has increased by 4 percent, rising from 55 percent in 2016 to 59 percent in 2021. Additionally, ITA2 trade was 2.6 times larger than ITA trade for non-participating economies in 2021. In non-participating economies, 72 percent of trade comprised ITA2 trade, while ITA trade accounted for 28 percent.



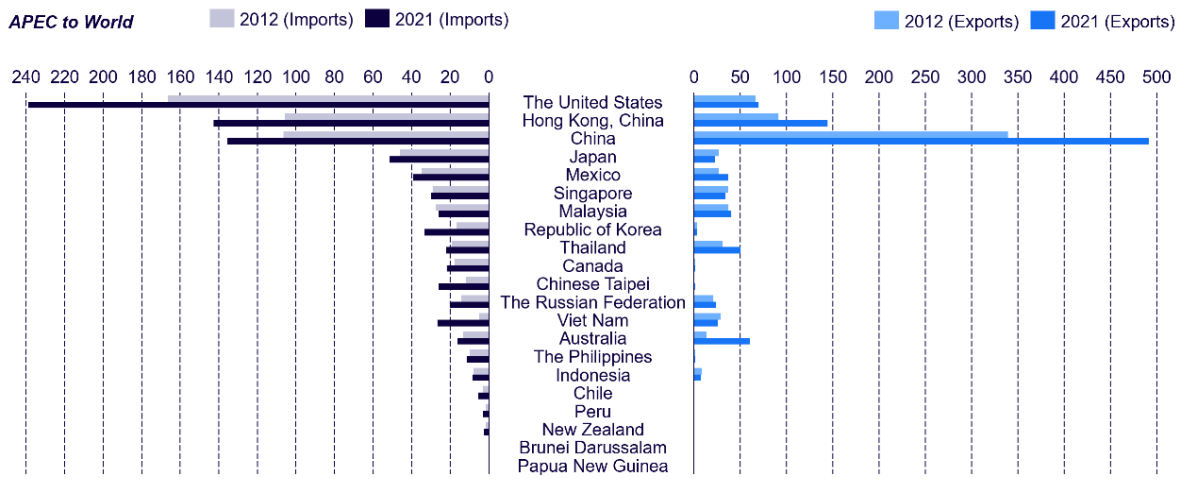
Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 10: ICT trade value of non-participating APEC economies in 2021 (ITA2), in billion USD

Further analysis into ITA2 ICT trade value of non-participating APEC economies in 2021, as seen in Figure 10, shows that 88 percent of trade contribution was by Viet Nam and Mexico. As emerging hubs for electronics manufacturing, Viet Nam contributed USD132 billion, while Mexico contributed USD55 billion.

3.2.4 Overview of trade flow for highest trading APEC economies by exports and imports

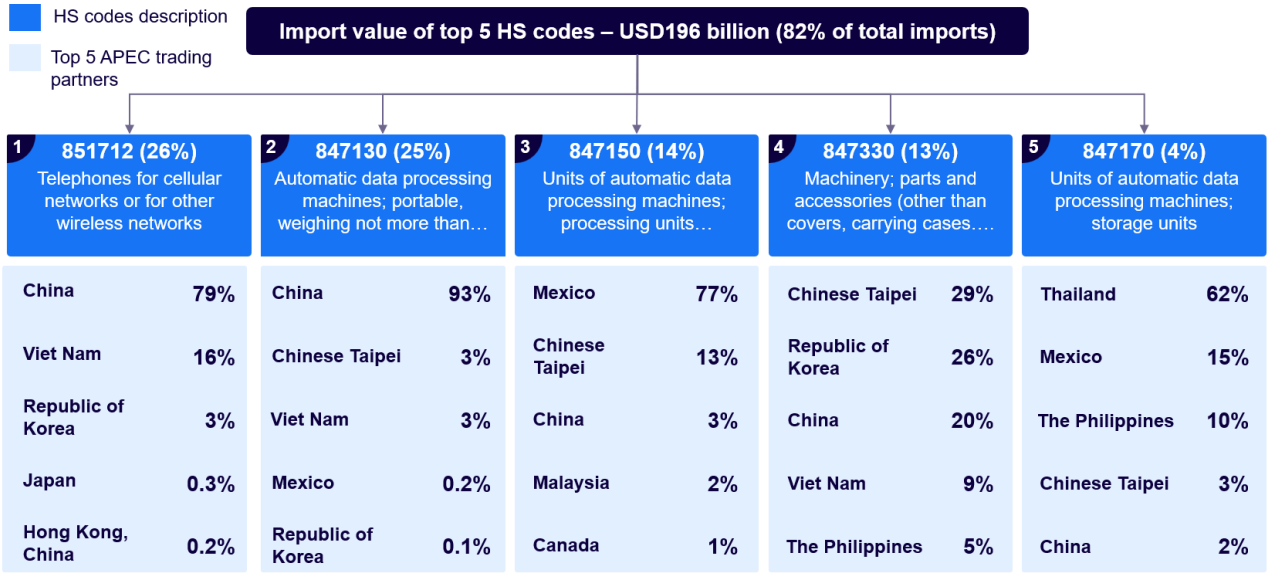
Analyzing the exports and imports of ICT products on an individual economy level identifies how the trade of ICT flowed across APEC economies. This analysis was separated into ITA and ITA2 ICT trade. China's exports and the United States' imports are the highest among APEC economies for ITA ICT trade in 2012 and 2021 (Figure 11). This primarily involves finished ICT products.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 11: Trade value (imports and exports) of ICT products included in ITA across APEC economies in 2012 and 2021, in billion USD

In 2021, the United States had the highest total ITA ICT imports of USD239 billion, while China had the highest ITA ICT exports of USD491 billion. When analyzing the imports of the United States and exports of China in 2021, it can be seen that each economy led imports and exports respectively for finished ICT products such as communication equipment, consumer electronic equipment, computers and peripheral equipment. This trend was also consistent in 2012 for the United States and China, which also had the highest imports and exports respectively.



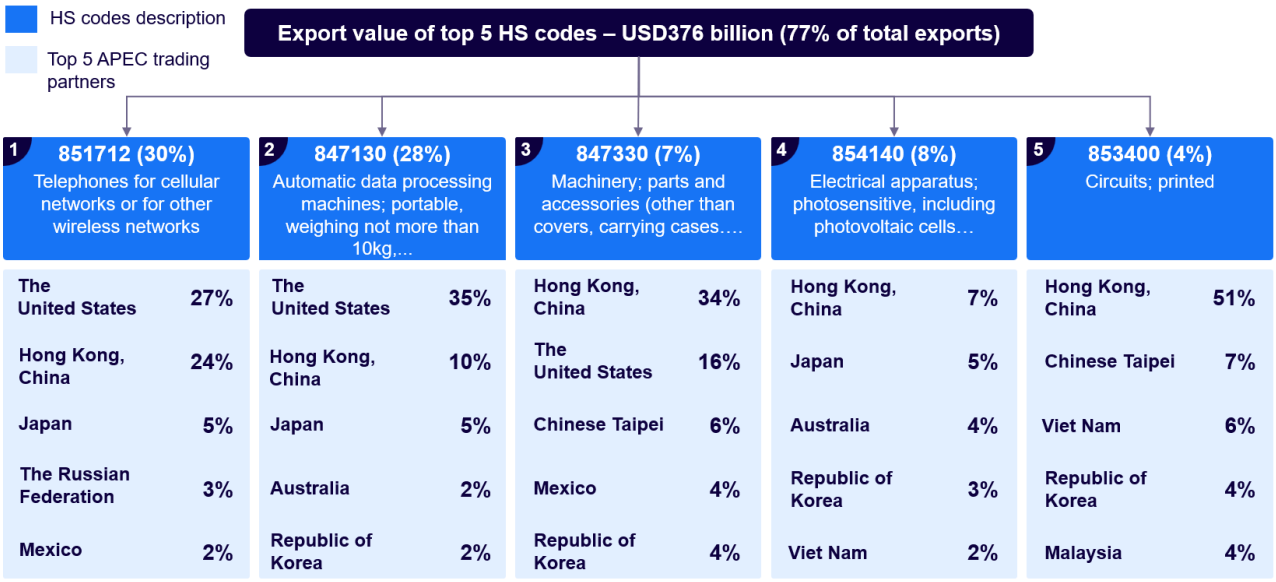
Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 12: Analysis of the United States' ITA ICT imports in 2021 (Refer to Table 17 for detailed analysis)

For 2021, a closer look at the imports for the United States reveals their top ITA ICT imports. These include phones and laptops from China, desktops and servers from Mexico, microprocessors from Chinese Taipei, and hard-disk drives (HDD) from Thailand. Figure 12 illustrates the import value of the top five HS codes, totaling USD196 billion and constituting 82 percent of total imports in 2021. The two most imported HS codes for the United States in 2021 were HS 851712 (mobile phones) and HS 847130 (laptops), which made up 51 percent of their imports that year. These two HS codes are the highest-imported HS codes, as mobile phones and laptops are the most popular devices among the nine most popular devices in the United

States[3]. On top of that, China serves as the primary trading partner for these items, as it accounted for 67 percent of global mobile phone manufacturing[4] and around 80 percent of laptop production in 2021[5] [6].

Additionally, the United States imported 77 percent of HS 847150 (desktops and servers) from Mexico, the latter being a major electronics manufacturing hub with the presence of companies such as Foxconn[7]. For HS 847330 (microprocessors, motherboards, etc.), the United States imported 55 percent from exporters in Chinese Taipei and the Republic of Korea, as these economies have the presence of large corporations such as TSMC and Samsung Electronics, which contributed 72 percent of the global semiconductor foundry revenue share in Q4 2022[8]. Finally, the United States' imports of HS 847170 (hard-disk drives) from Thailand were substantial because Thailand is the world's second-largest HDD maker after China, having held a 17.1 percent global market share for HDD exports in 2019. Seagate, who is a large HDD manufacturer, had also operated in Thailand since 1988[9].



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

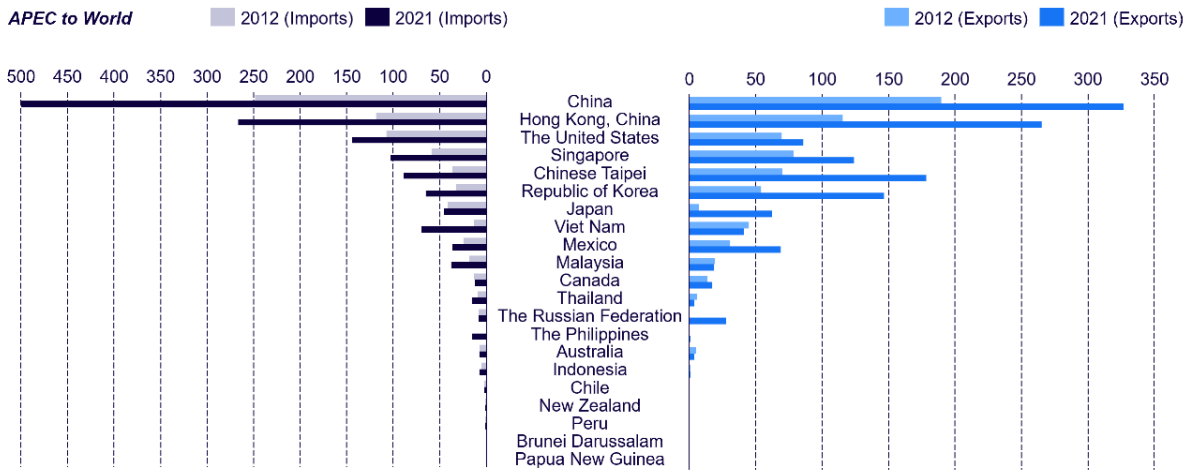
Figure 13: Analysis of China's ITA ICT exports in 2021 (Refer to Table 18 for detailed analysis)

In 2021, China's top-traded ITA ICT exports included phones and laptops to the United States, and microprocessors, photosensitive semiconductors, and PCB to Hong Kong, China. As shown in Figure 13, the export value of the top five HS codes amounted to USD376 billion, comprising 77 percent of total exports in 2021. This is because China is the largest exporter of HS 851712 (mobile phones) and HS 847130 (laptops) to the United States, having accounted for 67 percent of mobile phone manufacturing[10] and around 80 percent of laptop production in 2021 globally[11] [12]. Secondly, China is also a supplier of low-cost PCB (HS 853400) and has been responsible for approximately 50 percent of the world's total PCB annual output since 2018[13]. China's position in the world's PCB output could be primarily because of:

- Effective policy support for PCB, reliable product quality, and labor cost advantages
- Chinese PCB exporters providing direct access to purchasing PCBs, eliminating the costs of middle-men brokers

Also, Hong Kong, China is a large trading partner of China, in that a large percentage of exports (24 percent of HS 851712 (mobile phones), 34 percent of HS 847330 (microprocessors, motherboards, etc.), 7 percent of HS 854140 (semiconductors related to photosensitive semiconductor devices), and 51 percent of HS 853400 (PCB)) goes to Hong Kong, China. Further insight into Hong Kong, China's role in the global mobile phone trade revealed by an analysis of HS 851712 (mobile phones) exports shows that it re-exported 32 percent of the trade of mobile phones to APEC and 68 percent to the rest of the world after importing from China. This highlights Hong Kong, China's position in the global value chain, functioning as a re-export hub for mobile phones manufactured in China that are distributed across the globe.

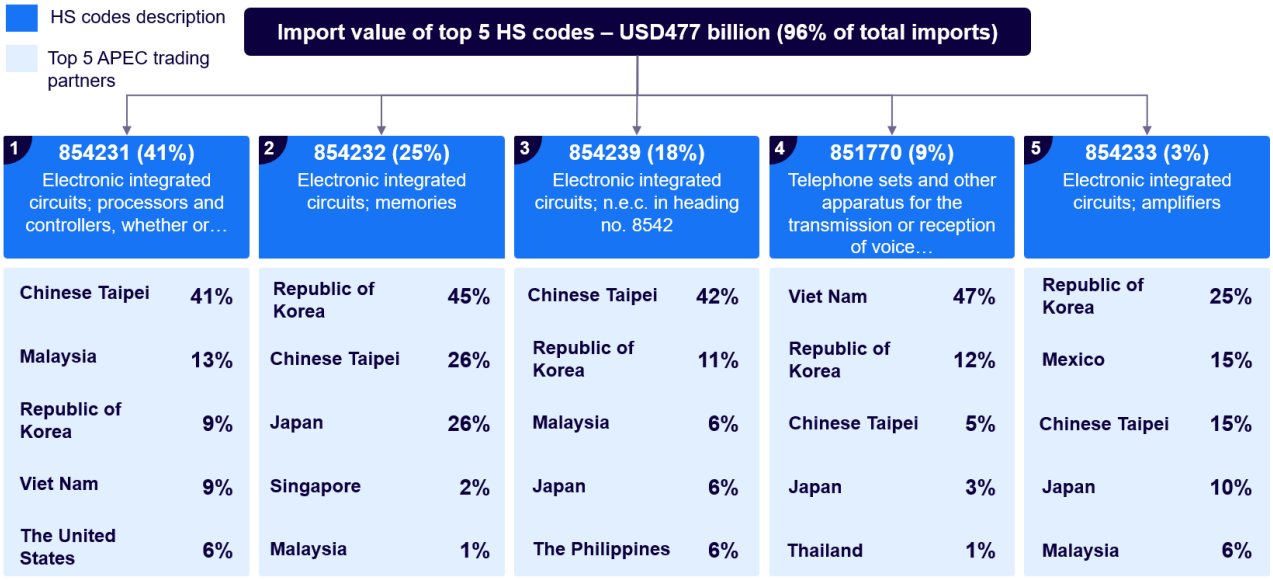
Several factors contribute to Hong Kong, China's and China's position in this role[14]. Firstly, logistics infrastructure offers well-functioning port facilities, frequent shipping schedules, and advanced logistics and transportation facilities. Additionally, Hong Kong, China's traders provide services such as volume consolidation and deconsolidation, evaluating and monitoring the quality of ICT products, and management of communications between buyers and Chinese ICT suppliers. The cumulative effect of these logistics advantages and added services results in a substantial increase in logistical efficiency. Furthermore, this leads to economies of scale that reduce transport costs and overall trade expenses. In essence, the position of Hong Kong, China as a global re-export hub makes it an indispensable player in the global ICT supply chain.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 14: Trade value (imports and exports) of ICT products included in ITA2 across APEC economies in 2012 and 2021, in billion USD

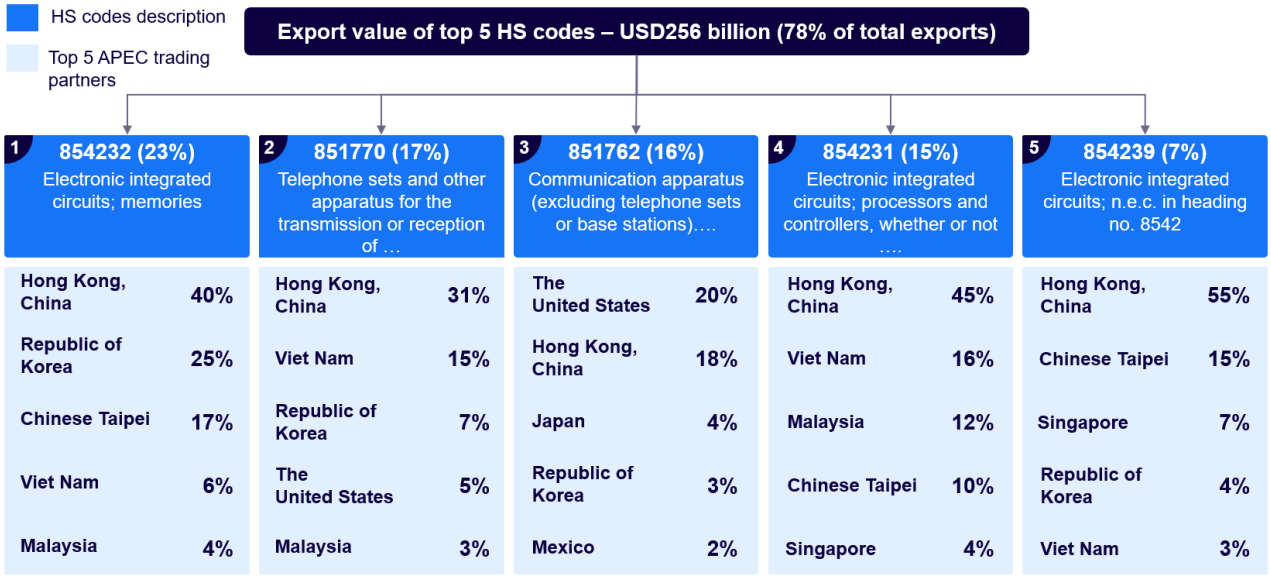
In 2021, China's imports and exports of ITA2 ICT products were the highest among APEC economies, and trade is a mix of semi-finished and finished ICT products such as electronic components and communication equipment (Figure 14). In 2021, China had the highest total ITA2 ICT imports of USD500 billion, as well as the highest ITA2 ICT exports of USD327 billion. This was also consistent in 2012, when China had the highest imports and exports of ITA2 ICT products.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 15: Analysis of China's ITA2 ICT imports in 2021 (Refer to Table 19 for detailed analysis)

In 2021, China's top traded ITA2 ICT imports included various semiconductors from Chinese Taipei and the Republic of Korea, as well as telephone parts from Viet Nam. As illustrated in Figure 15, the import value of the top five HS codes amounted to USD477 billion, contributing 96 percent of total ICT imports in 2021. When analyzing the top five ITA2 imports in China, four out of five top imported HS codes (HS 854231, 854232, 854239, and 854233) are electronic integrated circuits (semiconductors). Despite China being a major exporter of electronic integrated circuits, it is still a net importer of semiconductor products. Additionally, Chinese Taipei and the Republic of Korea are the top trading partners for electronic and integrated circuits, as they accounted for 82 percent of semiconductor foundries' revenue share worldwide in 2021[15]. China is also one of the largest importers of telephone parts from Viet Nam, as evidenced by HS 851770, where Viet Nam supplies 47 percent of China's Imports on this HS code. This is supported in that major Korean producers, such as Samsung, have set up manufacturing in Viet Nam. In 2022, Samsung had 28 factories producing electronics in Viet Nam across 11 provinces. (11 factories are in north Viet Nam, Bac Ninh.)[16]



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 16: Analysis of China's ITA2 ICT exports in 2021 (Refer to Table 20 for detailed analysis)

In 2021, China's top traded ITA2 ICT exports included various semiconductors (854232, 854231, 854239) and telephone equipment (851770) to Hong Kong, China, as well as communication apparatuses (851762) to the United States. As illustrated in Figure 16, the export value of the top five HS codes amounted to USD256 billion, contributing 78 percent of total exports in 2021. When analyzing the top five ITA2 HS codes exports in China, electronic and integrated circuits (854232, 854231, 854239) are the top exported products in China, likely because China is a global leader in the outsourced assembly, packaging, and testing (OSAT) category and held 38 percent of the global market share in 2021. Some examples of China's top semiconductor OSAT corporations include Jiangsu Changjiang Electronics Technology (JCET), Huatian Technology and Tongfu Microelectronics[17].

3.2.5 Trade flow of highest-traded ICT products by HS codes

APEC to World					
ICT HS codes	Brief details	HS code rank 2021	Direction of rank from 2012	Rank movement	Growth in trade (2012 to 2021)
854231	Electronic integrated circuits; processors and controllers, whether or not.....	1	⟷	-	2.1x
854239	Electronic integrated circuits; n.e.c. in heading no. 8542	2	⟷	-	2.0x
854232	Electronic integrated circuits; memories	3	▲	+4	3.5x
851712	Telephones for cellular networks or for other wireless networks	4	▼	-1	1.6x
847130	Automatic data processing machines; portable, weighing not more than 10kg.....	5	▼	-1	1.2x
847330	Machinery; parts and accessories of the machines of heading no. 8471....	6	▼	-1	1.4x
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	7	▼	-1	1.4x
851762	Communication apparatus (excluding telephone sets or base stations).....	8	⟷	-	1.6x
847150	Units of automatic data processing machines; processing units other than.....	9	NA	Not in top 10 HS codes list in 2012	2.2x
847170	Units of automatic data processing machines; storage units	10	▼	-1	-0.1x

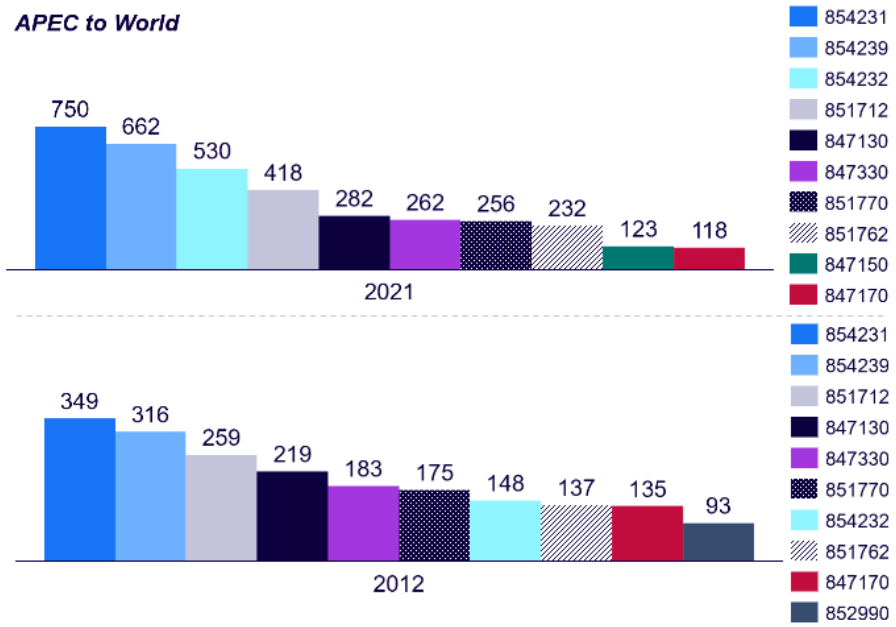
Highlighted HS codes are the products included in ITA2

Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 17: Overview of movement in ranks of top 10 highest-traded HS codes from 2012 to 2021

Through the analysis of the highest-traded ICT products by HS codes, it can be observed that the top three traded HS codes comprise various electronic and integrated circuits for trade between APEC and the rest of the world. The analysis identified the top 10 HS codes in 2021 and their rank movement within the top 10 highest-traded HS codes from 2012 to 2021. The top 10 highest-traded HS codes in 2021 comprised five HS codes that were included in ITA2, such as electronic integrated circuits, telephone sets for the transmission or reception of data, and communication apparatuses. The remaining five HS codes are products included in the ITA, such as telephones for cellular networks, automatic data processing machines, and machinery.

Three HS codes held the same rank in 2021; these included electronic integrated circuits (854231 and 854239) and communication apparatuses (851762). The HS code that had the highest growth in trade was electronic integrated circuits; memories (854232), which grew the most (3.5 times), increasing its ranking from seventh to third from 2012 to 2021. Five codes that fell by one rank include telephones (851712), automatic data processing machines (847130 and 847170), parts of telephone sets (851770), and machinery; parts and accessories of automatic data processing machines (847330). In terms of growth in trade from 2012 to 2021, nine out of 10 HS codes achieved a positive growth rate. Units of automatic data processing machines; storage units (847170) are the only code that had a negative growth rate of 0.1 times. Units of automatic data processing machines and processing units (847150) were the only HS code not in the top 10 traded HS codes list in 2012.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

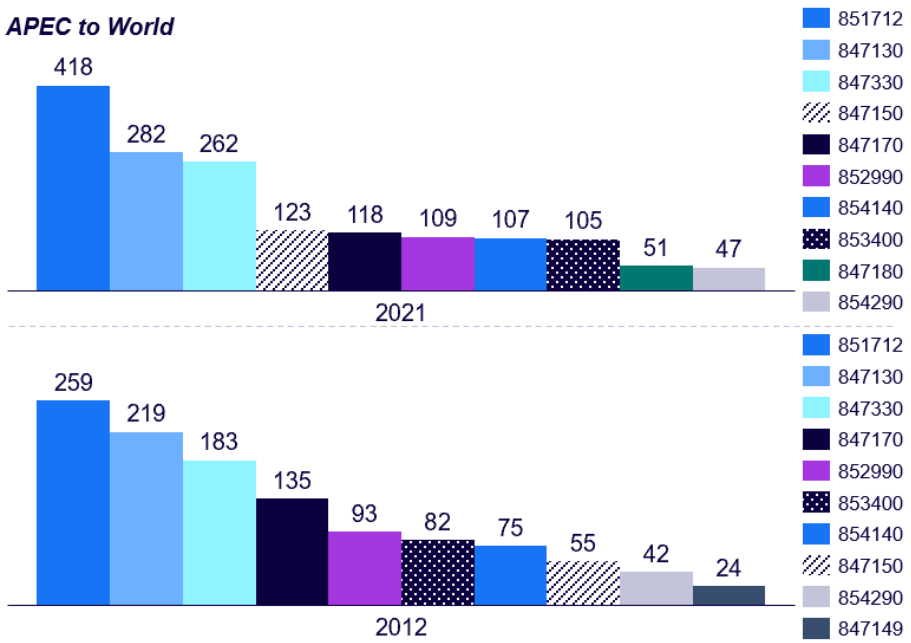
Figure 18: Top 10 highest-traded ICT HS codes (2012 and 2021), in billion USD

The total trade value of the top 10 traded HS codes to total trade grew from 69 percent in 2012 to 76 percent in 2021. The highest-traded HS code in both 2012 and 2021 was HS code 854231 (electronic integrated circuits [processors and controllers]), with a value of USD349 billion and USD750 billion, respectively. Additionally, the trade value of electronic integrated circuits and memories (854232) grew the largest by 3.6 times, from USD148 billion in 2012 to USD530 billion in 2021 (Figure 18).

The top 10 highest-traded HS codes in 2021 identified (Table 21):

- Three HS codes were associated with electronic integrated circuits (semiconductors) related to processors and controllers, and memories (854231, 854239, and 854232).
- Four HS codes were associated with laptops, processing units, and computer parts (847130, 847330, 847150, and 847170).
- Two HS codes were associated with telephones and phone parts (851712 and 851770).
- One HS code was associated with modems, switching, and routing apparatuses (851762).

When comparing the 2012 list to that of 2021 (Table 22), HS 852990 (parts of communication equipment) was removed from the top 10 traded HS code list from 2012 to 2021, while HS 847150 (processing units) was added into the 2021 list. Overall, semiconductors were highly traded in both 2012 and 2021.



Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

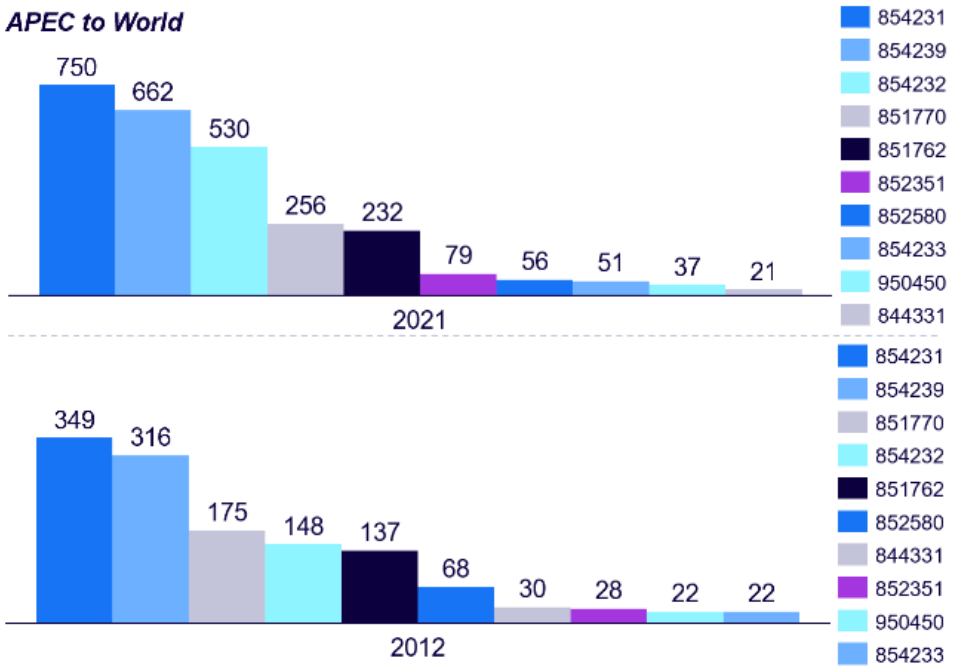
Figure 19: Top 10 highest-traded ITA ICT HS codes (2012 and 2021), in billion USD

The trade value of the top-traded ICT ITA HS codes to total ICT ITA trade was 85 percent in 2012 and 86 percent in 2021. The highest-traded HS code in both 2012 and 2021 was HS 851712 (telephones for cellular networks or other wireless networks), with a trade value of USD259 billion and USD418 billion in 2012 and 2021, respectively (Figure 19). Within the 10 highest-traded HS codes, the trade value for HS 847150 (units of automatic data processing machines) increased the most, from USD55 billion in 2012 to USD123 billion in 2021, achieving a 2.2 times growth in trade.

The top 10 highest-traded ITA ICT HS codes in 2021 identified (Table 23):

- Three codes were associated with semiconductors related to photosensitive semiconductor devices, PCB, and parts of electronic integrated circuits (854140, 853400, and 854290).
- Five codes were associated with laptops, computer parts, processing units, storage units, and other automatic data processing machines (847130, 847330, 847150, 847170, and 847180).
- One code was associated with telephones (851712).
- One code was associated with printed circuit assemblies of television apparatuses (852990).

When comparing the 2012 and 2021 lists (Table 24), HS 847180 (other data processing machines) was added to the top 10 traded HS code list in 2021, whereas HS 847149 (automatic data processing machines presented in the form of systems) was removed from the 2012 list.



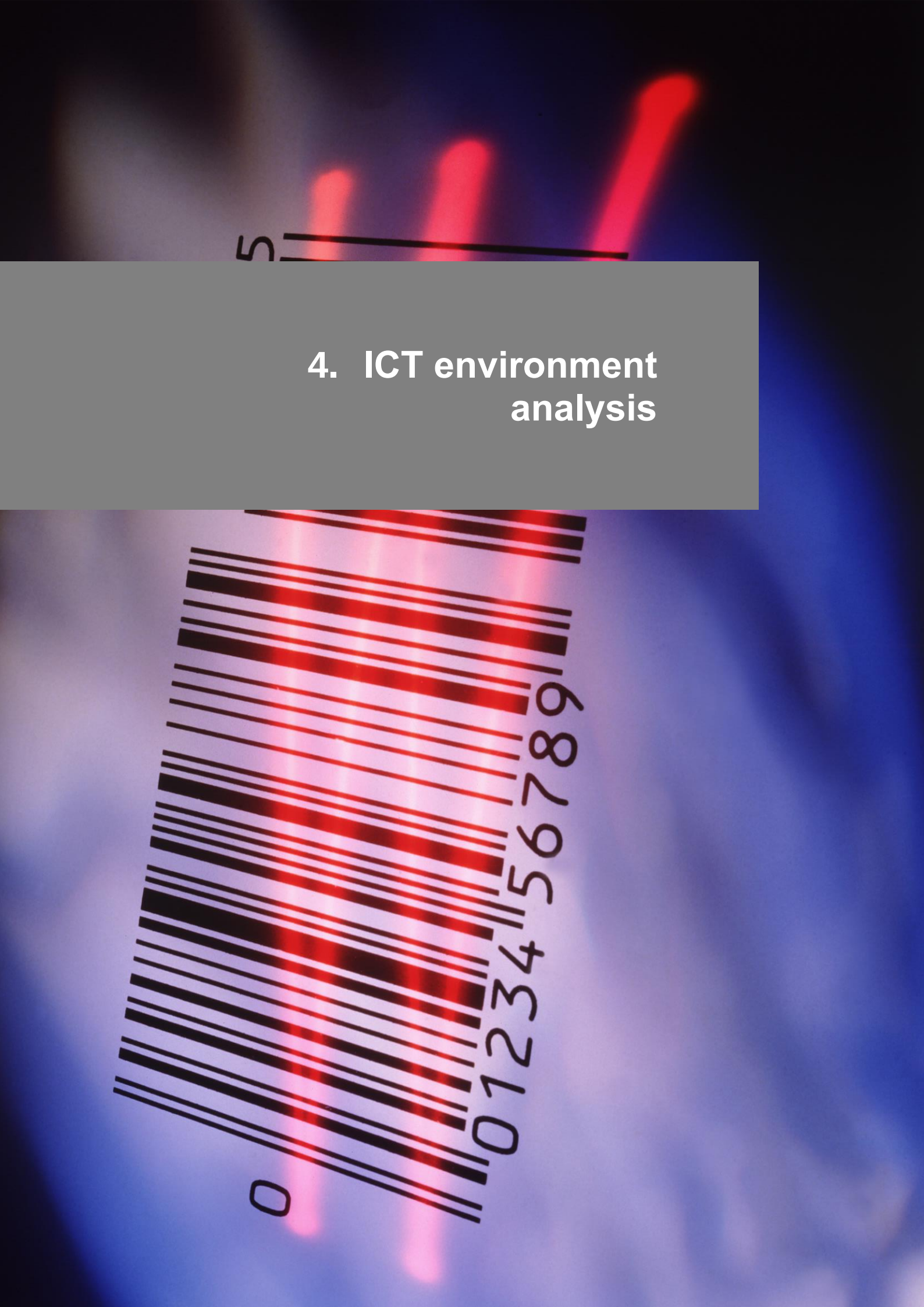
Source: The United Nations Comtrade (UNComtrade), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 20: Top 10 highest traded ITA2 ICT HS codes (2012 and 2021), in billion USD

The trade value of the top traded ITA2 ICT HS to total ICT ITA trade grew from 89 percent in 2012 to 99 percent in 2021 (Figure 20). The highest-traded HS code was HS code 854231 (electronic integrated circuits, processors, and controllers), and had a trade value of USD349 billion and USD750 billion in 2012 and 2021, respectively. Within the top 10 traded HS codes, trade for HS 854232 (electronic integrated circuits; memories) had the highest growth of 3.5 times, increasing from USD148 billion in 2012 to USD530 billion in 2021.

The top 10 highest traded ITA2 ICT HS codes in 2021 identified (Table 25):

- Five HS codes were associated with electronic integrated circuits (semiconductors) related to processors and controllers, parts of electronic integrated circuits; memories, and amplifiers (854231, 854239, 854232, 852351, and 854233)
- One HS code was associated with phone parts (851770)
- One HS code was associated with modems, switching, and routing apparatuses (851762)
- One HS code was associated with cameras (852580)
- One HS code was associated with video game consoles (950450)
- One HS code was associated with printers, copying machines, and facsimile machines (844331)
- When comparing the 2012 and 2021 lists (Table 26), the top five HS codes remained unchanged.



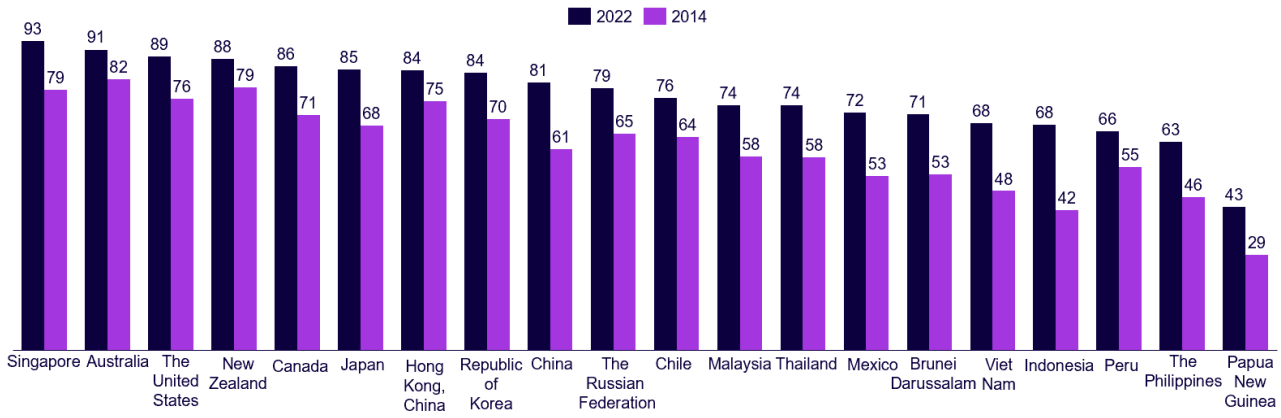
4. ICT environment analysis

4. ICT environment analysis

This section offers a thorough examination of the ICT landscape, concentrating on three key aspects. It delves into the analysis of mobile connectivity across APEC economies to illustrate advancements in narrowing the digital divide among them. Furthermore, it scrutinizes the vital infrastructure of internet access, shedding light on the affordability and accessibility of ICT services. Additionally, the section includes case studies that underscore the advantages of digitalization of cross-border customs procedures. Lastly, the section covers the causes and details of disagreements that were encountered in ITA and ITA2.

4.1 Digital divide

The digital divide refers to the gap between individuals, households, businesses, and geographic areas at different socio-economic levels regarding opportunities to access ICTs and use the internet for a wide variety of activities[18]. Understanding the digital divide is important in addressing societal inequalities with digitalization and facilitates the promotion of sustainable development. This section investigates the digital divide and its progression within APEC economies. The GSMA Mobile Connectivity Index is used to measure the digital divide and evaluates the performance of 170 economies against the key factors that facilitate the adoption of mobile internet. The index measures mobile data connectivity using four pillars – infrastructure, affordability, consumer readiness, and content and services (Table 27). Each indicator is normalized to a score from 0–100 that contributes to an economy's overall index score, with 100 being the most connected.



Source: Global System for Mobile Communications Association (GSMA), Arthur D. Little analysis

Figure 21: Overview of mobile connectivity index in APEC economies (2014 and 2022, out of 100 index score)

Comparing the index data between 2014 and 2022 for each APEC economy, the digital divide improved by 1.27 times across APEC (Figure 21). This was calculated by dividing the 2022 score against the 2014 score to calculate the growth of each APEC economy, and then taking an average to find the growth for APEC overall. While Chinese Taipei data is not available in the GSMA Connectivity Index, based on similar indexes, it is expected to be featured in the top 10 ranking among APEC economies. Our findings indicate that Singapore is the leading APEC economy in closing the digital divide, with the highest score of 93. From 2014 to 2022, Indonesia saw the largest improvement in closing the digital divide, with its score increasing from 42 to 68, a 1.6x increase. Among the four enablers, APEC economies improved the most in infrastructure (1.67x increase), followed by content and services (1.29x increase), consumer readiness (1.12x increase) and, lastly, affordability (1.10x increase). Among the APEC economies, Viet Nam improved the most for infrastructure (2.59x increase), Indonesia for affordability (1.58x increase), China for consumer readiness (1.22x increase), and Papua New Guinea for content and services (1.66x increase).

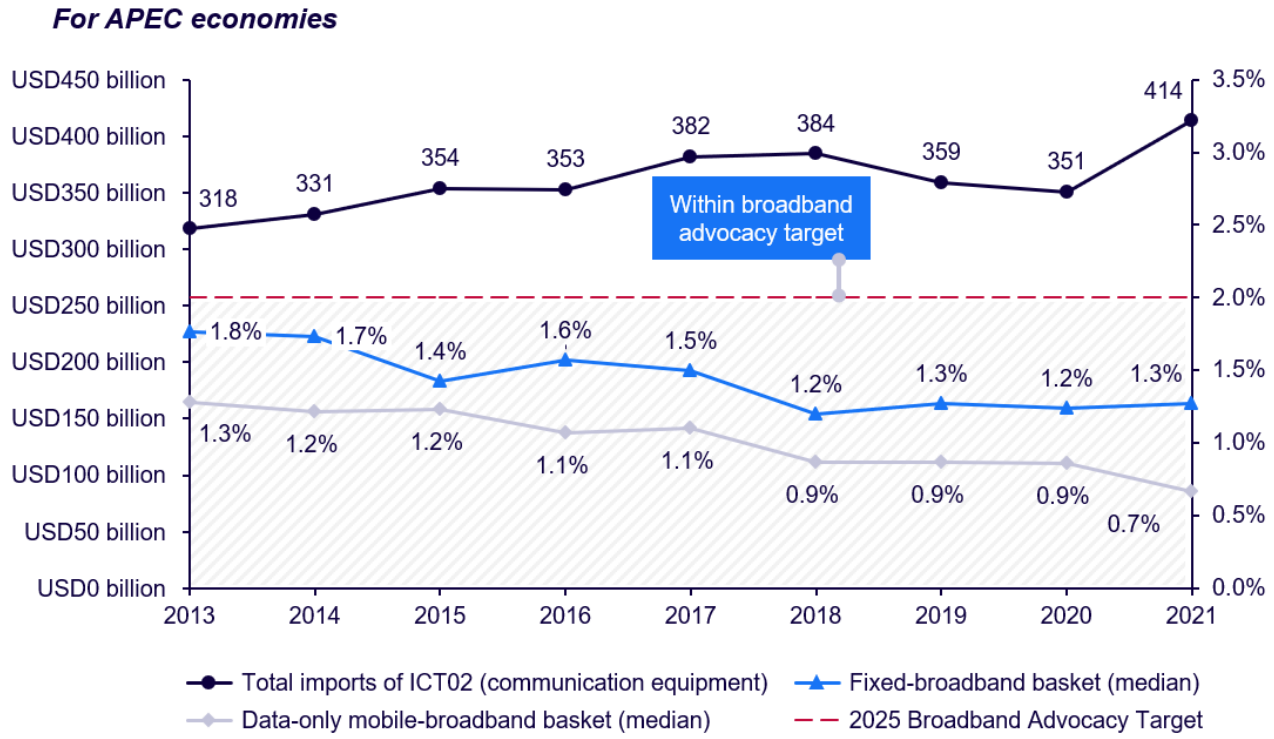
4.2 Fee or costs of communication networks and equipment

Calculating the costs of communication networks and equipment is aimed at assessing their affordability among APEC economies from 2013 to 2021. As ITA has removed import tariffs, it has led to lowering the costs of importing communication equipment, which may affect how the fees or costs have changed for communication networks. This section hopes to assess the impact of ITA on the affordability of

communication networks and equipment over the years, and how that affects the costs of communication networks over time.

To analyze the change in the costs of communication equipment, communication equipment imports were compared to selected ITU ICT price baskets. Firstly, the import value data of communication equipment for APEC economies was extracted from the relevant HS code category – ICT02 (communication equipment), which was defined by UNCTAD. A total of 40 HS codes were extracted, and the full list can be found in Table 32. Secondly, to analyze the change in costs of communication networks, fixed broadband and data-only mobile broadband baskets were considered when calculating ICT price baskets. This is because fixed broadband and data-only mobile broadband are typically the primary means of accessing the internet for the population, covering household and mobile networks, respectively. Given that these baskets are the primary means of accessing the internet, focusing on the costs of these baskets can help evaluate whether internet access is affordable for the population.

Among the APEC economies, the costs of communication networks have become more affordable, while the trade of communication equipment is increasing (Figure 22). The cost of the broadband basket has become increasingly affordable, exhibiting a steady decline. From 2013 to 2021, the data-only mobile broadband basket decreased from 1.3 percent gross national income (GNI) per capita to 0.7 percent GNI per capita, while the cost of the fixed-broadband basket fell from 1.8 percent GNI per capita to 1.3 percent GNI per capita. On the flip side, the trade of communication equipment is increasing. The total imports of ICT02 (communication equipment) increased from USD318 billion in 2013 to USD414 billion in 2021.



Source: The United Nations Comtrade (UNComtrade), International Telecommunication Union (ITU), Arthur D. Little analysis

Figure 22: Overview of the costs of communications for networks 2013–2021, in billion USD and % of GNI per capita

Costs of communication networks have remained affordable, as both data-only mobile broadband and fixed-broadband costs fall within the 2025 Broadband Advocacy Target of 2 percent GNI per capita. In 2021, out of the 21 APEC economies, data-only mobile broadband was affordable to most, as only two economies were above the target, while fixed broadband was relatively less affordable, as nine economies were above the target. However, overall, the average cost of all APEC economies was still below the 2 percent target. Since the introduction of ITA2 in 2016, which removed tariffs, the total imports of communication equipment have increased. This leads to greater access to communication equipment for the populations in different economies, leading to increased affordability. Apart from the decrease in ITA or ITA2 tariffs, the affordability of communication networks could be influenced by the following factors:

- Technological advancements that have brought about more efficient and economical solutions
- Other factors such as economies of scale, government subsidies and increased competition

4.3 Digitalization of customs clearance procedures

In an age of technological advancement, the computerization of customs clearance procedures is revolutionizing international trade. This shift from paperwork to streamlined digital processes results in efficiency, transparency, and cost reduction. Thus, examining case studies from different economies offers a global perspective on the adoption of technology in customs procedures, providing a broader understanding of the trend.

4.3.1 Automated System for Customs Data (ASYCUDA) program

The ASYCUDA serves as a compelling case study that harnesses computerization within customs processes. Developed by the UNCTAD, ASYCUDA is an integrated customs management system for international trade and transport operations. ASYCUDA aims to modernize customs operations through computerization for better revenue collection, enhance trade efficiency by reducing transaction time and costs, streamline goods clearance for improved security, increase transparency to combat corruption, and promote sustainable development by transitioning to electronic documents, thus reducing paper usage. The program features software applications designed and developed for customs administrations and the trade community to ensure compliance with international standards during import, export, and transit procedures[19].

This integrated platform includes Automated System for Performance Measurement (ASYPM), electronic Convention on International Trade in Endangered Species of Wild Fauna and Flora (eCITES), Automated System for Customs Data Hub (ASYHUB), and Automated System for Relief Consignments (ASYREC):

- **ASYPM** – Developed in 2014, ASYPM aims to detect poor practices and enhance operational efficiency. It utilizes 29 performance indicators to generate tables and diagrams, providing real-time and accurate information on all customs operations' performance.
- **eCITES** – Introduced in 2018, eCITES is a cloud-based electronic permit system. It automates the support for permit application, processing, issuance, and reporting for international trade of endangered species of fauna and flora.
- **ASYHUB** – Developed in 2020, ASYHUB is an open, standardized, cloud-native platform. Its objective is to digitize global maritime trade and offer a standardized platform for processing and integrating data between ASYCUDAWorld, which is the latest version of ASYCUDA's customs management software, and other external systems.
- **ASYREC** – In cooperation with the Office for the Coordination of Humanitarian Affairs (OCHA), a part of the United Nations responsible for bringing together humanitarian actors to ensure a coherent response to emergencies, ASYREC was developed in 2020. This development provides customs administrations and disaster management authorities with a tool to effectively manage the importation and exportation of relief consignments during humanitarian crises, such as the COVID-19 pandemic.

With the ongoing implementation and operational advancements, ASYCUDA has been adopted by 83 percent of the least developed economies, 66 percent of the landlocked developing economies, and 59 percent of the small island developing economies[20].

The implementation of ASYCUDA in both Jamaica and Sudan serves as a prime example of employing trade operation computerization to enhance clearance efficiency[21]:

Case study in Jamaica: Jamaica Single Window for Trade (JSWIFT)

- **Overview** – JSWIFT, built on the foundation of ASYCUDA, is revolutionizing business operations through the automation of pre-clearance procedures. This automation not only reduces operational costs, but also bolsters trade and eliminates trade barriers. JSWIFT functions as an integrated electronic system, enabling traders to submit licenses, permits, certificates, and other necessary documents at a centralized entry point, ensuring compliance with import and export regulations. The platform offers features such as real-time notifications, e-payment options, and track-and-trace capabilities. By transforming trade documents into electronic formats and centralizing them, JSWIFT streamlines customs processes, driving significant advancements in trade efficiency.
- **Impact** – The adoption of JSWIFT led to increased transparency and accountability by offering a unified platform for trade-related submissions, reducing the risk of fraudulent activities. Moreover, customs efficiency improved significantly, with processing time shortened to 28 hours and overall clearance time reduced to an average of 32 hours through centralized electronic document storage.

Additionally, JSWIFT's elimination of paper-based processes resulted in a substantial increase in customs revenue, rising from JMD191 billion (USD1.23 billion) in 2017 to JMD233 billion (USD1.5 billion) in 2019.

Case study in Sudan: Sudan ASYCUDA World

- **Overview** – Sudan's customs department harnessed ASYCUDAWorld to electronically collect customs duties and taxes, simplifying payment procedures, facilitating international trade, and eliminating the need for multiple declarations for the same goods. Customs introduced an e-payment interface within ASYCUDAWorld to seamlessly exchange declaration and payment information with banks. This interface enables direct duty payments through bank websites, ATMs, and cashiers. The computerization of tax and duty payments has proven to be so efficient that it is now used for all customs payments, including storage costs, fines, and sample analysis.
- **Impact** – The implementation of electronic payment processes has significantly enhanced payment convenience, enabling 24/7 digital payments as opposed to traditional cash transactions. Notably, 28 percent of e-payments in 2019 were conducted between 4pm and 7am. This transition has not only optimized payment methods, but also led to remarkable reductions in customs clearance times. Average customs clearance time decreased from 8.5 days in 2016 to 5.6 days in 2018, and further reduced to 3.9 days in 2019, accounting for a substantial 30 percent reduction. Furthermore, customs revenue increased by 48 percent between 2018 and 2019.

Emerging ICT shows potential as the future of ICT and is recognized in multiple use cases in enhancing trade operations. Given that AI and blockchain have the potential to revolutionize processes for customs and trade operations to make them more efficient and transparent, the research was focused on how these technologies are being implemented in trade operations.

4.3.1.1 Artificial Intelligence (AI)

Case Study in Brazil: Brazil SISAM

Brazil's customs department took a step in integrating AI to enhance trade operations in 2014 by developing and deploying an AI tool titled SISAM, a Portuguese acronym for "Customs Selection System through Machine Learning[22]. SISAM employs AI, powered by machine learning algorithms, to identify patterns and anomalies within import declarations. Its primary objective is to uncover instances of fraud, smuggling, and other illicit activities within both import and export processes[23].

- **Overview** – SISAM enables customs officers to use AI technology for analyzing import declarations and estimating the probability of errors, such as false goods descriptions, incorrect HS codes, errors in declared origins of the economies, missing licenses, and inappropriate tax regimes. It draws from a vast database of 8.5 billion trade patterns derived from examination of 150 million imported items. This allows SISAM to conduct precise error assessments and enhance customs procedures.
- **Impact** – SISAM significantly improves error detection, accurately identifying up to 30 types of errors in import declarations without requiring physical inspection. Moreover, it guides the selection of import declarations for physical inspection, as errors have been found in over 75 percent of selected cases by SISAM. While more than 95 percent of import declarations are cleared without interruption, SISAM helps to accurately detect the remaining 5 percent that should be checked, allowing the customs officer to choose the items that should be inspected more efficiently. This efficiency enhances the declaration process and reduces the workload of a customs officer, allowing them to inspect up to 100 percent of items in an import declaration.

AI, as one of the promising emerging ICT developments, can potentially play a vital role in improving inspection efficiency and uncovering concealed items. This is accomplished by conducting preliminary analyses and offering suggestions to customs officers for physical examinations whenever unusual patterns are detected. With use of datasets, machine learning algorithms empower these tools to scrutinize and detect anomalies that could indicate fraudulent or corrupt activities with heightened precision and accuracy.

4.3.1.2 Blockchain Technology

Case Study in Singapore: Accelerating Trade Digitalization Through TradeTrust

In trade, the persistent challenge of paper-based cross-border transactions remains a consistent impediment to efficiency, when emerging ICT technologies could be leveraged to offer promising solutions. In 2022, Singapore piloted TradeTrust, a blockchain framework specifically designed to address the inefficiencies

inherent in traditional paper-based trade documentation. This initiative effectively harnessed the power of blockchain technology to digitize and enhance the reliability of trade documents within Singapore[24].

Digitalizing and enhancing the trusted interoperability of trade documents in Singapore involved two steps:

- **TradeTrust** – Leveraging blockchain within the TradeTrust framework, trade documents witness improvements across various dimensions, including increased security through decentralizing and distributing documents among trade parties, improved verifiability by offering document history and source information, and assured digitalization and transferability through a standardized documentation framework within the blockchain platform. This ensures data compatibility for all trade parties.
- **Digital documents** – Under the TradeTrust framework, blockchain has been pilot-implemented in two categories of trade documents to elevate reliability and efficiency within trade processes. The first category is transferable documents, exemplified by the Bill of Lading, which are legal documents acknowledging the receipt and terms of shipment for goods transported by a carrier. Blockchain allowed the title ownership of the e-documents to be transparently transferred from one party to another. The second category is verifiable documents, represented by the Certificate of Origin, an official document that verifies the economy where exported goods were produced. Blockchain allowed the provenance and authenticity of the e-document to be easily verified by any involved party[25].

Source: TradeTrust

Figure 23: Map of states with the pilot launch of TradeTrust and digital documents

This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by APEC or Arthur D. Little.

The implementation has yielded impactful outcomes across several dimensions[26]:

- **Improved efficiency** – Efficiency has notably increased through eliminating the need for repetitive checks by multiple parties. Verification is now consolidated within one party, with outcomes seamlessly shared across the trade ecosystem. The documentation process time has been significantly curtailed, from an initial 45 days to 17 days.
- **Reduced cost** – The transition to digitized documents has led to substantial cost reductions, eradicating expenses related to printing and delivering paper-based documents. Estimated cost savings on a global scale are projected to reach billions of dollars in the long term.
- **Improved trade processes** – Collaborations have emerged as a driving force for improved trade processes. TradeTrust has been pilot-tested in international collaborations involving five economies – Singapore; the Netherlands; China; United Arab Emirates (UAE); and Australia, as illustrated in Figure 23. These collaborations have been instrumental in enhancing trade processes by digitizing pivotal documents, particularly exemplified by the digitalization of Bills of Lading.

The use of blockchain to digitalize paper-based documents has the potential to offer substantial advantages, including significant reductions in documentation time, instances of fraud, and errors, while concurrently

enhancing efficiency and transparency. These benefits contribute to savings in time and operational documentation costs, elevate trade processes, and foster heightened trust in cross-border trade.

Case Study in Latin America: CADENA Project

Economies including Bolivia; Chile; Colombia; Costa Rica; Ecuador; Guatemala; Mexico; and Peru have established trade agreements to enhance trade across Latin America by certifying companies within the agreement members and providing them with trade incentives. These incentives encompass faster customs declaration approval, reputational advantage, and tax benefits. However, they have encountered various issues concerning data exchange and access to certified company details. These issues include the potential for receiving false documents from unreliable sources, limited real-time data availability, and delays in fraud detection. In response to these challenges, in 2021, the CADENA (a Spanish word that means "chain") blockchain solution was introduced by the Inter-American Development Bank (IDB)[27].

To address these challenges, the IDB has been supporting the development of blockchain solutions that enable automated, secure, and efficient information sharing through the CADENA platform.

- **Overview –** CADENA aims to address issues related to secure data exchange, particularly concerning Mutual Recognition Arrangement (MRA) data sharing and the management of Authorized Economic Operator (AEO) certifications. AEOs are certifications granted to businesses meeting specific customs compliance standards. Furthermore, MRA pertains to agreements between different economies' customs administrations, recognizing each other's AEO programs and providing trade incentives to certified companies registered as AEO. In this context, CADENA supports the implementation of MRAs and the management of AEO certifications in several ways. These include secure and confidential data exchange among MRA members, real-time status updates of AEO certifications through digitization, and shared information across MRA members. Additionally, automated validation of AEOs within an MRA is achieved using smart contracts.
- **Impact** – CADENA yields several benefits to MRA members and businesses alike. Notably, it enhances the efficiency of MRA management, making it more streamlined and effective. Customs administrations now adopt a digitalized, secure, and reliable approach to exchanging information about AEO certificates. The integration of blockchain significantly augments transparency by providing digital access to certificate information and a list of AEO-certified companies in MRA economies. This reduces the time required for checks, as parties can readily access real-time AEO status instead of contacting the origin economy directly. Furthermore, blockchain implementation brings about cost reductions. Unlike traditional methods such as physical document distribution, using blockchain incurs no additional cost for delivering the current AEO status of each company among MRA members[28].

Blockchain technology has the potential to address challenges in the management of the AEO certification process and successful implementation of MRAs. As exemplified through its application in the AEO and MRA processes, blockchain's role serves as a compelling case study, with potential implications for other MRAs where its success could be emulated. Through this approach, blockchain not only ensures secure and efficient data transfer, but also establishes a framework of transparency and real-time accessibility that encompasses all parties involved.

5. Emerging ICT and industry 4.0 technologies

5. Emerging ICT and industry 4.0 technologies

To understand the future of ICT within APEC, this section focused on identifying emerging ICT that will mature by 2030. The analysis utilizes various sources of literature review, research papers, and reports, taking a seven-year outlook on the emerging ICT of the top five most technologically advanced APEC economies based on a readily available index.

5.1 Methodology

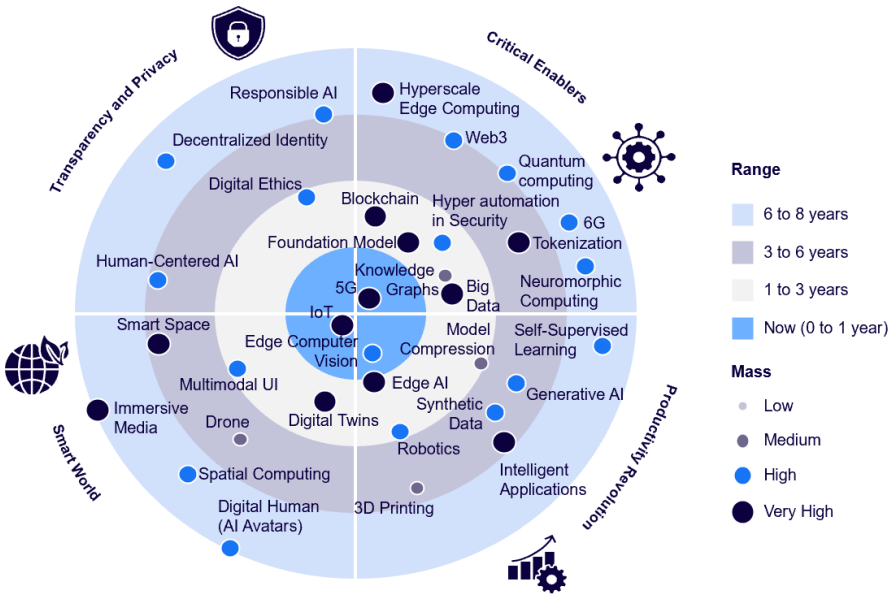
To find out the emerging ICT trends and products that are expected to shape the ICT landscape, a two-step approach was adopted:

- **Focus on emerging ICT trends and technologies with technology maturity expected by 2030:** Based on the literature review of research papers and reports, the long list of emerging ICT trends and products was identified globally. From the long list, ICT trends and products likely to mature by 2030 were selected, with a medium-term outlook of seven years taken to develop a middle list.
- **Shortlist based on the future technology priorities of the top five ranked APEC economies:** Map ICT technology priorities for the top five (based on a readily available index) APEC economies against a middle list of ICT trends and products. The next step is to identify the overlaps between the middle list and ICT priorities of the top five APEC economies to develop a shortlist of emerging ICT products.

Firstly, the literature review identified the long list of key ICT emerging trends and technologies globally across different maturities (1–8 years) (Figure 24). Based on a report, emerging ICT technologies can be organized into four categories[29]:

- **Critical Enablers** – Act as an additive force to bring emerging technologies and trends together, and heighten benefits by reshaping business practices, processes, methods, models and/or functions in markets where they are applied
- **Smart World** – Technologies here change how people interact with the world around them
- **Productivity Revolution** – Build on core technologies and extend computing ability
- **Transparency and Privacy** – Underscore the importance of protecting an increasingly digital world

The impact radar maps mapped the emerging ICT developments against two dimensions, range, and mass. Range refers to the time range these technologies took to come to maturity and be broadly adopted, while mass refers to the impact of technology on existing products and economies.



Source: Gartner, The Organization for Economic Cooperation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 24: Impact radar of key emerging ICT trends and products globally

These ICT trends and technologies have gained global attention, as they have the potential to improve efficiency, reduce costs, and enhance security in many industries. Key long-term trends and technologies beyond 2030 include metaverse, digital human, self-supervised learning, spatial computing, 6G, neuromorphic computing, and decentralized identity. Additionally, immersive media refers to augmented reality (AR), virtual reality (VR), mixed reality (MR), and metaverse. From this long list of emerging ICT products, technologies expected to mature by 2030 were selected for their relevance on the short- to mid-term horizon to develop a middle list.

Secondly, ICT priorities for the top five APEC economies were mapped against a middle list of ICT trends and products. The top five APEC economies were selected based on the 2022 Network Readiness Index, which ranks economies' preparedness for the future of the network economy and new technology trends. The top five APEC economies include the United States (1st position); Singapore (2nd position); Republic of Korea (7th position); Japan (10th position); and Canada (12th position).

Thereafter, for the top five ranked APEC economies, technology priorities were determined by analyzing government-published strategy documents, which serve as policy guidance on emerging technologies and outline the ICT sector goals. These documents also highlight emerging technology focus areas and priorities. Data for this analysis was extracted from the following key policy documents for the top five ranked APEC economies:

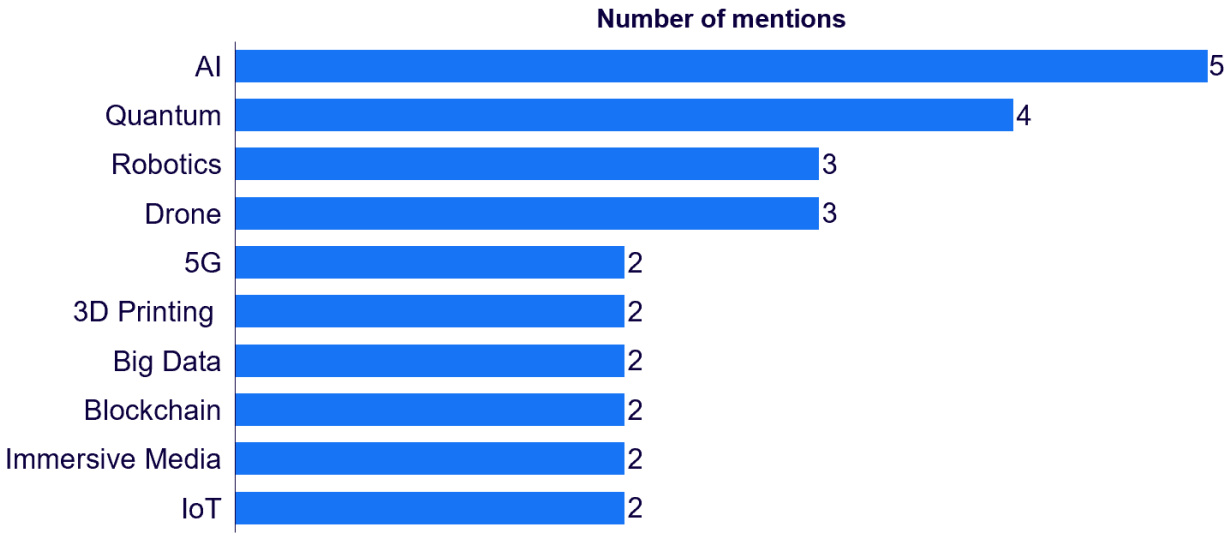
- **The United States** – Critical and Emerging Technologies List Update 2022 by the Science and Technology Council[30]
- **Singapore** – Frontier and Industry 4.0 technologies from Infocomm Media Development Authority (IMDA) and Enterprise Singapore[31]
- **Republic of Korea** – Digital New Deal from Korean Ministry of Science and ICT[32]
- **Japan** – 6th Science, Technology and Innovation Basic Plan by Council of Science, Technology, and Innovation[33]
- **Canada** – Science, Technology, and Innovation Priorities by Canada Excellence Research Chairs[34]

Through the analysis, the economies' emerging, and critical technology priorities were identified (Table 3):

Table 3: Top 5 APEC economies and their technology priorities

Source: Secondary research, Arthur D. Little analysis

Economies	APEC economies' emerging and critical technology priorities
The United States	Advanced Computing, Advanced Manufacturing Technology (including 3D printing), Advanced and Networked Sensing and Signature Management, AI, Robotics, Blockchain, Communications and Network Tech, Human-Machine Interface, Networked Sensors and Sensing, Quantum, Semiconductors and Microelectronics
Singapore	Additive Manufacturing (3D printing), AI, Cybersecurity, Digital Factory, Digital Twins, Immersive Media (VR, AR, MR, Metaverse), IoT, Robotics
Canada	5G, 6G, AI, Big Data, Blockchain, Cybersecurity, Drone, Material and Process Technology, Quantum, Semiconductors and Microelectronics, Advanced Manufacturing Tech
Japan	AI, Big Data, Digital Twins, Drone, IoT, Quantum, Robotics
Republic of Korea	5G, 6G, AI, Cloud Platform, Cybersecurity, Drone, Immersive Media, Quantum

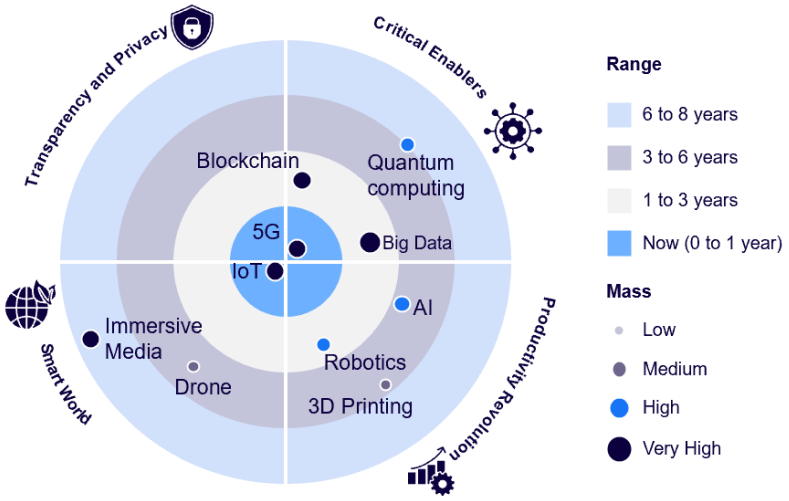


Source: Secondary research, Arthur D. Little analysis

Figure 25: Number of mentions of emerging ICT from economies' published policies

The shortlist of the top 10 emerging ICT is determined based on the number of times emerging technologies were mentioned in the policies of the top five APEC economies. AI was mentioned the most, as a priority area in ICT for the top five economies. This is followed by quantum, which was mentioned four times, and subsequently, robotics and drones, which were mentioned three times each.

5.2 Trends of shortlisted emerging technologies



Source: Gartner, The Organization for Economic Cooperation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 26: Overview of the top 10 shortlisted emerging ICT

Based on the top 10 emerging ICT (Figure 26), 5G and IoT are expected to be the earliest to maturity, and quantum computing and immersive media will be the latest. Out of these 10 technologies, those with the lowest mass were drone and 3D printing, while those with the highest mass were 5G, IoT, blockchain, big data, and immersive media. Under the shortlisted technologies, AI includes all aspects from the long list (responsible AI, human-centered AI, digital human [AI avatars], generative AI, edge AI).

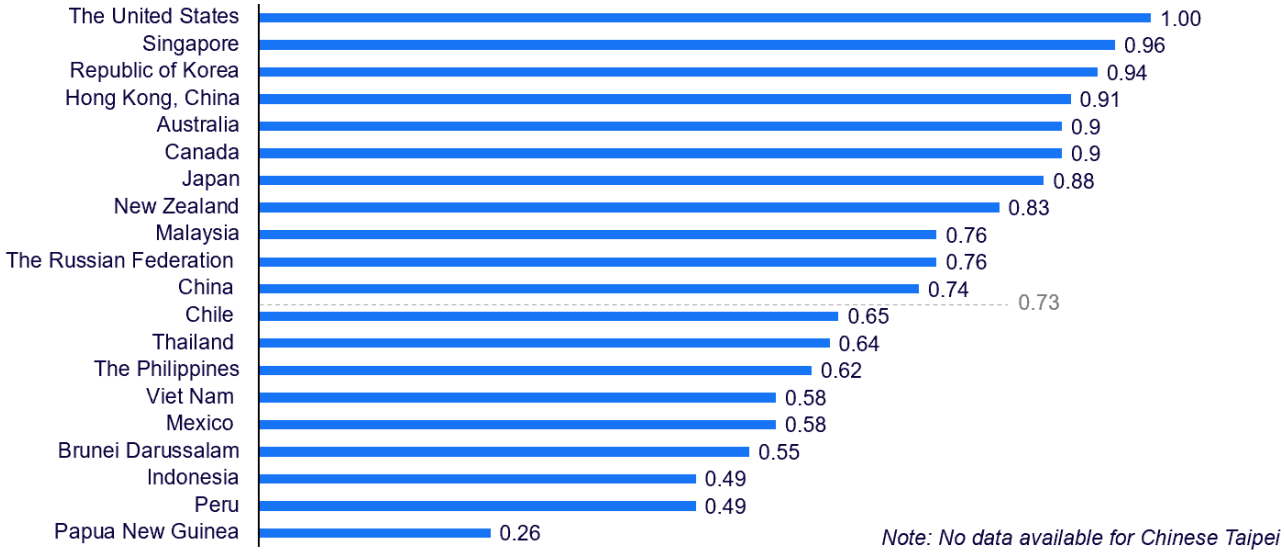
Table 4: Top 10 emerging ICT and their respective trends

Source: United Nations Conference on Trade and Development (UNCTAD), Bloch Advisory, Arthur D. Little analysis

Emerging ICT	Trends (non-exhaustive)
Artificial Intelligence	• Generative AI is creating a virtuous cycle of innovation, paving the way for new business models and applications • Generative AI speeds up product development, enhances customer experience and improves employee productivity • The cost of AI training is decreasing, while performance is rapidly improving
Big Data	• The big data market is already expanding quickly, particularly in developed economies, and will continue to add economic value as its uptake across industries drives impressive efficiency improvements in data analytics
Blockchain	• Blockchain applications have expanded to include financial transactions, the IoT, healthcare and supply chain management
Drones (Unmanned Aircraft)	• Technological improvement in cameras, mapping software, multidimensional mapping, and sensory applications is driving growth and application of drones in sectors such as infrastructure and domestic security
Immersive Media	• Metaverse applications are fast becoming the next form of the internet (Web 3.0), aided by advancement of wearable technologies such as AR/VR headsets and glasses • In the same way smartphones shifted the digital economy from personal computers to mobile phones, increasingly sophisticated AR/VR headsets and glasses could drive a shift in the digital economy from mobile phone screens to more immersive environments created by such wearable technologies • The industrial metaverse may become the future of the metaverse for businesses and has the potential to transform business productivity. The industrial metaverse is defined as a connected digital twin of a real system of physical infrastructure, such as cities, buildings, or other commercial or industrial facilities. The industrial metaverse has functionalities to interact with the real system in its actual environment, thus allowing its users to better understand the past and forecast the future of real systems
Internet of Things	• IoT market growth is driven largely by advances in semiconductor technology that enables development of lower-cost, lightweight, and more efficient devices • Demand for advanced consumer electronics in many economies is also driving IoT market growth, and the integration of AI and the IoT is expected to provide meaningful and timely insights into diverse domains and use cases such as agriculture, energy, manufacturing, public services, and transportation
Mobile Networks	• Innovation, investment, and standardization have driven the enormous and rapid deployment of 5G globally • Focus is shifting to the radio access network (i.e., OpenRAN) • 5G will transform traditional broadband access networks and technologies
Quantum Computing	• Increasing demand to solve complex computational problems at high speeds is driving the growth of this market • Interest and investment in quantum computing technology are growing among government, universities, and private companies
Robotics	• Costs of production in robotics have decreased, thus reducing prices – average robotics costs have seen more than a 50 percent drop since 1990
3D Printing	• Growth is contributed by increasing the variety of materials that can be 3D printed, production speed/resolution/accuracy, and the size of printable objects, while decreasing development cost and time • Industry demand mainly comes from healthcare, consumer electronics, automotive, dental, food, fashion, and jewelry

The top 10 emerging ICT products that are expected to shape the global ICT landscape by 2030 have been identified (Table 4).

Lastly, APEC economies were found to be global leaders in frontier technologies when ranking APEC economies based on the 2023 Frontier Technology Readiness Index by the UNCTAD[35]. APEC economies took four of the top 10 spots (The United States; Singapore; Republic of Korea; and Hong Kong, China) globally on frontier technology readiness, reflecting their position as global leaders in frontier technologies.



Source: United Nations Conference on Trade and Development (UNCTAD) Technology and Innovation report 2023, Arthur D. Little analysis

Figure 27: APEC economies ranking based on frontier technology readiness index

Frontier technologies are emerging at the intersection of radical scientific breakthroughs and real-world implementation. The index aims to assess economies' preparedness for frontier technologies and considers a wide variety of technologies, such as AI, drone technology, IoT, blockchain and nanotechnology, as well as an extensive number of indicators. The indicators include the mean download speed (Mbps), the number of patents and publications on frontier technology, and the number of internet users. The factors that the index considered can be found in Table 27. Each economy was scored on a scale of zero to one. Scores could be found for all APEC economies, except Chinese Taipei, where data was not available. Among the APEC economies, that with the highest score is the United States, which scored 1. The average score for APEC is. 0.73, and 11 APEC economies scored above the average (Figure 27).

6. Trade of New and Emerging ICT Products

6. Trade of new and emerging ICT products

More than 25 years have passed since the ITA was reached, but digital technologies and industries continue to develop and expand. As technology evolves at an unprecedented pace, analyzing the trade of new and emerging ICT products has become imperative because of their ability to shape the dynamics of global commerce in the future. This section aims to identify emerging ICT products and provide insights into their trade and growth.

6.1 Methodology

To identify the emerging ICT products, a two-step approach involving identification and data extraction, ranking, and analysis was performed. Analysis of emerging ICT products was completed on two levels:

- HS codes in the future ICT products list (Table 28) **–** 301 HS codes
    - Analyzing the HS codes in this list acts as a baseline for new and emerging existing HS codes that are being traded. These HS codes hold the potential to create impact today
- HS codes directly linked to top 10 emerging technologies (Table 29) – 12 HS codes
    - Analyzing HS codes that were directly linked to the list of top 10 emerging ICT products helps provide an outside-in analysis to identify new HS codes that hold the potential to impact and disrupt the market in the coming years. The additional HS codes identified act as a complementary list for new and emerging HS code analysis.

To ensure a comprehensive assessment of emerging HS codes and achieve a more accurate estimation of the impact of reduced tariffs, both the current (HS codes in the future ICT products list) and future (HS codes directly linked to the top 10 emerging technologies) perspectives were considered.

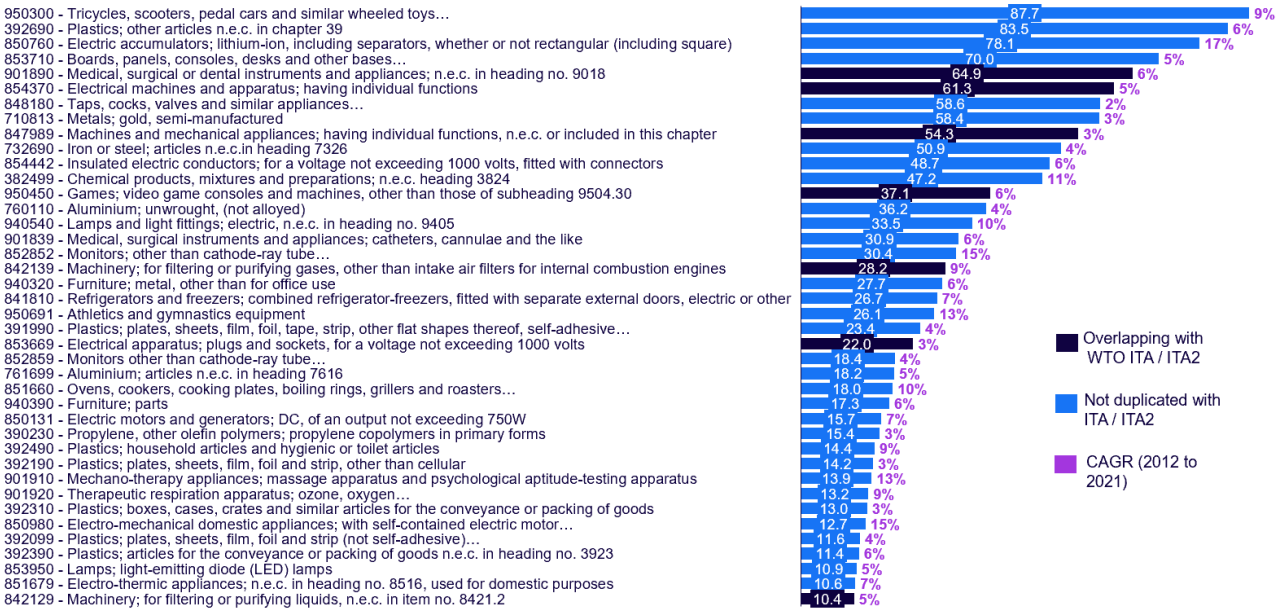
Firstly, HS codes were identified for the baseline and complementary list:

- Baseline list **–** 301 HS codes were identified for the baseline list from the future ICT products list (Table 28).
- Complementary list **–** 12 HS codes (covering drones, robotics, and 3D printing technology) were identified in the complementary list, as they can be directly linked to the top 10 emerging ICT products (Table 29), as mentioned in Chapter 5
    - HS codes found under immersive media, blockchain, 5G, IoT, big data, AI, and quantum computing cannot be directly linked to these technologies. This can be seen in Table 30, where multiple HS codes across semiconductors, GPU, and modems can be linked back to these emerging ICT products.
    - Technologies such as blockchain and AI also have considerable software and services involved; therefore, these HS codes do not directly link to these emerging ICT products.

Secondly**,** for HS codes in the future ICT products list, trade data was extracted for the years 2012 and 2021, as trade data between those periods was the most comprehensive as of the report analysis period (July to October 2023). Meanwhile, for HS codes directly linked to the top 10 emerging technologies, trade data was extracted for 2022, as data was only available for some HS codes found under emerging ICT products in 2022 as of the report analysis period. For both lists, trade data was extracted for trade between APEC to the rest of the World, and both lists were analyzed separately. The HS codes for both lists were ranked separately, based on the trade value in descending order, where the highest-traded (exports and imports) HS codes were ranked first. Next, for the future ICT products list, only the HS codes with a CAGR (2012 to 2021) that is higher than the median CAGR were selected, which represented more than 50 percent of the total trade for 301 HS codes. As for the HS codes that can be directly linked to the top 10 emerging technologies, HS codes that represent more than 95 percent of the trade value (12 HS codes) were selected as the top emerging ICT HS codes.

6.2 Shortlisted new and emerging ICT products

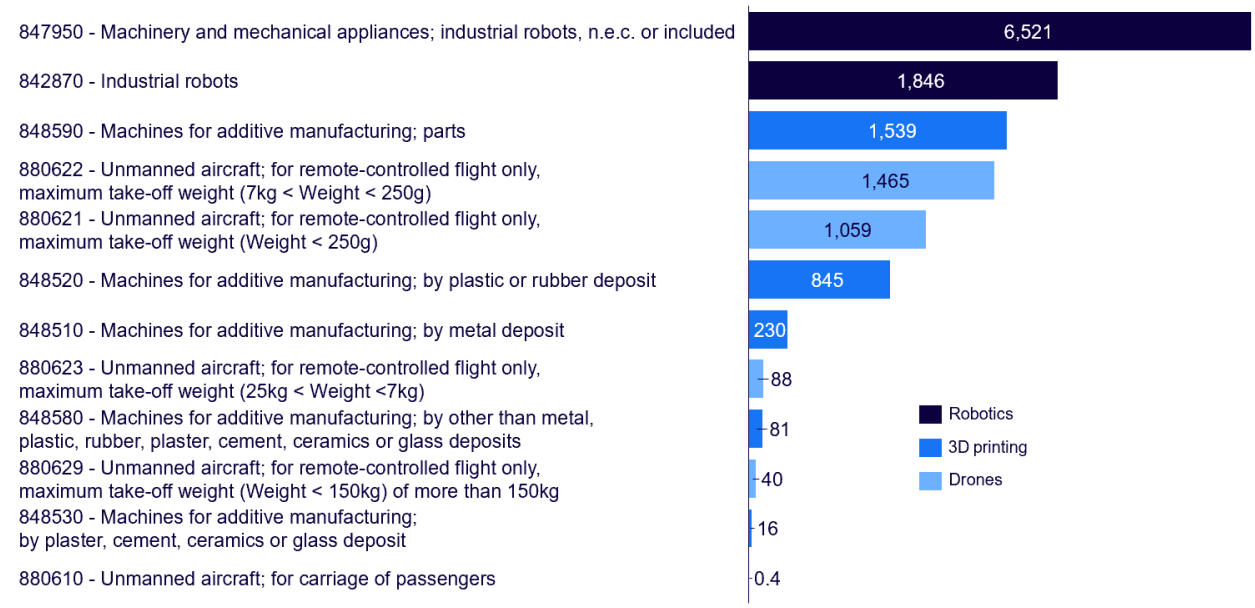
Based on the HS codes in the future ICT products list, the top 40 HS codes, representing 55 percent of the total trade, were shortlisted according to ranking by trade value and CAGR (Table 32).



Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Figure 28: Top 40 emerging future ICT product HS codes, 2021, in billion USD, CAGR% (2012 to 2021)

The emerging HS codes include tricycles, scooters, pedal cars (950300), plastics (392690), electric accumulators (850760), board panels, consoles, and desks (853710). There are a total of seven duplicated HS codes with ITA/ITA2 and 33 non-duplicated HS codes; the non-duplicated HS codes represent 43 percent of the trade (301 HS codes) in 2021. Duplicated HS codes include products such as medical instruments (901890) and electrical machines (854370), which have already been covered in Chapter 3.



Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Figure 29: Top-traded ICT HS codes from top 10 emerging ICT in 2022, in million USD

Next, as shown in Figure 29, the highest-traded emerging ICT HS codes include industrial robots, parts of 3D printers, and unmanned aircraft (7kg < Weight < 250g). For the HS codes that can be directly linked to the top 10 emerging ICT, the top seven HS codes (Table 31) within emerging ICT represented 98 percent of trade in 2022. Among the three technologies, robotics has the largest proportion and represents 61 percent of trade among 12 HS codes in 2022.

7. Impact of reduced tariffs on emerging ICT products

7. Impact of reduced tariffs on emerging ICT products

The ITA and ITA2 led to reduction in tariffs, which has had significant benefits. As reported by the WTO, removing tariffs on all ITA goods is estimated to boost imports and facilitate more trade, thus attracting more businesses and facilitating trade and economic growth for both developed and developing economies[36]. In terms of export growth, developing economies have expanded at a much faster rate than developed economies. Between 1996 and 2008, developing economies' ITA exports expanded at an annual growth rate of 33.6 percent, compared to 7.2 percent for developed economies. This has increased their market share in the region after joining the ITA, which shows the benefits of tariff elimination[37].

Examining global trade flows and the accession of new member economies, lowering tariffs will lower the cost of exporting goods, drive competitiveness, and expand opportunities for emerging ICT products, potentially boosting export revenue and fostering economic growth[38]. For many economies, tax revenues generated from enhanced economic growth gained from tariff elimination would more than make up for the tariff revenue forgone[39]. This section aims to analyze the impacts of tariff savings for APEC economies on emerging ICT products, and how they contribute to the growth of emerging ICT product imports in APEC economies.

7.1 Methodology

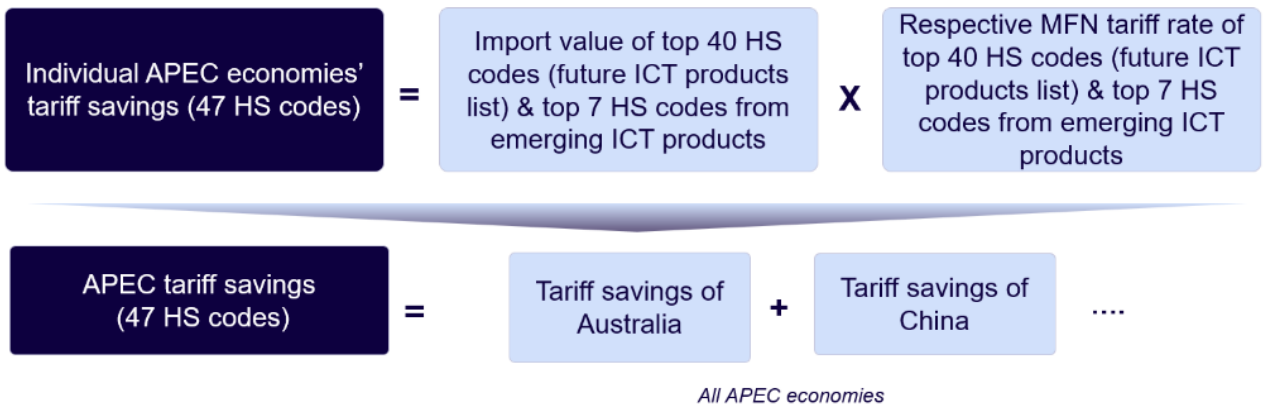
To assess the impact of tariff reductions for emerging HS codes (the focus of our analysis as identified in Chapter 6), a three-step approach involving data extraction and processing, tariff savings estimation, and synthesis was implemented. Gaps were uncovered during the data processing step, which has been addressed in Figure 52.

Data extraction and processing:

- Extraction of data for trade between APEC economies from the UNComtrade database:
  - Extraction of 2021 trade data for the top 40 HS codes from the future ICT products list (Table 32), as 2021 data was the most comprehensive as of the report analysis period (July to October 2023).
  - Extraction of 2022 trade data for the top seven HS codes (Table 31) from the top 10 shortlisted emerging ICT products, as only 2022 data was consistently available for HS codes found under emerging ICT products as of the report analysis period (July to October 2023).
- Extraction of MFN tariff rates between APEC economies from the Trademap database:
  - MFN rates of the top 40 HS codes from the future ICT products list, as well as the top seven HS codes from the top 10 emerging ICT products, were extracted from Trademap.
  - MFN rates are normal non-discriminatory tariff rates charged on imports, excluding preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas.
  - MFN rates are used to estimate tariff savings, but actual tariff savings may differ for each economy, as there are also existing trade agreements between APEC economies.

Tariff savings estimation:

- APEC tariff savings for emerging HS codes (47 HS codes) was determined by:

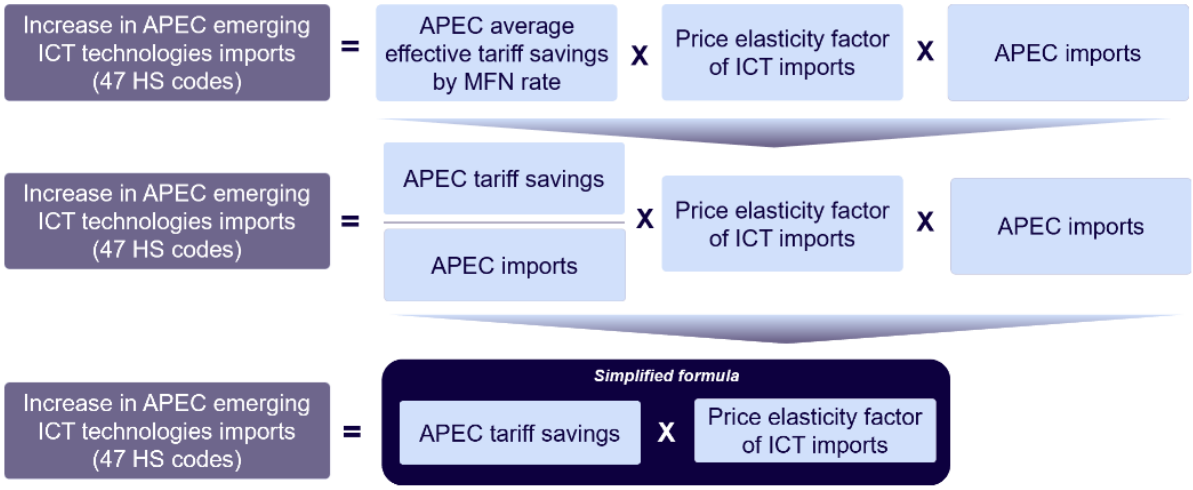


Source: Arthur D. Little analysis

Figure 30: Formula to determine APEC tariff savings

Tariff savings for individual APEC economies are calculated by multiplying the import value of the HS codes from the future ICT products list and the top seven codes from emerging ICT products with their respective MFN tariff rates. Import value can be multiplied against tariff rates, as it is recorded as cost, insurance, and freight (CIF) value. Next, total tariff savings in APEC are calculated after summing up individual APEC economies' tariff savings (Figure 30)

- APEC growth in emerging ICT imports (47 HS codes) was determined by:



Source: Arthur D. Little analysis

Figure 31: Formula to determine APEC growth in emerging ICT imports

APEC's growth in emerging ICT (47 HS codes) imports was determined by multiplying APEC tariff savings for emerging HS codes with the price elasticity factor of ICT imports (Figure 31). The analysis was done separately for the top 40 HS codes from the future ICT products list and the top seven HS codes from the top 10 emerging ICT products, as the data extracted is from different years.

Synthesis:

Lastly, the focus of the emerging HS codes (47 HS codes) tariff savings analysis is intra-APEC, as the majority of the imports occur within APEC economies. This can be observed in both the future ICT products list (Table 28) and the HS codes directly linked to the top 10 emerging ICT products (Table 29):

- Future ICT products list, 2021 imports
  - APEC to the World (301 HS codes) – USD1.1 trillion (100 percent of 2021 imports)
  - APEC to APEC (301 HS codes) – USD0.9 trillion (76 percent of 2021 imports)
  - APEC and APEC (top 40 emerging HS codes) – USD0.5 trillion (42 percent of 2021 imports)
- HS codes directly linked to the top 10 emerging ICT products, 2022 imports
  - APEC to the World (12 HS codes) – USD5.7 billion (100 percent of 2022 imports)
  - APEC and APEC (12 HS codes) – USD3.9 billion (67 percent of 2022 imports)
  - APEC to APEC (top seven emerging HS codes) – USD3.8 billion (66 percent of 2022 imports)

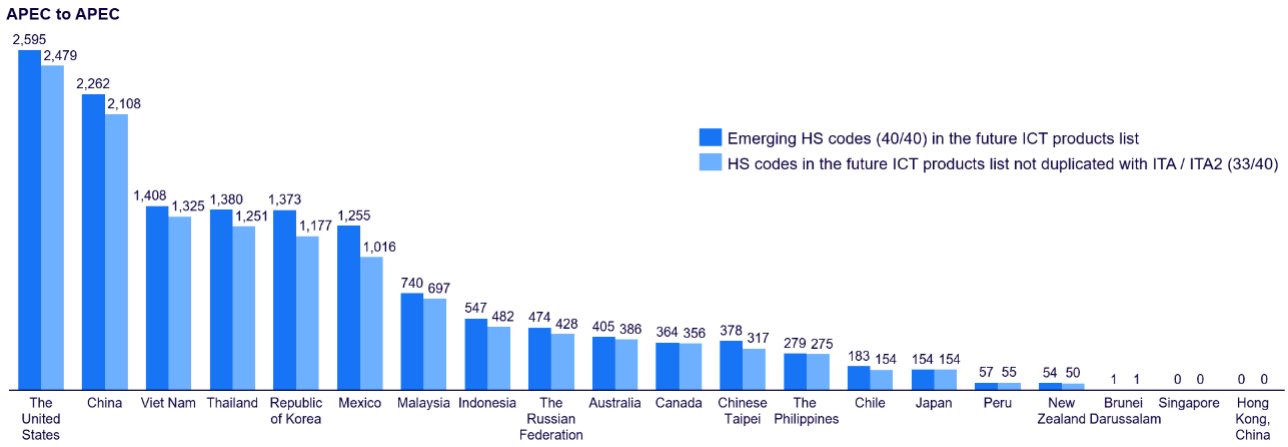
As the majority of the imports occur within APEC economies, the tariff savings for the top 40 HS codes from the future ICT products list (Table 32) and the top seven HS codes (Table 31) from the list of emerging ICT technologies between APEC and APEC economies were the focus area of the analysis.

Expanding further into the top 40 HS codes in the future ICT products list, seven HS codes were found to be duplicated with ITA or ITA2. The analysis focuses on overall tariff savings separated into two levels – all emerging future ICT products' HS codes (40 HS codes) and non-duplicated emerging future ICT products' HS codes (33 HS codes).

7.2 Findings from APEC tariff savings and growth in emerging ICT imports

7.2.1 APEC average effective tariff savings by MFN rate for emerging ICT HS codes

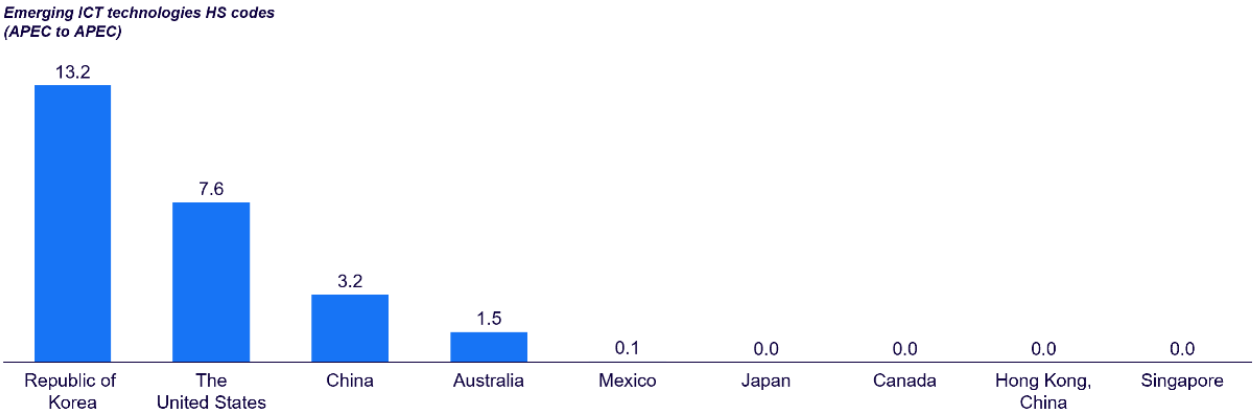
Through the analysis, APEC is expected to realize tariff savings of USD13.9 billion for the top 40 future ICT products' HS codes, and non-duplicated codes (33 HS codes) comprise USD12.7 billion, which is 91 percent of future ICT products' tariff savings. The full list of MFN tariff rates for the top 40 emerging future ICT products' HS codes by APEC economies can be found in the appendix (Table 33). If the tariff savings are calculated using a range of minimum to the average of trade agreement rates the tariff savings for emerging HS codes (future ICT product list) is between USD5.9 billion to USD10.1 billion.



Source: The United Nations Comtrade (UNComtrade), Trademap, Arthur D. Little analysis

Figure 32: APEC economies' tariff savings for top 40 future ICT products' HS codes by MFN rate in 2021, million USD

Further analysis into individual APEC economies' tariff savings for the top 40 emerging future ICT products' HS codes (Figure 32) shows that the top seven economies with the highest tariff savings (The United States; China; Viet Nam; Thailand; Republic of Korea; Mexico; and Malaysia) comprise 79 percent of future ICT products' tariff savings (top 40 HS codes). Additionally, Singapore and Hong Kong, China do not have tariff savings, as they are free trade zones that remove tariffs on imported goods.



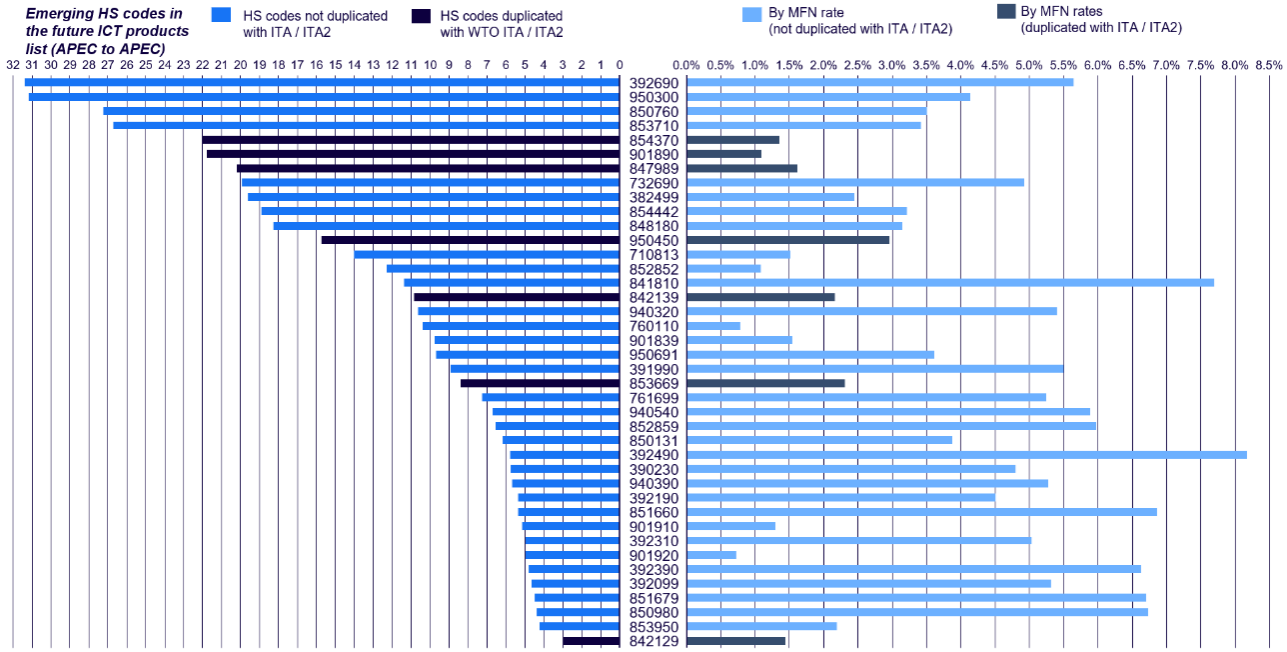
Source: The United Nations Comtrade (UNComtrade), Trademap, Arthur D. Little analysis

Figure 33: APEC economies' tariff savings on emerging ICT products in 2022, million USD

For emerging ICT products' HS codes, APEC is expected to realize tariff savings of USD25.6 million (seven HS codes). Further analysis into individual APEC economies' tariff savings on emerging ICT products (seven HS codes) reveals that the top three economies that have the highest tariff savings (Figure 33) include the Republic of Korea; the United States; and China. Japan and Canada have zero tariffs applied on these HS codes to other APEC economies for MFN rates, while Hong Kong, China; and Singapore are free trade zones, which remove tariffs on these HS codes when imported. The full list of MFN tariff rates for the

top 7 HS codes for emerging ICT products by APEC economies can be found in the appendix (Table 34). If the tariff savings are calculated using a range of minimum to the average of trade agreement rates the tariff savings for emerging ICT is between USD12.7 million to USD19.7 million.

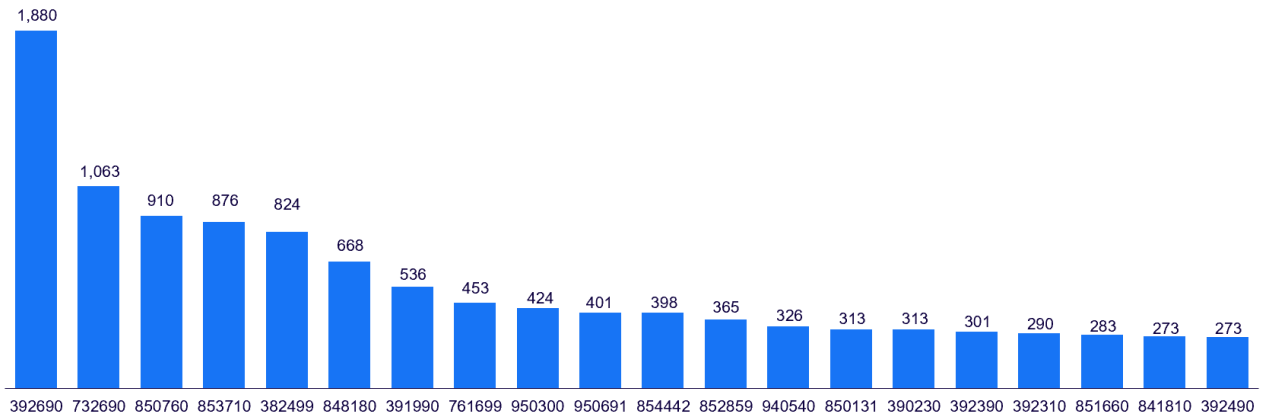
7.2.2 HS code level imports and tariff rates



Source: The United Nations Comtrade (UNComtrade), Trademap, Arthur D. Little analysis

Figure 34: Emerging future ICT products' HS codes, imports, and tariff rates by MFN rate, 2021, in billion USD and MFN rate, in %

Through analyzing import values and MFN rates for the top 40 emerging future ICT products' HS codes, the analysis found that seven duplicated HS codes had been included in the ITA or ITA2. As these duplicated codes have already enjoyed the benefits of lower tariffs from being included in the ITA or ITA2, they yield an immaterial impact of tariff savings of 9 percent. As seen in Figure 34, the MFN rates for duplicated codes are significantly less for the seven duplicated HS codes.

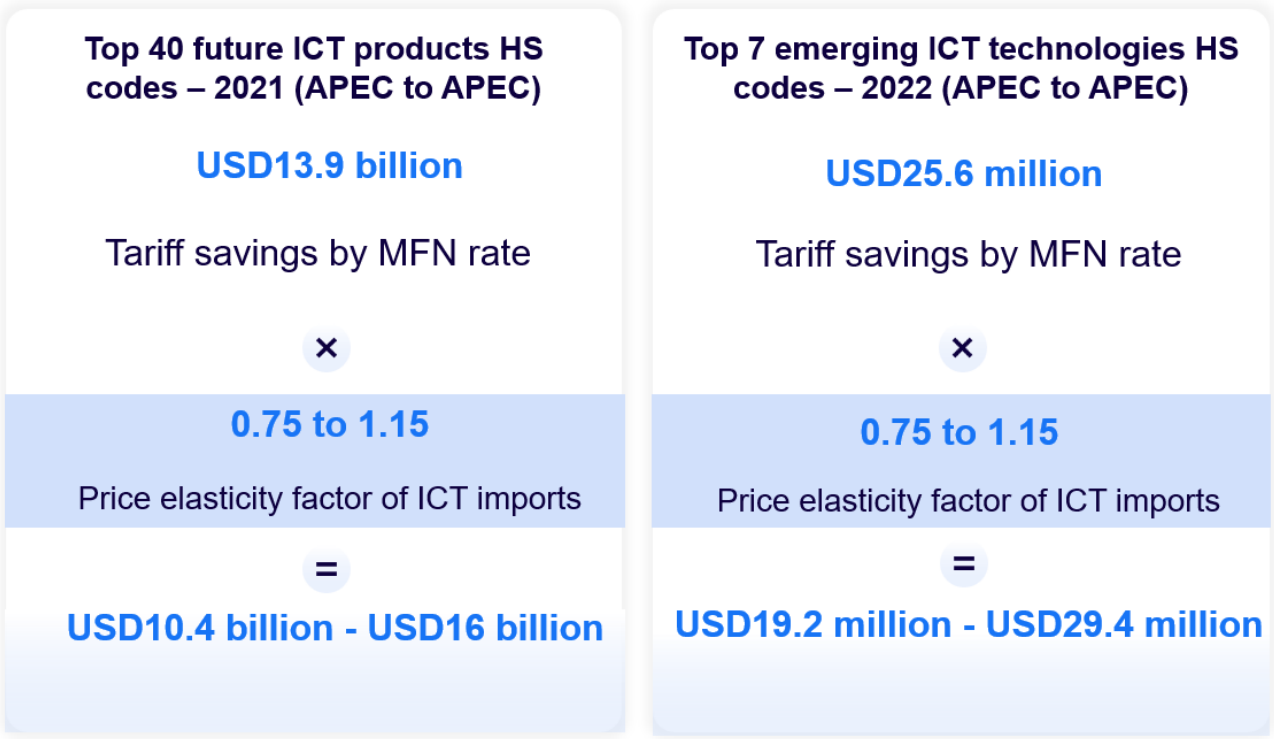


Source: The United Nations Comtrade (UNComtrade), Trademap, Arthur D. Little analysis

Figure 35: Top 20 non-duplicated HS code tariff savings by MFN rates, in million USD (Refer to Table 35 for detailed analysis)

Further analysis shows that the top 20 non-duplicated HS codes comprise 80 percent of emerging future ICT products' tariff savings (40 HS codes), while the top 10 non-duplicated HS codes comprise 58 percent of future ICT products' tariff savings (40 HS codes). Within the top 10 non-duplicated HS codes, the respective ICT products include lithium-ion batteries (850760), boards, panels, and consoles for electric control (853710), and parts of mobile phones (391990 and 761699).

7.2.3 APEC growth in emerging HS code imports



Source: The United Nations Comtrade (UNComtrade), Trademap, Arthur D. Little analysis

Figure 36: APEC growth in emerging HS code imports, in billion and million

Before calculating APEC growth in emerging HS code imports, the boundary conditions of the price elasticity of ICT imports need to be determined. Through the literature review[40], it is estimated that a 1 percent tariff reduction of ITA products would lead to a 0.7 percent to 0.8 percent increase in their imports. An additional report[41] also estimated that a 1 percent tariff reduction on products would cause a 1.1 percent to 1.2 percent increase in their imports. The boundary conditions of price elasticity of ICT imports were calculated using the average of these sources, in which a 1 percent fall in ICT price via removed tariffs induces a 0.75 percent to 1.15 percent increase in consumption of those goods.

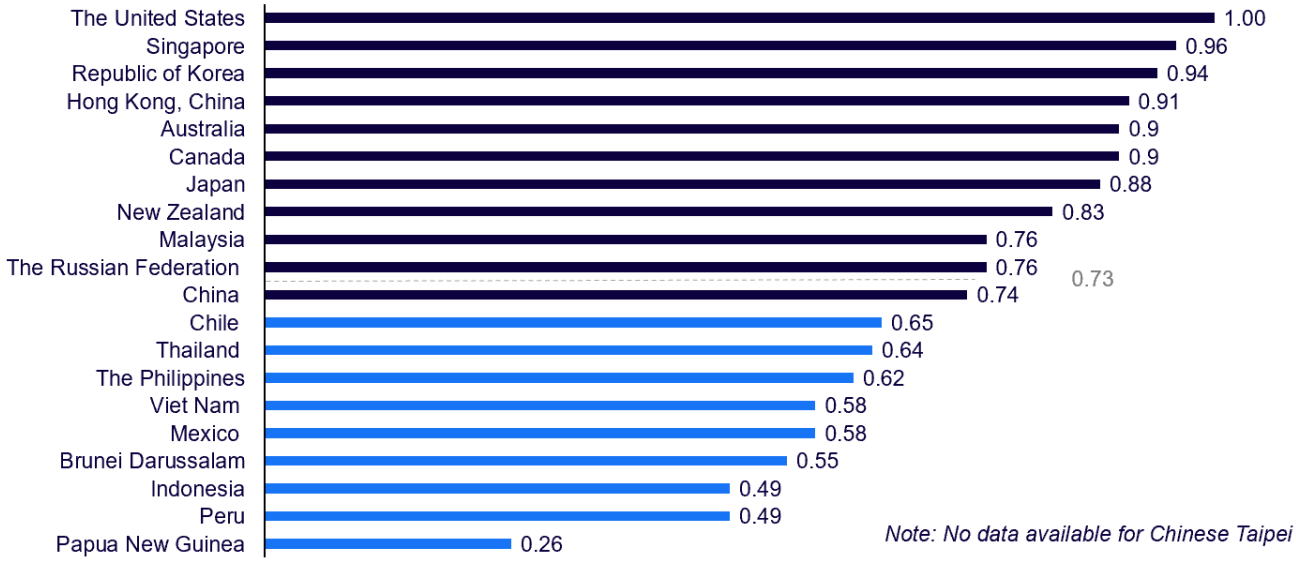
Eliminating tariffs lowers ICT prices, stimulates an increase in ICT consumption, and thus increases ICT imports. The analysis found that APEC's growth in emerging HS code imports by MFN rate is USD10.4 billion to USD6 billion for the top 40 HS codes extracted from the future ICT products list, and USD19.2 million to USD29.4 million for the seven HS codes extracted from the list of emerging ICT products. Even though the top seven emerging ICT HS codes only represent a relatively small increase in imports, they may have the potential for robust growth in the future. For example, favorable government policies on emerging ICT products, as seen in Chapter 8, could drive adoption of emerging technologies and create growth opportunities. Therefore, removing tariffs on emerging ICT HS codes can boost imports and facilitate more trade, which creates a potential multiplier effect for economic growth for APEC economies.

8. ICT policies and features in APEC

8. ICT policies and features in APEC

This section analyzes emerging ICT policies and features in APEC to understand how these economies intend to influence the growth of emerging ICT developments within their economy. The aim is to offer insights into the member economies' strategic priorities, initiatives, and investment costs associated with emerging ICT. These insights provide a view of how APEC economies intend to manage emerging ICT trade in the future.

8.1 Methodology



Source: United Nations Conference on Trade and Development (UNCTAD) Technology and Innovation report 2023, Arthur D. Little analysis

Figure 37: Overview of APEC Economies' ranking based on Frontier Technology Readiness Index

Through the first step, 11 APEC economies were identified, namely, the United States; Singapore; Republic of Korea; Hong Kong, China; Canada; Australia; Japan; New Zealand; The Russian Federation; Malaysia; and China, as the focus for analyzing emerging ICT policy and features. The frontier technology readiness index by UNCTAD was used as a baseline to identify economies' preparedness for frontier technologies. Economies that scored above the average of 0.73 were shortlisted (Figure 37). As these economies are ranked higher on the frontier technology readiness index, analyzing their policies would be a good representation of key technological features within APEC.

Table 5: List of overall strategy documents reviewed for each economy

Source: Secondary research, Arthur D. Little analysis

Economy	List of overall strategy documents	Year published
Australia[42]	Digital Economy Strategy 2030	2021
Canada[43]	Science, Technology, and Innovation Priorities	2022
China[44]	14th Five-Year Digital Economy Plan	2021
Hong Kong, China[45]	Hong Kong Innovation and Technology Blueprint	2022
Japan[46]	Digital Transformation in Japan	2022
Republic of Korea[47]	Roadmap of Digital ROK	2022
Malaysia[48]	Digital Economy Blueprint	2021
New Zealand[49]	2022–23 Action Plan for the Digital Strategy for Aotearoa	2022
The Russian Federation[50]	Digital Economy of the Russian Federation	2017

Singapore[51]	Smart Nation Strategy	2018
The United States[52]	Critical and emerging list update	2022

The second step determines each economy's emerging ICT priority areas through long-range strategy documents such as technology blueprints, digital economy plans, digital strategy, and transformation documents (Table 5). A long list of emerging ICT areas that each economy is inclined to prioritize was identified through these documents (Table 6)

Table 6: Overview of the 11 APEC economies and their area of focus for emerging ICT

Source: Secondary research, Arthur D. Little analysis

Economy	Area of Focus for Emerging ICT Technologies
Australia	Artificial Intelligence, Internet of Things, Data Analytics, Blockchain, Quantum Computing
Canada	Artificial Intelligence, Big Data Technologies, Drones, Next-Generation Communication Technology (e.g., 5G, 6G), Quantum Technologies (e.g., Quantum Computing, Quantum Sensing, Quantum Communications and Post-quantum Cryptography), Smart and Digital Manufacturing (e.g., Robotics, Embedded Sensors, 3D Printing)
China	5G, Metaverse, Quantum Computing, Artificial Intelligence, Big Data
Hong Kong, China	Artificial Intelligence, Blockchain, Internet of Things, Big Data
Japan	Artificial Intelligence, 6G Communication, Quantum Technologies
Republic of Korea	Artificial Intelligence, 5G and 6G communication, Quantum, Metaverse
Malaysia	Artificial Intelligence, Blockchain, Big Data, Internet of Things, Immersive Media (Virtual Reality and Augmented Reality), 3D Printing, Robotics
New Zealand	Artificial Intelligence, Internet of Things, Data Analytics, Blockchain, Quantum Computing
The Russian Federation	Artificial Intelligence, Big Data, Quantum Technologies, Robotics, New Production Technologies (i.e., Additive Technologies), Virtual and Augmented Reality Technology, Wireless Communication Technologies
Singapore	Artificial Intelligence, Immersive Media (VR, AR, MR, Metaverse), IoT, Robotics, Quantum Computing, Blockchain
The United States	Advanced Computing, Advanced Manufacturing Technology, Advanced and Networked Sensing and Signature Management, Artificial Intelligence, Robotics, Communication and Networking Technologies, Human-Machine Interfaces, Networked Sensors and Sensing, Quantum Information Technologies, Semiconductors and Microelectronics

Lastly, relevant documents and supplementary information on policies for emerging ICT were gathered from APEC economies that prioritized emerging ICT areas. These documents provided strategic priorities, initiatives, and investment costs associated with emerging ICT (Table 7).

Table 7: Documents referred to for each APEC economy, as well as their respective priorities for emerging ICT

Source: Secondary research, Arthur D. Little analysis

Economies	Documents referred	Areas of emerging ICT
Australia	• Australia's AI Action Plan	Artificial Intelligence
	• National Quantum Strategy	Quantum Technologies
	• National Blockchain Roadmap	Blockchain
Canada	• Pan-Canadian AI Strategy	Artificial Intelligence
	• Canada's Drone Strategy to 2025	Drones
	• National Quantum Strategy	Quantum Technologies
China	• Next-Generation Artificial Intelligence Development Plan	Artificial Intelligence

	• Action Plan for the Integration and Development of Virtual Reality and Industry Applications (2022–2026)	Immersive Media
	• Three-Year Action Plan for the Construction of New Infrastructure for the Internet of Things (2021–2023)	Internet of Things
	• 5G Application “Sail” Action Plan (2021–2023)	5G Communication
Hong Kong, China	• Hong Kong, China Innovation and Technology Development Blueprint • Development of Web3.0 Technologies	Blockchain
	• Licensing for Wireless Internet of Things (WIoT) • Initiatives by the Hong Kong, China Productivity Council	Internet of Things
	• Guidance on the Ethical Development and Use of Artificial Intelligence	Artificial Intelligence
Japan	• AI Strategy 2022	Artificial Intelligence
	• Quantum Technology and Innovation Strategy • Vision of Quantum Future Society • Strategy of Quantum Future Industry Development	Quantum Technologies
	• Beyond 5G Promotion Strategy – Roadmap towards 6G	6G Communication
Republic of Korea	• National Strategy for Artificial Intelligence • Digital New Deal	Artificial Intelligence
	• 6G R&D Implementation Plan • K-Network 2030 Strategy	6G Communication
	• Republic of Korea’s Quantum Science and Technology Strategy	Quantum Technologies
	• Digital New Deal 2.0	Metaverse
Malaysia	• National Internet of Things Strategic Roadmap	Internet of Things
	• National Blockchain Roadmap 2021–2025	Blockchain
	• National Artificial Intelligence Roadmap (referred to as AI-Rmap)	Artificial Intelligence
	• National Robotics Roadmap	Robotics
New Zealand	• Government Data Strategy and Roadmap 2021	Big Data
	• Government-published article: NZD5.1 million (USD3 million) for research into artificial intelligence to improve health outcomes • Government-published article: PlantTech Research Institute • Government-published document: Minute of Decision Update for Artificial Intelligence 2023 • Digital Technologies Industry Transformation Plan • 2022–23 Action Plan for the Digital Strategy for Aotearoa • Artificial Intelligence: Shaping a Future New Zealand	Artificial Intelligence
	• Lifting Connectivity in Aotearoa New Zealand	Internet of Things
The Russian Federation	• National Strategy for the Development of Artificial Intelligence	Artificial Intelligence
	• National Strategy for the Development of Additive Technologies	Additive Technologies
	• Roadmap for the Development of End-to-End Digital Technology – Virtual and Augmented Reality	Virtual and Augmented Reality

	• Roadmap for the Development of End-to-End Digital Technology – Quantum Technologies	Quantum Technologies
	• Roadmap for the Development of End-to-End Digital Technology – Robotics	Robotics
Singapore	• National AI Strategy • AI Singapore (AISG) National Program	Artificial Intelligence
	• IMDA IoT Policies • Technical References for IoT and Sensor Networks	Internet of Things
	• Robotics Program	Robotics
The United States	• American AI Initiative • National Artificial Intelligence R&D Strategic Plan • Developing AI Research Institutes to power responsible AI R&D	Artificial Intelligence
	• National Strategic Overview for Quantum Information Science • National Quantum Initiative Act • CHIPS and Science Act	Quantum Technologies
	• Comprehensive Framework for Responsible Development of Digital Assets	Blockchain
	• Future Advanced Computing Ecosystem Strategic Plan FY2022 Implementation Roadmap	Advanced Computing
	• National Strategy for Advanced Manufacturing	Additive Technologies

8.2 Summary of key takeaways

Through analyzing strategy documents on APEC economies' prioritized emerging ICT focus areas, emerging ICT policies were found to be centered around AI, quantum technologies, and IoT.

APEC economies have adopted AI strategies or comparable guiding policies to set strategic directions and initiatives to leverage the benefits of this ICT. These include AI-related priorities and goals and, in some cases, a detailed roadmap for achieving them. Many APEC economies see AI as a growth and innovation priority for their economy. Several common themes emerge when synthesizing the intent of these strategies as a whole:

- **Development of AI through R&D** – Many economies have a major focus on catalyzing economic development through R&D funding in AI, such as Singapore, which invested USD109 million in innovating AI solutions, and the United States, which invested USD140 million into AI research institutes. Similar funding efforts are taking place in the majority of the economies.
- **AI ethics-centered policies** – Most strategies also include provisions to ensure that AI systems are designed and implemented in an ethical and secure manner such as Australia, which aims to advance the implementation of Australia's AI Ethics Principles, and Hong Kong, China, which has released guidance on the ethical development and usage of artificial intelligence.
- **Move to commercialization** – Strategies have been put into place to set up the right infrastructure, such as education programs, research institutes, and incentives to promote the development and integration of AI. Economies such as Japan have promoted AI adoption in industries to enhance industrial competitiveness, while other economies, such as Canada; Malaysia; and New Zealand, have developed their AI talent pool.

Next, strategy documents for the Internet of Things were identified for approximately half of the shortlisted economies. APEC economies, ranging from advanced technology leaders to emerging economies, are harnessing the power of IoT to drive innovation, increase efficiency, and improve the quality of life for their citizens. In this aspect, they focus on:

- **Innovation through R&D** – Strategies have included policies to boost innovation, and economies such as China and Hong Kong, China have focused on R&D to create breakthroughs in innovation to develop domestic industries.
- **Improving quality of life** – Strategies have also been centered around developing economic prosperity for citizens or achieving economic growth. For example, New Zealand and Singapore aim to improve

convenience and connectivity for citizens, while Malaysia and China aim to use IoT as a source of economic growth.

Similarly, strategy documents for quantum technologies were found for approximately half of the shortlisted economies. APEC economies, spanning a spectrum of technological capabilities, are increasingly recognizing the potential of quantum technologies to revolutionize various sectors, from computing to security and defense. The majority of the economies are focused on:

- **Integration into critical industries** – Quantum technologies are revolutionizing advancements in security and defense applications, such as cryptography, cybersecurity, and enhanced sensors. Economies such as the Republic of Korea and Canada have put in place policies to promote integration of quantum technologies into defense and security systems.
- **Development of quantum technology infrastructure** – Economies have shaped their policies surrounding collaboration, R&D, and the development of a workforce that understands and leverages the benefits of quantum technology. For example, Japan and Republic of Korea hope to maintain active collaboration with leading quantum economies such as Europe and the United States. Conversely, Australia; the Republic of Korea; and the United States and aim to advance R&D and develop a talented quantum workforce.

8.3 APEC economies' polices on emerging ICT

Our final step involves synthesizing the findings from the literature review for each economy based on the policies found.

8.3.1 Australia

8.3.1.1 Artificial Intelligence

Artificial Intelligence (AI) Action Plan

Released in 2021 by the Ministry for Industry, Science and Technology, Australia's AI Action Plan[53] sets out the path that the Australian government plans to take to develop AI in the economy. The Action Plan includes a targeted AUD124.1 million (USD80 million) investment to strengthen Australia's leadership in developing AI. Australia aims to position itself as a worldwide frontrunner in the advancement and implementation of reliable, secure, and ethical AI technologies. The AI Action Plan was implemented under four focus areas:

- **Transforming businesses with AI** – Assist businesses in adopting AI technologies to boost productivity, create jobs and enhance competitiveness
  - Establish an AI Center, as well as four AI and Digital Capability Centers (AUD53.8 million [USD34 million])
  - Establish a program that will provide co-funded competitive grants to implement AI solutions in regional areas and raise awareness of AI's potential in addressing regional challenges (AUD12 million [USD8 million])
- **Attracting global AI talent** – Ensure that Australian businesses can access top-tier AI talent and expertise from around the world
  - Increase Australia's specialist AI talent using targeted scholarships through the Next-Generation AI Graduates program (AUD24.7 million [USD15 million])
  - AI research projects, linkages, and fellowships (more than AUD200 million [USD127 million])
- **Addressing challenges** – Leverage Australia's AI research capabilities to tackle domestic issues and ensure broad accessibility of AI benefits
  - Establish a Stronger Australia program aimed at collaborating with partners and developing AI solutions to tackle domestic issues (AUD33.7 million [USD21 million])
  - Transformative medical research projects using AI (AUD19 million [USD12 million])
  - Development of AI applications that can strengthen defense capabilities (AUD10 million [USD6 million])
- **Promoting responsible and inclusive AI** – Ensure that AI technologies are inclusive and aligned with Australian values, which is to strive for responsible and ethical AI leadership on a global scale
  - Advancing the implementation of Australia's AI Ethics Principles
  - Engage in global forums to shape AI discussions and policies for Australia

8.3.1.2 Quantum Technologies

National Quantum Strategy

In 2023, the Australian government published its National Quantum Strategy[54], which sets out a long-term vision of how Australia plans to harness the opportunities presented by quantum technologies. Australia's scope of quantum technologies includes quantum sensing, quantum computers, and communications.

Australia's quantum strategy is based on five themes:

- **Quantum advancements** – Further advancements in research and development, investments, and applications in quantum technologies
  - Design new programs to fast-track quantum projects to solve challenges, support initiatives that are focused on enhancing collaboration with strategic partners, and grow a pipeline of quantum companies and technologies for potential future investment through the AUD15 billion (USD10 billion) of the Reconstruction Fund
- **Infrastructure access** – Ensure availability and accessibility to crucial quantum infrastructure and materials
  - Conduct an audit of quantum-related research to identify capability gaps, and actively monitor supply chain challenges and opportunities
- **Quantum workforce** – Nurture a skilled and growing quantum workforce
  - Increase academic collaboration, release a quantum workforce report to identify workforce needs, integrate quantum science into education, and explore measures such as targeted incentives to attract global quantum talent
- **Standards alignment** – Establish standards and frameworks that align with and promote the member economy's domestic interests
  - Ensure regulatory frameworks are fit for purpose and explore options to strengthen collaboration with established partners
- **Ethical ecosystem** – Establish a quantum ecosystem characterized by trust, ethics, and inclusivity
  - Work with industry, academia, and states to develop principles, and ensure that Australia is actively represented in international quantum standards-setting bodies

8.3.1.3 Blockchain

National Blockchain Roadmap

Released in 2020 by the Ministry for Industry, Science and Technology, the National Blockchain Roadmap[55] outlines a comprehensive strategy for growth and development to elevate Australia's rapidly expanding blockchain industry to a global level. Australia has achieved six out of 12 signposts since the roadmap's launch in 2020 (Table 8):

Table 8: Australia's goals in blockchain technology

Source: Secondary research, Arthur D. Little analysis

Australia's goals from 2020–2025	Progress
Create a Blockchain Roadmap Steering Committee to oversee the strategic direction of blockchain adoption at a domestic level	Significant progress made as of 2023[56]
Formulate a collaborative framework involving industry, the research sector, and government, with working groups tasked to advance the examination of potential use cases	
Conduct an in-depth exploration of three specific use cases outlined in the roadmap – using blockchain in the agriculture, education, and financial sectors	
Establish and coordinate a network of government blockchain users	
Implement a capability development program aimed at fostering growth among Australian blockchain start-ups	
Forge strong partnerships with blockchain service providers to actively participate in the Business Research and Innovation Initiative (BRII) program	

Examine global examples to identify economies that have successfully employed blockchain technology to enhance the efficiency of government service delivery	Other signposts
Ensure the integration of blockchain into broader policy initiatives is aimed at enhancing management capabilities in the realm of digital technologies	
Collaborate with industry and education institutions in the creation of shared frameworks and course materials for blockchain certification programs	
Implement a blockchain-focused inbound investment program aimed at introducing prospective investors to opportunities in Australia	
Utilize established bilateral agreements to explore the possibility of initiating pilot initiatives or partnerships that integrate blockchain technology with other economies	
Collaborate with pertinent government departments to ensure that Australian enterprises can seamlessly integrate into the evolving digital trade infrastructure currently in development	

8.3.2 Canada

8.3.2.1 Artificial Intelligence

Pan-Canadian Artificial Intelligence (AI) Strategy

In 2017, the Government of Canada established the Pan-Canadian Artificial Intelligence (AI) Strategy and this was entrusted to the Canadian Institute for Advanced Research (CIFAR) to implement some elements of the Strategy, including the Canada-CIFAR AI Chairs Program. CIFAR received CAD125 million (USD93 million) in funding from 2017-18 to 2021-22 to implement the Strategy. The objectives of the first phase of the Strategy were:

- **Retain Talent** – Attract and retain top-tier AI talent within Canadian universities and industry, bolstering AI research capacity through a diverse range of training avenues
- **Increase Workforce** – Increase the number of post-graduate trainees and researchers in AI
- **Strengthen collaboration** – Create and promote collaboration across three National Artificial Intelligence Institutes: Amii in Edmonton, Mila in Montréal, and the Vector Institute in Toronto

Building on the success of the first phase of the Strategy, Canada's federal Budget 2021 renewed and expanded the Strategy CAD443 million (USD325 million) to a second phase. It is supported by three pillars[57] to facilitate the adoption of AI across Canada's economy and society. The second phase of the Strategy bridges Canada's world-class talent and research capacity with programs to enable commercialization and adoption to help ensure that Canadian ideas and knowledge are mobilized and commercialized here at home.

- **Commercialization**
  - **National Artificial Intelligence Institutes** – Support AI research-to-commercialization and foster business capacity for technology adoption through three institutes in Canada. CAD60 million (USD45 million) was provided in Budget 2021, and each institute eligible will receive up to CAD20 million (USD15 million) in funding from 2021-22 and 2025-26
  - **Canada's Global Innovation Clusters** – Boost Canada's innovation ecosystem with the adoption of homegrown AI tech by key businesses, as well in as the public and non-profit sectors. CAD125 million (USD93 million) in funding was provided in Budget 2021 over five years, from 2021-22 to 2025-26
- **Standards**
  - **Standards Council of Canada** – Promote the advancement and adoption of AI standards. CAD8.6 million (USD6 million) in funding was provided in Budget 2021 over five years, from 2021-22 to 2025-26
- **Talent and Research**
  - **Canada entrusted the CIFAR** to enhance efforts to attract, retain and develop research talent within three National Artificial Intelligence Institutes, supporting research and academic hubs. CAD208 million (USD155 million) in funding was provided in Budget 2021 over 10 years, from 2021-22 to 2030-31

- **Compute by the Digital Research Alliance of Canada** – Allocate specialized computing resources for AI researchers throughout. CAD40 million (USD30 million) in funding was provided in Budget 2021 over five years, from 2022-23 to 2026-27

The objectives of the Strategy's second phase are to:
- Continue advancing the objectives of the Strategy's first phase
- Support the commercialization of AI innovations and research
- Provide dedicated research computing capacity for AI researchers
- Advance the development and adoption of standards related to artificial intelligence

8.3.2.2 Drones

Canada's Drone Strategy to 2025

In 2021, Canada's Ministry of Transport unveiled a 2025 Drone Strategy highlighting five key priorities:
- **Support innovation through safety regulations** – Prioritize the development of regulations for lower-risk Beyond Visual Line Of Sight operations, which refers to the distance where drones operate outside the normally visible range, in rural and remote areas
- **Manage drone traffic** – Launch additional operational trials such as exploring options to remotely identify drones and establish a drone traffic management system
- **Understand and address drone security risks** – Focus on the aviation sector to understand the security threats and risks posed by drones
- **Support economic growth** – Continue to pursue partnerships to advance drone R&D, develop strategies to enable cutting-edge drone technologies that are ready to expand internationally, and work with stakeholders to develop an economic strategy to modernize the current framework
- **Increase public trust in drones** – Enhance comprehension of how the public perceives and embraces drones and collaborate with various government tiers to strategize for urban operations involving drones

In terms of Drone R&D activities, Transport Canada has been delivering on regulatory R&D priorities to address safety-critical questions scoped to inform regulatory developments and guidance materials. Through collaboration with research partners, Transport Canada coordinates a range of safety-critical research that supports the integration of drones to Canadian airspace while maintaining Canada's high civil aviation safety standards. These research projects range from studies on collision risks, operations in severe weather, cyber security, and command and control link integrity.

8.3.2.3 Quantum Technologies

National Quantum Strategy

On 13 January 2023, the Government of Canada announced a National Quantum Strategy[58] to ensure that Canadian scientists, researchers, and entrepreneurs are ready for the quantum era. Building on more than CAD1 billion (USD724 million) in investments in quantum research and science since 2012, the government has committed CAD360 million (USD261 million) over seven years, starting in 2021-22, to advance three missions in key areas of quantum technology:
- **Computer Hardware and Software –** To make Canada a world leader in the continued development, deployment and use of these technologies
- **Communications –** To provide Canada with a national network for secure quantum communications and post-quantum cryptography
- **Sensors** – To support Canadian developers and early adopters of new quantum sensing technologies

The missions will be achieved through investments in three pillars, and where security and intellectual property are cross-cutting themes of the strategy:
- **Research** – To support basic and applied research to realize new solutions and innovations
- **Talent** – To develop, attract and retain experts from Canada and around the world to build the quantum sector
- **Commercialization** – To transform research into scalable commercial products and services that will benefit Canadians, our industries and the world

For each of the strategy's missions, a comprehensive deployment plan will be implemented in collaboration with experts from academia and industry. These plans will include detailed objectives, milestones and actions required from academia, industry, not-for-profit organizations and government to achieve the objectives of each mission.

8.3.3 China

8.3.3.1 Artificial Intelligence

Next-Generation Artificial Intelligence Development Plan

In 2017, the Ministry of Science and Technology (MOST) introduced the Next-Generation Artificial Intelligence Development Plan[59], which outlines China's goals and strategies that it plans to undertake in the aspect of AI. The plan establishes three strategic goals for China:

- **Commercialization of AI** – Achieve global excellence in AI technology by 2020, making the AI industry a key driver of economic growth and improving people's lives, while fostering innovation and comprehensive prosperity
- **Advancement in AI** – Strive for major advancements in AI theories, leveraging AI to drive industrial upgrades and economic transformation while advancing the vision of an intelligent society by 2025
- **Global leadership** – Attain global leadership in AI theory, technology and applications, positioning China as a premier global AI innovation hub, and making substantial progress toward an intelligence-driven economy and society by 2030

To achieve these goals, China aims to accomplish the following tasks:

- **AI innovation system** – Set up and coordinate the development of the next-generation AI innovation system, and accelerate the cultivation of high-level AI talent
- **High-efficiency economy** – Vigorously develop AI enterprises and emerging AI technologies, build infrastructure for AI development, and establish a high-end environment for AI innovation
- **Safe intelligent society** – Develop convenient and efficient intelligent services, and use AI to promote intelligent social governance, protect public security, and promote mutual trust and sharing in society
- **Civil-military AI integration** – Deploy AI for civil-military sharing and set up communication mechanisms between education and research institutions with military institutes
- **AI infrastructure** – Upgrade network infrastructure and build efficient computing and big data infrastructure
- **Next-gen AI programs** – Establish domestic programs using next-generation AI as the core

In terms of resource allocation, China hopes to leverage existing resources such as capital and infrastructure, while strategically allocating resources for innovation domestically and internationally. A key priority is establishing AI innovation bases. China's strategy aims to create a new framework supported by fiscal, financial, and social capital to advance AI development.

8.3.3.2 Immersive Media

Action plan for the Integration and Development of Virtual Reality and Industry Applications (2022–2026)

In 2022, the Action Plan for the Integration and Development of Virtual Reality (VR) and Industry Applications (2022–2026)[60] was issued by the state to detail China's development goals until 2026, as well as the key tasks that China would like to take in the aspect of VR. By 2026, China hopes to achieve significant advancements in the key technologies of 3D, virtual and real fusion, immersive audio, and video, while enriching a new generation of human-friendly VR terminal products. The Action Plan proposes five key tasks:

- **Integration and innovation of key technologies** – Boost "Virtual Reality +" by advancing key technologies such as displays, rendering, interaction, and security. Integrate VR with 5G and AI
- **Improve supply capacity** – Enhance the industrial supply capacity of vital VR-related products. Improve comfort, user-friendliness, and safety of end products
- **Commercialization** – Integrate VR into industries such as manufacturing, tourism, education, sports, creativity, entertainment, safety, disability support and smart cities
- **Strengthen public service platforms for the industry** – Build public service platforms for technology support and integration of immersive content, as well as continuously support the development of the VR industry

- **Enhance industry standards** – Enhance industry standards, including those related to health and comfort, to support the VR ecosystem

8.3.3.3 Internet of Things

Three-year Action Plan for the Construction Of New Infrastructure for the Internet of Things (2021–2023)

In 2021, the Ministry of Industry and Information Technology introduced a Three-Year Action Plan for the Construction of New Infrastructure for the Internet of Things (2021–2023)[61]. The Action Plan aims to establish a comprehensive, efficient, and functional modern infrastructure system, advance the development of new IoT infrastructure, and harness the significant potential of the IoT in driving digital economic growth and facilitating modernization of traditional industries. China aims to build the new infrastructure for IoT in major cities in China and solidify the foundation for governance, digital transformation, and livelihood consumption by 2023. Additionally, China aims to meet the following targets:

- **Improve IoT innovation capabilities** – Elevate high-end sensors, IoT chips, and operating systems. Integrate IoT with 5G, AI, blockchain and big data
- **Improve industrial ecology** – Promote IoT enterprises that are capable of becoming leaders with a net worth exceeding 10 billion yuan. Foster domestic demonstration bases and expedite IoT industry growth
- **Accelerate the deployment of IoT** – Accelerate the deployment of sensing technologies in critical sectors, such as smart cities, intelligent transportation and construction. Encourage widespread adoption of Ipv6
- **Establish standards** – Enhance the IoT system by developing over 40 local or industry standards, establish IoT security measures, and create public service platforms for testing and talent development

8.3.3.4 5G Technology Adoption

5G Application Sail Action Plan (2021–2023)

In 2021, the Ministry of Industry and Information Technology introduced the 5G Application “Sail” Action Plan (2021–2023)[62]. China aims to meet the following targets by the end of 2023[63]:

- 40 percent user penetration rate for 5G for citizens
- 50 percent 5G network traffic access for total mobile internet access
- 35 percent transmittance penetration rate for large industrial enterprises
- 200 percent annual growth rate for 5G IoT end users
- 18 base stations per 10,000 people in the economy
- 3000 5G industry virtual private networks
- 100 5G application standards for each industry

Additionally, China aims to strengthen the 5G industry foundation:

- **Enhance 5G technology** – Strengthen research on system equipment, developing advanced base stations and consolidating mid-band 5G capabilities
- **Invest in 5G components** – Develop specialized 5G chips, and advance high-precision instruments while innovating in core devices
- **Expedite 5G consumer product development** – Encourage eSIM for wearables, and research on immersive tech such as VR

8.3.4 Hong Kong, China

8.3.4.1 Blockchain

Development of Web3.0 Technologies

In 2023, the Hong Kong, China government announced its plan to brace the development and adoption of Web 3.0[64], which includes blockchain technology, virtual assets such as cryptocurrency, non-fungible tokens (NFTs) and metaverse technologies. Hong Kong, China’s financial secretary announced in the 2023–2024 budget that the government plans to nurture a Web 3.0 ecosystem. It has allocated HKD50 million (USD 6 million) to accelerate the development of the Web 3.0 ecosystem through initiatives such as hosting key international seminars to encourage cross-sectoral business collaboration and organizing workshops for young people. Hong Kong, China has selected several technologies to prioritize blockchain development –

asset tokenization, decentralized finance, and decentralized autonomous organization. Some initiatives that the government has established include:

- Web3.0 Innovation Hub to support local innovators and attract international companies to settle in Hong Kong, China in 2023
- Shared blockchain platform in 2022 to facilitate government bureaus / departments in the development of blockchain applications
- Four pilot blockchain projects in 2020 to explore the applicability and benefits of blockchain technology for different e-government services. These projects include streamlining the process of transferring trademarks, enhancing the efficiency of preparing environmental impact assessment reports, optimizing pharmaceutical product traceability and enhancing monitoring of company filings

Hong Kong, China Innovation and Technology Development Blueprint

In 2022, the Hong Kong, China Innovation and Technology Development Blueprint[65] was released and established to formulate digitalization strategies and measures, with the government being at the forefront of adopting these technologies, including blockchain. The government plans to leverage advanced IT such as blockchain to implement and revamp over 100 digital government initiatives by the end of 2025 to provide more electronic government services for the convenience of the general public and business sector.

8.3.4.2 Internet of Things

Wireless Internet of Things (WIoT) Licensing

In 2017, the Communications Authority (CA) introduced a new licensing regime for the provision of WIoT platforms and services using the shared frequency band of 920 – 925 MHz. Since the services authorized under the WIoT License only support automated machine to machine type data communications, the CA adopted a licensing regime with less stringent regulatory control and lower license fees as compared with the current carrier license with a view to facilitating the development of these emerging and innovative services for the benefit of the Hong Kong, China community, paving the way for future IoT, 5G and smart city applications. The validity period of the WIoT License is five years and, subject to the discretion of the CA, may be extended for a further period of up to five years. As of 2023, four WIoT licenses had been issued[66]. Besides WIoT licensees, mobile network operators and mobile virtual network operators are authorized to provide WIoT services.

With the development of new mobile and wireless technologies, the number of WIoT devices connecting to public telecommunications networks is expected to increase in the future.

Commercialization of IoT

Hong Kong, China Productivity Council spearheads R&D to assist businesses in advancing their utilization of IoT applications, including providing[67]:

- **Automatic warehousing and logistics system** – Utilize advanced radio frequency identification (RFID) technology to enable a real-time track-and-trace capability
- **Real-time manufacturing tacking system** – Leverage mold and die location tracking to increase the traceability of production outputs
- **Location-based services and location analytics** – Use new wireless technologies and provide data analytics to enhance business opportunities; however this is only applicable to the retail, exhibition and tourism industries

8.3.4.3 Artificial Intelligence

Ethical Development Guidance on Artificial Intelligence

In 2021, the Office of the Privacy Commissioner for Personal Data, Hong Kong, China released guidance on the ethical development and use of AI[68], which outlines the ethical principles for AI. Organizations are encouraged to be accountable; be prepared for human intervention if the use of AI is assessed as high risk, transparent and interpretable; protect individuals' personal data; be fair to all individuals; ensure that AI provides only benefits to human beings, businesses and the wider community; and operate reliably. In addition, organizations are expected to formulate an AI strategy that outlines the intended uses and objectives of AI, while also demonstrating the commitment of the top management to the ethical development of AI.

8.3.5 Japan

8.3.5.1 Artificial Intelligence

AI Strategy 2022

Japan introduced the AI Strategy 2022 [69], which outlines its goals and action plans in the aspect of developing AI adoption in the economy. Japan's goals are:

- Establish a robust system and technological infrastructure capable of safeguarding lives and property during crises, such as pandemics and large-scale disasters
- Cultivate a workforce capable of thriving in the AI era and attract global talent
- Promote AI adoption in industries such as medicine and materials science to enhance industrial competitiveness
- Develop a framework to establish and operate a series of technological systems
- Establish international AI research, education and social infrastructure

To implement AI in society, Japan has adopted the following initiatives:

- **Technology integration** – Accelerate the development of technologies that can improve AI reliability by promoting integration between cybersecurity and AI
- **Data enhancement** – Enhance the data that is meant to support AI usage by improving the research database and facilitating effective use of confidential data
- **HR development** – Enhance efforts to secure human resources by creating educational opportunities
- **Government AI utilization** – Promote the use of AI in the government by introducing AI in government agencies
- **AI integration** – Integrate AI with fields where Japan has strengths to address challenges unique to Japan

8.3.5.2 Quantum Technologies

Strategy of Quantum Future Industry Development

In 2022, the Integrated Innovation Strategy Promotion Council released the Strategy of Quantum Future Industry Development, which outlines the strategic and initiative directions that the Japanese government would like to take in the aspect of quantum technology. Japan's future industrial directions[70] include the:

- **Participation, collaboration, and co-creation of diverse industries (software and hardware)**
  - Focus on the services sector, with active involvement from diverse users
  - Collaborate between hardware and system manufacturing and involve various industries, including small and medium-sized enterprises
- **Increase accessibility of quantum technology**
  - Make quantum technology accessible to all through user-friendly services that blend classical and quantum tech with a familiar interface
  - Prioritize hybrid quantum-classical systems to enhance capabilities, instead of fully transitioning to quantum-only systems. A hybrid quantum-classical system involves the integration of classical and quantum components, instead of solely relying on quantum
- **Creation and growth of start-ups, venture companies and new businesses**
  - Reinvest profits in quantum set-ups through the Venture ecosystem, foster tech-savvy entrepreneurs, and attract long-term investors to contribute resources to emerging technologies
- **Global collaboration and development**
  - Maintain active global collaboration and expand in Europe, the United States, and Asia to capture the global market
- **Promotion of industrialization through collaboration**
  - Bridge basic research and practical industry use; the Council for the Quantum STrategic industry Alliance for Revolution (Q-STAR) and the Quantum Technology Innovation Hubs (QIH) will collaborate systematically

Vision of Quantum Future Society

According to the Vision of Quantum Future Society released by the Integrated Innovation Strategy Promotion Council in 2022, Japan aims to reach these targets in 2030[71]:

- 10 million users of quantum technology in Japan
- Quantum technology to increase production value to JPY50 trillion (USD338 billion)

- Creating a quantum unicorn venture company that opens up the future

Quantum Technology and Innovation Strategy

In 2020, the Integrated Innovation Strategy Promotion Council released the Quantum Technology and Innovation Strategy, which details the vision and strategies that Japan aims to take for realizing quantum technology innovation. The main technology areas that Japan would like to focus on are quantum computers or quantum simulation, quantum communication, quantum measurement or sensing, and quantum materials[72].

8.3.5.3 6G Communication

In 2020, the Ministry of Internal Affairs and Communications released the Beyond 5G Promotion Strategy – Roadmap towards 6G[73], which details Japan's plans to ensure 6G adoption around 2030. The roadmap states a need for Japan to focus on improving the research and development capabilities for advanced technologies critical to Japan to ensure international competitiveness in the beyond-5G era.

According to the roadmap, Japan has three strategies to fulfill its goal, which include:
- **Market entry strategy** – To reduce supply chain risks and create market entry opportunities
  - Build infrastructure, enhance collaboration, and ensure that activities adhere to international standards
- **R&D strategy** – To create one of the world's best R&D environments
  - Create an environment that promotes R&D initiatives for 6G and roll out these technologies in the private sector
- **Rollout strategy** – To create an environment ready for Beyond 5G
  - Promote digitalization, and roll out 6G to the entire society and ensure its security

8.3.6 Republic of Korea

8.3.6.1 Artificial Intelligence

Digital New Deal

In 2021, the Republic of Korea released a Digital New Deal initiative[74] that was aimed at building a digital economy and heightening the competitiveness of the Republic of Korea and its industries by establishing digital infrastructure. Artificial intelligence was made a key element in three goals that were outlined:
- To enhance data collection, sharing and utilization in everyday sectors, strengthening the entire data life cycle of AI applications
- To apply 5G and AI to all sectors of industry, from primary and secondary to tertiary
- To create a personalized 5G and AI-driven government for faster public services

National Strategy for Artificial Intelligence

In 2019, the Republic of Korea released its National Strategy for Artificial Intelligence, which spells out its core strategies and action plans for the Republic of Korea to bolster the development of AI domestically and become the world leader in AI[75]. The Republic of Korea aims to focus on three main areas for AI and achieve these goals by 2030:
- **To innovate to ensure AI competitiveness and establish a global leading AI ecosystem**
  - Revamp AI infrastructure, fortify competitiveness in AI technology, revise laws, and cultivate global AI start-ups
- **To fully use AI to become the economy that makes the best use of AI, including improving the basic AI ability of people**
  - Nurture AI talent and raise public awareness of AI, integrate AI across all industry sectors, and establish an efficient digital government
- **To ensure harmony and coexistence with AI and realize people-centered AI**
  - Create an inclusive job safety network and establish AI ethics

The Republic of Korea's key strategy is to expand and improve data supply and demand generation systems that align with private sector needs. Additionally, the strategy involves securing substantial high-performance computing resources to facilitate data usage effectively, and establishing AI innovation clusters in major hubs throughout the economy to foster balanced development across the economy.

8.3.6.2 6G Communication

K-Network 2030 Strategy

In 2023, the Ministry of Science and ICT (MSIT) announced the K-Network 2030 Strategy[76], which is meant to help the Republic of Korea secure top-tier 6G tech, innovate software networks, and strengthen supply chains. The strategy outlines three action plans:

- **Ramp up innovation efforts for the next-generation network to become a market leader**
  - Advancement in 6G R&D – MSIT will take a leading role in contributing to Asia-Europe research will share the Republic of Korea's policy experiences
- **Build a more robust and safe network infrastructure**
  - Expand the use of Wifi 6E and promote evolution to Wifi 7 in 2024
  - Secure AI chip technology for communication and use the technology to pursue low-power networks
- **Create a more robust and competitive ecosystem for the industry**
  - Address the weaknesses of domestic small and medium-sized network equipment manufacturers, and establish a supportive ecosystem for the emerging OpenRAN equipment industry
  - Actively participate in discussions on reshaping the global supply chains to support the economy's network equipment export and expand Korean companies' presence in the global market
  - Nurture talent to lead next-generation network innovation

6G R&D Implementation Plan

In 2021, the Republic of Korea's Ministry of Science and ICT (MSIT) unveiled a five-year plan for the development of core technologies for 6G – the 6G R&D Implementation Plan. 6G includes having intelligent wireless access and networking, having space mobile communications and communications, and having wireless and optical communication at a maximum of 1tbps speed. The Republic of Korea intends to take the lead in rolling out 6G technology, and plans to implement the following actions[77]:

- Secure the next-generation key original technologies
- Gain dominance in international standards and patents
- Lay the foundation for 6G research and industry

Additionally, the government pledges to spend KRW220 billion (USD193 million) on development of core technologies for 6G.

8.3.6.3 Quantum Technologies

Republic of Korea's Quantum Science and Technology Strategy

In 2023, the Ministry of Science and ICT (MSIT) announced the Republic of Korea's Quantum Science and Technology Strategy[78], which is the first domestic strategy that encompasses the medium- to long-term vision and comprehensive development strategy for quantum science and technology. The Republic of Korea aims to become the global hub for the quantum economy in 2035, through these seven major strategic directions:

- **Develop talent** – Secure quantum experts (the highest priority) by establishing new departments in the field of quantum science and technology
- **Secure resources** – Promote mission-oriented research and development by securing core technologies for developing a universal quantum computer based on superconductivity and a 100-km-scale quantum network in the 2030s
- **Develop facilities** – Enhance quantum research and industrial infrastructure by expanding open quantum lab facilities
- **Nurture businesses** – Establish an industrial foundation for the quantum economy by focusing on nurturing quantum businesses
- **Strengthen security** – Integrate defense and security systems when advancing Korean algorithms to prepare for cyber security challenges
- **Develop alliances** – Secure global quantum leadership by enhancing technological alliances with quantum-leading economies such as the United States and the European Union at the domestic level
- **Establish funding** – Establish a sustainable support system by striving for more than KRW3 trillion (USD2 million) investment in joint support from the government and private sector

8.3.6.4 Metaverse

Digital New Deal 2.0

In 2022, the Ministry of Science and ICT (MSIT) announced a pan-government strategy on the metaverse, which is aimed at helping the Republic of Korea better respond to disruptive innovation and emerging ICT, as well as to be better prepared for the future. The Republic of Korea's metaverse strategy focuses on four main subjects[79]:

- **Metaverse ecosystem** – Reinvigorate the metaverse platform ecosystem and foster an environment for metaverse platforms to grow
- **Talent development** – Nurture experts and talent in the metaverse field, provide people with opportunities to access the metaverse, and participate in a variety of metaverse events
- **Infrastructure support** – Nurture leading companies specializing in metaverse by providing metaverse infrastructure such as funding and metaverse demonstration facilities
- **Ethical standards** – Create an exemplary metaverse world by setting ethical principles for the metaverse

The Ministry has announced plans to invest KRW223.7 billion (USD177 million) to foster a metaverse ecosystem[80]. The Ministry plans to use the investment cost on:

- **Integrated metaverse development** – Create metaverse platforms catering to industrial integration and everyday life and economy (KRW34 billion [USD25 million])
- **Metaverse academy and training** – Establish a Metaverse Academy for young developers and creators (KRW4.6 billion [USD3 million])
- **Metaverse labs support** – Support the operation of 10 Metaverse Labs (KRW2.4 billion [USD2 million])
- **Metaverse graduate programs** – Establish metaverse-focused graduate programs (KRW1 billion [USD1 million])
- **Metaverse hub operations** – Operate a domestic Metaverse hub in Pingyao (KRW6.7 billion [USD5 million])
- **Metropolitan metaverse hubs** – Create two specialized metropolitan metaverse hubs (KRW2 billion won [USD2 million])
- **Expanding infrastructure** – Link metaverse-related facilities (KRW18.1 billion [USD13 million])
- **Metaverse content support** – Support domestic metaverse content development (KRW9.6 billion [USD7 million])
- **Immersive technology investment** – Invest in XR twin technology [KRW7.2 billion [USD5 million]], VR/AR device core technology (KRW11.2 billion [USD8 million]), immersive technology core technology (KRW25.9 billion [USD19 million]), and hologram core technology (KRW25.2 billion [USD19 million]) development
- **Overseas expansion consulting** – Offer customized overseas expansion consulting for domestic digital content companies (KRW11.2 billion [USD8 million])

8.3.7 Malaysia

8.3.7.1 Internet of Things

National Internet of Things Strategic Roadmap

Published in 2014 by MIMOS, the National Internet of Things Strategic Roadmap[81] details the Malaysian government's goals and strategies regarding the IoT. The document aims to realize the vision of Malaysia as the premier regional IoT development hub, with the mission of creating an ecosystem to enable the proliferation of use and industrialization of the IoT as a new source of growth for the economy. Overall, Malaysia hopes to achieve the following three goals:

- **Create a conducive IoT industry ecosystem**
  - Formulate an interoperability framework to streamline diverse standards and technologies for rapid IoT development, establish a centralized regulatory body for addressing privacy and security concerns, and foster strategic collaborations between multinational corporations and local entities to promote the development, diffusion and adoption of IoT technologies
- **Strengthen technopreneur capabilities in the applications and services layer**
  - Empower small and medium enterprises (SMEs) as IoT enablers for globally competitive products, promote generic solutions across industries, initiate flagship projects to support start-ups, and nurture IoT talent

- **Establish Malaysia as the regional development hub for IoT**
    - Establish Malaysia as the top choice for global IoT outsourcing services, create an integrated center for IoT solutions with facilities for testing and development, and leverage the local market's complexity to showcase cutting-edge IoT technologies

In the short term, Malaysia plans to emphasize the transformation of SMEs and alignment of IoT initiatives through pilot projects. Looking further ahead (beyond 2020), the roadmap envisions the creation of an IoT-driven Malaysia, establishment of an open innovation framework, and development of an open community data framework as part of its long-term strategies.

8.3.7.2 Blockchain

National Blockchain Roadmap 2021–2025

Published by the Ministry of Science, Technology and Innovation (MOSTI), the National Blockchain Roadmap 2021–2025[82] outlines the framework and structure of the implementation of blockchain in Malaysia. This document is meant to aid Malaysia in embracing blockchain 2.0 and solidifying its leadership position in the blockchain domain to enhance economic competitiveness and foster growth. Malaysia will focus on asset tracking, document management, and workflow optimization regarding blockchain. Malaysia's blockchain strategy is shaped by the following:

- **Enable blockchain growth** – Create a business-friendly environment conducive to sustainable blockchain system growth through government-to-government and multi-level agency collaboration
- **Empower developers for innovation** – Offer learning opportunities to the developer community to work on cutting-edge technologies and foster innovation through the implementation of government-led projects such as the Blockchain Acceleration Hub
- **Cultivate digital tech talent** – Nurture multidisciplinary digital technology expertise through market-relevant courses
- **Drive transformation with transparency** – Facilitate transparency such as catalyzing innovation through regulatory amendments and establishing a legal framework for data standardization
- **Accelerate technology innovation** – Accelerate schemes to encourage Malaysian technology companies to become more innovative in adapting existing technologies and creating new ones, such as ensuring reliable internet connectivity and accelerating financial facilities

8.3.7.3 Artificial Intelligence

National Artificial Intelligence Roadmap (AI-Rmap)

MOSTI published the National Artificial Intelligence Roadmap (referred to as AI-Rmap)[83] in 2021, detailing Malaysia's strategic vision for harnessing and propelling its AI capabilities over the next five years, from 2021 to 2025. The roadmap aspires to transform Malaysia into an economy where AI plays a pivotal role in augmenting jobs, enhancing competitiveness, and encouraging innovation and entrepreneurship, ultimately leading to economic prosperity, societal benefits, and improved well-being for its people. The overarching goal is to establish a thriving AI ecosystem in the economy, ensuring that everyone, including the government, businesses, and citizens, can safely harness the benefits of AI. The roadmap sets a five-year objective to create a self-sustaining AI innovation ecosystem based on quadruple helix collaboration guided by Responsible AI Principles. The roadmap has outlined six key strategies that Malaysia plans to take:

- **Establish AI governance** – Implement a digital platform for committee interaction, and institutionalize cybersecurity policies, AI principles, and clear guidelines for government data sharing to facilitate AI implementation
- **Advance AI R&D** – Promote AI adoption in R&D across various fields, institutionalize and leverage AI within all research institutes
- **Escalate digital infrastructure to enable AI –** Promote the adoption of cloud computing and storage for AI, encourage data sharing, and improve network connectivity to broaden access to AI digital infrastructure
- **Foster AI talent –** Provide inclusive AI education, reskill and upskill the existing workforce, and attract or retain AI talent
- **Acculturate AI –** Cultivate AI awareness and accelerate its adoption
- **Kickstart an AI innovation system in their economies –** Implement proposed AI use cases that emphasize AI-driven supply chains, establish a collaborative platform for AI R&D, and engage with global knowledge and innovation networks to advance AI development

Malaysia's AI use cases are in its critical priority areas, which include agriculture, forestry, medical and healthcare, smart cities and transportation, and education and public services, to drive progress and innovation across key sectors.

8.3.7.4 Robotics

National Robotics Roadmap

MOSTI published the National Robotics Roadmap[84], detailing Malaysia's strategic vision for harnessing and propelling its robotics capabilities over the next 10 years, from 2021 to 2030. The roadmap aspires to establish Malaysia as a prominent regional hub for robotics in key sectors by 2030. Malaysia's overall goal is to strengthen its robotics ecosystem and accelerate the development of homegrown technologies and innovations. Malaysia plans to focus on its high-impact sectors: service, agriculture, and manufacturing. To achieve these objectives, Malaysia has planned for five main strategies:

- **Develop sustainable ecosystem and governance**
  - Institutionalize governance for robotics and nurture an integrated robotics ecosystem
- **Nurture and develop industry-ready talent for robotics**
  - Ensure long-term commitment to developing the robotics supply chain, strengthen a certification pathway for robotics professionals, and nurture interest in robotics
- **Advance and intensify research, development, commercialization, innovation and the economy**
  - Utilize robotics in Malaysia's priority areas, promote research collaboration, elevate and strengthen local robotics research, incentivize companies producing robotics-related products, obtain foreign domestic investment for high-potential robotics business, strengthen Malaysia's robotics exports through participating in regional sandboxes, and facilitate the adoption of robotics among local business enterprises
- **Strengthening standards, safety and regulation**
  - Review and coordinate the current robotics standards and nurture awareness among enterprises on the importance of adopting robotics standards
- **Mitigate socio-economic issues**
  - Empower women toward adoption of robotics, utilize robotics to improve quality of life and solve poverty challenges, and increase awareness of the benefits of robotics to the public

8.3.8 New Zealand

8.3.8.1 Big Data

Government Data Strategy and Roadmap 2021

In 2018, the New Zealand government published the Government Data Strategy and Roadmap 2021[85] to outline New Zealand's focus areas and roadmap. The New Zealand government aims to create an inclusive and integrated data system that supports innovation safely, and would like to focus on the following:

- **Data capture** – Provide the right data by ensuring current and future data needs across the data system are captured
- **HR development** – Develop capabilities and skills within people to create, collect, manage and use data
- **Develop guidelines** – Ensure leadership, transparent guidelines, and clear system settings are put in place
- **Build infrastructure** – Build the infrastructure that allows for efficient data management and the ability to reuse data effectively
- **Security** – Ensure that the information provided to the government will be gathered, handled and employed in a secure and responsible manner

8.3.8.2 Artificial Intelligence

Overview of Artificial Intelligence Strategy

In 2018, AI New Zealand Forum released an analysis report, Artificial Intelligence – Shaping a Future New Zealand[86], which provides recommendations for New Zealand's next steps regarding AI, including crafting an AI strategy, fostering awareness of AI, facilitating its adoption, enhancing access to reliable data, expanding the AI talent pool, and adjusting to its impact on legal, ethical and societal aspects.

New Zealand's plans include:

- Development of a cross-agency work program on AI by early 2024[87], as stated in a 2023 AI update by MBIE
- Establish a Center for Data Ethics by 2025[88] to develop ethical principles for AI, as stated in the 2023 Digital Technologies Industry Transformation Plan
- Advance an AI strategy, and ensure that all AI innovation and adoption across New Zealand is done safely and ethically[89], as stated in the 2022–23 Action Plan for the Digital Strategy for Aotearoa

New Zealand has invested NZD8.425 million (USD5 million) in the PlantTech Research Institute to expedite progress in innovation and discover solutions to horticultural challenges[90], and awarded NZD5.1 million (USD3 million) to explore how AI could enhance healthcare accessibility[91] in 2022.

8.3.8.3 Internet of Things

In 2022, the Ministry of Business, Innovation and Employment published a government statement of intent for improving digital connectivity – Lifting Connectivity in Aotearoa New Zealand[92]. The document outlined New Zealand's government priorities and strategic directions to make broadband and voice connectivity available for all citizens. In terms of promoting IoT, the government is expected to play an educational role and will focus on raising awareness of the opportunities of wireless extension technologies, while exploring various options to optimize capabilities and deliver cost-effective local solutions. IoT has since been deployed in the energy sector, agriculture, and healthcare. Additionally, New Zealand hopes to achieve the following goals by 2032:

- For every rural and remote resident to have the connectivity they need to access IoT
- Have a resilient telecommunication network that can withstand damage and restore IoT services quickly

8.3.9 The Russian Federation

8.3.9.1 Artificial Intelligence

National Strategy for the Development of Artificial Intelligence

Approved in 2019, the Russian Federation released the National Strategy for the Development of Artificial Intelligence[93], which outlines a comprehensive vision for the economy's AI development until 2030. This strategy defines clear goals and objectives for advancing AI within the Russian Federation, as well as measures aimed at safeguarding the economy's interest and priorities in the realm of scientific and technological development.

The overarching objectives of the Russian Federation's AI development strategy encompass improving the well-being and quality of life of the Russian population, bolstering security, upholding the rule of law, and positioning the Russian economy as a global leader in AI. To achieve these goals, the strategy focuses on six primary objectives:

- **Research support** – Support scientific research to ensure rapid development of AI
- **Software engineering** – Engineer and develop software that employs AI technologies
- **Quality of life** – Increase the availability of AI and improve quality of life using AI technologies
- **Hardware availability** – Increase the availability of hardware needed to solve problems
- **Talent development** – Increase the extent to which the Russian AI technology market is provided with qualified personnel, as well as the level of public awareness of potential areas of use
- **Regulatory framework** – Create an integrated system for regulating the social relations arising in line with the development and use of AI technologies

Additionally, the Russian Federation has committed to the following strategies:

- **Job creation** – Create new, high-productivity jobs related to AI and increase the level of employment of the populace
- **Competitive compensation** – Assure competitive financial remuneration of specialists in the field of AI and create conditions that are favorable for their work
- **Talent attraction** – Assure conditions are met to attract the best specialists in the field of AI
- **Global promotion** – Support the export of Russian products created using AI and their promotion in the global market
- **R&D incentives** – Create incentives for research and development in the field of AI

- **Security measures** – Put together an integrated security system during the creation, development, introduction and use of AI technologies

8.3.9.2 Additive Technologies (3D Printing)

National Strategy for the Development of Additive Technologies

Established in 2021, the National Strategy for the Development of Additive Technologies[94] in the Russian Federation for the period up to 2030 delineates the core facets of state policy within the additive technologies industry. Additive manufacturing includes 3D printing and is defined as:

- **Universal additive equipment** – Equipment that is manufactured to solve problems by different consumers in different industries
- **Specialized additive equipment** – Equipment that is manufactured to solve a highly specialized, specific task of a particular consumer

The strategy's overarching aim is to stimulate the expansion of the Russian additive technologies market, covering equipment, components, materials, services and software. Central to this effort is the development of competitive additive equipment and materials rooted in Russian technical innovations, along with the creation of software to support the economy's projects. The strategy also seeks to establish domestic dominance in the additive technologies market, with strong emphasis on significantly boosting exports of additive equipment and components. The Russian government has outlined its plans in three stages:

- **2021–2022** – Increase the share of Russian additive equipment, services and materials in the additive technology industry in the domestic economy
- **2023–2025** – Promote Russian products and services of additive technology, as well as services of the additive technology industry, and access to new international economies
- **2026–2030** – Ensure sustainable growth in the additive technologies industry and its leadership position in promising economies

8.3.9.3 Quantum Technologies

Roadmap for the Development of End-to-End Digital Technology – Quantum technology

In 2019, the Russian Federation released the Roadmap for the Development of End-to-End Digital Technology – Quantum Technologies[95], which details the economy's strategic directions, targets and action plans regarding quantum. The program proposed a total budget of RUB51.1 billion (USD0.5 billion). The Russian Federation defines quantum technologies as quantum computing, quantum communications, and quantum sensors. The Russian Federation aims to obtain world-class results in these technologies by supporting research and launch of infrastructure projects in its economy, as well as implementing organizational measures to overcome obstacles. The roadmap proposes the following:

- **Breakthroughs in quantum tech** – Provide comprehensive support for the breakthrough of scientific and technological projects aimed at developing quantum technologies
- **Global scientific collaboration** – Consolidate the scientific and technological community around the creation of domestic and global projects
- **Innovation ecosystem** – Create an innovation ecosystem in the economy and facilitate the transition of quantum developments into society
- **Collaboration with users** – Facilitate organization cooperation between research divisions and potential consumers of quantum technologies
- **Quantum workforce development** – Develop human resources in the field of quantum technologies
- **Streamline procedures** – Execute a set of organizational measures to reduce bureaucratic friction

8.3.9.4 Robotics

Roadmap for the Development of End-to-End Digital Technology – Robotics

In 2019, the Russian Federation released the Roadmap for the Development of End-to-End Digital Technology – Robotics[96], which details its goals and Action Plan regarding robotics. The Russian Federation committed RUB50.7 billion (USD0.5 billion) to support this, aiming to achieve the following:

- Develop and implement algorithms and technologies that facilitate human-machine interaction
- Develop and implement technologies that facilitate sensory-motor coordination and spatial positioning
- Develop technologies required for sensors and sensory information processing

8.3.9.5 Virtual and Augmented Reality

In 2019, the Russian Federation released the Roadmap for the Development of End-to-End Digital Technology – Virtual (VR) and Augmented Reality (AR)[97], which details its strategic direction and targets regarding VR and AR. The Russian Federation aims to occupy more than 15 percent of the market share of the global VR or AR industry by 2024. It also aims to ensure its technological leadership by using VR or AR to generate positive social impact such as increasing the quality of health care and creating services for socially important areas, as well as facilitating digital transformation in relevant industries. Priority areas include education and corporate training, industry and construction, healthcare, and mass consumer services. The Russian Federation plans to provide the following:

- Grant support to enterprises to facilitate usage of VR and AR
- Support projects for digital transformation of priority industries
- Provide subsidies to credit institutions providing preferential loan rates for scaling and replicating projects

8.3.10 Singapore

8.3.10.1 Artificial Intelligence

Artificial Intelligence (AI) Strategy

In November 2019, Singapore released its strategy for Artificial Intelligence – the Artificial Intelligence (AI) Strategy[98], which spells out Singapore's plans to deepen the use of AI technologies for Singapore to become a leader in developing and deploying scalable and impactful AI solutions by 2030. Singapore's objectives are to:

- **Become an innovation hub for AI solutions** – A hub that can develop, test-bed and scale these solutions
- **Generate economic gains –** For governments and businesses to benefit from the use of AI
- **Increase AI awareness** – For Singaporeans to understand AI technologies and the benefits they can bring

Additionally, the Singapore government will focus on driving AI deployment in the following nine sectors: transport and logistics, manufacturing, finance, safety and security, cybersecurity, smart cities and estates, healthcare, education, and government. Singapore has already committed over SGD500 million (USD366 million) for AI-related research and innovation under the Research Innovation Enterprise Plan (RIE 2020).

AI Singapore (AISG)

Established by the member economy's research foundation in 2017, AI Singapore (AISG)[99] is a domestic program for AI that brings together Singapore researchers and companies to jointly develop innovative AI solutions and grow a pipeline of AI talent for industry. Up to SGD150 million (USD109 million) will be invested over five years by the NRF. AISG work is anchored on five key pillars:

- **AI Research** – Research fundamental AI techniques and ideas to ensure SG's relevance in the global AI race
- **AI Governance** – Research in governance, ethics and accountability of AI systems at the domestic level
- **AI Technology** – Mount domestic challenges in applied AI that are aligned with the AI Strategy
- **AI Innovation** – Accelerate industry adoption of AI with industry-focused programs and talent deployment
- **AI Products** – Develop open-sourced AI products and frameworks to accelerate AI adoption by the industry, and establish generational AI capability programs to build AI-aware and AI-ready talent

8.3.10.2 Internet of Things

IMDA IoT Policies

In 2022, IoT was identified as a key frontier technology for development in Singapore by Singapore's official media authority, Infocomm Media Development Authority (IMDA). Singapore plans to use it for[100]:

- **Economic reasons** – Increase productivity through operational efficiency and address manpower shortage
- **Societal reasons** – Optimize healthcare delivery and offer lifestyle convenience

- **Safety and security** – Improve food safety by using IoT to provide accurate information on food inventory items, as well as safeguard Singapore's security

IMDA is also currently working on the following to grow the IoT ecosystem in Singapore:
- **Catalyzing NB-IoT development** – Create affordable and durable sensors for diverse applications
- **Developing IoT clusters** – Partner with industry leaders to foster local and multinational collaboration
- **Enabling the IoT ecosystem** – Craft policies for data security and cyber threat management

To establish open standard interfaces between devices and systems, and lower the expenses associated with deploying, operating, and maintaining sensor applications, IMDA has introduced Technical References for IoT and sensor networks.[101] Some examples of references include:
- **Sensor Network (public areas)** – Framework and standards aimed at facilitating the development and deployment of sensor networks in public areas across Singapore
- **IoT reference architecture** – A collection of international or industry standards that are needed to ensure information and service interfaces are interoperable and able to support various applications across multiple industries
- **IoT information and services interoperability** – Specifies a technology-independent reference architecture to ensure interoperability among IoT and sensor networks, and to facilitate seamless data exchange and information usage through well-defined interfaces
- **Guidelines for IoT security** – Introduces essential IoT security concepts and outlines an approach to address threats and vulnerabilities in IoT

8.3.10.3 Robotics

Robotics Program

Established in 2016, Singapore's Robotics Program[102] is a multi-agency government initiative that encompasses the entire spectrum of robotics development, from funding, research and development (R&D) to fostering partnerships aimed at translating and adopting innovative solutions for maximum socio-economic impact. The program aspires to cultivate a dynamic and inventive robotics ecosystem, one capable of delivering cutting-edge solutions to solidify Singapore's position as a global hub for the study, research, development, manufacturing and application of robotics solutions. Singapore is keen to develop its domain sectors (healthcare, built environment and environmental services) through robotics R&D, and directs its two funding initiatives – Robotics Enabling Capacity Technology (RECT) and Robotics Domain Specific (RDS) [103] – to these areas. The RECT focuses on building robotics technologies use cases, while the RDS co-funds projects with public agencies to innovate robotic solutions. For example, through the RDS funding initiative, the built environment robotics R&D program was established to focus on advancing the use of automation in manufacturing, improving on-site productivity through robotics in assembly, and establishing smart solutions for facilities operation, while tackling challenges associated with older buildings by developing smart and sustainable assets. Additionally, the program was granted an SGD450 million (USD329 million) endowment in 2016 over three years[104].

8.3.11 The United States

8.3.11.1 Artificial Intelligence

National Artificial Intelligence R&D Strategic Plan

Updated in 2023, the National Artificial Intelligence Research and Development (R&D) Strategic Plan 2023[105] is a government-published plan that provides a roadmap and strategies to achieve continued United States leadership in AI. The roadmap stated nine strategies to help the United States underscore a coordinated approach to international collaboration in AI research:
- Make long-term investments in AI research
- Develop effective methods for human-AI collaboration
- Understand and address the ethical, legal and societal implications of AI
- Ensure the safety and security of AI systems
- Develop shared public datasets and environments for AI training and testing
- Measure and evaluate AI technologies through standards and benchmarks
- Better understanding of the needs of the AI R&D workforce
- Expand public-private partnerships to accelerate advances in AI
- Establish a principled and coordinated approach to international collaboration in AI research

Developing AI Research Institutes to Power Responsible AI R&D

In 2023, the Biden Administration introduced a significant development in the United States AI landscape, earmarking USD140 million in funding for the establishment of seven new AI Research Institutes[106], in addition to the existing 18 institutes already in operation. The primary strategy behind these newly funded institutes is to catalyze collaboration across a spectrum of stakeholders, including institutions of higher education, federal agencies, and industry partners. These institutes will also serve as a pivotal component in bolstering the economy's AI R&D infrastructure, while simultaneously fostering the growth of a diverse and skilled AI workforce.

American AI Initiative

The American AI Initiative[107], begun in 2019, recognizes the strategic significance of AI for the United States and its security. It encompasses five key lines of effort regarding AI, including:

- Increasing AI research investment
- Unleashing federal AI computing and data resources
- Setting AI technical standards
- Nurturing an AI workforce
- Collaborating with international allies

These efforts were subsequently codified into law in the AI Initiative Act of 2020. Under the initiative, federal agencies were directed to prioritize AI within their annual budget reports and called for comprehensive development of an agency-by-agency breakdown of non-defense AI R&D spending. After the establishment of this act, the President's FY2021 budget spending for AI R&D and interdisciplinary research at the economy's science foundation increased more than 70 percent over the FY2020 budget, and was worth more than USD830 million. The economy's energy agency invested USD125 million in AI research, and its agriculture agency provided USD100 million for the Agriculture and Food Research Initiative, which will enhance the application of advanced technology, including AI, in agricultural systems. The health agency invested USD50 million for new research on chronic diseases using AI and related approaches, the defense agency for advanced research invested USD459 million in AI R&D, and the defense agency for AI increased its budget to USD290 million[108].

8.3.11.2 Quantum Technologies

National Quantum Initiative Act

Signed into law in 2018, the Quantum Initiative Act[109] recognizes the economic and security significance of quantum technology, setting the stage for a comprehensive strategy to harness its potential. The act is designed to accelerate quantum R&D, with a clear focus on bolstering the member's economic and domestic security interests.

In 2022, the National Quantum Initiative Act was amended via the CHIPS and Science Act[110] to facilitate historic investment, authorizing R&D initiatives[111] aimed at accelerating the discovery and deployment of quantum applications. The act aims to develop a diverse domestic quantum workforce and critical infrastructure to facilitate R&D and create standards in quantum networking and communication. The annual authorized investment for quantum-specific programs is USD153 million.

National Strategic Overview for Quantum Information Science

Established in 2018, the National Strategic Overview for Quantum Information Science[112] sets the United States strategy for ensuring continued leadership in quantum information science. The United States defines quantum information science as quantum sensing, quantum computing and quantum networking, as well as scientific advances enabled by quantum devices and theory advances. The United States quantum strategy can be summarized as:

- Understanding quantum information science, applications, timelines, and overcoming roadblocks for societal benefits
- Boosting competitiveness through accelerated QIS technology deployment for economic and mission goals, while collaborating internationally and ensuring domestic security
- Empowering individuals through talent development and fostering new opportunities with QIS[113]

8.3.11.3 Blockchain

Comprehensive Framework for Responsible Development of Digital Assets

In 2022, the United States released the Comprehensive Framework for Responsible Development of Digital Assets, which outlined the government's approach to addressing the risks and harnessing the benefits of digital assets and their underlying technology. Nine reports were conducted among diverse stakeholders to establish a clear framework for responsible digital asset development with the following actions:

- **Protecting stakeholders** – Protect consumers, investors and businesses by issuing guidance, increasing enforcement resources, and aggressively pursuing fraudulent actors
- **Enhancing financial access** – Promote access to safe, affordable financial services by encouraging the adoption of instant payment systems
- **Fostering responsible innovation** – Advance responsible innovation by developing a Digital Assets Research and Development Agenda to kickstart research
- **Reinforce global financial leadership** – Leverage the United States' position to promote the value of digital assets

8.3.11.4 Advanced Manufacturing

National Strategy for Advanced Manufacturing

In 2022, the member economy's science and technology council released the Strategy for Advanced Manufacturing[114], which outlines the goals the United States would like to achieve through the development of advanced manufacturing technologies. It also presents a vision for United States leadership in the sector. The United States aims to achieve the following goals:

- **Increase the adoption of advanced manufacturing technologies** – Foster the creation of innovative materials and processing technologies, while integrating AI into manufacturing processes
- **Cultivate a skilled workforce** – Diversify the pool of talent, expanding education programs and strengthening ties between employers and educational institutions
- **Increasing the resilience of supply chains** – Improve supply chains' interconnectedness, reducing vulnerabilities, and support technology transitions to bolster advanced manufacturing ecosystems

8.3.11.5 Advanced Computing

Future Advanced Computing Ecosystem Strategic Plan FY2022 Implementation Roadmap

In 2022, the member economy's science and technology council introduced the roadmap[115] that laid out the strategic objectives and directions to achieve a Future Advanced Computing Ecosystem for the United States. The United States aims to make the advanced computing ecosystem a strategic asset for its economy and security, as well as solve challenges and achieve the following four sub-objectives:

- Use an advanced computing ecosystem as a strategic asset that can provide resources to government, academics, nonprofits and industry
- Build a sustainable and robust ecosystem
- Support advancing computing R&D to drive the industry's development
- Cultivate a diverse, capable and flexible workforce to build and sustain the future of the advanced computing ecosystem

8.4 Collaborations among APEC economies surrounding ICT policies

To facilitate trade among APEC economies, more cooperation and collaboration can help in terms of ICT policies. In the current context, APEC economies have endorsed the TEL Strategic Plan (SAP) for 2021–2025, which is aimed at establishing ICT infrastructure and connectivity, promoting collaboration by having yearly meetings to discuss the benefits of telecommunications, and developing policies that can encourage innovation and advance the development of emerging digital technologies. Some APEC member economies have recognized that their ICT policies will be focused on encouraging innovation, economic integration, and inclusiveness within the economies. For example, through the ASEAN ICT Masterplan 2020, the economies in ASEAN have agreed to create initiatives to address emerging digital divides in ASEAN, develop standardized guidelines for new ICT applications, and share best practices of technology innovation. Economies have also stated their willingness to cooperate with other APEC economies in their policies, such as the Republic of Korea, which stated its intention to form quantum technological alliances with other economies, such as the United States. Future cooperation from economies to come together to develop policies would help advance the growth of emerging ICT.

9. Achievement and possibilities of ICT to solve global issues

9. Achievement and possibilities of ICT to solve global issues

In an era marked by global challenges, ICT has evolved to become a potent catalyst for addressing and mitigating global issues. From poverty alleviation to healthcare to education, the transformative power of ICT offers innovative solutions that hold the potential to solve major challenges. By scrutinizing the achievements and untapped possibilities of ICT, this section aims to show how ICT has solved global issues through tackling SDGs that define our global sustainable development landscape.

9.1 Methodology

To find out how ICT plays a crucial role in addressing global issues, the SDGs were referenced. These goals are designed to tackle challenges such as poverty, inequality, climate change, environmental degradation and peace on a global scale. The following three-step approach was adopted to identify the relevant SDGs where ICT has higher impact:

1. **Identify relevant literature** – The literature review encompassed several documents and tools, ensuring a comprehensive overview of the key SDGs that will be highly impacted by ICT. The documents and tools included:

- Reports such as Huawei ICT SDGs Benchmark and ITU reports
- Tools such as the SDG Mapping Tool by ITU and SDG Mapping Tool by WSIS

2. **Apply a frequency ranking approach to identify highly impacted SDGs –** Based on the recency of the research, the SDG Mapping Tool by ITU and the SDG Mapping Tool by WSIS were used to identify SDGs that were highly impacted by ICT. ITU's tool assesses the number of ICT projects associated with each SDG, ranking them by quantity for impact assessment, and WSIS provides a similar list

SDG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Avg.-Median range
No. of projects - SDG mapping tool by ITU	21	14	31	41	26	14	13	39	107	27	39	10	30	0	8	14	55	~26-30
No. of projects - SDG mapping tool by WSIS	280	141	363	484	306	63	66	481	412	321	270	135	117	25	68	389	291	~248-280

Source: United Nations, International Telecommunication Union (ITU), Arthur D. Little analysis

Figure 38: Methodology to rank the impact that ICT has on SDG's based on the frequency of projects

3. **Analyze and evaluate data** – Analyze the stated number of projects from each tool mentioned in step two, and select only the SDGs with the most significant number of projects overlapping among the two tools, as illustrated in Table 9**.** The SDGs that have the most significant number of projects were highlighted in both the SDG Mapping Tool by ITU and the SDG Mapping Tool by WSIS

- The average and median number of projects were identified. Only SDGs whose number of ICT projects were higher than the range between the average or median number of projects were chosen
- Out of the 17 SDGs, eight were chosen based on the overlap in the lists by the WSIS and ITU tools. The SDGs shortlisted served as the focus for the case studies. The shortlisted SDGs include:

Table 9: Main SDGs Impacted and their respective description

Source: United Nations, International Telecommunication Union (ITU), Arthur D. Little analysis

Main SDGs impacted	Description
3 GOOD HEALTH AND WELL-BEING	Ensure healthy lives and promote well-being for all at all ages
4 QUALITY EDUCATION	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
5 GENDER EQUALITY	Achieve gender equality and empower all women and girls

Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

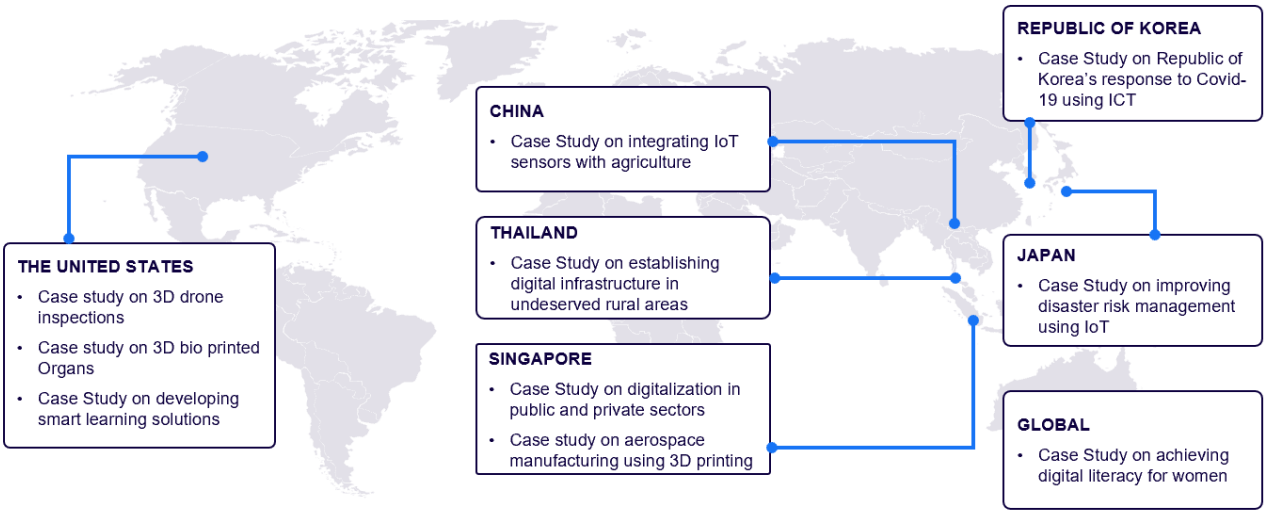
Reduce inequality within and among economies

Make cities and human settlements inclusive, safe, resilient, and sustainable

Strengthen the means of implementation and revitalize the global partnership for sustainable development

9.2 Selected case studies in APEC economies

Selected case studies (Figure 39) highlight the impact of ICT in addressing global issues related to the following eight shortlisted SDGs: SDG 3, 4, 5, 8, 9, 10, 11 and 17.



Source: Arthur D. Little analysis

Figure 39: Selected case studies across different APEC economies

This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by APEC or Arthur D. Little

9.2.1 China

Case study on integrating IoT sensors with agriculture

Since 2019, China Mobile and agricultural tech firm LinkDotter have been integrating IoT technology in strawberry farming in the Shunyi District, Beijing, aiming to maximize profitability. This innovative initiative commenced with pilot testing. China mobile provides support on IoT implementation by offering a Standard Agriculture Service Package. The package is composed of two key components[116]:

- IoT systems provided to farmers, including the drip fertigation system, which ensures accurate nutrient delivery to crops
- Substrate heating systems that control growing substrate temperatures, as well as atomization humidification and cooling systems that efficiently manage humidity and temperature levels within the farm

The collected data from each IoT device is aggregated and stored, and subsequently transmitted to China Mobile's cloud-based platform (OneNet) for further processing. This accumulated IoT big data is then analyzed using the LinkDotter Agri-Master software, facilitating comprehensive insights and informed decision-making in the agricultural context. Integrating IoT technology into strawberry farming has led to significant benefits, including data-driven decision-making, reduced harvesting cycles, and increased profits. By harnessing IoT technologies in the strawberry farms, farmers can make more informed decisions on irrigation, fertilization, and pest control, which is an enhancement over traditional methods, in which farmers often rely on their subjective experience, resulting in higher likelihood of errors. Moreover, it leads to an accelerated greenhouse harvest turnaround, which translates to increased income for farmers and the potential for crops to be harvested 20 days earlier than in conventional greenhouses. Also, these advancements extend to harvest output improvements, cost reductions, and enhancements in the overall bottom line:

- Harvests can be increased by more than 100 percent
- Water and fertilizer use decreases by 50 percent per kilogram of strawberries
- Labor costs decrease by 50 percent per kilogram of strawberries
- Profits surge by 75 percent compared to traditional farming methods

The impact of the integration of this ICT application in agriculture addresses SDG 8: Decent Work and Economic Growth. By facilitating more informed decisions on irrigation, fertilization and pest control, this innovative approach significantly bolsters efficiency and productivity within the agricultural sector. The resulting accelerated harvesting, optimized resource use, and lowered labor costs increase profits and foster local economic growth, exemplify progress toward cultivating a robust economy, and ensure decent work and growth for all.

9.2.2 Japan

Case study on improving disaster risk management using ICT

Japan, prone to earthquakes and floods that cause significant human losses, has been actively exploring ICT's role in disaster risk management for resilience. It introduced solutions in Early Warning Systems (EWSs) for rapid risk communication and Disaster Information Management Systems (DIMSs) for easy access to disaster-related information. These initiatives aim to enhance preparedness, reduce loss, and optimize disaster response through the strategic use of ICT.[117]

- **Early Warning Systems (EWSs):**
  - **Key systems** – EWS in Japan for earthquakes uses seismic wave data to calculate earthquake parameters, issuing warnings before earthquakes occur. The J-ALERT system, an economic-wide warning system, delivers alerts through disaster prevention radios, broadcast media, and mobile phones. The emergency alert mail (EAM) broadcasts early warnings to mobile phones, providing essential disaster and evacuation information
  - **Impacts** – EWS ensures 80 percent of residents receive timely notifications, prompting 40 percent to take preventive action and reducing the loss of life during disasters. The J-ALERT system pre-warns 99.6 percent of municipalities 30 minutes ahead, and the EAM is considered vital by 51 percent of residents, especially during events such as the 2016 Kumamoto Earthquake
- **Disaster Information Management Systems (DIMSs):**
  - **Key systems** – The L-ALERT system acts as a centralized information hub, delivering disaster warnings and information through various channels, such as TV, radio, mobile phones, and web portals. Additionally, the geographic information systems-based disaster information management system (GIS-based DIMS) uses GIS technology to manage and share disaster-related data. This enables rapid damage assessments, prioritizes search and rescue efforts, and investigates building damages after accidents
  - **Impact** – The L-ALERT system notifies local officials within approximately one second and citizens within four to 20 seconds, allowing quick preventive action and saving lives during disasters. The disaster damage map, using GIS, provides pre- and post-disaster images within three days of an earthquake. This accelerates damage assessment and recovery planning, surpassing the speed and safety of human inspections and facilitating efficient decision-making

The disaster risk management solutions pioneered in Japan have served as prototypes for at least seven other economies, including China; Italy; Mexico; Romania; Chinese Taipei; Turkey; and the United States. These economies have looked to Japan's experiences to glean insights and adapt successful approaches to their own disaster preparedness and response frameworks.

The impact of disaster management systems such as EEWS, J-ALERT and EAM is closely aligned with SDG 3: (Good Health and Well-Being). These systems safeguard residents' lives and well-being by providing timely notifications and enabling preventive actions during disasters, thereby reducing loss of life and injuries and promoting overall well-being in the population.

Furthermore, the impact of these disaster management systems also aligns with SDG 9 (Industry, Innovation, and Infrastructure). They showcase the pivotal role of advanced infrastructure and innovative technologies in enhancing disaster response capabilities. The efficient communication systems and use of cutting-edge technology for damage assessment and recovery planning demonstrate the integration of innovation with resilient infrastructure. These systems exemplify industry-driven innovation, emphasizing the importance of building resilient infrastructure and significantly contributing to the advancement of SDG 9 objectives for a more sustainable and prepared society.

9.2.3 Republic of Korea

Case study on the Republic of Korea's response to COVID-19 using ICT

In the face of a surge in COVID-19 infections in 2020, the Republic of Korea orchestrated a highly effective response, leveraging ICT to achieve a significant turnaround and recovery. Through collaborative efforts involving government departments and private entities, the Republic of Korea managed to flatten the infection curve within a remarkable 20-day period, all while avoiding the imposition of severe restrictions on people's freedom and movement. The ICT solutions launched by the Korean government focus on four major areas: social distancing, rapid testing, COVID-19 tracing, and new treatment approaches:[118]

- **Social distancing:**
  - **Key actions** – Implemented an emergency broadcasting service for COVID-19 alerts and guidelines. Facilitated a swift transition to online platforms, encouraging virtual alternatives such as video conferences and online learning
  - **Impacts** – Emergency text alerts reduced infection spread by informing individuals of potential exposure, promoting COVID-19 testing and avoiding clustering. Reduction of in-person meetings minimized close-contact interactions, contributing to infection control
- **Rapid testing:**
  - **Key actions** – Korean companies leveraged AI for rapid virus test-kit development. AI image analysis in chest X-rays accelerated diagnosis, providing crucial determinations in seconds
  - **Impacts** – AI integration reduced virus diagnostic kit development time to two weeks. Hospitals swiftly identified patients needing intensive care, enhancing critical determinations
- **COVID-19 tracing:**
  - **Key actions** – Implemented a self-diagnosis and quarantine app for symptom monitoring. Established a robust contact-tracing mechanism using GPS, card transactions, and CCTV recordings
  - **Impacts** – The self-diagnosis app empowered travelers to take prompt precautions. Effective tracking of quarantine patients, with only three to four subjects per day leaving designated locations in one week
- **Treatment:**
  - **Key Actions** – Leveraged AI for medicine development, predicting drug-protein interactions. Used supercomputers to repurpose existing drugs to combat the virus
  - **Impacts** – Atazanavir, a drug for HIV treatment, was identified as a promising candidate for COVID-19 treatment. Further research identified 20 repurposed drugs effective against COVID-19 in 2020

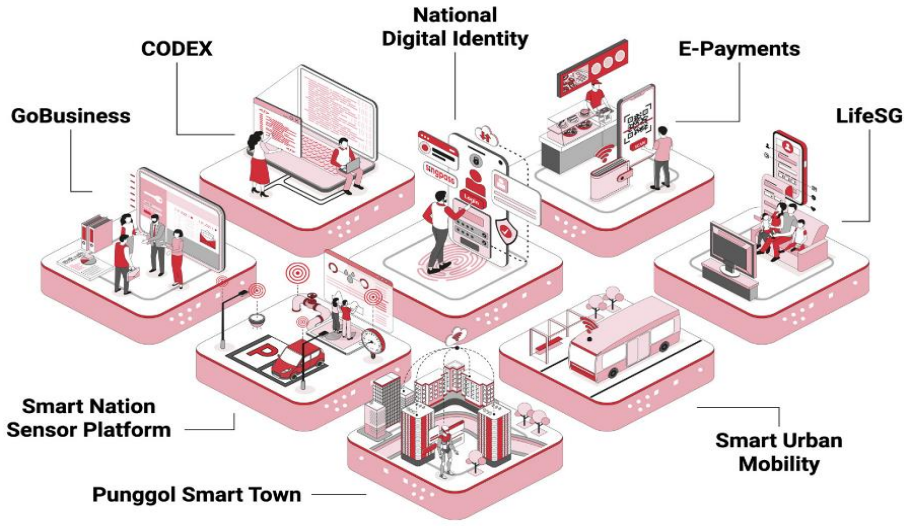
The Republic of Korea effectively managed the COVID-19 situation through the strategic use of ICT. These measures included timely information dissemination via data analysis and text messages, employing AI and supercomputers for diagnosis and treatment, and monitoring infected individuals through GPS, cameras, mobile apps and online platforms. These efforts align with SDG 3 (Good Health and Well-Being), as they significantly contributed to reducing infection spread and improving health outcomes, reflecting the Republic of Korea's commitment to prioritizing public health in challenging times.

9.2.4 Singapore

Case study on digitalization in public and private sectors

Singapore's Smart Nation Initiative, launched in 2014, is a comprehensive digital transformation project that aims to leverage technology and data to enhance various aspects of life. The initiative focuses on three

major pillars: Digital Society, Digital Economy and Digital Government, with eight projects (Figure 40) strategically aligned with these pillars[119].



Source: Smart Nation Singapore

Figure 40: Key eight strategic projects under Singapore's Smart Nation Initiative

The three pillars and the respective key projects

- **Digital society:**
  - **Key projects** – Punggol Smart Town, Smart Nation Sensor Platform (SNSP), and Smart Urban Mobility
  - **Impact** – Punggol Smart Town aims to generate jobs and integrate a digitally enhanced district. SNSP collects data for policy formulation, and Smart Urban Mobility uses data for customized bus routes, ensuring efficient public transportation
- **Digital economy:**
  - **Key projects** – E-Payments and GoBusiness
  - **Impact** – E-Payments saw a significant increase in mobile payment usage, and GoBusiness facilitated seamless access to over 300 government e-services, streamlining business interactions with government processes
- **Digital government:**
  - **Key projects –** CODEX, LifeSG, and Singpass
  - **Impact –** CODEX tripled the development speed of ICT projects and reduced costs. LifeSG and Singpass enhanced user efficiency, enabling the digital completion of 99 percent of services from end to end as of 2021

The Smart Nation Initiative leverages ICT, including data analysis, AI, IoT, autonomous vehicles and online portals. It follows a citizen-centric approach, engaging citizens in planning and development to address real-life challenges and deliver meaningful benefits.

The impacts of the initiative align with SDG 9 (Industry, Innovation, and Infrastructure) by fostering inclusive and sustainable industrialization and stimulating innovation. By applying data-driven solutions and smart city technologies, Singapore contributes to the development of resilient and sustainable infrastructure, fulfilling key aspects of SDG 9.

Furthermore, the initiative's efforts toward creating efficient, interconnected cities align with SDG 11 (Sustainable Cities and Communities), contributing to building inclusive, safe, resilient, and sustainable urban communities. Overall, the Singapore Smart Nation Initiative demonstrates a commitment to technological advancement and innovation, addressing multiple SDGs.

Case study on aerospace manufacturing using 3D printing 

ICT, especially 3D printing technology, has been used in the aerospace industry. Rolls-Royce has harnessed 3D printing in its operations in Singapore, specifically additive layer manufacturing (ALM), to revolutionize turbine engine production[120]. ALM enables rapid design iteration, customization, and the use of advanced materials such as ceramic matrix composites (CMCs). These materials provide high-temperature durability and reduce weight, aiming to enhance engine performance and production efficiency. This exemplifies how innovative ICT solutions are transforming aerospace manufacturing, emphasizing increased precision and effectiveness in processes. This innovative use of ICT has several key aspects:

- **Engine manufacturing:**
  - **Key actions –** 3D printing is employed to manufacture components, including a 1.5-meter diameter nickel piece for the Trent XWB-97 engine and complex parts for the UltraFan engine[121]
  - **Impact –** Integrating 3D printing into manufacturing reduces lead time by 30 percent, enhances aerodynamics, increases fuel efficiency, and improves overall engine performance. For the Trent XWB-97 engine, this technology has led to a 10 percent reduction in fuel burn, resulting in significant annual fuel cost savings for customers. The UltraFan Engine benefits from weight reduction and improved fuel consumption
- **Component repairs:**
  - **Key actions –** Rolls-Royce uses 3D printing for repairing turbine blades and core engine components
  - **Impact –** 3D printing facilitates the creation of intricate geometries for engine components that require repair, addressing the challenge posed by their complex shapes and reducing manufacturing times compared to traditional methods

By leveraging 3D printing technology, Rolls-Royce has not only improved product quality and manufacturing efficiency, but also achieved significant reductions in expenses, such as fuel costs. This initiative aligns with SDG 9 (Industry, Innovation, and Infrastructure) by enhancing the industry's capacity to innovate and improve efficiency, contributing to resilient and sustainable infrastructure through streamlined production and optimized resource utilization. The use of ICT in aerospace manufacturing exemplifies the potential of technology to drive industrial progress and growth, in line with the goals of SDG 9.

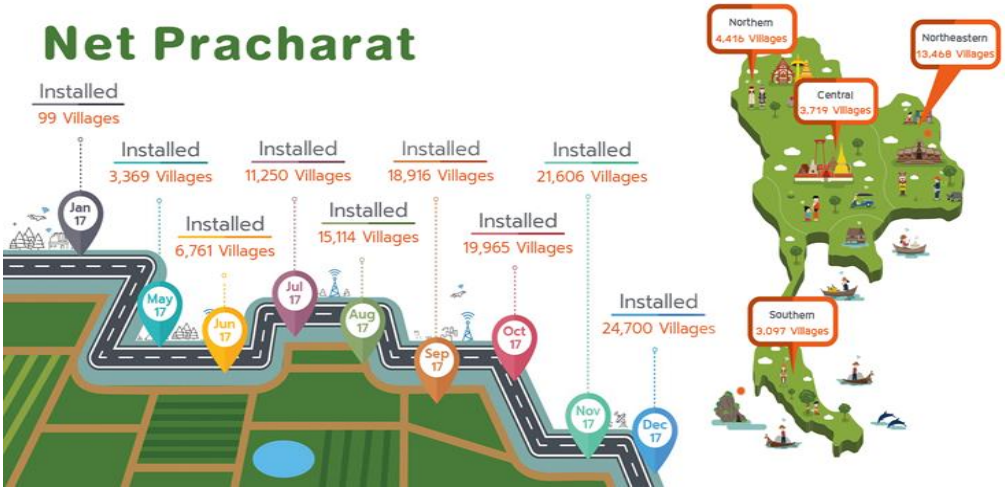
9.2.5 Thailand

Case study on establishing digital infrastructure in undeserved rural areas 

Introduced in 2017, the Thai government's Net Pracharat Initiative focuses on addressing the digital divide in underserved rural areas. The initiative aims to strengthen the domestic broadband network, bridge the urban-rural digital gap, and extend high-speed internet service to all villages in the economy[122].

The initiative has two main pillars: expanding digital infrastructure and increasing digital awareness among locals.

- **Digital infrastructure**[123]:
  - **Key actions –** Collaborating with TOT, the initiative established free public Wifi hotspots with speeds of 30/10 Mbps, and initiated the Open Access Network (OAN) program, enabling ISPs to use the existing network without fees
  - **Impact –** Internet connectivity has reached 24,700 rural villages, serving 6.6 million users, alongside 1,700 rural schools and hospitals, as illustrated in Figure 41. The OAN program reduced investment expenses for ISPs, contributing to more affordable internet services. This initiative unlocked access to essential services, including education, teleconsultation, and e-government services
- **Increase digital awareness:**
  - **Key actions –** Net Pracharat developed a curriculum on internet fundamentals, provided access to e-commerce platforms, and sent trained teachers to rural villages for digital education
  - **Impact –** Over 1.2 million locals were trained, leading to improved digital literacy[124]. Locals actively use e-commerce platforms to promote local products, generating additional income



Source : Net Pracharat

Figure 41 : Net Pracharat's current installation progress

The Net Pracharat Initiative, by leveraging ICT, improved quality of life, financial stability, and digital literacy for 6.6 million individuals. It aligns with SDG 9 (Industry, Innovation, and Infrastructure) by establishing resilient and inclusive technological infrastructure in underserved areas. Additionally, it addresses SDG 10 (Reduced Inequalities) by narrowing the digital divide and promoting equitable opportunities, contributing to reduced societal disparities and fostering inclusivity. The initiative collaboration with ISPs aligns with SDG 17 (Partnerships for the Goals), showcasing the significance of collaborative endeavors in achieving sustainable development objectives.

9.2.6 The United States

Case study on 3D drone inspections

The current trend in various industries involves leveraging ICT, particularly drones, to address diverse challenges. In 2021, Skydio introduced an autonomous drone designed for inspecting building infrastructure such as bridges. The goal is to enhance safety and efficiency for inspectors while reducing inspection costs and time. Departments of Transportation (DOT) in multiple states have adopted these drones, eliminating the need for manual inspections and improving workflow efficiency, while reducing costs. Through partnerships with Skydio, public departments use autonomous drones for data capture, analysis, decision-making, and flaw detection.

The autonomous drone technology consists of two key processes, which are autonomous 3D scanning and data analytics[125]:

- **Autonomous 3D scanning –** Skydio's autonomous drones, equipped with advanced sensors and 4K cameras, automate data capture using 3D scan software. They identify previously unnoticed structural issues, allowing for efficient repairs. Achieving eight to 12 bridge inspections per day, these drones have inspected 13,500 bridges in North Carolina, showcasing their effectiveness in streamlining infrastructure assessment
- **Data analytics –** Data analytics plays a crucial role in turning raw data collected through drone inspections into valuable insights by utilizing advanced analytics techniques such as machine learning algorithms, advanced predictive AI, and pattern recognition, enabling DOT to analyze and interpret the vast amounts of data collected during inspections

The implementation of autonomous drones has delivered substantial benefits, including a significant reduction in overall inspection costs, enhanced safety for inspectors, and decreased inspection time. The adoption of autonomous drones by the West Virginia Department of Transportation to survey stockpiles has yielded a 75 percent reduction in overall inspection costs, equivalent to monthly savings of over USD343,000. Drones enhance inspector safety by efficiently surveying challenging infrastructures, such as bridges, which are difficult to inspect manually. Compared to traditional methods, which require 15 days, drones complete the same workload in just nine days.

The implementation of autonomous drones ensures consistent, accurate data collection, improving inspection efficiency. Data analytics further provides the DOT with quantitative insights for informed decision-making, predictive maintenance, and optimized asset management, resulting in tangible cost savings and improved infrastructure performance. Overall, autonomous drones not only automate complex infrastructure inspections, but also contribute to economic growth through resource savings, increased productivity, and safer working conditions, aligning with the objectives of SDG 8 to promote decent work and economic growth.

Case study on 3D bio-printed organs

In the United States, there are 106,800 people on the organ transplant waiting list, but the shortage of living donors results in only about 6,000 organs per year. There is also the additional risk of organ rejection when performing an organ transplant surgery. To address this challenge, the healthcare industry is turning to ICT, with 3D printing emerging as a key solution. The Wake Forest Institute for Regenerative Medicine, led by Anthony Atala, has made notable progress in using 3D printing to create artificial organs, obtaining patient cells for bioink development and employing bioprinting for organ creation[126]:

- **Bioink development –** To 3D print artificial organs, a small biopsy of the patient's cells is taken and cultured. The cells are mixed with bioink, mimicking the natural extracellular matrix and serving as a glue. This process forms the foundation for 3D printing tissue structures for transplantation
- **Bioprinting –** Bioink is loaded into a printing chamber, and bioprinters use printheads to layer it, gradually building up tissue or organs. Diverse bioinks with various cell types create intricate structures. The bio-printed organ is then implanted into a patient

The integration of 3D printing technology into organ transplantation has yielded significant benefits for patients, including cost reductions (USD100,000 vs USD443,000), faster replacement processes (four to six weeks versus one to five years), and improved patient safety by reducing the likelihood of organ rejection.

This integration of 3D printing aligns with SDG 3 by enhancing healthcare accessibility and equity, addressing transplant rejection, and making organ implantation more affordable and accessible, potentially saving millions of lives compared to traditional methods.

Case study on developing smart learning solutions

AT&T's free-device programs, initiated in 2021, have addressed challenges faced by millions of the United States students in virtual learning. Leveraging ICT, the program focuses on connected learning centers and affordable broadband services to bridge the digital divide:[127]

- **Connected learning centers** – AT&T established 20 online learning centers in underserved areas, providing high-speed internet, computers and Wifi. This initiative enhances digital literacy skills and offers a free year of internet connectivity and wireless hotspots to 35,000 students[128]
- **Affordable broadband services** – AT&T provides a discounted broadband offering at USD10 per month, investing USD2 billion over three years to narrow the digital divide. More than 135,000 educational institutions and 500,000 students and educators have gained access to AT&T's low-cost broadband service

The program contributes to SDG 4 (Quality Education) by ensuring inclusive, equitable education and promoting digital literacy. It also aligns with SDG 8 (Decent Work and Economic Growth) by preparing learners for the modern job market, fostering sustainable economic growth, and creating decent work opportunities. AT&T's initiative demonstrates the potential of ICT to provide educational resources, enrich learning experiences, and contribute to inclusive and sustainable economic growth.

9.2.7 Global

Case study on achieving digital literacy for women

In 2011, the ITU and the Telecenter Foundation (TCF), an international organization that supports the establishment and sustainable growth of telecenters, jointly launched the Telecenter Women (TCW) program, an initiative dedicated to advancing digital literacy tailored specifically for women. The program adopted a multifaceted approach, emphasizing[129]:

- **Contextualize the content taught** – TCF collaborated closely with local telecenter partner organizations, encouraging them to autonomously develop content that resonated with the unique economic context of each community. This strategy ensured that the educational material was finely tuned to the specific needs of women, adding significant contextual value

- **Peer learning networks** – Fostering collaborative learning, the program encouraged women learners to form small groups, enhancing motivation and the overall effectiveness of the learning process. This collaborative approach empowered women through shared experiences, promoting a supportive environment for skill development
- **Enhanced women leadership involvement** – TCF took measures to involve women in the management of telecenters. This strategic move not only ensured that women directly benefited from the training, but also played a pivotal role in raising awareness within the broader community.

The TCW program has significant impacts:

- **Quality education –** Over 1 million previously unskilled women across 79 economies have received quality education in computer skills and ICT applications. The establishment of 350,000 telecenters, serving as dedicated classrooms, has created a robust learning environment, empowering women on the ground
- **Reduction of inequality –** Access to ICT resources and digital training has contributed to reducing societal inequalities. Women, equipped with technological skills, have significantly improved their prospects for future careers, leading to increased household income and better economic outcomes[130]

In developing economies, telecenters are crucial for enhancing ICT access and bridging the digital divide, providing affordable access to communities with limited personal ICT ownership. The initiative aligns with various SDGs:

- **SDG 4 (Quality Education) –** The campaign extends quality education to unskilled women, contributing to inclusive and equitable education. The establishment of telecenter classrooms also supports accessible and relevant education
- **SDG 5 (Gender Equality) –** By targeting unskilled women for digital literacy and ICT skills, the initiative addresses gender disparities in technology, promoting gender equality and empowering women to overcome traditional barriers
- **SDG 10 (Reduced Inequalities) –** The initiative bridges societal inequalities by providing access to ICT resources and digital training. It empowers underserved women with technological skills and economic opportunities. This aligns with SDG 10's goals for an inclusive and equitable society

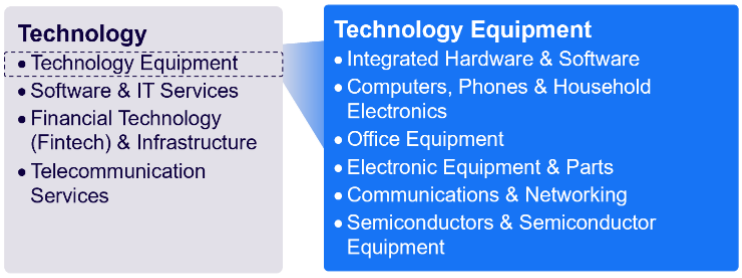
10. APEC economies involvement in supply chain

10. APEC economies' involvement in ICT supply chain

The ICT industry relies heavily on global networks for the production and distribution of hardware, software, and services. The ICT supply chain encompasses the entire life cycle of ICT hardware, software, and managed services and a wide range of entities. This includes third-party vendors, suppliers, service providers and contractors. This section aims to analyze the supply chain of the highest-traded ICT equipment to provide a more comprehensive overview of APEC's involvement in the ICT supply chain.

10.1 Methodology

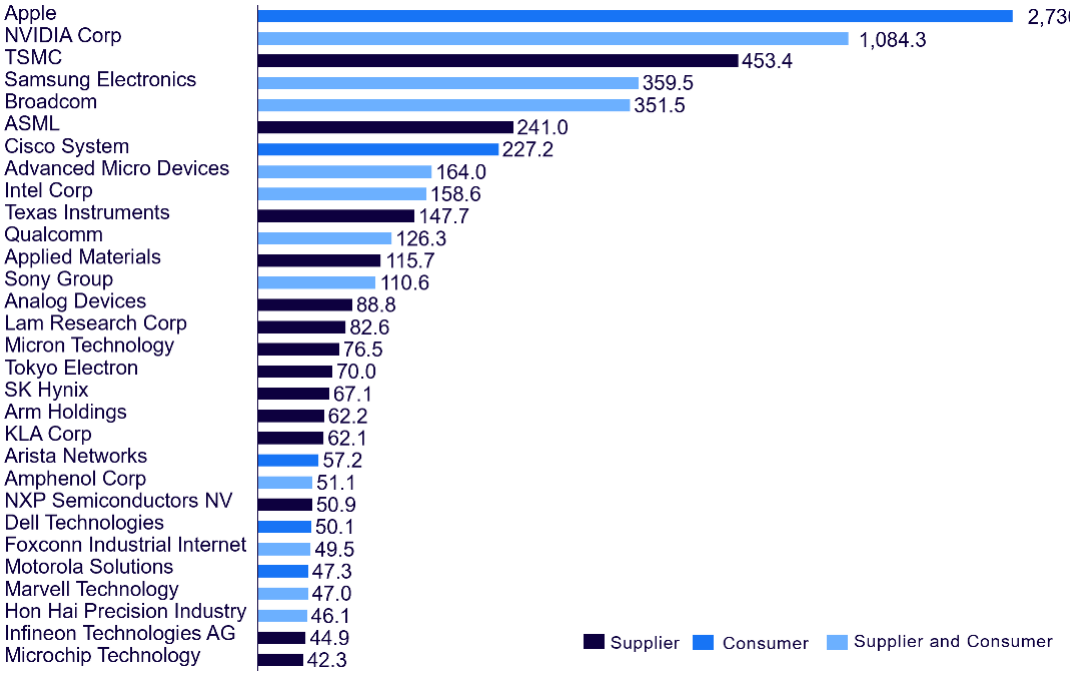
To analyze the supply chain of the highest-traded ICT equipment and provide a more comprehensive overview of APEC involvement in the ICT supply chain, a two-step approach involving identification and data extraction and processing was completed:



Source: Thomson Reuters

Figure 42: Breakdown of technology equipment in Thomson Reuters

- Identify the market capitalization of the top 30 technology equipment companies
  - The top 30 technology equipment companies ranked by market capitalization were identified by Thomson Reuters
  - Analyzing the supply chain for technology equipment is crucial because it helps identify vulnerabilities and security risks, ensuring the integrity of hardware and software components and preventing potential threats to the entire ICT infrastructure. The breakdown of categories the technology equipment companies belong to can be found in Figure 42
  - The underlying technology equipment identified among the top 30 technology equipment companies by market capitalization will be the focus area for ICT supply chain analysis



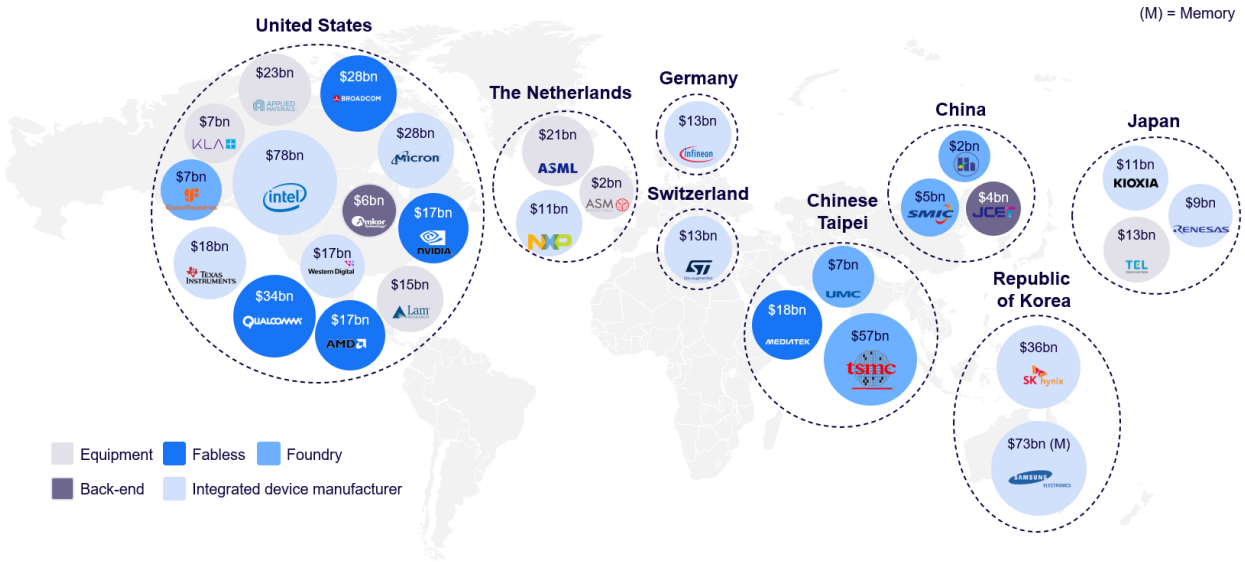
Source: Thomson Reuters, Arthur D. Little analysis

Figure 43: Top 30 market capitalization of technology equipment companies[131], in billion USD

- Data extraction and processing
  - The top 30 technology equipment companies shortlisted revealed that every company plays a role in the global supply and demand of semiconductors and semiconductor equipment
  - All of these companies are either suppliers, consumers, or both, in the semiconductor industry. Suppliers refer to companies focusing on design, manufacturing, EDA and core IP, materials and equipment, and tools
    - **Suppliers:** 14 out of 30 of the top technology equipment companies are purely suppliers of semiconductors and semiconductor equipment, e.g., TSMC and ASML
    - **Consumers:** five out of 30 of the top technology equipment companies are purely consumers of semiconductors, e.g., Apple and Cisco Systems
    - **Suppliers/consumers:** 11 out of 30 of the top technology equipment companies are suppliers and consumers of semiconductors, e.g., Samsung Electronics and Broadcom Inc

The top 30 companies of technology equipment firms by market capitalization comprise 85 percent of the total market cap of the top 100 technology equipment firms. Consequently, this underscores that semiconductors should be the focus of ICT supply chain analysis.

10.2 Analysis of APEC involvement in the semiconductor supply chain



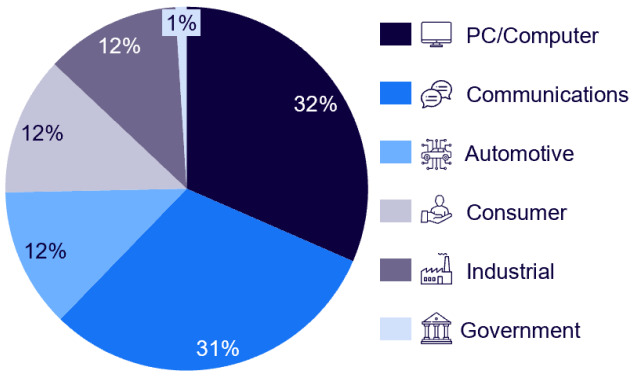
Source: S&P Capital IQ, Arthur D. Little analysis

Figure 44: Key semiconductor companies by economy and their respective revenue in 2021[132]

This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by APEC or Arthur D. Little

APEC economies such as China; Japan; Republic of Korea; Chinese Taipei; the United States play a major role in the semiconductor supply chain (Figure 44), with presence across various segments. These semiconductor companies are grouped into five categories, namely, equipment, fabless, foundry, back end, and integrated device manufacturer. The United States has a high prevalence of fabless semiconductor companies, such as AMD, Nvidia, Qualcomm and Broadcom. Other APEC economies, such as Chinese Taipei, have the presence of large semiconductor foundries such as TSMC and Samsung. China's key semiconductor companies include foundries such as SMIC and back-end outsourced semiconductor assembly and test companies (OSAT) such as JCET. While China holds a significant market share in the area of assembly, testing and packaging, other APEC economies such as Singapore[133] and the Philippines[134] are also well noted players in APEC with economies such as Malaysia growing in recent years from Chinese semiconductor design companies investments[135]. Japan's key semiconductor companies include integrated device manufacturers such as Kioxia, and those focused on semiconductor equipment such as TEL.

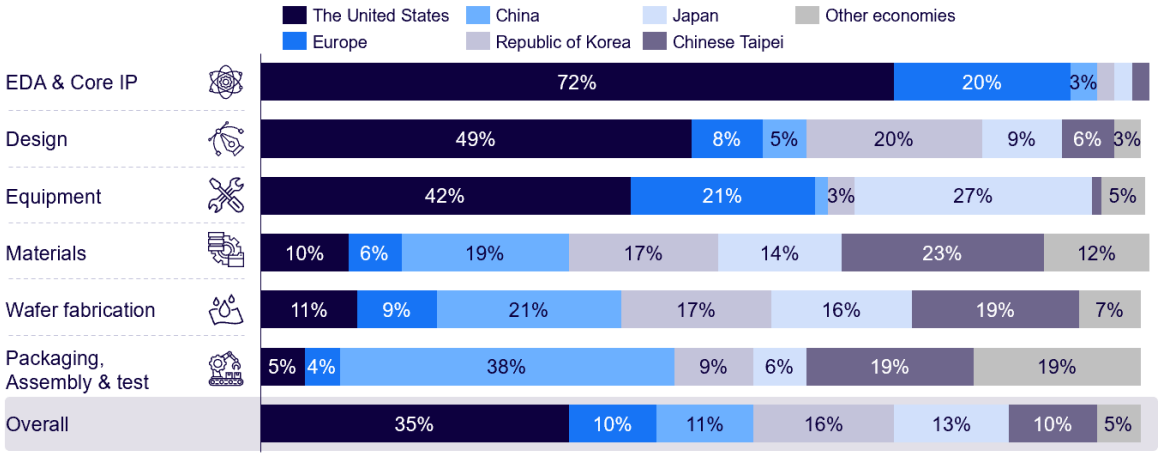
Other economies outside of APEC also play a role in the global semiconductor supply chain, such as the Netherlands, which has the presence of ASML, which sells systems and software used in the manufacturing of semiconductor microchips. Germany and Switzerland have the presence of integrated device manufacturers such as Infineon and ST Microelectronics.



Source: Semiconductor Industry Association (SIA), Arthur D. Little analysis

Figure 45: Use cases of semiconductors globally in 2021 (%)[136]

The total global semiconductors market value is USD556 billion in 2021, and its demand is driven by end consumers spanning various industries (Figure 45). Semiconductors can be used in six categories: PC or computer, communications, automotive, consumer, industrial and government (which includes military use). The most common use case of semiconductors globally is for PCs or computers, which has a 32 percent share. Communications devices relating to smartphones were the second most common use case, and have a 31 percent share. This shows that global semiconductor sales are driven by products ultimately purchased by consumers, such as laptops and smartphones. Increasingly, consumer demand is driven in emerging economies within and outside APEC.



Source: Semiconductor Industry Association (SIA), Arthur D. Little analysis

Figure 46: Semiconductor industry value added by activity and economy 2021 (%)[137]

Additionally, Figure 46 identified that APEC economies are major players in the end-to-end semiconductor supply chain. Within APEC, China; Japan; Republic of Korea; Chinese Taipei; the United States were identified as major economies, while economies outside of APEC, such as Europe, were also major players. The six segments of the semiconductor industry that were considered include EDA and core IP; design; equipment; materials; wafer fabrication; and packaging, assembly and testing. The market leader for EDA and core IP, design, and equipment is currently the United States. The market leader for materials is Chinese Taipei, and the market leader for wafer fabrication and packaging, assembly, and testing is China. Considering the industry value added by activity across the six segments, the United States occupies the largest share of 35 percent, followed by the Republic of Korea (16 percent); Japan (13 percent); China (11 percent); and Chinese Taipei (10 percent). As for economies outside of APEC, Europe's total value added to the industry is 10 percent, while the rest of the economies' value added is 5 percent. Among these six key supply chain categories, numerous companies based in APEC economies play an important role in the value chain of different manufacturing aspects (Figure 53).

Other APEC economies, have also strengthened their semiconductor sectors. The following economies are playing an increasing role in the semiconductor supply chain:

- **Indonesia** – Infineon plans to increase its investment by EUR35.37 million (USD37 million) by 2025. Infineon also plans to increase investment to EUR83.57 million (USD89 million) until 2030[138]
- **Malaysia** – Infineon plans to invest EUR5 billion (USD5.3 billion) in August 2023 into building the world's largest 200-millimeter silicon carbide (SIC) power fabrication plant[139]. The Malaysian government also aims to strengthen the semiconductor ecosystem and is committed to achieving a 15 percent market share by 2030, compared with 13 percent currently[140]
- **The Philippines** – Analog Devices plans to invest USD200 million in the Philippines in 2023 to build a new R&D facility[141]
- **Singapore** – Soitec will invest EUR400 million (USD430 million) to double the capacity of its wafer plant, which is scheduled to be completed in 2024. Applied Materials will invest SGD600 million (USD450 million) in a plant that is scheduled to be completed in 2024. GlobalFoundries opened a USD4 billion plant in 2023[142]

- **Viet Nam** – Samsung opened a semiconductor plant called “Electro-Mechanics Viet Nam” in July 2023 to mass produce ball grid array products[143]. Intel invested an additional USD475 million in January 2021[144]
- **Mexico; Thailand; Viet Nam** – HP plans to transfer laptop production from China to Thailand and Mexico in 2023, while a shift in production to Viet Nam is slated for 2024[145]. Production for commercial notebooks is planned to be in Mexico, while manufacturing of consumer laptops will be in Thailand

11. Non-tariff measures affecting IT and ICT trade

11. Non-tariff measures affecting IT and ICT trade

NTMs, ranging from subsidies to import and export restrictions, play a pivotal role in shaping trade dynamics in ICT goods and services across borders. This section aims to evaluate the NTMs in APEC economies to facilitate a more comprehensive understanding of international trade in the ICT sector.

11.1 Methodology

NTMs are "policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both." [146] NTMs are often imposed to address market failures and remain a neutral concept. However, if NTMs are discriminatory and more trade-restrictive than necessary, they can be regarded as non-tariff barriers (NTBs). Labeling an NTM as an NTB may be contentious between trade partners that hold differing views on whether a specific NTM's motive is discriminatory or protectionist. NTMs are not NTBs unless they have been challenged within the WTO dispute settlement process.[147] NTMs and NTBs were not differentiated in this report. This report aims to identify ICT-related NTMs in APEC economies, and analyzes prevalent themes of these measures. The following three-step approach was adopted for identification of the NTMs impacting ICT products across 21 APEC economies:

1. **Identify relevant literature:** The literature review encompassed over 80 reports from the following four distinct sources:

- International Organizations such as the WTO, United Nations (UN), Economic Research Institute for ASEAN and East Asia (ERIA), and others
- Professional services such as law firms and public consulting firms
- Trade associations such as the Information Technology Industry Council (ITI)
- Government reports published by selected APEC economies

2. **Apply a gated approach to filter and identify relevant NTMs:** For the relevant documents identified in the literature review, a three-step gated approach was applied to identify relevant IT or ICT NTMs across APEC economies:

- Filter off trade-related measures not taken by APEC economies
- Filter off trade measures related to tariffs and taxes
- Filter off non-ICT-related NTMs

3. **Collect and evaluate data:** Organize the identified NTMs by APEC economies and group them into seven categories set forth by the UNCTAD – (Table 10):

- Out of the NTMs recognized in Step 2, the frequently employed measures include technical trade barriers, import and export limitations, local content rules, subsidies, and government procurement. The rest of the NTMs are categorized as "others."
- In total, 67 NTMs identified were grouped into seven categories:

Table 10: Types of NTMS and their respective descriptions

Source: United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Type	Description
Technical barriers to trade	• Measures relating to product characteristics such as technical specifications and quality requirements • Conformity assessment such as certification, testing and inspection
Import restrictions	• Control measures aimed at prohibiting or restricting imports, such as import licensing
Export restrictions	• Control measures aimed at prohibiting or restricting exports, such as export licenses, export quotas and export prohibition
Local content measures	• Requirements to purchase or use certain minimum levels or types of domestically produced or sourced products, or restrictions on the purchase or use of imported products

Subsidies	• A financial transfer attributable to an identifiable beneficiary or group of beneficiaries that creates, or could potentially create, an advantage for those beneficiaries
Government procurement	• Restrictive measures that bidders may encounter when trying to sell their products and services to a foreign government
Others	• Other NTMs such as price-control measures of ICT products, local ownership requirements for foreign businesses and data localization requirements for data to be stored or processed within the borders of an economy

4. **Analysis and synthesis**: Based on the above information, for NTMs for ICT products in APEC, identify common NTMs and trends.

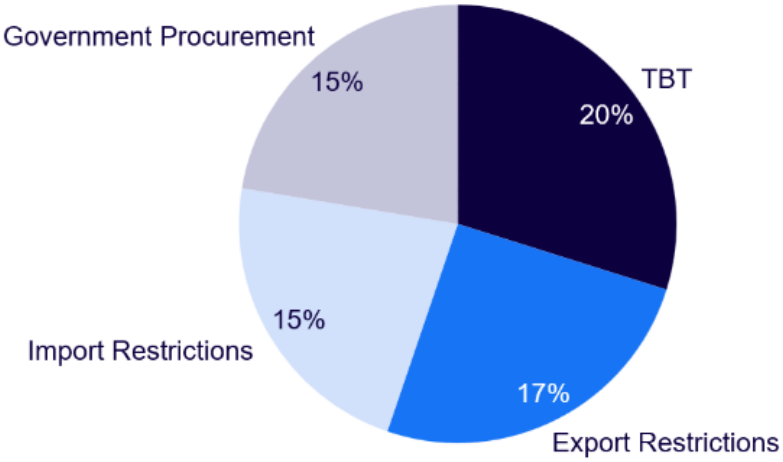
11.2 Summary

NTMs serve as tools for economies to achieve public policy objectives. These objectives often include addressing market imperfections like information imbalances or imperfect competition, and fulfilling non-economic goals such as safeguarding domestic security or promoting public health. While NTMs primarily serve public policy objectives, they can also result in trade barriers. In the ICT sector, the impact of NTMs on trade is pronounced due to the unique characteristics of ICT products, tailored to the global market. They encompass numerous areas within intricate global supply chains, evolve continuously in response to user preferences and technological advancements, find application in diverse sectors and scenarios, and are highly configurable[148]. Within the realm of ICT, 67 NTMs were identified that yielded key observations. Firstly, domestic security matters frequently drive export restrictions in the ICT domain. Secondly, NTMs such as TBTs, import and export restrictions, and government procurement have been employed in the ICT sector. Thirdly, local content measures certain are adopted to safeguard domestic industries. Fourth, data localization mandates could affect trade in ICT products within APEC economies. Finally, there have been increased subsidies and government support allocated to the semiconductor industry. It underscores the duality of NTMs as both facilitators of public policy objectives and potential trade barriers.

1. Domestic security is a common driver for export restrictions in ICT

In the identified NTMs, “domestic security” is cited as the reason for import or export restrictions in eight out of 67 NTM cases. Regarding export restrictions, economies have been imposing controls on specific ICT products intended for export, citing the safeguarding of domestic security interests as the impetus.

2. TBT, import and export restrictions, and government procurement are frequently used NTMs for ICT



Source: United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Figure 47: Distribution of NTMs

Among the NTMs identified, no single NTM stands out as the most prevalent. The distribution of NTMs: 20 percent TBT, 17 percent Export Restrictions, 15 percent Import Restrictions, and 15 percent Government Procurement (Figure 47).

3. Local content measures and government procurement are to safeguard the domestic ICT industry

Among the identified NTMs, local content measures and government procurement stand as pivotal strategies employed to bolster domestic ICT industries. Economies has enforced regulations mandating that smartphones contain a minimum of 30 percent local content, alongside allocating a substantial 40 percent of government procurement contracts to local SMEs. Similarly, other economies has imposed restrictions on procuring specific products from foreign companies, accompanied by a 30 percent price preference for state-owned enterprises during government procurement processes. This commitment to domestic industry finds resonance in initiatives that underpin targeted objectives to elevate the prominence of domestically manufactured goods.

4. Data localization requirements are found in APEC economies

ICT development propels the implementation of data protection measures. Within APEC, a multitude of new data localization regulations have emerged. These regulations are said to be aimed at fostering privacy and data protection, facilitating access to data for law enforcement agencies, and stimulating domestic digital industries[149]. Nevertheless, an overabundance of data protection regulations can exert adverse effects on trade, innovation, and competition.

- For example some economies require critical information infrastructure operators and processors handling personal information, personal data are mandated to retain this information within their territory. Cross-border data transfers necessitate security assessments by the local cyberspace department and other pertinent authorities.
- On the other hand, other economies have recently eased its data localization rules, gaining industry support. Initially, an economy required domestic storage of certain data from websites and applications serving others for governmental oversight. However, a subsequent regulation focused solely on the onshore storage and processing of government data. Private sector data, categorized as commercial and non-strategic, can now be stored abroad

5. Increased subsidies and government support are being allocated to the semiconductor industry

In recent times, there has been a notable surge in government subsidies to industries across APEC economies, with a pronounced focus on the semiconductor sector. For example:

- An economy introduced a technology research and development act provided funding to support local semiconductor research, development, manufacturing, and workforce enhancement.
- Furthermore, another economy legislative body passed a bill that provides significant tax incentives to strategic industries, including the semiconductor sector, to encourage domestic investment, bolster supply chain security, and stimulate economic growth.
- Another economy has also expressed its commitment to matching semiconductor aid offered by other economies.

11.3 Non-tariff measures in APEC economies

1. Technical Barriers to Trade

Technical Barriers to Trade (TBT) within APEC economies present a complex landscape of regulatory challenges impacting international trade. TBT refer to measures and regulations implemented by economies to protect human health, safety, the environment, and other non-economic factors. The aim is to ensure that products entering a market meet certain technical specifications. TBT measures are meant to address legitimate concerns but can sometimes be used as non-tariff barriers, impacting international trade by creating obstacles for foreign goods that do not conform to the specified technical requirements. Various economies have implemented a range of measures focusing primarily on product specifications, import restrictions, certification and testing requirements.

Examples of TBT in APEC economies:

- **Unique Technical Specifications:** Some APEC economies have established their own technical specifications for products, particularly for radio devices and telecommunication equipment. These unique specifications may differ from the International Electrotechnical Commission (IEC) standard. This adds an additional level of complexity for exporters as they will be required to modify products to meet the specific requirements of each economy.
- **Prohibition of Certain Communications Equipment:** Some economies have established rules prohibiting the importation and sale of equipment deemed a risk to the safety of local people.
- **Mandatory Certification Requirements:** Some economies require specific safety and quality marks or technical compliance certifications for products such as computers, wireless devices and radio devices. This process typically involves additional testing, inspection, and compliance with local standards. Some economies also accept relevant international standards e.g. IEC 950. However, for other economies, these standards diverge from international standards, necessitating additional certification procedures.
- **In-Economy Testing:** Some economies require in-economy testing of specifications. For instance, in a given economy, in-economy testing of the Specific Absorption Rates (SAR) of mobile telecommunications products is required, even if they have been tested and certified elsewhere. The testing requirements refer to specific local standards instead of recent guidance from the IEC and Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). For another economy, there are specific requirements for conformity assessments regarding a wide variety of consumer goods including electronics and home appliances. It is also required that all steps of product testing be conducted by a local citizen residing in the domestic economy.

2. Import Restrictions

Import restrictions are a form of non-tariff measure used by governments to control or limit the import of certain goods. In the context of APEC economies, import restrictions can take many forms, from outright prohibitions to requiring special licenses or pre-shipment inspections. These restrictions apply to a wide range of products and services, including technologies with risks to domestic security, used products, controlled waste, telecommunications equipment, and strategic goods. Economies impose import restrictions as a non-tariff measure for varying reasons such as domestic security, however these measures might inadvertently become barriers to trade.

Examples of Import Restrictions in APEC Economies:

- **Prohibited/Restricted Products for Import:**
  - **Domestic Security and Public Interest Risks:** Technologies posing risks to domestic security or public interest are subject to import restrictions or prohibitions through various methods such as a prohibited list of information and communication technologies and services
  - **Used and Refurbished Products Protection:** Import restrictions on used or refurbished IT products is one of the representative measures.
- **Special Permits or License Requirements:**

    - **Controlled Waste:** Import restrictions in this category involve special permits for importing controlled waste, including e-waste such as television sets, computers, printers, scanners and monitors.
    - **Telecommunications Equipment & Electrical Products:** Certain telecommunication, radio-communication, and broadcasting equipment such as telephones, voice scramblers, scanning receivers or transmitters require special approvals or licenses for import.
    - **Strategic Goods & Technologies:** Import restriction on strategic goods and technologies is one of the representative measures.
- **Additional Pre-Shipment Verification Requirements**: For a range of products including electronics, a given economy mandates pre-shipment inspections. These verifications, aimed at ensuring compliance with local standards, are conducted at the importer's expense and require certification from designated companies.

3. Export Restrictions

Export restrictions are regulatory measures employed by governments to control or limit the export of certain goods and technologies. Export restrictions are often implemented by governments to achieve various policy objectives, such as ensuring domestic supply, protecting natural resources, however these measures can have a significant impact on international trade. Various economies have implemented a range of measures focusing primarily on export permits and restrictions for particular categories of items including strategic goods, advanced technologies, industrial products and rare earth materials.

Examples of Export Restrictions in APEC Economies:

- **Export Permits or Licenses:**
    - **Strategic Goods & Advanced Technologies:** A number of economies enforce restrictions on strategic goods for domestic security reasons, whereby a strategic goods permit is required for the export of software, technologies, or military and dual-use goods that could be used to produce conventional or mass destruction weapons.
- **Export Bans or Restrictions:**
    - **Industrial Products:** A given economy had imposed a temporary ban on the export of several industrial products, including technological, communication and medical equipment, and electrical equipment.

4. Local Content Measures

Local content measures are regulatory policies implemented by governments to encourage the use of domestically produced or sourced products and services. Local content measures are often implemented with the aim of fostering economic development, creating jobs, and enhancing the capabilities of domestic industries. While these measures can be used to achieve legitimate policy objectives, they also have the potential to distort international trade by discriminating against foreign producers or creating barriers to entry for foreign businesses. Various economies have implemented a range of measures focusing primarily on strategic sector development to boost the use of domestically produced goods, and local content thresholds such as specifying the minimum proportion or percentage of inputs, components, or labor that must be sourced locally in the production of goods or services.

5. Subsidies

Subsidies are financial contributions provided by the governments to support specific industries or activities. Various economies have implemented a range of measures focusing primarily on direct funding, tax breaks and loan incentives. Subsidies may fall into the category of trade-distorting non-tariff measures because they can create an uneven playing field by providing artificial advantages to domestic industries, potentially leading to market distortions and affecting international competition. Representative measures which fall into this category are direct funding for domestic sectors, tax breaks for strategic industries and loan and guarantee policies for digital sectors, etc.

6. Government Procurement

Government procurement refers to the process through which governments purchase goods, services, or construction projects for public use. They can impact international trade by affecting the ability of foreign suppliers to compete on an equal footing with domestic suppliers in government procurement opportunities. Foreign bidders may encounter restrictive measures when trying to sell their products and services to a local

government. Various economies have implemented a range of government procurement measures, focusing primarily on incentives for domestic products, mandatory requirements, exclusion of foreign products in critical sites and domestic partnership requirements.

7. Others

Other non-tariff measures implemented amongst APEC economies include data localization, local ownership requirements and price-control measures. These measures constitute regulatory and policy actions by governments that impact trade by influencing the conditions, prices, and ownership structures of goods and services,

11.4 Solutions to Non-tariff measures

The impact of NTMs and NTBs on ICT trade is multifaceted. These measures, which have included stringent quality standards, conformity requirements, data localization laws, and complex customs procedures, could be potential roadblocks for ICT companies looking to expand globally. Policymakers could focus on harmonizing international standards, enhancing transparency, and simplifying regulations. Simultaneously, businesses are leveraging technology and supply chain optimization. These combined efforts promote innovation, accelerate technology adoption, and ensure smoother global trade, benefiting both the ICT sector and consumers. It is also important to ensure that regulatory measures are no more trade restrictive than necessary to achieve a legitimate objective

11.4.1 Policy-related solutions

Policy-driven solutions to NTMs are pivotal to minimizing their adverse impact on ICT trade. These strategies, often focusing on harmonization, transparency, and regulatory efficiency, aim to reduce trade barriers, enabling smoother cross-border commerce and fostering economic growth on a global scale.

Harmonization and mutual recognition of standards

Harmonization on NTMs is commonly achieved through international agreements, such as the WTO Agreement on TBTs, or through regional agreements. Economies should also consider endorsing Mutual Recognition Agreements[150](MRAs) and adhering to international standards[151]. This could be achieved through dialogue between economies for regional accreditation and mutual recognition of each other's standards or conformance on specific products or sectors of interest.

Notable initiatives proposed by economies are:

- **Acceptance of International Standards**: In June 2022, Israel allowed automatic entry for products accepted by the United States standard[152], with the FCC and NRTL mark, and EU standard, with the CE mark. Recognizing these widely accepted certifications helps to reduce TBTs, as the simplification of import processes for businesses will help them to navigate the complex web of regulations and standards in the exchange of ICT goods
- **Increase Mutual Recognition Agreements (MRA)**: Economies reduce TBTs by increasing MRAs[153] and encouraging the regulatory bodies to accept conformity assessment results from listed laboratories for select partners. For example, Australia and the EU agree on joint MRAs covering some ICT sectors such as automotive, electromagnetic compatibility (EMC), telecommunications terminal equipment (TTE), good manufacturing practices (GMPs), etc.
- **Address NTMs within Free Trade Agreements (FTA):** Within the EU-South Korea trade agreement, The Republic of Korea streamlined import procedures with the European Union (EU) on technical regulations, set standards, and conformity assessments on three ICT sectors[154]: electrical and electronic equipment, medical devices, motor vehicles, and parts. This initiative is to promote international cooperation and simplify the importation of high-tech devices, ensuring that ICT products that meet the rigorous quality and safety criteria in both regions can enter the Republic of Korea efficiently
- **Introduction of bilateral agreement**: Japan and Mexico recognized each other's certifications for ICT devices[155]. Products like smartphones and wireless routers that were certified as meeting quality and safety standards by Japan's MIC (Ministry of Internal Affairs and Communications) and Mexico's COFETEL (Comisión Federal de Telecomunicaciones) could be imported and sold in both economies without the need for additional certification processes. This joint agreement aimed to promote trade and innovation in the ICT sector between Japan and Mexico

2. Enhancing transparency on NTMs

To increase transparency on NTMs regionally and multilaterally, economies can participate in regional cooperation and information-sharing initiatives, including regulations and procedures, as well as best

practices for addressing NTMs. Several international and regional bodies cooperate to improve NTM transparency through:

- **Technical Barriers to Trade (TBT) Committee**[156]: The WTO's TBT Committee provides a triennial forum for members to discuss NTMs and their technical regulations, conformity assessment procedures and standards
- **APEC Telecommunications and Information Working Group (TEL):** TEL aims to streamline conformity assessment bodies[157] (CAB) to foster transparent NTMs between APEC economies while advancing the development of ICT infrastructure and services. TEL also promotes cooperation, information sharing, and the development of effective ICT policies and regulations in the Asia-Pacific region[158]. Moreover, the APEC working group enhances social and economic development in the region through the effective use of ICT and promotes a secure and trusted ICT environment
- **ASEAN Trade in Goods Agreement (ATIGA):** The ATIGA works on provisions and non-binding guidelines that promote transparency and management of NTMs[159]. The main responsibility is to notify NTMs that could affect the ATIGA's operation
- **Notification of measures:** Improving the notification of regulatory measures, and the provision of adequate time and opportunities to comment on them and implement them

3. Review of the prevalence of NTMs in the region

The regional review of NTMs would involve examining the extent to which non-tariff measures are present in trade activities. Additionally, the roles of the concerned institutions would be assessed to understand their involvement in implementing and enforcing these measures. The goal of these reviews is to gain a comprehensive understanding of the current situation and identify areas for improvement to facilitate trade in the region.

The Economic and Social Commission for Asia and the Pacific[160] (ESCAP) reviews NTMs' impact on each economy's trade outcomes, including ICT goods. ESCAP also recommends ASEAN economies establish different initiatives such as the National Trade Facilitation Committee for border agencies' cooperation, and government agencies delegating border controls.

4. Streamlining and digitizing customs procedures

Streamlining and digitizing customs procedures is an essential approach, that involves modernizing and simplifying the complex and paper-intensive customs clearance procedures at borders. By leveraging digital technologies, automation, and data-sharing platforms, economies can expedite the movement of goods across borders, reduce delays, and enhance trade efficiency. Furthermore, streamlined customs procedures can also contribute to improved transparency and reduced opportunities for corruption, fostering a more conducive environment for businesses engaged in global trade.

11.4.2 Business-related solutions

Businesses are proactively tackling NTMs by leveraging technology, diversifying products, and creating collaborations. These efforts streamline compliance, improve product quality, and enhance supply chain efficiency, enabling companies to thrive despite NTMs challenges, ultimately bolstering global trade resilience and competitiveness

Local partnerships

Multinational businesses in the ICT industry are motivated to partner with local entities to tackle NTMs of that market and to leverage their market entries. Many economies have specific regulations and standards related to the ICT industry, and therefore, local partnerships help businesses navigate the complex regulatory environment and the NTM landscape. Some examples include:

- Huawei “Global” IoT ecosystem: With this ecosystem, global carriers can quickly build cross-industry and cross-domain ecosystems to overcome difficulties involving import restrictions and local regulations. Moreover, the Global ecosystem enables fast replication of successful experiences, so that carriers can quickly transplant solutions at low costs[161]
- Cisco: Cisco works with local businesses, governments, and organizations to address NTM-related challenges such as TBTs and region-specific IoT challenges and opportunities[162]

Industry association

- The Japan Electronics and Information Technology Industries Association (JEITA) works on behalf of Japanese ICT companies to negotiate with foreign governments to eliminate TBT, ensuring ICT products from Japanese companies comply with both international standards like ISO and domestic technical standards

Manufacturing Diversification

- Samsung: Samsung has diversified its production across economies like Viet Nam, China, and the Republic of Korea, receiving financial incentives for its business from local government while mitigating the impact of corporate tax rates in economies. This decision enables Samsung to reduce production costs and revenue loss by high tariff rates.
- HP: HP plans to relocate their PC assembly to Mexico; Thailand; and Viet Nam in 2024[163]

12. Key Findings and Recommendations

12. Key Findings and Recommendations

The analysis offered in this report provides a comprehensive overview of the current and future ICT landscape and its potential to shape future global commerce and address global challenges, particularly in APEC. It delves into the evolution of ICT since the inception of the ITA and ITA2 more than two decades ago. The report demonstrates how ICT trade dynamics have developed and identifies the impact that NTMs had on ICT trade. Emerging ICT technologies were identified and analyzed within the APEC region. Several ICT technologies have shown the ability to address global challenges through their impact on SDGs. Furthermore, the benefits of reduced tariffs identified for emerging ICT products were studied. The report identifies APEC economies' substantial roles in the global semiconductor supply chain. As emerging ICT continues to progress at a rapid pace, APEC's economies have created ICT policies to leverage the benefits of emerging ICT in trade and beyond.

12.1 Benefits of ITA participation

Participation in the ITA has provided much benefits to economies from increase trade to bridging the digital divide and more. As seen in chapter 1, through a critical analysis of the ITA, it can be seen that there have been positive impact of ITAs on trade flows, revealing a fourfold increase in ITA and ITA2 trade (imports and exports) from 1996 to 2021. Furthermore, the analysis of ITA2 ICT trade, shows a 56 percent increase from 2016 to 2021 based on a detailed 96 HS6 code assessment. The imperative for periodic updates to ITAs is evident, as advancing technologies render products obsolete, as exemplified by the 60 percent ITA2 trade value in 2021. To develop economy specific insights, economies should leverage methodologies presented in this report and conduct detailed analyses with the most granular data available to their economy. Specific actions include applying trade flow analysis methodologies with HS8/10 codes to identify overall ICT trade and top products within each economy and employing emerging ICT technology methodologies to identify impactful technologies by 2030. In doing so, economies will be able to use a data-driven approach to not only identify more specific product categories for potential inclusion into the ITA, but also to drive policy decision making in general. The impact of ITA should also go beyond increase in trade, therefore economies should also assess ITA participation's additional impacts beyond trade. These extended impact areas encompass bridging the digital divide, fostering services industries, enabling digital public services, and attracting Foreign Direct Investment (FDI) for further job creation.

12.2 ICT's role in accelerating SDGs

ICT's vital role in accelerating SDGs calls for economies to leverage unique narratives and peer insights to fast-track learning and amplify impact on SDG advancement. In the pursuit of advancing SDGs, the pivotal role of ICT demands that economies harness unique narratives and insights from peers to expedite learning and magnify the impact on SDG advancement. Through various case studies as seen in chapter 9, ICT has shown to act as a catalyst for accelerating SDGs. ICT's role in addressing global challenges, ranges from climate change and poverty to inequality and healthcare. Global case studies underscore ICT's essential role in accelerating SDGs and delivering societal benefits, including examples such as 3D drone inspections, 3D bio-printed organs, and enhanced disaster risk management through the use of IoT. These cases serve as exemplars, emphasizing the broader importance of ICT in SDG acceleration. The key implication is to actively promote ICT for SDG acceleration, recognizing that each economy possesses distinctive narratives which are capable of inspiring various stakeholders to harness ICT for expediting progress in SDGs. Furthermore, economies are urged to leverage insights gained from other economies, facilitating a shorter learning curve and amplifying the impact by applying these lessons locally, ultimately accelerating progress toward SDG objectives.

12.3 Recommendations

APEC should prioritize knowledge sharing and technical assistance as essential components of capacity building while concurrently advocating for the standardization of ICT products. Capacity building would take a two prong approach of knowledge and experience sharing as well as technical assistance. To facilitate knowledge and experience sharing, APEC should establish a dedicated forum for disseminating best practices, insights, and expertise related to both the ICT sector and ITA. Efforts to raise awareness about the benefits of ITA are crucial for garnering broad based support for its expansion. In the realm of technical assistance, developed APEC economies should actively support their developing counterparts by providing assistance in areas such as certification procedures, compliance with trade regulations, testing, and verification. Informational campaigns, workshops, seminars, and peer-to-peer learning sessions can serve

as effective tools in these endeavors. Additionally, APEC should play a pivotal role in promoting the adoption of common standards, particularly conformity assessment for ICT products. This proactive approach aims to mitigate technical barriers to trade, ultimately reducing costs and streamlining trade requirements and processes for businesses. Harmonization agreements, including Mutual Recognition Arrangements (MRAs), can contribute to this effort, alongside the drafting of guidelines through workshops on best practices.

To foster equitable integration of ICT across all economies, it is crucial to proactively monitor the impact of ITA and stay informed about emerging technological developments. The goal of engaging more stakeholders is through empowering all economies to lower instances where APEC economies choose not to participate in either ITA or ITA2. It emphasizes the potential under-utilization of ITA benefits by certain member economies, which may be caused by their lower prominence in the global ICT industry supply chain. APEC, facilitated by ABAC, can actively create inclusive opportunities. This involves enabling non-participating economies to integrate into the ICT supply chain, attracting FDIs, and fostering job creation. Such efforts aim to encourage eventual participation in ITA, which can be fostered through industry dialogues and investment forums. Additionally, conducting regular assessments such as trade data collection and analysis using HS 8/10 codes helps to gauge ITA impact and expansion within APEC economies provides actionable insights for future policy formulation. Technological foresight, involving systematic analysis of future technological trends, ensures long-term planning and a data-driven approach to inform ICT-related policy-making.

Furthermore, a deep dive into emerging ICT technologies also allows APEC member economies to ascertain their wider impact and benefits beyond trade. This could include detailed examinations of IoT applications in healthcare, agriculture, and smart cities, as well as adoption rates and barriers to 3D printing. The deep dives delve into robotics applications for potential productivity improvements, scrutinizing blockchain technology's role in trade facilitation such as in paperless trade platforms, and exploring the economic potential and challenges associated with integrating the metaverse in industrial and commercial applications. Lastly, ethical considerations and the establishment of governance structures for AI implementation are also key aspects of this thorough examination.

In moving forward towards the future, some of the immediate next steps for APEC could include:

- **ITA Expansion and APEC Support**: Advocate for additional workshops on ITA and consider potential opportunities for APEC economies to support any future ITA expansion
- **Global Promotion of ITA Ideas:** While the WTO remains the appropriate forum to consider any potential future commitments related to the ITA, APEC could play a role in promoting key ideas of the ITA. Examples of such key ideas to enhance would be realizing the liberalization of trade in ICT products through the elimination of tariffs, which in turn leads to the diffusion of ICT products to bring about a more convenient and affluent society
- **ICT for Economic Development:** Focus on how ICT can benefit developing and least developed economies, addressing their challenges for economic sustainability
- **Additional Workshops and Information Sharing:** Explore physical events and workshops for in-depth discussions on ICT goods, and digital services in digital trade. Ensure workshop findings are shared at the APEC summit
- **Continuous Monitoring:** Stay updated on technological advancements, ITA expansion, and anticipate the next ICT paradigm shift

13.Appendix

13. Appendix

13.1 Webinar conducted on 10 November 2023

To facilitate the dissemination of the insights contained in this report, a webinar was held on 10 November 2023, with three primary objectives:

- Deepen stakeholders' understanding of ICT trade flow analysis in APEC as a comprehensive entity, shed light on new and emerging ICT products, elucidate the implications of reduced tariffs on emerging ICT products, and explore the potential of ICT in addressing global challenges
- Aid in enhancing knowledge on current and future ICT landscape to help facilitate more ICT trade opportunities in the future
- Seek input and guidance on the integration of feedback and commentary provided into the final report

Six main topics were discussed at the webinar:

- ICT trade flows
- Emerging ICT and industry 4.0 technologies
- New and emerging ICT HS codes
- Impact of tariff reductions on emerging HS codes
- Achievement and possibilities of ICT in solving global issues
- Conclusion and recommendations

The webinar had a turnout of +75 participants across 13 APEC economies in attendance. Female representation was 45 percent of all participants.

Economies Present	
Canada	Malaysia
Chile	The Philippines
China	Switzerland[1]
Hong Kong, China	Chinese Taipei
Indonesia	Thailand
Japan	The United States
Lao PDR[1]	

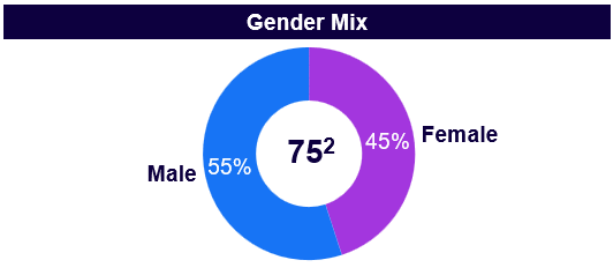


Figure 48: Webinar turnout and statistics

As shown in Figure 49 feedback from the webinar was positive across the board.

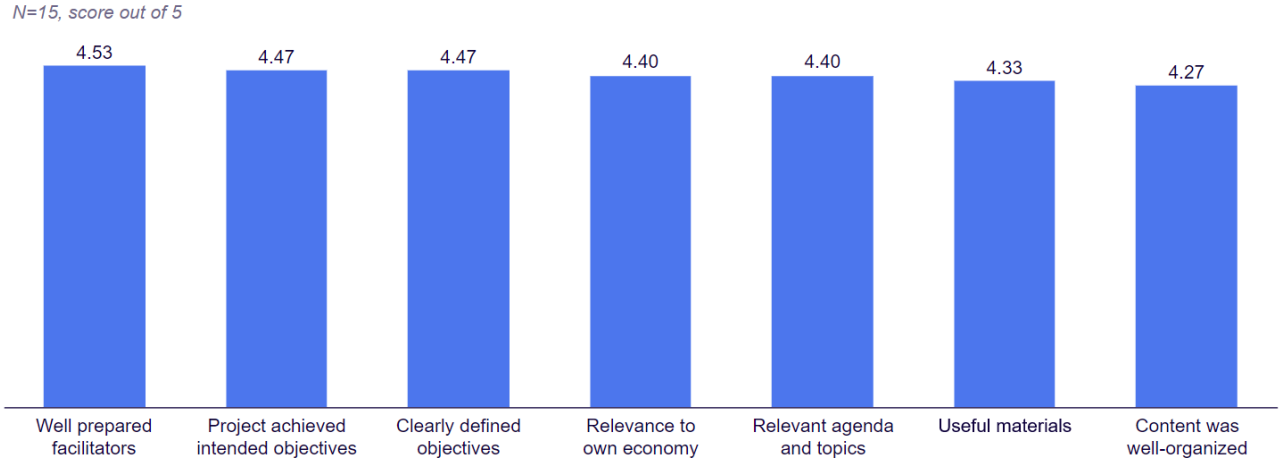


Figure 49: Webinar outcomes and feedback from participants

Participants noted that they gained new knowledge from the webinar, including:

- Emerging Trends in ICT Trade:
  - Enhanced understanding of emerging ICT products and the prevailing ICT trade trends within the APEC region.
  - Learnt about potential future ITA expansion products and gained insights into ICT tariff dynamics.

- ITA Benefits and Challenges:
    - Gained understanding about the dual aspects of benefits and challenges in ICT trade through ITA participation.
    - Recognized the pivotal role of the ICT sector in economic plans and gained diverse perspectives from other economies
- Knowledge Enhancement on ICT in Solving Global Issues:
    - Expanded knowledge of ICT capability and possibility in addressing global issues.
    - Developed a deeper appreciation for the ITA's significance in boosting ICT trade which allows ICT to solve sustainable development goals at a larger scale

There were three discussion points raised both during the webinar and in the post-webinar feedback that have been incorporated in more detail as part of individual sections within this post-webinar final report. A summary of discussion points and remarks are summarized in Table 11

Table 11: Webinar discussion points

#	Discussion points	Remarks
1	Future Information and Communications Technologies (ICT) that will have major impact on the APEC region over the next decade	Emerging technologies such as IoT, big data, metaverse, etc. as well as new products such as green energy and intelligent products are expected to bring a significant benefits to APEC economies. Additionally, ICT also benefits economies with rural regions. For instance, in China's Shandong province, e-commerce played a pivotal role in the revitalization of the traditional Chinese clothing industry known as Hanfu. This e-commerce-driven transformation not only generated a multitude of job opportunities but also gave rise to the establishment of 615 e-commerce enterprises, resulting in an e-commerce transaction volume of CNY8 billion within the province. Moreover, green energy made significant contributions to the development of the rural construction sector. In China's context, photovoltaic power generation has proven to be a reliable source of electricity supply in rural desert areas.
2	Emerging ICT address global issues and benefit economies, while catering to the individual economies specific needs	ICT have proven instrumental in addressing critical social challenges. In the case of Japan, the aging population presents significant challenges that impact social welfare, including social security and long-term care administration. Emerging technologies, such as electronic health record systems efficiently capture and manage patient information, thereby enhancing the quality and safety of healthcare services. Additionally, telemedicine platforms facilitate communication between patients and physicians, thereby improving healthcare accessibility. The semiconductor industry plays an indispensable role in supporting ICT advancements across various domains. Semiconductors serve as a linchpin for addressing a multitude of societal challenges. Innovations in semiconductor technology enable the development of emerging ICT products poised to tackle global social issues on a broader and larger scale. ITA can play a pivotal role by eliminating tariffs on semiconductors

		and ICT goods, thereby enhancing the availability of innovative products, including those designed to reduce greenhouse gas emissions, advance medical devices, and remote healthcare solutions.
3	Useful measures that improve capacity building for non-ITA participating economies	Many non-participating economies are least developed economies. Therefore, these non-participating economies encounter significant hurdles in obtaining access to and harnessing the advantages of ITA, primarily due to deficient infrastructure, limited application capabilities, and a pronounced digital divide. To underscore the advantages of ITA, it is imperative to implement capacity-building initiatives including: • promoting the benefits of ITA through extensive discussions and knowledge sharing with non-participating economies, emphasizing real-world use cases and their associated advantages; • offering educational training programs to address infrastructure challenges, thereby facilitating the implementation of ITA in non-participating economies.
4	Challenges expanding ITA membership	Participation in the ITA entails the elimination of tariffs on ICT products, which, in turn, leads to a reduction in tariff revenues for economies. However, the substantial benefits derived from the growth of the ICT industry within the economy far outweigh the forgone tariff revenues. Some economies opt not to participate in the ITA with the aim of safeguarding their domestic ICT manufacturing sector. However, it is crucial to recognize that the most significant advantages stemming from ICT come from its widespread usage. The removal of tariffs on ICT products makes them more accessible across the entire economy. Therefore, the expansion of ITA membership holds considerable significance, including the inclusion of Least Developed Economies, as they stand to gain substantially from participating in the ITA.

13.2 ICT trade flow analysis

Table 12: 96 ICT HS codes

**ITA and ITA2 categorization is determined through ITA and ITA2 lists from WTO and ITIF, while ICT categorization is determined through UNCTAD ICT categorization*

Source: The United Nations Comtrade (UNComtrade), World Trade Organization (WTO), The Information Technology and Innovation Foundation (ITIF), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

No.	HS Code	HS Code Description	ITA Category*	ICT Category*
1	844331	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network	ITA2	ICT01
2	844332	Printing, copying, and facsimile machines; single-function printing, copying or facsimile machines, capable of	ITA2	ICT01

		connecting to an automatic data processing machine or to a network		
3	847050	Cash registers	ITA	ICT01
4	847130	Automatic data processing machines; portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display	ITA	ICT01
5	847141	Automatic data processing machines; comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined, n.e.c. in item no. 8471.30	ITA	ICT01
6	847149	Automatic data processing machines; presented in the form of systems, n.e.c. in item no. 8471.30 or 8471.41	ITA	ICT01
7	847150	Units of automatic data processing machines; processing units other than those of item no. 8471.41 or 8471.49, whether or not containing in the same housing one or two of the following types of unit: storage units, input units or output units	ITA	ICT01
8	847160	Units of automatic data processing machines; input or output units, whether or not containing storage units in the same housing	ITA	ICT01
9	847170	Units of automatic data processing machines; storage units	ITA	ICT01
10	847180	Units of automatic data processing machines; n.e.c. in item no. 8471.50, 8471.60 or 8471.70	ITA	ICT01
11	847190	Magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, not elsewhere specified or included	ITA	ICT01
12	847290	Office machines; not elsewhere classified	ITA	ICT01
13	847330	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	ITA	ICT01
14	847340	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8472	ITA2	ICT01
15	847350	Machines; parts and accessories (other than covers, carrying cases and the like) equally suitable for use with machines of two or more of the headings 8470 to 8472	ITA	ICT01
16	852842	Monitors; cathode-ray tube, capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	Non-ITA	ICT01
17	852852	Monitors; other than cathode-ray tube; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	Non-ITA	ICT01
18	851711	Line telephone sets with cordless handsets	ITA	ICT02
19	851712	Telephones for cellular networks or for other wireless networks	ITA	ICT02
20	851718	Telephone sets n.e.c. in item no. 8517.1	ITA	ICT02
21	851761	Base stations	ITA2	ICT02
22	851762	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	ITA2	ICT02
23	851769	“Communication apparatus (excluding telephone sets or base stations); machines for the transmission or reception of voice, images or other data (including wired/wireless networks), n.e.c. in item no. 8517.6”	ITA2	ICT02
24	851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	ITA2	ICT02
25	852550	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, not incorporating reception apparatus	ITA2	ICT02

26	852560	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, incorporating reception apparatus	ITA2	ICT02
27	853110	Signaling apparatus; electric, sound or visual, burglar or fire alarms and similar, other than those of heading no. 8512 or 8530	Non-ITA	ICT02
28	851810	Microphones and stands therefor	ITA	ICT03
29	851821	Loudspeakers; single, mounted in their enclosures	ITA2	ICT03
30	851822	Loudspeakers; multiple, mounted in the same enclosure	ITA2	ICT03
31	851829	Loudspeakers; not mounted in their enclosures	ITA	ICT03
32	851830	Headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers	ITA	ICT03
33	851840	Amplifiers; audio-frequency electric	ITA2	ICT03
34	851850	Amplifier sets; electric sound	ITA2	ICT03
35	851890	Microphones, headphones, earphones, amplifier equipment; parts of the equipment of heading no. 8518	ITA2	ICT03
36	851920	Sound recording or reproducing apparatus; operated by coins, banknotes, bank cards, tokens or by other means of payment	Non-ITA	ICT03
37	851930	Sound recording or reproducing apparatus; turntables (record-decks)	Non-ITA	ICT03
38	851950	Sound recording or reproducing apparatus; telephone answering machines	ITA	ICT03
39	851981	Sound recording or reproducing apparatus; using magnetic, optical or semiconductor media, n.e.c. in item no 8519.20, 8519.30 or 8519.50	ITA2	ICT03
40	851989	Sound recording or reproducing apparatus; n.e.c. in heading no 8519	ITA2	ICT03
41	852110	Video recording or reproducing apparatus; magnetic tape-type	ITA2	ICT03
42	852190	Video recording or reproducing apparatus; other than magnetic tape-type	ITA2	ICT03
43	852210	Sound recording or reproducing apparatus; parts and accessories thereof, pick-up cartridges	Non-ITA	ICT03
44	852290	Sound or video recording or reproducing apparatus; parts and accessories thereof, other than pick-up cartridges	ITA2	ICT03
45	852580	Television cameras, digital cameras and video camera recorders	ITA2	ICT03
46	852712	Radio broadcast receivers capable of operating without an external power source; pocket-size radio cassette-players	ITA2	ICT03
47	852713	Radio broadcast receivers capable of operating without an external power source; apparatus (other than pocket-size radio cassette-players), combined with sound recording or reproducing apparatus	ITA2	ICT03
48	852719	Radio broadcast receivers capable of operating without an external power source; n.e.c. in item no. 8527.1	ITA2	ICT03
49	852721	Radio broadcast receivers not capable of operating without an external source of power, of a kind used in motor vehicles; combined with sound recording or reproducing apparatus	ITA2	ICT03
50	852729	Radio broadcast receivers not capable of operating without an external source of power, of a kind used in motor vehicles; not combined with sound recording or reproducing apparatus	ITA2	ICT03
51	852791	Radio broadcast receivers n.e.c. in heading no. 8527; combined with sound recording or reproducing apparatus	ITA2	ICT03

52	852792	Radio broadcast receivers n.e.c. in heading no. 8527; not combined with sound recording or reproducing apparatus but combined with a clock	ITA2	ICT03
53	852799	Radio broadcast receivers n.e.c. in heading no. 8527; not combined with sound recording or reproducing apparatus and not combined with a clock	ITA2	ICT03
54	852849	Monitors; cathode-ray tube, n.e.c. in subheading 8528.42, whether or not color	ITA2	ICT03
55	852859	Monitors other than cathode-ray tube; n.e.c. in subheading 8528.52, whether or not color	Non-ITA	ICT03
56	852862	Projectors; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	Non-ITA	ICT03
57	852869	Projectors; n.e.c. in subheading 8528.62, whether or not color	Non-ITA	ICT03
58	852871	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; not designed to incorporate a video display or screen	ITA2	ICT03
59	852872	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; incorporating a color video display or screen	Non-ITA	ICT03
60	852873	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; incorporating a monochrome video display or screen	Non-ITA	ICT03
61	950450	Games; video game consoles and machines, other than those of subheading 9504.30	ITA2	ICT03
62	852321	Magnetic media; cards incorporating a magnetic stripe, whether or not recorded, excluding products of Chapter 37	ITA2	ICT04
63	852352	Semiconductor media; smart cards, whether or not recorded, excluding products of Chapter 37	ITA2	ICT04
64	853400	Circuits; printed	ITA	ICT04
65	854011	Tubes; cathode-ray television picture tubes, including video monitor cathode-ray tubes, color	Non-ITA	ICT04
66	854012	Tubes; cathode-ray television picture tubes, including video monitor cathode-ray tubes, monochrome	Non-ITA	ICT04
67	854020	Tubes; television camera tubes, image converters and intensifiers, other photo-cathode tubes	Non-ITA	ICT04
68	854040	Tubes; data/graphic display tubes, monochrome; data/graphic display tubes, color, with a phosphor dot screen pitch smaller than 0.4mm	Non-ITA	ICT04
69	854060	Tubes; cathode ray, n.e.c. in heading no. 8540	Non-ITA	ICT04
70	854071	Tubes; microwave, magnetrons, excluding grid-controlled tubes	Non-ITA	ICT04
71	854079	Tubes; microwave (for example klystrons, traveling wave tubes, carlinotrons), excluding magnetrons and grid-controlled tubes	Non-ITA	ICT04
72	854081	Valves and tubes; receiver or amplifier	Non-ITA	ICT04
73	854089	Valves and tubes; n.e.c. in heading no. 8540	Non-ITA	ICT04
74	854091	Tubes; parts of cathode-ray tubes	Non-ITA	ICT04
75	854099	Valves and tubes; parts of the valves and tubes of heading no. 8540, excluding parts of cathode- ray tubes	Non-ITA	ICT04
76	854110	Electrical apparatus; diodes, other than photosensitive or LED	ITA	ICT04

77	854121	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of less than 1W	ITA	ICT04
78	854129	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of 1W or more	ITA	ICT04
79	854130	Electrical apparatus; thyristors, diacs and triacs, other than photosensitive devices	ITA	ICT04
80	854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED	ITA	ICT04
81	854150	Electrical apparatus; photosensitive semiconductor devices n.e.c. in heading no. 8541, including photovoltaic cells, whether or not assembled in modules or made up into panels	ITA	ICT04
82	854160	Crystals; mounted piezo-electric	ITA	ICT04
83	854190	Electrical apparatus; parts for diodes, transistors and similar semiconductor devices and photosensitive semiconductor devices	ITA	ICT04
84	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	ITA2	ICT04
85	854232	Electronic integrated circuits; memories	ITA2	ICT04
86	854233	Electronic integrated circuits; amplifiers	ITA2	ICT04
87	854239	Electronic integrated circuits; n.e.c. in heading no. 8542	ITA2	ICT04
88	854290	Parts of electronic integrated circuits	ITA	ICT04
89	852351	Semiconductor media; solid-state non-volatile storage devices, whether or not recorded, excluding products of Chapter 37	ITA2	ICT05
90	852359	Semiconductor media; other than smart cards, whether or not recorded, excluding products of Chapter 37	ITA2	ICT05
91	852380	Media n.e.c. in heading 8523, whether or not recorded, excluding products of Chapter 37	ITA2	ICT05
92	852910	Reception and transmission apparatus; aerials and aerial reflectors of all kinds and parts suitable for use therewith	ITA	ICT05
93	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	ITA	ICT05
94	901320	Lasers; other than laser diodes	ITA2	ICT05
95	854072	Tubes; microwave, klystrons, excluding grid-controlled tubes	Non-ITA	ICT04
96	854050	Data/graphic display tubes, black and white/other monochrome	Non-ITA	ICT04

Table 13: Categories of ICT HS codes

Source: The United Nations Comtrade (UNComtrade), World Trade Organization (WTO), The Information Technology and Innovation Foundation (ITIF), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Code	Code Description	ITA / ITA2 / Excluded from ITA
851711	Line telephone sets with cordless handsets	ITA
851712	Telephones for cellular networks or for other wireless networks	ITA
851718	Telephone sets n.e.c. in item no. 8517.1	ITA
851761	Base stations	ITA2

851762	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	ITA2
851769	Communication apparatus (excluding telephone sets or base stations); machines for the transmission or reception of voice, images or other data (including wired/wireless networks), n.e.c. in item no. 8517.6	ITA2
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	ITA2
852550	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, not incorporating reception apparatus	ITA2
852560	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, incorporating reception apparatus	ITA2
853110	Signaling apparatus; electric, sound or visual, burglar or fire alarms and similar, other than those of heading no. 8512 or 8530	Non-ITA

Table 14: List of HS codes in ITA

Source: The United Nations Comtrade (UNComtrade), World Trade Organization (WTO), The Information Technology and Innovation Foundation (ITIF), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

No.	HS Code	HS Code Description
1	846911	Word processing machines
2	847010	Calculating machines; electronic calculators capable of operation without an external source of electric power and pocket-size data recording, reproducing and displaying machines with calculating functions
3	847021	Calculating machines; electronic, incorporating a printing device, needing an external source of power
4	847029	Calculating machines; electronic, (not incorporating a printing device), needing an external power source
5	847030	Calculating machines; non-electronic
6	847040	Accounting machines
7	847050	Cash registers
8	847090	Machines incorporating a calculating device; n.e.c. in heading no. 8470
9	847110	Analogue or hybrid automatic data processing machines
10	847130	Automatic data processing machines; portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display
11	847141	Automatic data processing machines; comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined, n.e.c. in item no. 8471.30
12	847149	Automatic data processing machines; presented in the form of systems, n.e.c. in item no. 8471.30 or 8471.41
13	847150	Units of automatic data processing machines; processing units other than those of item no. 8471.41 or 8471.49, whether or not containing in the same housing one or two of the following types of unit: storage units, input units or output units
14	847160	Units of automatic data processing machines; input or output units, whether or not containing storage units in the same housing
15	847170	Units of automatic data processing machines; storage units
16	847180	Units of automatic data processing machines; n.e.c. in item no. 8471.50, 8471.60 or 8471.70
17	847190	Magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, not elsewhere specified or included
18	847290	Office machines; not elsewhere classified
19	847321	Calculating machines; parts and accessories of the electronic calculating machines of item no. 8470.10, 8470.21 or 8470.29 (other than covers, carrying cases and the like)

20	847329	Machinery; parts and accessories of the machines of item no. 8470.30. 8470.50 or 8470.90 (other than covers, carrying cases and the like)
21	847330	Machinery; parts and accessories of the machines of heading no. 8471 (other than covers, carrying cases and the like)
22	847350	Machines; parts and accessories equally suitable for use with machines of two or more of the headings 8469 to 8472 (other than covers, carrying cases and the like)
23	850440	Electrical static converters
24	850450	Electrical inductors; n.e.c. in heading no. 8504
25	851711	Line telephone sets with cordless handsets
26	851719	Other telephone sets and videophones
27	851721	Facsimile machines
28	851722	Teleprinters
29	851730	Telephonic or telegraphic switching apparatus
30	851750	Other apparatus, for carrier-current line systems or for digital line systems
31	851780	Other apparatus including entry-phone systems
32	851790	Parts of apparatus of heading 8517
33	851810	Microphones and stands therefor
34	851830	Headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers
35	851829	Loudspeakers; not mounted in their enclosures
36	852020	Telephone answering machines
37	852311	Magnetic tapes of a width not exceeding 4 mm
38	852312	Magnetic tapes of a width exceeding 4 mm but not exceeding 6,5 mm
39	852313	Magnetic tapes of a width exceeding 6,5 mm
40	852320	Magnetic disks
41	852390	Other
42	852431	Disks for laser reading systems for reproducing phenomena other than sound or image
43	852439	Other :- for reproducing representations of instructions, data, sound, and image, recorded in a machine readable binary form, and capable of being manipulated or providing interactivity to a user, by means of an automatic data processing machine
44	852440	Magnetic tapes for reproducing phenomena other than sound or image
45	852491	Media for reproducing phenomena other than sound or image
46	842499	Other :- for reproducing representations of instructions, data, sound, and image, recorded in a machine readable binary form, and capable of being manipulated or providing interactivity to a user, by means of an automatic data processing machine
47	852510	Transmission apparatus other than apparatus for radio-broadcasting or television
48	852520	Transmission apparatus incorporating reception apparatus
49	852540	Digital still image video cameras
50	852790	Portable receivers for calling, alerting or paging
51	852910	Aerials or antennae of a kind used with apparatus for radio-telephony and radio-telegraph
52	852990	Parts of transmission apparatus other than apparatus for radio-broadcasting or television transmission apparatus incorporating reception apparatus digital still image video cameras, portable receivers for calling, alerting or paging
53	853120	Indicator panels incorporating LCD or LED
54	853190	Parts of apparatus of subheading 8531 20
55	853210	Electrical capacitors; fixed, designed for use in 50/60 Hz circuits and having a reactive power handling capacity of not less than 0.5 kvar (power capacitors)
56	853221	Electrical capacitors; fixed, tantalum
57	853222	Electrical capacitors; fixed, aluminum electrolytic
58	853223	Electrical capacitors; fixed, ceramic dielectric, single layer

59	853224	Electrical capacitors; fixed, ceramic dielectric, multilayer
60	853225	Electrical capacitors; fixed, dielectric of paper or plastics
61	853229	Electrical capacitors; fixed, n.e.c. in heading no. 8532
62	853230	Electrical capacitors; variable or adjustable (pre-set) capacitors
63	853290	Electrical capacitors; parts of the capacitors of heading no. 8532
64	853310	Electrical resistors; fixed carbon resistors, composition or film types (including rheostats and potentiometers but excluding heating resistors)
65	853321	Electrical resistors; fixed, for a power handling capacity not exceeding 20W (including rheostats and potentiometers but excluding heating resistors and carbon resistors)
66	853329	Electrical resistors; fixed, for a power handling capacity exceeding 20W (including rheostats and potentiometers but excluding heating resistors and carbon resistors)
67	853331	Electrical resistors; wire wound variable, including rheostats and potentiometers, for a power handling capacity not exceeding 20W (excluding heating)
68	853339	Electrical resistors; wire wound variable, including rheostats and potentiometers, for a power handling capacity exceeding 20W (excluding heating)
69	853340	Electrical resistors; variable, including rheostats and potentiometers (excluding heating)
70	853390	Resistors; parts of the resistors of heading no. 8533
71	853650	Electrical apparatus; switches n.e.c. in heading no. 8536, for a voltage not exceeding 1000 volts
72	853669	Electrical apparatus; plugs and sockets, for a voltage not exceeding 1000 volts
73	853690	Electrical apparatus; n.e.c. in heading no. 8536, for switching or protecting electrical circuits, for a voltage not exceeding 1000 volts
74	854110	Electrical apparatus; diodes, other than photosensitive or LED
75	854121	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of less than 1W
76	854129	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of 1W or more
77	854130	Electrical apparatus; thyristors, diacs and triacs, other than photosensitive devices
78	854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED
79	854150	Electrical apparatus; photosensitive semiconductor devices n.e.c. in heading no. 8541, including photovoltaic cells, whether or not assembled in modules or made up into panels
80	854160	Crystals; mounted piezo-electric
81	854190	Electrical apparatus; parts for diodes, transistors and similar semiconductor devices and photosensitive semiconductor devices
82	854212	Cards incorporating an electronic integrated circuit (‘smart’ cards)
83	854213	Metal oxide semiconductors (MOS technology)
84	854214	Circuits obtained by bipolar technology
85	854219	Other monolithic digital integrated circuits, including circuits obtained by a combination of bipolar and MOS technologies (BIMOS technology)
86	854230	Other monolithic integrated circuits
87	854240	Hybrid integrated circuits
88	854250	Electronic microassemblies
89	854290	Parts of electronic integrated circuits
90	854381	Proximity cards and tags
91	854389	Electrical machines with translation or dictionary functions
92	854441	Other electric conductors, for a voltage not exceeding 80 V, fitted with connectors, of a kind used for telecommunications

93	854449	Insulated electric conductors; for a voltage not exceeding 1000 volts, not fitted with connectors
94	854451	Other electric conductors, for a voltage exceeding 80 V but not exceeding 1000 V, fitted with connectors, of a kind used for telecommunications
95	854470	Insulated electric conductors; optical fiber cables
96	900911	Electrostatic photocopying apparatus, operating by reproducing the original image directly onto the copy (direct process)]
97	900921	Other photocopying apparatus, incorporating an optical system
98	900990	Parts and accessories
99	902610	Instruments and apparatus; for measuring or checking the flow or level of liquids
100	902620	Instruments and apparatus; for measuring or checking pressure
101	902680	Instruments and apparatus; for measuring or checking variables of liquids or gases (excluding pressure or the flow and level of liquids and those of heading no. 9014, 9015, 9028 and 9032)
102	902690	Instruments and apparatus; parts and accessories for those measuring or checking the flow, level, pressure or other variables of liquids or gases (excluding those of heading no. 9014, 9015, 9028 or 9032)
103	902720	Chromatographs and electrophoresis instruments
104	902730	Spectrometers, spectrophotometers and spectrographs; using optical radiations (UV, visible, IR)
105	902750	Instruments and apparatus; using optical radiations (UV, visible, IR), (other than spectrometers, spectrophotometers and spectrographs)
106	902780	Instruments and apparatus; for physical or chemical analysis, for measuring or checking viscosity, porosity, expansion, surface tension or quantities of heat, sound or light, n.e.c. in heading no. 9027
107	902790	Microtomes and parts and accessories thereof
108	903040	Instruments and apparatus; specially designed for telecommunications (e.g. cross-talk meters, gain measuring instruments, distortion factor meters, psophometers)
109	701710	Glassware; laboratory, hygienic or pharmaceutical, whether or not graduated or calibrated, of fused quartz or other fused silica
110	841989	Machinery, plant and laboratory equipment; for treating materials by change of temperature, other than for making hot drinks or cooking or heating food
111	841990	Machinery, plant and laboratory equipment; parts of equipment for treating materials by a process involving a change of temperature
112	842119	Centrifuges; n.e.c. in heading no. 8421, including centrifugal dryers (but not clothes-dryers)
113	842191	Centrifuges; parts thereof, including parts for centrifugal dryers
114	842489	Mechanical appliances; for projecting, dispersing or spraying liquids or powders, for other than agricultural or horticultural use, whether or not hand-operated
115	842490	Mechanical appliances; parts of machines projecting, dispersing or spraying liquids or powders, whether or not hand-operated
116	845610	Machine tools; for working any material by removal of material, operated by laser or other light or photon beam processes
117	845691	Apparatus for stripping or cleaning semiconductor wafers; Machines for dry-etching patterns on semiconductor materials
118	845699	Focused ion beam milling machines to produce or repair masks and reticles for patterns on semiconductor devices
119	846410	Machine tools; sawing machines, for working stone, ceramics, concrete, asbestos-cement or like mineral materials or for cold working glass
120	846420	Machine tools; grinding or polishing machines, for working stone, ceramics, concrete, asbestos-cement or like mineral materials or for cold working glass
121	846490	Machine tools; for working stone, ceramics, concrete, asbestos-cement or like mineral materials or for cold working glass, (other than sawing, grinding or polishing machines)

122	846691	Parts and accessories suited for use solely/principally; for the machines of heading no. 8464, n.e.c. in heading no. 8466
123	846693	Parts and accessories suited for use solely/principally with machines of headings 8456-8465; n.e.c. in heading no. 8466
124	845693	Parts of apparatus for stripping or cleaning semiconductor wafers
125	847710	Machinery; injection-molding machines, for working rubber or plastics or for the manufacture of products from these materials
126	847790	Machinery; parts of the machines of heading no. 8477, n.e.c. in item no. 8477.90
127	847950	Machinery and mechanical appliances; industrial robots, n.e.c. or included
128	847989	Machines and mechanical appliances; having individual functions, n.e.c. or included in this chapter
129	847990	Machines and mechanical appliances; parts, of those having individual functions
130	848071	Molds; for rubber or plastics, injection or compression types
131	851410	Furnaces and ovens; electric, for industrial or laboratory use, resistance heated
132	851420	Furnaces and ovens; electric, for industrial or laboratory use, functioning by induction or dielectric loss
133	851430	Furnaces and ovens; electric, for industrial or laboratory use, other than those functioning by induction, dielectric loss or resistance heated
134	851490	Furnaces, ovens and heating equipment; parts of the industrial or laboratory equipment of heading no. 8514
135	854311	Ion implanters for doping semiconductor materials
136	854330	Electrical machines and apparatus; for electroplating, electrolysis or electrophoresis
137	854390	Electrical machines and apparatus; parts of the electrical goods of heading no. 8543
138	901041 to 901049	Apparatus for projection, drawing or plating circuit patterns on sensitized semiconductor materials and flat panel displays
139	901090	Photographic laboratory apparatus and equipment (including cinematographic); parts and accessories
140	901110	Microscopes, compound optical; stereoscopic microscopes
141	901120	Microscopes, compound optical; for photomicrography, cinephotomicrography or microprojection
142	901190	Microscopes, compound optical; parts and accessories (including those for photomicrography, cinephotomicrography or microprojection)
143	901210	Microscopes (excluding optical microscopes); diffraction apparatus
144	901290	Microscopes (excluding optical microscopes); diffraction apparatus; parts and accessories
145	901720	Drawing, marking-out or mathematical calculating instruments
146	901790	Drawing, marking-out equipment and mathematical instruments; parts and accessories
147	903082	Instruments and apparatus; for measuring or checking semiconductor wafers or devices
148	903090	Instruments, apparatus for measuring, checking electrical quantities, not meters of heading no. 9028; parts and accessories, for measuring or detecting alpha, beta, gamma, x-ray, cosmic and other radiations

149	903141	Optical instruments and appliances; for inspecting semiconductor wafers or devices or for inspecting photomasks or reticles used in manufacturing semiconductor devices, n.e.c. in Chapter 90
150	903149	Optical instruments and appliances; for measuring or checking, n.e.c. in Chapter 90
151	903190	Instruments, appliances and machines; parts and accessories for those measuring or checking devices of heading no. 9031
152	851712	Telephones for cellular networks or for other wireless networks
153	851718	Telephone sets n.e.c. in item no. 8517.1
154	851950	Sound recording or reproducing apparatus; telephone answering machines
155	853400	Circuits; printed

Table 15: List of HS codes in ITA2

Source: The United Nations Comtrade (UNComtrade), World Trade Organization (WTO), The Information Technology and Innovation Foundation (ITIF), United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

No	HS Code	HS Code Description
1	350691	Adhesives; prepared, based on polymers of heading 3901 to 3913 or on rubber
2	370130	Photographic plates and film; in the flat, sensitized, unexposed, with any side exceeding 225mm, of any materials other than paper, paperboard or textiles
3	370199	Photographic plates and film; (for other than color photography), in the flat, sensitized, unexposed, with no side exceeding 255mm, of any material other than paper, paperboard or textiles
4	370590	Photographic plates and film; exposed and developed, (other than cinematographic film or for offset reproduction)
5	370790	Photographic goods; chemical preparations other than sensitized emulsions, put up in measured portions or put up for retail sale in a form ready for use
6	390799	Polyesters; n.e.c. in heading no. 3907, saturated, in primary forms
7	841459	Fans; n.e.c. in item no. 8414.51
8	841950	Heat exchange units; not used for domestic purposes
9	842010	Machines; Calendaring or other rolling machines, for other than metal or glass
10	842129	Machinery; for filtering or purifying liquids, n.e.c. in item no. 8421.2
11	842139	Machinery; for filtering or purifying gases, other than intake air filters for internal combustion engines
12	842199	Machinery; parts for filtering or purifying liquids or gases
13	842320	Weighing machines; scales for continuous weighing of goods on conveyors
14	842330	Weighing machines; constant weight scales and scales for discharging a predetermined weight of material into a bag or container, including hopper scales
15	842381	Weighing machines; having a maximum weighing capacity not exceeding 30kg (excluding balances of a sensitivity of 5cg or better)
16	842382	Weighing machines; having a maximum weighing capacity exceeding 30kg but not exceeding 5000kg
17	842389	Weighing machines; having a maximum weighing capacity exceeding 5000kg
18	842390	Weighing machines; weights of all kinds, parts of weighing machinery
19	842489	Mechanical appliances; for projecting, dispersing or spraying liquids or powders, for other than agricultural or horticultural use, whether or not hand-operated
20	842490	Mechanical appliances; parts of machines projecting, dispersing or spraying liquids or powders, whether or not hand-operated
21	844230	Machinery, apparatus and equipment (excluding machine tools of heading no. 8456 to 8465) for preparing or making printing components
22	844240	Machinery, apparatus and equipment (excluding machine tools of heading no. 8456 to 8465) for preparing or making printing components; parts thereof

23	844250	Plates, cylinders and other printing components; lithographic stones prepared for printing purposes (for example, planed, grained or polished)
24	844331	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network
25	844332	Printing, copying, and facsimile machines; single-function printing, copying or facsimile machines, capable of connecting to an automatic data processing machine or to a network
26	844339	Printing, copying, and facsimile machines; single-function printing, copying or facsimile machines, not capable of connecting to an automatic data processing machine or to a network
27	844391	Printing machinery used for printing by means of plates, cylinders and other printing components of heading 8442; parts and accessories
28	844399	Printing machinery; parts and accessories, n.e.c. in item no. 8443.91
29	845610	Machine tools; for working any material by removal of material, operated by laser or other light or photon beam processes
30	846693	Parts and accessories suited for use solely/principally with machines of headings 8456-8465; n.e.c. in heading no. 8466
31	847210	Office machines; duplicating machines
32	847290	Office machines; not elsewhere classified
33	847310	Typewriters and word processing machines; parts and accessories of the machines of heading 84.69 (other than covers, carrying cases and the like)
34	847340	Machinery; parts and accessories of the machines of heading no. 8472 (other than covers, carrying cases and the like)
35	847521	Machines; for manufacturing or hot working glass or glassware, for making optical fibers and preforms thereof
36	847590	Machines; parts, of those for assembling electric or electronic lamps, tubes, valves or flashbulbs, in glass envelopes and manufacturing or hot working glass or glassware
37	847689	Machines; automatic goods-vending machines, (e.g. postage stamp, cigarette, food or money-changing machines, excluding beverage-vending machines), not incorporating heating or refrigerating devices
38	847690	Machines; parts of automatic goods-vending machines
39	847989	Machines and mechanical appliances; having individual functions, n.e.c. or included in this chapter
40	847990	Machines and mechanical appliances; parts, of those having individual functions
41	848610	Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers
42	848620	Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor devices or of electronic integrated circuits
43	848630	Machines and apparatus of a kind used solely or principally for the manufacture of flat panel displays
44	848640	Machines and apparatus of a kind used solely or principally for the manufacture or repair of masks and reticles, assembling semiconductor devices or electronic integrated circuits, or for lifting, handling, loading or unloading items of heading 8486
45	848690	Machines and apparatus of heading 8486; parts and accessories
46	850440	Electrical static converters
47	850450	Electrical inductors; n.e.c. in heading no. 8504
48	850490	Electrical transformers, static converters and inductors; parts thereof
49	850590	Magnets; electro-magnets, holding devices and parts n.e.c. in heading no. 8505
50	851430	Furnaces and ovens; electric, for industrial or laboratory use, other than those functioning by induction, dielectric loss or resistance heated
51	851490	Furnaces, ovens and heating equipment; parts of the industrial or laboratory equipment of heading no. 8514
52	851519	Brazing or soldering machines and apparatus; other than soldering irons and guns, whether or not capable of cutting
53	851590	Welding, brazing or soldering machines; parts of the machines of heading no. 8515

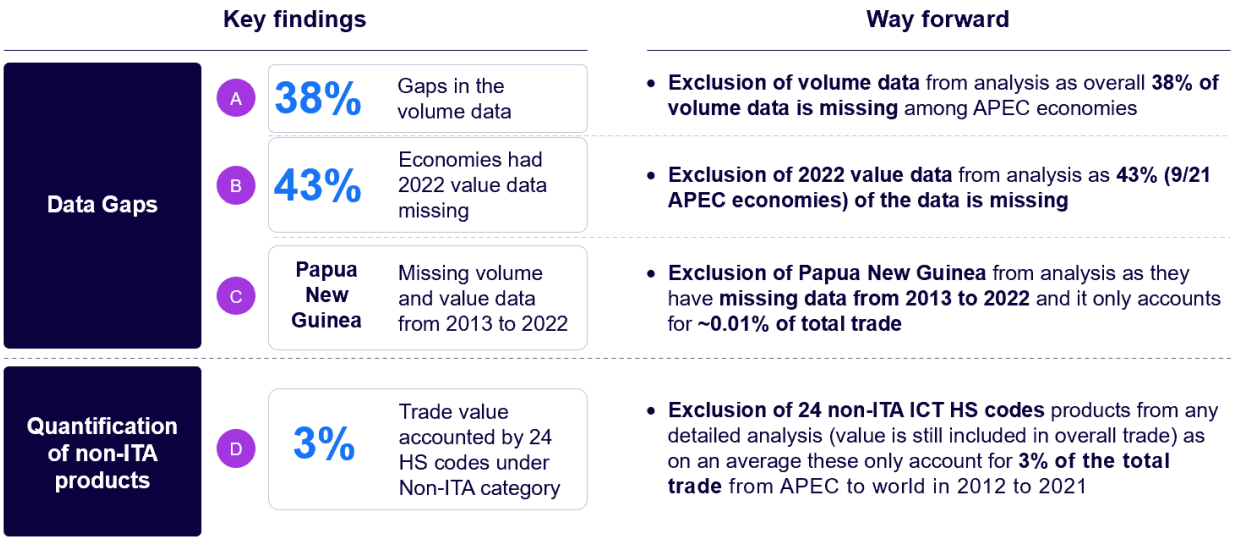
54	851761	Base stations
55	851762	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus
56	851769	Communication apparatus (excluding telephone sets or base stations); machines for the transmission or reception of voice, images or other data (including wired/wireless networks), n.e.c. in item no. 8517.6
57	851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts
58	851810	Microphones and stands therefor
59	851821	Loudspeakers; single, mounted in their enclosures
60	851822	Loudspeakers; multiple, mounted in the same enclosure
61	851829	Loudspeakers; not mounted in their enclosures
62	851830	Headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers
63	851840	Amplifiers; audio-frequency electric
64	851850	Amplifier sets; electric sound
65	851890	Microphones, headphones, earphones, amplifier equipment; parts of the equipment of heading no. 8518
66	851981	Sound recording or reproducing apparatus; using magnetic, optical or semiconductor media, n.e.c. in item no 8519.20, 8519.30 or 8519.50
67	851989	Sound recording or reproducing apparatus; n.e.c. in heading no 8519
68	852110	Video recording or reproducing apparatus; magnetic tape-type
69	852190	Video recording or reproducing apparatus; other than magnetic tape-type
70	852290	Sound recording or reproducing apparatus; parts and accessories thereof, other than pick-up cartridges
71	852321	Magnetic media; cards incorporating a magnetic stripe, whether or not recorded, excluding products of Chapter 37
72	852329	Magnetic media; other than cards incorporating a magnetic stripe, whether or not recorded, excluding products of Chapter 37
73	852340	Optical media, whether or not recorded, excluding products of Chapter 37
74	852351	Semiconductor media; solid-state non-volatile storage devices, whether or not recorded, excluding products of Chapter 37
75	852352	Semiconductor media; smart cards, whether or not recorded, excluding products of Chapter 37
76	852359	Semiconductor media; other than smart cards, whether or not recorded, excluding products of Chapter 37
77	852380	Media n.e.c. in heading 8523, whether or not recorded, excluding products of Chapter 37
78	852550	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, not incorporating reception apparatus
79	852560	Transmission apparatus for radio-broadcasting or television, whether or not incorporating sound recording or reproducing apparatus, incorporating reception apparatus
80	852580	Television cameras, digital cameras and video camera recorders
81	852610	Radar apparatus
82	852691	Radio navigational aid apparatus
83	852692	Radio remote control apparatus
84	852712	Radio broadcast receivers capable of operating without an external power source; pocket-size radio cassette-players
85	852713	Radio broadcast receivers capable of operating without an external power source; apparatus (other than pocket-size radio cassette-players), combined with sound recording or reproducing apparatus
86	852719	Radio broadcast receivers capable of operating without an external power source; n.e.c. in item no. 8527.1

87	852721	Radio broadcast receivers not capable of operating without an external source of power, of a kind used in motor vehicles; combined with sound recording or reproducing apparatus
88	852729	Radio broadcast receivers not capable of operating without an external source of power, of a kind used in motor vehicles; not combined with sound recording or reproducing apparatus
89	852791	Radio broadcast receivers n.e.c. in heading no. 8527; combined with sound recording or reproducing apparatus
90	852792	Radio broadcast receivers n.e.c. in heading no. 8527; not combined with sound recording or reproducing apparatus but combined with a clock
91	852799	Radio broadcast receivers n.e.c. in heading no. 8527; not combined with sound recording or reproducing apparatus and not combined with a clock
92	852849	Monitors; cathode-ray tube, n.e.c. in subheading 8528.42, whether or not color
93	852871	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; not designed to incorporate a video display or screen
94	852910	Reception and transmission apparatus; aerials and aerial reflectors of all kinds and parts suitable for use therewith
95	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors
96	853180	Signaling apparatus; electric, sound or visual, apparatus n.e.c. in heading no. 8531, excluding those of heading no. 8512 or 8530
97	853190	Signaling apparatus; parts of the electric, sound or visual apparatus of heading no. 8531
98	853630	Electrical apparatus; for protecting electrical circuits, n.e.c. in heading no. 8536, for a voltage not exceeding 1000 volts
99	853650	Electrical apparatus; switches n.e.c. in heading no. 8536, for a voltage not exceeding 1000 volts
100	853690	Electrical apparatus; n.e.c. in heading no. 8536, for switching or protecting electrical circuits, for a voltage not exceeding 1000 volts
101	853810	Electrical apparatus; parts (e.g. boards, panels, consoles, desks, cabinets, other bases), for goods of heading no. 8537, not equipped with their apparatus
102	853939	Lamps; discharge, (excluding ultraviolet, excluding fluorescent, hot cathode)
103	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
104	854232	Electronic integrated circuits; memories
105	854233	Electronic integrated circuits; amplifiers
106	854239	Electronic integrated circuits; n.e.c. in heading no. 8542
107	854290	Parts of electronic integrated circuits
108	854320	Electrical machines and apparatus; signal generators
109	854330	Electrical machines and apparatus; for electroplating, electrolysis or electrophoresis
110	854370	Electrical machines and apparatus; having individual functions, not specified or included elsewhere in this chapter, n.e.c. in heading no. 8543
111	854390	Electrical machines and apparatus; parts of the electrical goods of heading no. 8543
112	880260	Spacecraft; (including satellites) and suborbital and spacecraft launch vehicles
113	880390	Aircraft and spacecraft; parts thereof n.e.c. in Chapter 88
114	880521	Ground flying trainers and parts thereof; air combat simulators and parts thereof
115	880529	Ground flying trainers and parts thereof; other than air combat simulators and parts thereof
116	900120	Optical elements; polarizing material, sheets and plates thereof
117	900190	Optical elements; lenses n.e.c. in heading no. 9001, prisms, mirrors and other optical elements, unmounted, of any material (excluding elements of glass not optically worked)
118	900219	Lenses; objective, (other than for cameras, projectors or photographic enlargers or reducers), mounted, of any material (excluding elements of glass not optically worked)

119	900220	Filters; mounted as parts or fittings for instruments or apparatus, of any material (excluding elements of glass not optically worked)
120	900290	Optical elements; n.e.c. in heading no. 9002 (e.g. prisms and mirrors), mounted, being parts or fittings for instruments or apparatus, of any material (excluding elements of glass not optically worked)
121	901050	Photographic laboratory apparatus and equipment; n.e.c. in item no. 9010.10, for photographic (including cinematographic) laboratories; negatoscopes
122	901060	Photographic laboratory apparatus and equipment (including cinematographic); projection screens
123	901090	Photographic laboratory apparatus and equipment (including cinematographic); parts and accessories
124	901110	Microscopes, compound optical; stereoscopic microscopes
125	901180	Microscopes, compound optical; (other than stereoscopic and microscopes for photomicrography, cinephotomicrography or microprojection)
126	901190	Microscopes, compound optical; parts and accessories (including those for photomicrography, cinephotomicrography or microprojection)
127	901210	Microscopes (excluding optical microscopes); diffraction apparatus
128	901290	Microscopes (excluding optical microscopes); diffraction apparatus; parts and accessories
129	901310	Optical appliances and instruments; telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of this chapter
130	901320	Lasers; other than laser diodes
131	901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013
132	901410	Navigational instruments and appliances; direction finding compasses
133	901420	Navigational instruments and appliances; for aeronautical or space navigation (excluding compasses)
134	901480	Navigational instruments and appliances; for navigation other than aeronautical or space navigation (excluding direction finding compasses)
135	901490	Navigational instruments and appliances; parts and accessories
136	901510	Rangefinders
137	901520	Surveying equipment; theodolites and tacheometers
138	901540	Surveying equipment; photogrammetrical surveying instruments and appliances
139	901580	Surveying equipment; articles n.e.c. in heading no. 9015, including hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances (excluding compasses)
140	901590	Surveying equipment; parts and accessories for articles of heading no. 9015
141	901811	Medical, surgical instruments and appliances; electro-cardiographs
142	901812	Medical, surgical instruments and appliances; ultrasonic scanning apparatus
143	901813	Medical, surgical instruments and appliances; magnetic resonance imaging apparatus
144	901819	Medical, surgical instruments and appliances; electro-diagnostic apparatus (including apparatus for functional exploratory examination or for checking physiological parameters), n.e.c. in item no. 9018.1
145	901820	Medical, surgical instruments and appliances; ultraviolet or infra-red ray apparatus
146	901850	Ophthalmic instruments and appliances
147	901890	Medical, surgical or dental instruments and appliances; n.e.c. in heading no. 9018
148	902150	Pacemakers; for stimulating heart muscles (excluding parts and accessories)
149	902190	Appliances; worn, carried or implanted in the body, to compensate for a defect or disability
150	902212	Apparatus based on the use of x-rays; including radiography or radiotherapy apparatus, whether or not for medical, surgical, dental or veterinary uses, computed tomography apparatus
151	902213	Apparatus based on the use of x-rays; including radiography or radiotherapy apparatus, for dental uses, excluding computed tomography apparatus

152	902214	Apparatus based on the use of x-rays; including radiography or radiotherapy apparatus, for medical, surgical or veterinary uses, not dental uses, excluding computed tomography apparatus
153	902219	Apparatus based on the use of x-rays, including radiography or radiotherapy apparatus; for other than medical, surgical, dental or veterinary uses
154	902221	Apparatus based on the use of alpha, beta or gamma radiations, including radiography or radiotherapy apparatus; for medical, surgical, dental or veterinary uses
155	902229	Apparatus based on the use of alpha, beta or gamma radiations, including radiography or radiotherapy apparatus; (for other than medical, surgical, dental or veterinary uses)
156	902230	X-ray tubes
157	902290	Apparatus based on use of x-rays and similar; parts and accessories (x-ray generators, tubes, high tension generators, control panels and desks, screens, examination or treatment tables, chairs and like)
158	902300	Instruments, apparatus and models; designed for demonstrational purposes (in education or exhibitions), unsuitable for other uses
159	902410	Machines and appliances; for testing the hardness, strength, compressibility, elasticity or other mechanical properties of metals
160	902480	Machines and appliances; for testing the hardness, strength, compressibility, elasticity or other mechanical properties of materials other than metals
161	902490	Machines and appliances; parts and accessories for those testing hardness, strength, compressibility, elasticity or other mechanical properties of materials (e.g. metal, wood, textiles, paper, plastics)
162	902519	Thermometers and pyrometers; (other than liquid filled, for direct reading), not combined with other instruments
163	902590	Hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments, parts and accessories
164	902710	Instruments and apparatus; gas or smoke analysis apparatus, for physical or chemical analysis
165	902780	Instruments and apparatus; for physical or chemical analysis, for measuring or checking viscosity, porosity, expansion, surface tension or quantities of heat, sound or light, n.e.c. in heading no. 9027
166	902790	Microtomes and parts and accessories thereof
167	902830	Meters; electricity supply or production meters, including calibrating meters thereof
168	902890	Meters; parts and accessories of gas, liquid, electricity supply or production meters, including calibrating meters thereof
169	903010	Instruments and apparatus; for measuring or detecting ionizing radiations
170	903020	Oscilloscopes and oscillographs
171	903031	Multimeters; for measuring or checking voltage, current, resistance or power, without a recording device
172	903032	Multimeters; for measuring or checking voltage, current, resistance or power, with a recording device
173	903033	Instruments and apparatus; for measuring or checking voltage, current, resistance or power, without a recording device (excluding multimeters)
174	903039	Instruments and apparatus; for measuring or checking voltage, current, resistance or power, with a recording device (excluding multimeters)
175	903084	Instruments and apparatus; n.e.c. in heading no. 9030, with a recording device
176	903089	Instruments and apparatus; n.e.c. in heading no. 9030, without a recording device
177	903090	Instruments, apparatus for measuring, checking electrical quantities, not meters of heading no. 9028; parts and accessories, for measuring or detecting alpha, beta, gamma, x-ray, cosmic and other radiations
178	903110	Machines; for balancing mechanical parts
179	903149	Optical instruments and appliances; for measuring or checking, n.e.c. in Chapter 90
180	903180	Instruments, appliances and machines; for measuring or checking n.e.c. in Chapter 90
181	903190	Instruments, appliances and machines; parts and accessories for those measuring or checking devices of heading no. 9031

182	903220	Regulating or controlling instruments and apparatus; automatic, manostats
183	903281	Regulating or controlling instruments and apparatus; automatic, hydraulic or pneumatic
184	950410	Video games; of a kind used with a television receiver
185	950430	Games; operated by coins, banknotes, bank cards, tokens or by other means of payment, other than billiard articles and accessories, and automatic bowling alley equipment
186	950490	Games; articles for funfair, table or parlor games, including printables, tables for casino games, bowling alley equipment, n.e.c. in heading no. 9504
187	950450	Games; video game consoles and machines, other than those of subheading 9504.30



Source: Arthur D. Little analysis

Figure 50: Gaps identified that are excluded from ICT trade flow analysis

Table 16: APEC economies participation in ITA and ITA2

Source: United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

	Economy	Participant in ITA?	Participant in ITA2?
1	Australia	Yes	Yes
2	Brunei Darussalam	No	No
3	Canada	Yes	Yes
4	Chile	No	No
5	China	Yes	Yes
6	Hong Kong, China	Yes	Yes
7	Indonesia	Yes	No
8	Japan	Yes	Yes
9	Republic of Korea	Yes	Yes
10	Malaysia	Yes	Yes
11	Mexico	No	No
12	New Zealand	Yes	Yes
13	Papua New Guinea	No	No
14	Peru	Yes	No
15	The Philippines	Yes	Yes

16	The Russian Federation	Yes	No
17	Singapore	Yes	Yes
18	Chinese Taipei	Yes	Yes
19	Thailand	Yes	Yes
20	The United States	Yes	Yes
21	Viet Nam	Yes	No

Table 17: Analysis of the United States' ITA ICT imports in 2021, in billion USD

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

HS Code	HS Code Description	Import Value (% Of Total Imports)	Top 5 APEC Trading Partner	Import Value (% Of Imports By HS Code)
851712	Telephones for cellular networks or for other wireless networks	**USD50.96 billion (26%)**	China	USD40.26 billion (79%)
			Viet Nam	USD8.15 billion (16%)
			Republic of Korea	USD1.53 billion (3%)
			Japan	USD0.15 billion (0.3%)
			Hong Kong, China	USD0.10 billion (0.2%)
847130	Automatic data processing machines; portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display	**USD49 billion (25%)**	China	USD45.57 billion (93%)
			Chinese Taipei	USD1.47 billion (3%)
			Viet Nam	USD1.47 billion (3%)
			Mexico	USD0.10 billion (0.2%)
			Republic of Korea	USD0.05 billion (0.1%)
847150	Units of automatic data processing machines; processing units other than those of item no. 8471.41 or 8471.49, whether or not containing in the same housing one or two of the following types of unit: storage units, input units or output units	**USD27.44 billion (14%)**	Mexico	USD21.13 billion (77%)
			Chinese Taipei	USD3.57 billion (13%)
			China	USD0.82 billion (3%)
			Malaysia	USD0.55 billion (2%)
			Canada	USD0.27 billion (1%)
847330	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	**USD23.52 billion (12%)**	Chinese Taipei	USD6.82 billion (29%)
			Republic of Korea	USD6.12 billion (26%)
			China	USD4.70 billion (20%)
			Viet Nam	USD2.12 billion (9%)
			The Philippines	USD1.18 billion (5%)
847170		**USD7.84 billion (4%)**	Thailand	USD4.86 billion (62%)

	Units of automatic data processing machines; storage units		Mexico	USD1.18 billion (15%)
			The Philippines	USD0.78 billion (10%)
			Chinese Taipei	USD0.24 billion (3%)
			China	USD0.16 billion (2%)

Table 18: Analysis of China's ITA exports in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

HS Code	HS Code Description	Import Value (% Of Total Imports)	Top 5 APEC Trading Partner	Import Value (% Of Imports By HS Code)
851712	Telephones for cellular networks or for other wireless networks	**USD112.8 billion (30%)**	The United States	USD30.46 billion (27%)
			Hong Kong, China	USD27.07 billion (24%)
			Japan	USD5.64 billion (5%)
			The Russian Federation	USD3.38 billion (3%)
			Mexico	USD2.26 billion (2%)
847130	Automatic data processing machines; portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display	**USD105.28 billion (28%)**	The United States	USD36.85 billion (35%)
			Hong Kong, China	USD10.53 billion (10%)
			Japan	USD5.26 billion (5%)
			Australia	USD2.11 billion (2%)
			Republic of Korea	USD2.11 billion (2%)
847330	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	**USD26.32 billion (7%)**	Hong Kong, China	USD8.95 billion (34%)
			The United States	USD4.21 billion (16%)
			Chinese Taipei	USD1.58 billion (6%)
			Mexico	USD1.05 billion (4%)
			Republic of Korea	USD1.05 billion (4%)
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED	**USD26.32 billion (7%)**	Hong Kong, China	USD1.84 billion (7%)
			Japan	USD1.32 billion (5%)
			Australia	USD1.05 billion (4%)
			Republic of Korea	USD0.79 billion (3%)
			Viet Nam	USD0.53 billion (2%)
853400	Circuits; printed	**USD15.04 billion (4%)**	Hong Kong, China	USD7.67 billion (51%)

			Chinese Taipei	USD1.05 billion (7%)
			Viet Nam	USD0.90 billion (6%)
			Republic of Korea	USD0.60 billion (4%)
			Malaysia	USD0.60 billion (4%)

Table 19: Analysis of China's ITA2 imports in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

HS code	HS code description	Import Value (% of total imports)	Top 5 APEC Trading Partner	Import Value (% of imports by HS code)
854231	Electronic integrated circuits; Processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	**USD195.57 billion (41%)**	Chinese Taipei	USD80.18 billion (41%)
			Malaysia	USD25.42 billion (13%)
			Republic of Korea	USD17.60 billion (9%)
			Viet Nam	USD17.60 billion (9%)
			The United States	USD11.73 billion (6%)
854232	Electronic integrated circuits; memories	**USD119.25 billion (25%)**	Republic of Korea	USD53.66 billion (45%)
			Chinese Taipei	USD31.01 billion (26%)
			Japan	USD8.35 billion (7%)
			Singapore	USD2.39 billion (2%)
			Malaysia	USD1.19 billion (1%)
854239	Electronic integrated circuits; n.e.c. in heading no. 8542	**USD85.86 billion (18%)**	Chinese Taipei	USD36.06 billion (42%)
			Republic of Korea	USD9.44 billion (11%)
			Malaysia	USD5.15 billion (6%)
			Japan	USD5.15 billion (6%)
			The Philippines	USD5.15 billion (6%)
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	**USD42.93 billion (9%)**	Viet Nam	USD20.18 billion (47%)
			Republic of Korea	USD5.15 billion (12%)
			Chinese Taipei	USD2.15 billion (5%)
			Japan	USD1.29 billion (3%)
			Thailand	USD0.43 billion (1%)
854233	Electronic integrated circuits, amplifiers	**USD14.31 billion (3%)**	Republic of Korea	USD3.58 billion (25%)

			Mexico	USD2.15 billion (15%)
			Chinese Taipei	USD2.15 billion (15%)
			Japan	USD1.43 billion (10%)
			Malaysia	USD0.86 billion (6%)

Table 20: Analysis of China's ITA2 exports in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

HS Code	HS Code Description	Import Value (% Of Total Imports)	Top 5 APEC Trading Partner	Import Value (% Of Imports By HS Code)
854232	Electronic integrated circuits, memories	**USD58.88 billion (23%)**	Hong Kong, China	USD23.55 billion (40%)
			Republic of Korea	USD14.72 billion (25%)
			Chinese Taipei	USD10.01 billion (17%)
			Viet Nam	USD3.53 billion (6%)
			Malaysia	USD2.36 billion (4%)
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	**USD43.52 billion (17%)**	Hong Kong, China	USD13.49 billion (31%)
			Viet Nam	USD6.53 billion (15%)
			Republic of Korea	USD3.05 billion (7%)
			The United States	USD2.18 billion (5%)
			Malaysia	USD1.31 billion (3%)
851762	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	**USD40.96 billion (16%)**	The United States	USD8.19 billion (20%)
			Hong Kong, China	USD7.37 billion (18%)
			Japan	USD1.64 billion (4%)
			Republic of Korea	USD1.23 billion (3%)
			Mexico	USD0.82 billion (2%)
854231	Electronic integrated circuits; Processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	**USD38.4 billion (15%)**	Hong Kong, China	USD17.28 billion (45%)
			Viet Nam	USD6.14 billion (16%)
			Malaysia	USD4.61 billion (12%)
			Chinese Taipei	USD3.84 billion (10%)
			Singapore	USD1.54 billion (4%)
854239		**USD17.92 billion (7%)**	Hong Kong, China	USD9.86 billion (55%)

	Electronic integrated circuits; n.e.c. in heading no. 8542		Chinese Taipei	USD2.69 billion (15%)
			Singapore	USD1.25 billion (7%)
			Republic of Korea	USD0.72 billion (4%)
			Viet Nam	USD0.54 billion (3%)

Table 21: Top 10 highest-traded HS codes in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
2	854239	Electronic integrated circuits; n.e.c. in heading no. 8542
3	854232	Electronic integrated circuits; memories
4	851712	Telephones for cellular networks or for other wireless networks
5	847130	Automatic data processing machines; portable, weighing not more than 10kg…..
6	847330	Machinery; parts and accessories of the machines of heading no. 8471….
7	851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts
8	851762	Communication apparatus (excluding telephone sets or base stations)…..
9	847150	Units of automatic data processing machines; processing units other than…..
10	847170	Units of automatic data processing machines; storage units

Table 22: Top 10 highest-traded HS codes in 2012

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
2	854239	Electronic integrated circuits; n.e.c. in heading no. 8542
3	851712	Telephones for cellular networks or for other wireless networks
4	847130	Automatic data processing machines; portable, weighing not more than 10kg.....
5	847330	Machinery; parts and accessories of the machines of heading no. 8471….
6	851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts
7	854232	Electronic integrated circuits; memories
8	851762	Communication apparatus (excluding telephone sets or base stations)…..
9	847170	Units of automatic data processing machines; storage units
10	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors

Table 23: Top 10 highest-traded ICT ITA HS codes in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	851712	Telephones for cellular networks or for other wireless networks
2	847130	Automatic data processing machines; portable, weighing not more than 10kg…
3	847330	Machinery; parts and accessories of the machines of heading no. 8471…
4	847150	Units of automatic data processing machines; processing units other than…..
5	847170	Units of automatic data processing machines; storage units
6	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors
7	854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED
8	853400	Circuits; printed
9	847180	Units of automatic data processing machines; n.e.c. in item no. 8471.50, 8471.60 or 8471.70
10	854290	Parts of electronic integrated circuits

Table 24: Top 10 highest-traded ICT ITA HS codes in 2012

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	851712	Telephones for cellular networks or for other wireless networks
2	847130	Automatic data processing machines; portable, weighing not more than 10kg…
3	847330	Machinery; parts and accessories of the machines of heading no. 8471…
4	847170	Units of automatic data processing machines; storage units
5	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors
6	853400	Circuits; printed
7	854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED
8	847150	Units of automatic data processing machines; processing units other than…..
9	854290	Parts of electronic integrated circuits
10	847149	Automatic data processing machines; presented in the form of systems, n.e.c. in item no. 8471.30 or 8471.41

Table 25: Top 10 highest-traded ICT ITA2 HS codes in 2021

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
2	854239	Electronic integrated circuits; n.e.c. in heading no. 8542
3	854232	Electronic integrated circuits; memories
4	851770	Telephone sets and other apparatus for the transmission….
5	851762	Communication apparatus (excluding telephone sets…..)
6	852351	Semiconductor media; solid-state non-volatile storage devices, whether or not recorded, excluding products of Chapter 37
7	852580	Television cameras, digital cameras and video camera recorders
8	854233	Electronic integrated circuits; amplifiers
9	950450	Games; video game consoles and machines, other than those of subheading 9504.30

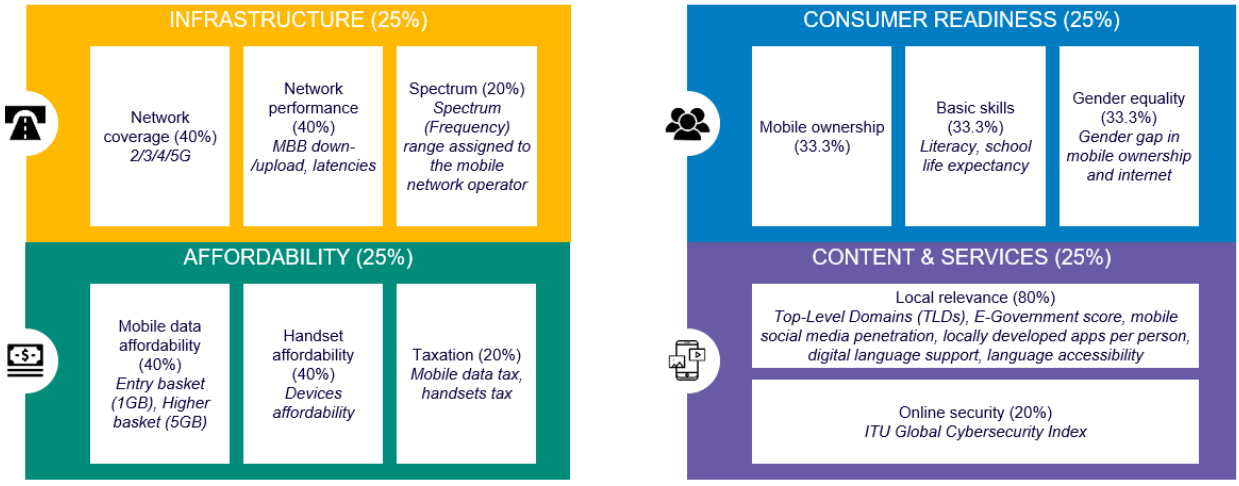
10	844331	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network

Table 26: Top 10 highest-traded ICT ITA2 HS codes in 2012

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

Rank	HS Code	HS Code Description
1	854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
2	854239	Electronic integrated circuits; n.e.c. in heading no. 8542
3	851770	Telephone sets and other apparatus for the transmission….
4	854232	Electronic integrated circuits; memories
5	851762	Communication apparatus (excluding telephone sets…..)
6	852580	Television cameras, digital cameras and video camera recorders
7	844331	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network
8	852351	Semiconductor media; solid-state non-volatile storage devices, whether or not recorded, excluding products of Chapter 37
9	950450	Games; video game consoles and machines, other than those of subheading 9504.30
10	854233	Electronic integrated circuits; amplifiers

13.3 ICT environment analysis



Source: Global System for Mobile Communications Association (GSMA), Arthur D. Little analysis

Figure 51: Composition of GSMA mobile connectivity index

Table 27: Composition of readiness for frontier technologies index

Source: United Nations Conference on Trade and Development (UNCTAD), Arthur D. Little analysis

Capacity to use, adopt and adapt frontier technologies (Readiness for frontier technologies index)	
ICT deployment	• Internet users • Mean download speed
Skills	• Expected years of schooling • High-skill employment
R&D activity	• Number of publications • Number of patents

Industry activity	• High-technology manufactures exports • Digitally-deliverable services exports
Access to finance	• Domestic credit to private sector

13.4 Trade of new and emerging ICT products

Table 28: List of HS codes in the future ICT products list

Source: The United Nations Comtrade (UNComtrade), Information Technology and Innovation Foundation (ITIF), Arthur D. Little analysis

#	HS Code	Label
1	280461	Silicon; containing by weight not less than 99.99% of silicon
2	281122	Silicon dioxide
3	281820	Aluminum oxide; other than artificial corundum
4	282300	Titanium oxides
5	282590	Inorganic bases, metal oxides, hydroxides and peroxides; n.e.c. in heading no. 2825
6	282619	Fluorides; other than of aluminum
7	283090	Sulfides and polysulphides; whether or not chemically defined, other than sulfides of sodium
8	284690	Compounds, inorganic or organic (excluding cerium), of rare-earth metals, of yttrium, scandium or of mixtures of these metals
9	391620	Vinyl chloride polymers; monofilament, of which any cross-sectional dimension exceeds 1mm, rods, sticks and profile shapes, whether or not surface-worked but not otherwise worked
10	391690	Plastics; monofilament, of plastics n.e.c. in heading no. 3916, cross-sectional dimension exceeds 1mm, rods, sticks and profile shapes, whether or not surface-worked but not otherwise worked
11	392390	Plastics; articles for the conveyance or packing of goods n.e.c. in heading no. 3923
12	392490	Plastics; household articles and hygienic or toilet articles
13	750210	Nickel; unwrought, not alloyed
14	750890	Nickel; other articles thereof n.e.c., (other than cloth, grill and netting, of nickel wire)
15	760110	Aluminum; unwrought, (not alloyed)
16	760519	Aluminum; (not alloyed), wire, maximum cross-sectional dimension is 7mm or less
17	761290	Aluminum; casks, drums, cans, boxes and the like for any material (not compressed or liquefied gas), 300l capacity or less, whether or not lined or heat-insulated, no mechanical or thermal equipment
18	800110	Tin; unwrought, not alloyed
19	800700	Tin ; articles n.e.c. in Chapter 80
20	810194	Tungsten (wolfram); unwrought, including bars and rods obtained simply by sintering
21	810199	Tungsten (wolfram); articles n.e.c. in heading no. 8101
22	810294	Molybdenum; unwrought, including bars and rods obtained simply by sintering
23	842211	Dish washing machines; of the household type
24	842240	Machinery; for packing or wrapping
25	842310	Weighing machines; personal (including baby scales) and household scales
26	842710	Fork-lift and other works trucks; fitted with lifting or handling equipment, self-propelled by electric motor
27	843311	Mowers; lawn, parks or sports-grounds, powered, with the cutting device rotating in a horizontal plane
28	845710	Machining centers; for working metal
29	845720	Machines; unit construction machines (single station), for working metal
30	845730	Metal machines; multi-station transfer machines, for working metal
31	851440	Heating equipment; for the heat treatment of materials by induction or dielectric loss, industrial or laboratory, other than furnaces and ovens
32	851610	Heaters; electric, instantaneous or storage water and immersion heaters
33	851650	Ovens; microwave, of a kind used for domestic purposes

34	851660	Ovens, cookers, cooking plates, boiling rings, grillers and roasters; of a kind used for domestic purposes (excluding microwaves)
35	851671	Electro-thermic appliances; coffee or tea makers, of a kind used for domestic purposes
36	851680	Resistors; electric heating, other than those of heading no. 8545
37	851690	Electro-thermic appliances; parts, of heating resistors, of water, space and soil heaters, hair-dressing apparatus, hand dryers, smoothing irons and other domestic appliances of heading no. 8516
38	851920	Sound recording or reproducing apparatus; operated by coins, banknotes, bank cards, tokens or by other means of payment
39	851930	Sound recording or reproducing apparatus; turntables (record-decks)
40	852210	Sound recording or reproducing apparatus; parts and accessories thereof, pick-up cartridges
41	854099	Valves and tubes; parts of the valves and tubes of heading no. 8540, excluding parts of cathode-ray tubes
42	901730	Mathematical equipment; micrometers, calipers and gauges
43	901780	Mathematical instruments and equipment; n.e.c. in heading no. 9017
44	901831	Medical, surgical instruments and appliances; syringes, with or without needles
45	901832	Medical, surgical instruments and appliances; tubular metal needles and needles for sutures
46	901839	Medical, surgical instruments and appliances; catheters, cannulae and the like
47	901920	Therapeutic respiration apparatus; ozone, oxygen, aerosol therapy apparatus; artificial respiration or other therapeutic respiration apparatus
48	902140	Hearing aids (excluding parts and accessories)
49	845640	Machine tools; for working any material by removal of material; operated by plasma arc processes;
50	320890	Paints and varnishes; based on polymers n.e.c. in heading no. 3208, dispersed or dissolved in a non-aqueous medium
51	321410	Mastics; painters' fillings
52	350699	Glues and other adhesives; prepared, n.e.c. in heading no. 3506, not exceeding a net weight of 1kg
53	400510	Rubber; unvulcanized, compounded with carbon black or silica, in primary forms or in plates, sheets or strip
54	680421	Millstones, grindstones, grinding wheels and the like; of agglomerated synthetic or natural diamond
55	690912	Ceramic wares; for laboratory, chemical or other technical uses, articles having a hardness equivalent to 9 or more on the Mohs scale
56	700220	Glass; unworked, in rods
57	700231	Glass; unworked, in tubes, of fused quartz or other fused silica
58	700600	Glass of heading no. 7003, 7004 or 7005; bent, edge-worked, engraved, drilled, enameled or otherwise worked, but not framed or fitted with other materials
59	810320	Tantalum; unwrought, including bars and rods obtained simply by sintering, powders
60	810390	Tantalum; articles n.e.c. in heading no. 8103
61	810520	Cobalt; mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, powders
62	810820	Titanium; unwrought, powders
63	810890	Titanium; other than unwrought, n.e.c. in heading no. 8108
64	811219	Beryllium and articles thereof; wrought other than waste and scrap
65	811221	Chromium and articles thereof; unwrought chromium, powders
66	811229	Chromium and articles thereof; wrought other than waste and scrap
67	811292	Gallium, germanium, hafnium, indium, niobium (columbium), rhenium and vanadium; articles thereof, unwrought, including waste and scrap, powders
68	811299	Gallium, germanium, hafnium, indium, niobium (columbium), rhenium and vanadium; articles thereof, other than unwrought including waste and scrap and powders
69	820239	Tools, hand; circular saw blades (including slitting or slotting saw blades), with working part of materials (other than steel)
70	820890	Tools; knives and cutting blades, for machines or mechanical appliances, n.e.c. in heading no. 8208
71	830130	Locks; of a kind used for furniture (key, combination or electrically operated), of base metal

72	830140	Locks; (other than those for motor vehicles or furniture), (key, combination or electrically operated), of base metal
73	845811	Lathes; for removing metal, horizontal, numerically controlled
74	845891	Lathes; for removing metal, numerically controlled, other than horizontal lathes
75	845921	Machine tools; for drilling by removing metal, numerically controlled
76	845931	Machine tools; for boring-milling by removing metal, numerically controlled
77	845951	Machine tools; for milling by removing metal, knee-type, numerically controlled
78	845961	Machine tools; for milling by removing metal, (not knee-type), numerically controlled
79	845970	Machine tools; for threading or tapping by removing metal
80	846031	Machine tools; sharpening (tool or cutter grinding) machines, numerically controlled
81	846040	Machine tools; for honing or lapping
82	850231	Electric generating sets; wind-powered, (excluding those with spark-ignition or compression-ignition internal combustion piston engines)
83	853110	Signaling apparatus; electric, sound or visual, burglar or fire alarms and similar, other than those of heading no. 8512 or 8530
84	900110	Optical fibers, optical fiber bundles and cables; excluding those of heading no. 8544
85	900510	Binoculars
86	900580	Monoculars; other optical telescopes and astronomical instruments, excluding instruments for radio-astronomy
87	902511	Thermometers and pyrometers; liquid filled, for direct reading, not combined with other instruments
88	902910	Meters and counters; revolution counters, production counters, taximeters, mileometers, pedometers and the like
89	902920	Meters; speed indicators and tachometers; stroboscopes
90	902990	Meters and counters; parts and accessories for revolution and production counters, taximeters, mileometers, pedometers and the like; speed indicators, tachometers (excluding heading no. 9015), stroboscopes
91	903210	Regulating or controlling instruments and apparatus; automatic type, thermostats
92	845941	Machine tools; for boring by removing metal, numerically controlled boring machines, n.e.c. in heading 8459
93	846012	Machine tools; flat-surface grinding machines, numerically controlled
94	846022	Machine tools; grinding machines (excluding flat-surface), centerless, numerically controlled
95	846023	Machine tools; cylindrical grinding machines (excluding flat-surface and centerless), numerically controlled
96	846024	Machine tools; grinding machines (excluding flat-surface, cylindrical and centerless), numerically controlled
97	852842	Monitors; cathode-ray tube, capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71
98	871160	Motorcycles (including mopeds) and cycles; fitted with auxiliary motor, with electric motor for propulsion, with or without side-cars; side-cars
99	381010	Pickling preparations for metal surfaces; soldering, brazing or welding powders and pastes consisting of metal and other materials
100	391610	Ethylene polymers; monofilament, of which any cross-sectional dimension exceeds 1mm, rods, sticks and profile shapes, whether or not surface-worked but not otherwise worked
101	710691	Metals; silver, unwrought, (but not powder)
102	710813	Metals; gold, semi-manufactured
103	711590	Metal; precious or metal clad with precious metal, other than that of item no. 7115.10
104	720390	Ferrous products; spongy ferrous products and iron having a minimum purity by weight of 99.94%, in lumps, pellets or similar forms
105	732690	Iron or steel; articles n.e.c.in heading 7326
106	740319	Copper; refined, unwrought, n.e.c. in item no. 7403.1
107	740819	Copper; wire, of refined copper, of which the maximum cross-sectional dimension is 6mm or less
108	740829	Copper; wire, of copper alloys (other than copper-zinc base alloys, copper-nickel base alloys or copper-nickel-zinc base alloys)
109	740919	Copper; plates and sheets, of a thickness exceeding 0.15mm, of refined copper, not in coils

110	741999	Copper; articles n.e.c. in heading no. 7419
111	841381	Pumps and liquid elevators; n.e.c. in heading no. 8413
112	841583	Air conditioning machines; containing a motor driven fan, other than window or wall types, not incorporating a refrigerating unit
113	841821	Refrigerators; for household use, compression-type, electric or other
114	841911	Heaters; instantaneous gas water heaters, for domestic or other purposes
115	846090	Machine tools; for deburring, polishing or otherwise finishing metal, sintered metal carbides or cermets by means of grinding stones, abrasives or polishing products, n.e.c. in heading no. 8460
116	846120	Machine tools; shaping or slotting machines, working by removing metal, sintered metal carbides or cermets
117	846130	Machine tools; broaching machines, working by removing metal, sintered metal carbides or cermets
118	846150	Machine tools; sawing or cutting-off machines, working by removing metal, sintered metal carbides or cermets
119	846190	Machine tools; planing machines, and other machine tools n.e.c. in heading no. 8461; working by removing metal, sintered metal carbi des or cerments
120	846231	Machine tools; shearing machines (including presses), (other than combined punching and shearing machines), numerically controlled, for working metal
121	846241	Machine tools; punching or notching machines (including presses), including combined punching and shearing machines, numerically controlled, for working metal
122	846291	Machine tools; presses for working metal or metal carbides, n.e.c. in heading no. 8462, hydraulic presses
123	846299	Machine tools; presses for working metal or metal carbides, n.e.c. in heading no. 8462, other than hydraulic presses
124	846510	Machine tools; which can carry out different types of machining operations without tool change between such operations, for working wood, cork, bone, hard rubber, hard plastics or similar
125	846592	Machine tools; planing, milling or molding (by cutting) machines, for working wood, cork, bone, hard rubber, hard plastics or similar hard materials
126	846595	Machine tools; drilling or morticing machines, for working wood, cork, bone, hard rubber, hard plastics or similar hard materials
127	850980	Electro-mechanical domestic appliances; with self-contained electric motor, other than vacuum cleaners of heading 85.08, n.e.c. in heading no. 8509
128	851290	Lighting or signaling equipment; electrical, (excluding articles of heading no. 8539), windscreen wipers, defrosters and demisters; parts, of those kinds used for cycles or motor vehicles
129	851310	Lamps; portable, electric, designed to function by their own source of energy (excluding lighting equipment of heading no. 8512)
130	854011	Tubes; cathode-ray television picture tubes, including video monitor cathode-ray tubes, color
131	854012	Tubes; cathode-ray television picture tubes, including video monitor cathode-ray tubes, monochrome
132	854020	Tubes; television camera tubes, image converters and intensifiers, other photo-cathode tubes
133	854040	Tubes; data/graphic display tubes, monochrome; data/graphic display tubes, color, with a phosphor dot screen pitch smaller than 0.4mm
134	854060	Tubes; cathode ray, n.e.c. in heading no. 8540
135	854081	Valves and tubes; receiver or amplifier
136	854091	Tubes; parts of cathode-ray tubes
137	900590	Binoculars, monoculars, other optical telescopes, astronomical instruments (excluding those of radio-astronomy); parts and accessories (including mountings)
138	900630	Cameras, photographic (excluding cinematographic); specially designed for underwater use, aerial survey, medical or surgical examination of internal organs; comparison cameras for forensic or criminological use
139	901530	Surveying equipment; levels
140	901600	Balances; of a sensitivity of 5cg or better, with or without weights
141	901710	Drafting tables and machines; whether or not automatic

142	940169	Seats; with wooden frames, not upholstered, (excluding medical, surgical, dental, veterinary or barber furniture)
143	940592	Lamps and light fittings; parts thereof, of plastics
144	950300	Tricycles, scooters, pedal cars and similar wheeled toys; dolls' carriages; dolls; other toys; reduced-size (scale) models and similar recreational models, working or not; puzzles of all kinds
145	281290	Halides and halide oxides of non-metals; excluding chloride
146	282739	Chlorides; other than of ammonium, calcium, magnesium, aluminum and nickel
147	284590	Isotopes (excluding those of heading no. 2844); compounds, inorganic or organic, of such isotopes, whether or not chemically defined
148	285000	Hydrides, nitrides, azides, silicides and borides, whether or not chemically defined, other than compounds which are also carbides of heading no. 2849
149	292090	Esters; other than thiophosphoric esters (phosphorothioates) and their salts, their halogenated, sulphonated, nitrated or nitrosated derivatives
150	292111	Amine-function compounds; acyclic monoamines and their derivatives, methylamine, di- or trimethylamine and their salts
151	293190	Organo-inorganic compounds; other than tetramethyl lead, tetraethyl lead, and tributyltin compounds
152	321590	Ink; writing, drawing and other inks, n.e.c. in heading no. 3215, whether or not concentrated or solid
153	340220	Washing and cleaning preparations; surface-active, whether or not containing soap (excluding those of heading no. 3401), put up for retail sale
154	340290	Washing and cleaning preparations; surface-active, whether or not containing soap (excluding those of heading no. 3401), including auxiliary washing preparations, not for retail sale
155	340590	Polishes, creams and similar preparations; n.e.c. in heading no. 3405, excluding waxes of heading no. 3404
156	370242	Photographic film; in rolls, (other than for color photography), sensitized, unexposed, without sprocket holes, of a width exceeding 610mm and of a length exceeding 200m (other than of paper, paperboard or textiles)
157	370710	Photographic goods; sensitized emulsions, put up in measured portions or put up for retail sale in a form ready for use
158	380110	Graphite; artificial
159	390230	Propylene, other olefin polymers; propylene copolymers in primary forms
160	390290	Propylene, other olefin polymers; n.e.c. in heading no. 3902, in primary forms
161	390469	Halogenated olefin polymers; fluoro-polymers (other than polytetrafluoroethylene), in primary forms
162	390599	Vinyl acetate, vinyl ester polymers, vinyl polymers; n.e.c. in heading no. 3905, in primary forms, other than copolymers
163	390730	Epoxide resins; in primary forms
164	390740	Polycarbonates; in primary forms
165	391000	Silicones; in primary forms
166	391740	Plastics; tube, pipe and hose fittings (e.g. joints, elbows, flanges)
167	391910	Plastics; plates, sheets, film, foil, tape, strip, other flat shapes thereof, self-adhesive, in rolls of a width not exceeding 20cm
168	391990	Plastics; plates, sheets, film, foil, tape, strip, other flat shapes thereof, self-adhesive, other than in rolls of a width not exceeding 20cm
169	392049	Plastics; polymers of vinyl chloride, containing by weight, less than 6% of plasticizers; plates, sheets, film, foil and strip (not self-adhesive), non-cellular and not reinforced, laminated, supported or similarly combined with other materials
170	392099	Plastics; plates, sheets, film, foil and strip (not self-adhesive), of plastics n.e.c. in heading no. 3920, non-cellular and not reinforced, laminated, supported or similarly combined with other materials
171	392119	Plastics; plates, sheets, film, foil and strip, of plastics n.e.c. in heading no. 3921, cellular
172	392190	Plastics; plates, sheets, film, foil and strip, other than cellular
173	392310	Plastics; boxes, cases, crates and similar articles for the conveyance or packing of goods
174	392610	Plastics; office or school supplies
175	392690	Plastics; other articles n.e.c. in Chapter 39

176	540771	Fabrics, woven; containing 85% or more by weight of synthetic filaments (excluding nylon or other polyamides and polyesters), unbleached or bleached
177	560311	Nonwovens; whether or not impregnated, coated, covered or laminated, of man-made filaments, (weighing not more than 25g/m2)
178	591140	Textile products and articles for technical uses; straining cloth of a kind used in oil presses and the like, including that of human hair
179	681510	Stone articles and other mineral substances, non-electrical articles of graphite or other carbon
180	690911	Ceramic wares; for laboratory, chemical or other technical uses, of porcelain or china
181	690919	Ceramic wares; for laboratory, chemical or other technical uses, other than articles having a hardness equivalent to 9 or more on the Mohs scale or of porcelain or china
182	702000	Glass; articles n.e.c. in Chapter 70
183	761699	Aluminum; articles n.e.c. in heading 7616
184	841410	Pumps; vacuum
185	841490	Pumps and compressors; parts, of air or vacuum pumps, air or other gas compressors and fans, ventilating or recycling hoods incorporating a fan
186	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
187	841919	Heaters; instantaneous or storage water heaters, non-electric, other than instantaneous gas water heaters
188	842121	Machinery; for filtering or purifying water
189	285390	Phosphides, chemically defined or not, not ferrophosphorus; other inorganic compounds n.e.c. (including distilled, conductivity water and water of like purity); liquid air, rare gases removed or not; compressed air; amalgams, not precious metal amalgams
190	293139	Organo-inorganic compounds; other organo-phosphorus derivatives, n.e.c. in heading no. 2931
191	382499	Chemical products, mixtures and preparations; n.e.c. heading 3824
192	845011	Washing machines; household or laundry-type, fully-automatic, (of a dry linen capacity not exceeding 10kg)
193	847480	Machines; for agglomerating, shaping or molding solid mineral fuels, ceramic paste, unhardened cements, plastering materials in powder or paste form, machines for forming foundry molds of sand
194	847529	Machines; for manufacturing or hot working glass or glassware, not for making optical fibers and preforms thereof
195	848180	Taps, cocks, valves and similar appliances; for pipes, boiler shells, tanks, vats or the like, including thermostatically controlled valves
196	848410	Gaskets and similar joints; of metal sheeting combined with other material or two or more layers of metal
197	850131	Electric motors and generators; DC, of an output not exceeding 750W
198	850133	Electric motors and generators; DC, of an output exceeding 75kW but not exceeding 375kW
199	850134	Electric motors and generators; DC, of an output exceeding 375kW
200	850161	Generators; AC generators, (alternators), of an output not exceeding 75kVA
201	850162	Electric generators; AC generators, (alternators), of an output exceeding 75kVA but not exceeding 375kVA
202	850163	Electric generators; AC generators, (alternators), of an output exceeding 375kVA but not exceeding 750kVA
203	850164	Electric generators; AC generators, (alternators), of an output exceeding 750kVA
204	850431	Electrical transformers; n.e.c. in item no. 8504.2, having a power handling capacity not exceeding 1kVA
205	850511	Magnets; permanent magnets and articles intended to become permanent magnets after magnetization, of metal
206	850519	Magnets; permanent magnets and articles intended to become permanent magnets after magnetization, other than of metal
207	850610	Cells and batteries; primary, manganese dioxide
208	845650	Machine tools; for working any material by removal of material; operated by water-jet cutting machines
209	850640	Cells and batteries; primary, silver oxide
210	850650	Cells and batteries; primary, lithium

211	850660	Cells and batteries; primary, air-zinc
212	850680	Cells and batteries; primary, (other than manganese dioxide, mercuric oxide, silver oxide, lithium or air-zinc)
213	850720	Electric accumulators; lead-acid, (other than for starting piston engines), including separators, whether or not rectangular (including square)
214	850730	Electric accumulators; nickel-cadmium, including separators, whether or not rectangular (including square)
215	850740	Electric accumulators; nickel-iron, including separators, whether or not rectangular (including square)
216	850750	Electric accumulators; nickel-metal hydride, including separators, whether or not rectangular (including square)
217	850760	Electric accumulators; lithium-ion, including separators, whether or not rectangular (including square)
218	850780	Electric accumulators; other than lead-acid, nickel-cadmium, nickel-iron, nickel-metal hydride and lithium-ion, including separators, whether or not rectangular (including square)
219	850790	Electric accumulators; parts n.e.c. in heading no. 8507
220	851679	Electro-thermic appliances; n.e.c. in heading no. 8516, used for domestic purposes
221	852859	Monitors other than cathode-ray tube; other than of a kind solely or principally used in an automatic data processing system of heading 84.71
222	852869	Projectors; other than of a kind solely or principally used in an automatic data processing system of heading 84.71
223	852872	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; incorporating a color video display or screen
224	852873	Reception apparatus for television, whether or not incorporating radio broadcast receivers or sound or video recording or reproducing apparatus; incorporating a monochrome video display or screen
225	853540	Electrical apparatus; lightning arresters, voltage limiters and surge suppressors (for a voltage exceeding 1000 volts)
226	853590	Electrical apparatus; n.e.c. in heading no. 8535, for switching or protecting electrical circuits, for a voltage exceeding 1000 volts
227	853610	Electrical apparatus; fuses, for a voltage not exceeding 1000 volts
228	853641	Electrical apparatus; relays, (for a voltage not exceeding 60 volts)
229	852852	Monitors; other than cathode-ray tube; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71
230	852862	Projectors; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71
231	853710	Boards, panels, consoles, desks and other bases; for electric control or the distribution of electricity, (other than switching apparatus of heading no. 8517), for a voltage not exceeding 1000 volts
232	853890	Electrical apparatus; parts suitable for use solely or principally with the apparatus of heading no. 8535, 8536 or 8537
233	854079	Tubes; microwave, other than magnetrons and klystrons, (for example traveling wave tubes, carlinotrons), excluding grid-controlled tubes
234	854089	Valves and tubes; n.e.c. in heading no. 8540
235	854419	Insulated electric conductors; winding wire, (of other than copper)
236	854420	Insulated electric conductors; co-axial cable and other co-axial electric conductors
237	854519	Carbon electrodes; with or without metal, of a kind used for other than furnaces
238	854690	Electrical insulators; other than of glass and ceramics
239	853670	Connectors for optical fibers, optical fiber bundles or cables
240	854310	Electrical machines and apparatus; particle accelerators
241	854442	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors
242	853950	Lamps; LED lamps
243	854710	Insulating fittings; of ceramics, for electrical machines, of insulating material only (except minor assembly parts), excluding those of heading no. 8546
244	854720	Insulating fittings; of plastics, for electrical machines, of insulating material only (except minor assembly parts), excluding those of heading no. 8546

245	854790	Insulating fittings; (other than of ceramics or plastics), for electrical machines, appliances and equipment, excluding insulators of heading no. 8546
246	880220	Airplanes and other aircraft; of an unladen weight not exceeding 2000kg
247	880240	Airplanes and other aircraft; of an unladen weight exceeding 15,000kg
248	900211	Lenses; objective, for cameras, projectors or photographic enlargers or reducers, mounted, being parts or fittings for instruments or apparatus, of any material (excluding glass not optically worked)
249	900490	Spectacles, goggles and the like; (other than sunglasses) corrective, protective or other
250	900691	Cameras, photographic (excluding cinematographic); parts and accessories
251	900699	Photographic flashlight apparatus; parts and accessories, for other than cameras
252	900850	Image projectors, photographic enlargers and reducers, excluding cinematographic
253	880211	Helicopters; of an unladen weight not exceeding 2000kg
254	880212	Helicopters; of an unladen weight exceeding 2000kg
255	880230	Airplanes and other aircraft; of an unladen weight exceeding 2000kg but not exceeding 15,000kg
256	901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)
257	901814	Medical, surgical instruments and appliances; scintigraphic apparatus
258	901910	Mechano-therapy appliances; massage apparatus and psychological aptitude-testing apparatus
259	902580	Hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments (excluding thermometers and barometers not combined with other instruments)
260	902810	Meters; gas, supply or production meters, including calibrating meters thereof
261	902820	Meters; liquid supply or production meters, including calibrating meters thereof
262	903289	Regulating or controlling instruments and apparatus; automatic, other than hydraulic or pneumatic
263	903290	Regulating or controlling instruments and apparatus; automatic, parts and accessories
264	903300	Machines and appliances; instruments or apparatus of Chapter 90; parts and accessories n.e.c. in Chapter 90
265	910291	Pocket watches and other watches, including stop-watches; (excluding wrist-watches), other than those of heading no. 9101, electrically operated
266	910511	Clocks; (excluding those with watch movements and instrument panel clocks), alarm clocks, electrically operated
267	911320	Watch straps, watch bands, watch bracelets, and parts thereof; of base metal, whether or not gold- or silver-plated
268	911390	Watch straps, watch bands, watch bracelets, and parts thereof; n.e.c. in heading no. 9113
269	940310	Furniture; metal, for office use
270	940320	Furniture; metal, other than for office use
271	940390	Furniture; parts
272	940540	Lamps and light fittings; electric, n.e.c. in heading no. 9405
273	950691	Athletics and gymnastics equipment
274	950450	Games; video game consoles and machines, other than those of subheading 9504.30
275	854330	Electrical machines and apparatus; for electroplating, electrolysis or electrophoresis
276	902290	Apparatus based on use of x-rays and similar; parts and accessories (x-ray generators, tubes, high tension generators, control panels and desks, screens, examination or treatment tables, chairs and like)
277	350691	Adhesives; prepared, based on polymers of heading 3901 to 3913 or on rubber
278	841950	Heat exchange units; not used for domestic purposes
279	901310	Optical appliances and instruments; telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of this chapter
280	901720	Drawing, marking-out or mathematical calculating instruments
281	701710	Glassware; laboratory, hygienic or pharmaceutical, whether or not graduated or calibrated, of fused quartz or other fused silica
282	841989	Machinery, plant and laboratory equipment; for treating materials by change of temperature, other than for making hot drinks or cooking or heating food
283	842129	Machinery; for filtering or purifying liquids, n.e.c. in item no. 8421.2

284	842139	Machinery; for filtering or purifying gases, other than intake air filters for internal combustion engines
285	847590	Machines; parts, of those for assembling electric or electronic lamps, tubes, valves or flashbulbs, in glass envelopes and manufacturing or hot working glass or glassware
286	847790	Machinery; parts of the machines of heading no. 8477, n.e.c. in item no. 8477.90
287	847950	Machinery and mechanical appliances; industrial robots, n.e.c. or included
288	847989	Machines and mechanical appliances; having individual functions, n.e.c. or included in this chapter
289	847990	Machines and mechanical appliances; parts, of those having individual functions
290	848071	Molds; for rubber or plastics, injection or compression types
291	850590	Magnets; electro-magnets, holding devices and parts n.e.c. in heading no. 8505
292	851410	Furnaces and ovens; electric, for industrial or laboratory use, resistance heated
293	851430	Furnaces and ovens; electric, for industrial or laboratory use, other than those functioning by induction, dielectric loss or resistance heated
294	852721	Radio broadcast receivers not capable of operating without an external source of power, of a kind used in motor vehicles; combined with sound recording or reproducing apparatus
295	853669	Electrical apparatus; plugs and sockets, for a voltage not exceeding 1000 volts
296	854449	Insulated electric conductors; for a voltage not exceeding 80 volts, not fitted with connectors
297	854370	Electrical machines and apparatus; having individual functions, not specified or included elsewhere in this chapter, n.e.c. in heading no. 8543
298	880260	Spacecraft; (including satellites) and suborbital and spacecraft launch vehicles
299	901090	Photographic laboratory apparatus and equipment (including cinematographic); parts and accessories
300	901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013
301	901890	Medical, surgical or dental instruments and appliances; n.e.c. in heading no. 9018
297	854370	Electrical machines and apparatus; having individual functions, not specified or included elsewhere in this chapter, n.e.c. in heading no. 8543
298	880260	Spacecraft; (including satellites) and suborbital and spacecraft launch vehicles
299	901090	Photographic laboratory apparatus and equipment (including cinematographic); parts and accessories
300	901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013
301	901890	Medical, surgical or dental instruments and appliances; n.e.c. in heading no. 9018

Table 29: 12 HS codes directly linked to top 10 emerging ICT technologies

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

#	Technology	HS 6 Code	Label
1	Robotics	847950	Machinery and mechanical appliances; industrial robots, n.e.c. or included
2		842870	Industrial robots
3	Drones	880622	Unmanned aircraft; for remote-controlled flight only, other than for carriage of passengers, with a maximum take-off weight of more than 250g but not more than 7kg
4		880621	Unmanned aircraft; for remote-controlled flight only, other than for carriage of passengers, with a maximum take-off weight of not more than 250g
5		880623	Unmanned aircraft; for remote-controlled flight only, other than for carriage of passengers, with a maximum take-off weight of more than 7kg but not more than 25kg
6		880629	Unmanned aircraft; for remote-controlled flight only, other than for carriage of passengers, with a maximum take-off weight of more than 150kg
7		880610	Unmanned aircraft; for carriage of passengers
8	3D printing	848590	Machines for additive manufacturing; parts
9		848520	Machines for additive manufacturing; by plastic or rubber deposit
10		848510	Machines for additive manufacturing; by metal deposit
11		848580	Machines for additive manufacturing; other than metal, plastic, rubber, plaster, cement, ceramics, or glass deposits

12		848530	Machines for additive manufacturing; by plaster, cement, ceramics, or glass deposit

Table 30: Examples of HS codes that cannot be directly linked to emerging ICT technologies

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

#	Technology	HS 6 Code	Label
1	Immersive Media	852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528,
2		900490	Spectacles, goggles, and the like; (other than sunglasses) corrective, protective, or other
3		852859	Monitors other than cathode-ray tube; n.e.c. in subheading 8528.52, whether or not color
4		900691	Cameras, photographic (excluding cinematographic); parts and accessories
5		852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528,
6		900490	Spectacles, goggles, and the like; (other than sunglasses) corrective, protective, or other
7	Blockchain	847180	Units of automatic data processing machines; n.e.c. in item no. 8471.50, 8471.60 or 8471.70
8		847330	Machinery; parts and accessories (other than covers, carrying cases, and the like) of the machines
9	5G	851762	Communication apparatus (excluding telephone sets or base stations)
10	IoT, Big data, AI and Quantum computing	854231	Electronic integrated circuits: Processors and controllers
11		847141	Data processing machines, automatic, comprising the same housing at least a central processing unit

Table 31: Top 7 traded ICT HS codes (emerging technologies)

Source: The United Nations Comtrade (UNComtrade), Arthur D. Little analysis

#	HS codes	Description
1	847950	Machinery and mechanical appliances; industrial robots
2	842870	Industrial robots
3	848590	Machines for additive manufacturing; parts
4	880622	Unmanned aircraft; for remote-controlled flight only, for other than for carriage of passengers, with the maximum take-off weight of more than 250g but not more than 7kg
5	880621	Unmanned aircraft; for remote-controlled flight only, for other than for carriage of passengers, with the maximum take-off weight of not more than 250g
6	848520	Machines for additive manufacturing; by plastic or rubber deposit
7	848510	Machines for additive manufacturing; by metal deposit

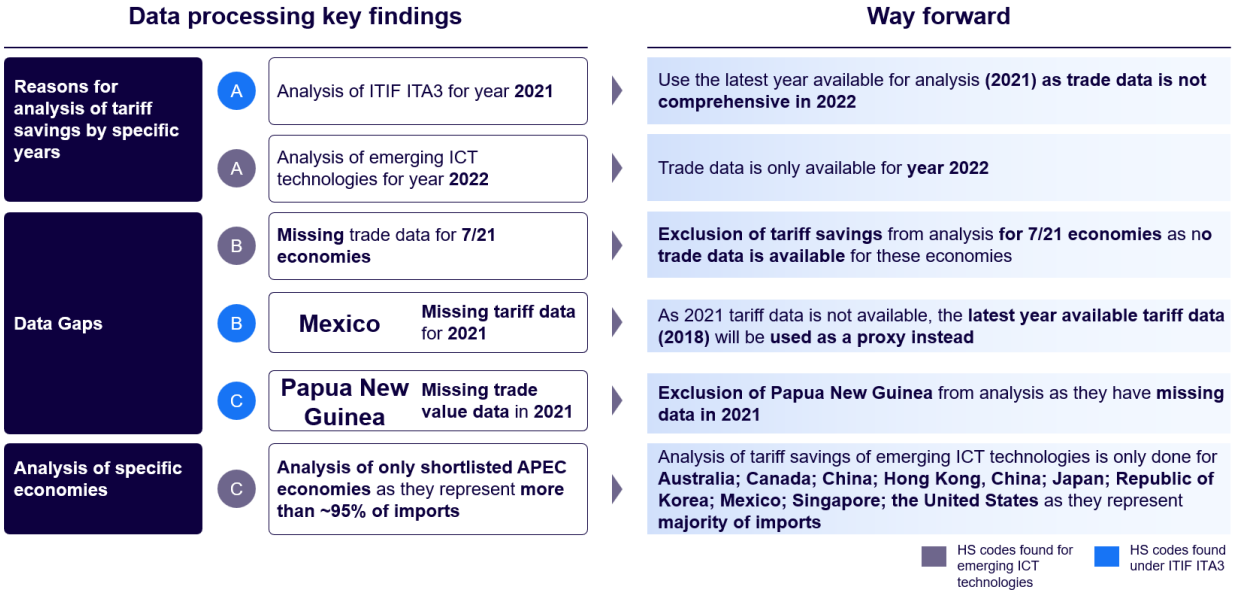
13.5 Impact of reduced tariffs on emerging ICT products

Table 32: Details of top 40 emerging ICT HS codes in the future ICT products list

Source: The United Nations Comtrade (UNComtrade), Information Technology and Innovation Foundation (ITIF), Arthur D. Little analysis

#	HS Code	Label	Duplicated / Non-duplicated with ITA or ITA2
1	950300	Tricycles, scooters, pedal cars and similar wheeled toys; dolls' carriages; dolls; other toys; reduced-size (scale) models and similar recreational models, working or not; puzzles of all kinds	Non-duplicated
2	392690	Plastics; other articles n.e.c. in Chapter 39	Non-duplicated
3	850760	Electric accumulators; lithium-ion, including separators, whether or not rectangular (including square)	Non-duplicated
4	853710	Boards, panels, consoles, desks and other bases; for electric control or the distribution of electricity, (other than switching apparatus of heading no. 8517), for a voltage not exceeding 1000 volts	Non-duplicated
5	848180	Taps, cocks, valves and similar appliances; for pipes, boiler shells, tanks, vats or the like, including thermostatically controlled valves	Non-duplicated
6	710813	Metals; gold, semi-manufactured	Non-duplicated
7	732690	Iron or steel; articles n.e.c.in heading 7326	Non-duplicated
8	854442	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors	Non-duplicated
9	382499	Chemical products, mixtures and preparations; n.e.c. heading 3824	Non-duplicated
10	950450	Games; video game consoles and machines, other than those of subheading 9504.30	Duplicated
11	760110	Aluminum; unwrought, (not alloyed)	Non-duplicated
12	940540	Lamps and light fittings; electric, n.e.c. in heading no. 9405	Non-duplicated
13	901839	Medical, surgical instruments and appliances; catheters, cannulae and the like	Non-duplicated
14	852852	Monitors; other than cathode-ray tube; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	Non-duplicated
15	940320	Furniture; metal, other than for office use	Non-duplicated
16	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other	Non-duplicated
17	950691	Athletics and gymnastics equipment	Non-duplicated
18	391990	Plastics; plates, sheets, film, foil, tape, strip, other flat shapes thereof, self-adhesive, other than in rolls of a width not exceeding 20cm	Non-duplicated
19	852859	Monitors other than cathode-ray tube; other than of a kind solely or principally used in an automatic data processing system of heading 84.71	Non-duplicated
20	761699	Aluminum; articles n.e.c. in heading 7616	Non-duplicated
21	851660	Ovens, cookers, cooking plates, boiling rings, grillers and roasters; of a kind used for domestic purposes (excluding microwaves)	Non-duplicated
22	940390	Furniture; parts	Non-duplicated
23	850131	Electric motors and generators; DC, of an output not exceeding 750W	Non-duplicated
24	390230	Propylene, other olefin polymers; propylene copolymers in primary forms	Non-duplicated
25	392490	Plastics; household articles and hygienic or toilet articles	Non-duplicated
26	392190	Plastics; plates, sheets, film, foil and strip, other than cellular	Non-duplicated
27	901910	Mechano-therapy appliances; massage apparatus and psychological aptitude-testing apparatus	Non-duplicated
28	901920	Therapeutic respiration apparatus; ozone, oxygen, aerosol therapy apparatus; artificial respiration or other therapeutic respiration apparatus	Non-duplicated
29	392310	Plastics; boxes, cases, crates and similar articles for the conveyance or packing of goods	Non-duplicated
30	850980	Electro-mechanical domestic appliances; with self-contained electric motor, other than vacuum cleaners of heading 85.08, n.e.c. in heading no. 8509	Non-duplicated
31	392099	Plastics; plates, sheets, film, foil and strip (not self-adhesive), of plastics n.e.c. in heading no. 3920, non-cellular and not reinforced, laminated, supported or similarly combined with other materials	Non-duplicated

32	392390	Plastics; articles for the conveyance or packing of goods n.e.c. in heading no. 3923	Non-duplicated
33	853950	Lamps; LED lamps	Non-duplicated
34	851679	Electro-thermic appliances; n.e.c. in heading no. 8516, used for domestic purposes	Non-duplicated
35	842129	Machinery; for filtering or purifying liquids, n.e.c. in item no. 8421.2	Duplicated
36	901890	Medical, surgical or dental instruments and appliances; n.e.c. in heading no. 9018	Duplicated
37	853669	Electrical apparatus; plugs and sockets, for a voltage not exceeding 1000 volts	Duplicated
38	854370	Electrical machines and apparatus; having individual functions, not specified or included elsewhere in this chapter, n.e.c. in heading no. 8543	Duplicated
39	847989	Machines and mechanical appliances; having individual functions, n.e.c. or included in this chapter	Duplicated
40	842139	Machinery; for filtering or purifying gases, other than intake air filters for internal combustion engines	Duplicated



Source: Arthur D. Little analysis

Figure 52: Data gaps identified that was excluded from the impact of tariff reductions on emerging HS codes

Table 33: APEC economies MFN tariff rates for the top 40 future ICT products emerging HS codes

Source: Trademap, Arthur D. Little analysis

HS codes	392490	841810	851660	850980	851679	392390	852859	940540	392690	391990
Thailand	30.00%	30.00%	20.00%	30.00%	20.00%	10.00%	20.00%	20.00%	8.95%	30.00%
Indonesia	20.00%	15.00%	15.00%	10.00%	15.00%	15.00%	10.00%	7.50%	16.58%	10.00%
Viet Nam	22.00%	14.00%	20.00%	25.00%	22.50%	12.50%	11.00%	11.67%	9.26%	12.00%
Malaysia	4.00%	30.00%	20.00%	20.00%	20.00%	20.00%	25.00%	12.50%	17.37%	14.00%
The Philippines	15.00%	6.50%	7.00%	5.00%	7.00%	15.00%	15.00%	4.00%	9.00%	15.00%
Chile	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
China	6.50%	8.33%	7.00%	8.00%	7.00%	10.00%	17.50%	8.67%	10.00%	4.70%
Republic of Korea	6.50%	8.00%	8.00%	8.00%	8.00%	0.00%	8.00%	8.00%	6.50%	0.00%

The Russian Federation	6.50%	9.50%	10.00%	5.00%	10.00%	6.50%	2.50%	8.79%	4.40%	6.50%
Mexico[2]	7.50%	12.50%	11.25%	10.38%	10.00%	15.00%	5.00%	15.00%	6.94%	0.00%
Australia	5.00%	5.00%	5.00%	2.50%	5.00%	5.00%	0.00%	5.00%	5.00%	2.50%
Peru	6.00%	11.00%	6.00%	6.00%	6.00%	6.00%	6.00%	0.00%	6.00%	6.00%
Chinese Taipei	5.00%	4.92%	5.93%	6.00%	3.70%	5.00%	0.00%	5.42%	5.00%	3.33%
New Zealand	5.00%	5.00%	3.33%	1.25%	1.67%	5.00%	0.00%	4.29%	1.92%	5.00%
The United States	3.30%	0.00%	1.35%	1.40%	2.70%	3.00%	2.07%	3.65%	4.22%	6.15%
Papua New Guinea[3]	21.43%	0.00%	0.00%	0.00%	0.00%	5.00%	0.00%	0.00%	2.00%	0.00%
Canada	6.50%	4.00%	5.33%	4.00%	3.25%	3.25%	3.60%	4.33%	2.44%	0.00%
Japan	3.90%	0.00%	0.00%	0.00%	0.00%	3.90%	0.00%	0.00%	2.92%	0.00%
Brunei Darussalam	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	0.00%	0.00%
Hong Kong, China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Singapore	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HS codes	**940320**	**392099**	**940390**	**761699**	**392310**	**732690**	**390230**	**392190**	**950300**	**850131**
Thailand	20.00%	30.00%	10.00%	8.67%	10.00%	10.00%	30.00%	0.00%	10.00%	10.00%
Indonesia	10.00%	13.33%	15.00%	6.11%	15.00%	7.50%	7.50%	10.00%	15.00%	10.00%
Viet Nam	12.50%	6.00%	20.00%	17.22%	11.00%	11.88%	3.00%	6.00%	15.00%	14.33%
Malaysia	0.00%	14.17%	0.00%	20.00%	16.67%	8.13%	10.00%	14.09%	0.00%	0.00%
The Philippines	15.00%	7.00%	12.50%	11.00%	10.00%	11.14%	10.00%	15.00%	8.71%	0.00%
Chile	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
China	0.00%	6.50%	0.00%	8.00%	5.00%	8.00%	6.50%	6.50%	0.00%	12.00%
Republic of Korea	0.00%	5.67%	8.00%	8.00%	0.00%	8.00%	6.50%	6.50%	3.33%	8.00%
The Russian Federation	7.19%	6.50%	11.37%	7.71%	6.50%	7.75%	6.50%	6.50%	9.00%	0.00%
Mexico	7.00%	0.00%	0.00%	4.44%	15.00%	0.00%	3.00%	0.70%	9.05%	5.83%
Australia	5.00%	5.00%	5.00%	5.00%	2.50%	5.00%	5.00%	2.50%	3.50%	5.00%
Peru	6.00%	0.00%	6.00%	0.00%	6.00%	0.00%	0.00%	6.00%	6.00%	0.00%
Chinese Taipei	0.00%	4.11%	0.00%	3.57%	2.50%	6.21%	2.50%	5.10%	0.00%	6.33%
New Zealand	2.50%	3.75%	5.00%	2.50%	3.33%	2.50%	0.00%	5.00%	1.25%	5.00%
The United States	0.00%	5.33%	0.00%	1.25%	1.50%	3.22%	6.50%	5.30%	0.00%	3.00%
Papua New Guinea	15.00%	0.00%	15.00%	0.00%	0.00%	10.00%	0.00%	0.00%	0.00%	0.00%
Canada	8.00%	0.00%	0.00%	3.25%	0.00%	3.25%	0.00%	0.00%	4.00%	0.00%
Japan	0.00%	3.70%	0.00%	3.00%	0.00%	0.00%	2.80%	4.10%	0.00%	0.00%
Brunei Darussalam	5.00%	0.00%	2.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.36%	0.00%
Hong Kong, China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Singapore	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HS codes	**950691**	**850760**	**853710**	**854442**	**848180**	**950450**	**382499**	**853669**	**853950**	**842139**
Thailand	10.00%	10.00%	10.00%	6.25%	0.69%	5.00%	2.50%	0.00%	10.00%	17.50%
Indonesia	15.00%	10.00%	5.00%	0.00%	8.05%	15.00%	5.00%	3.33%	5.00%	2.50%
Viet Nam	5.00%	0.00%	7.78%	8.81%	8.52%	20.00%	3.25%	16.11%	0.00%	0.00%
Malaysia	0.00%	6.67%	13.33%	21.18%	8.86%	5.00%	6.67%	8.33%	0.00%	5.00%
The Philippines	1.00%	2.33%	3.83%	7.00%	4.66%	0.00%	2.75%	1.44%	1.00%	0.67%

Chile	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
China	6.00%	10.00%	6.50%	0.00%	6.87%	0.00%	6.64%	0.00%	8.00%	3.30%
Republic of Korea	8.00%	8.00%	6.67%	4.00%	8.00%	0.00%	6.33%	4.00%	8.00%	3.11%
The Russian Federation	5.00%	0.00%	0.00%	4.25%	4.56%	8.33%	4.07%	2.00%	0.00%	0.40%
Mexico	0.00%	0.00%	2.86%	4.17%	1.92%	0.00%	0.00%	1.67%	0.00%	1.67%
Australia	5.00%	5.00%	2.50%	2.50%	2.50%	0.00%	1.00%	2.50%	0.00%	2.50%
Peru	6.00%	6.00%	0.00%	0.00%	0.00%	6.00%	0.53%	0.00%	0.00%	0.00%
Chinese Taipei	3.00%	2.50%	3.75%	3.33%	2.56%	0.00%	2.86%	1.75%	3.40%	2.47%
New Zealand	5.00%	5.00%	5.00%	2.50%	2.50%	0.00%	0.26%	2.50%	5.00%	2.50%
The United States	4.60%	3.40%	2.03%	0.87%	3.65%	0.00%	4.12%	1.35%	2.00%	0.00%
Papua New Guinea	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Canada	0.00%	2.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Japan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.88%	0.00%	0.00%	0.00%
Brunei Darussalam	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hong Kong, China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Singapore	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HS codes	**847989**	**901839**	**710813**	**842129**	**854370**	**901910**	**901890**	**852852**	**760110**	**901920**
Thailand	0.00%	5.00%	0.00%	2.50%	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Indonesia	7.00%	5.00%	5.00%	5.00%	4.00%	5.00%	5.00%	0.00%	0.00%	5.00%
Viet Nam	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0.00%
Malaysia	0.00%	0.00%	0.00%	1.67%	0.83%	0.00%	0.00%	0.00%	0.00%	0.00%
The Philippines	0.80%	1.00%	3.00%	0.29%	0.50%	1.00%	0.75%	7.50%	1.00%	1.00%
Chile	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
China	0.00%	4.00%	0.00%	3.32%	0.89%	7.00%	2.25%	8.33%	5.00%	4.00%
Republic of Korea	6.54%	8.00%	3.00%	3.88%	4.44%	0.00%	3.33%	0.00%	1.00%	0.00%
The Russian Federation	0.40%	0.00%	15.00%	1.00%	2.86%	1.67%	1.10%	2.00%	0.00%	0.00%
Mexico	6.61%	5.00%	0.00%	1.11%	1.67%	6.67%	5.63%	0.00%	0.00%	0.00%
Australia	1.25%	0.00%	0.00%	2.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Peru	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chinese Taipei	2.25%	0.00%	0.00%	2.00%	1.25%	0.00%	0.00%	0.00%	0.00%	0.00%
New Zealand	2.50%	0.00%	0.00%	2.50%	0.83%	1.25%	0.00%	0.00%	0.00%	0.00%
The United States	1.01%	0.00%	1.37%	0.00%	0.69%	0.00%	0.00%	0.00%	1.30%	0.00%
Papua New Guinea	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Canada	1.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Japan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Brunei Darussalam	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hong Kong, China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Singapore	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 34: APEC economies MFN tariff rates for top seven HS codes within emerging ICT technologies

Source: Trademap, Arthur D. Little analysis

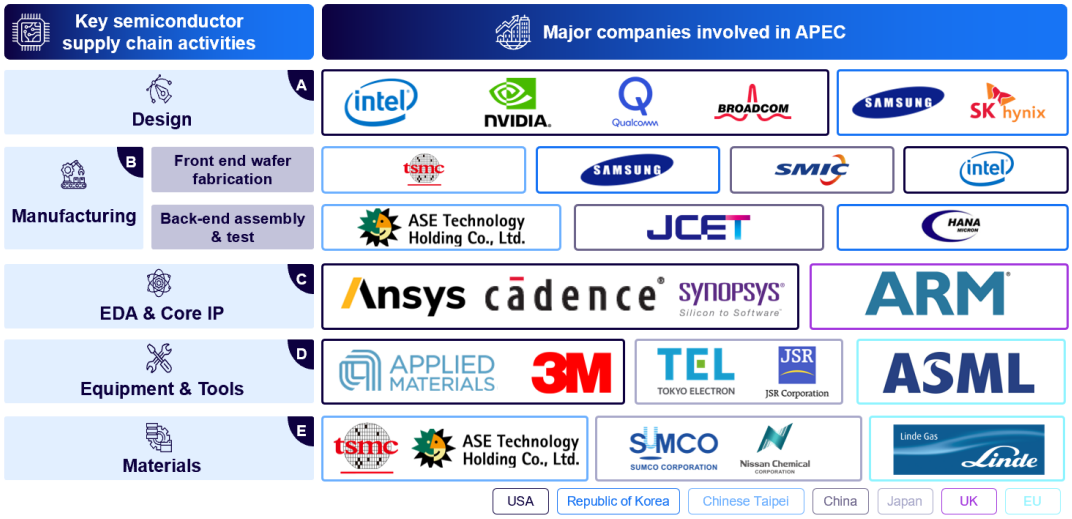
HS code	848520	848510	848590	842870	847950	880622	880621
Republic of Korea	8.00%	8.00%	8.00%	0.00%	8.00%	0.00%	0.00%
China	5.00%	9.00%	4.71%	5.00%	0.00%	1.75%	1.17%
Australia	5.00%	0.00%	3.33%	5.00%	3.33%	0.00%	0.00%
The United States	3.10%	2.50%	1.55%	0.00%	2.50%	0.00%	0.00%
Mexico	0.00%	0.00%	0.00%	5.00%	0.00%	0.00%	0.00%
Canada	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hong Kong, China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Japan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Singapore	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 35: Top 20 non-duplicated future ICT products HS codes

Source: The United Nations Comtrade (UNComtrade), Information Technology and Innovation Foundation (ITIF), Arthur D. Little analysis

#	HS Code	HS Code Description
1	392690	Plastics; other articles n.e.c. in Chapter 39
2	732690	Iron or steel; articles n.e.c.in heading 7326
3	850760	Electric accumulators; lithium-ion, including separators, whether or not rectangular (including square)
4	853710	Boards, panels, consoles, desks and other bases; for electric control or the distribution of electricity, (other than switching apparatus of heading no. 8517), for a voltage not exceeding 1000 volts
5	382499	Chemical products, mixtures and preparations; n.e.c. heading 3824
6	848180	Taps, cocks, valves and similar appliances; for pipes, boiler shells, tanks, vats or the like, including thermostatically controlled valves
7	391990	Plastics; plates, sheets, film, foil, tape, strip, other flat shapes thereof, self-adhesive, other than in rolls of a width not exceeding 20cm
8	761699	Aluminum; articles n.e.c. in heading 7616
9	950300	Tricycles, scooters, pedal cars and similar wheeled toys; dolls' carriages; dolls; other toys; reduced-size (scale) models and similar recreational models, working or not; puzzles of all kinds
10	950691	Athletics and gymnastics equipment
11	854442	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors
12	852859	Monitors other than cathode-ray tube; n.e.c. in subheading 8528.52, whether or not color
13	940540	Lamps and light fittings; electric, n.e.c. in heading no. 9405
14	850131	Electric motors and generators; DC, of an output not exceeding 750W
15	390230	Propylene, other olefin polymers; propylene copolymers in primary forms
16	392390	Plastics; articles for the conveyance or packing of goods n.e.c. in heading no. 3923
17	392310	Plastics; boxes, cases, crates and similar articles for the conveyance or packing of goods
18	851660	Ovens, cookers, cooking plates, boiling rings, grillers and roasters; of a kind used for domestic purposes (excluding microwaves)
19	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
20	392490	Plastics; household articles and hygienic or toilet articles

13.6 APEC economies involvement in supply chain



Source: Secondary research, Arthur D. Little analysis

Figure 53: Examples of semiconductor companies in APEC

14. References and sources

14. References and sources

1 United Nations Conference on Trade and Development. (n.d.) Impacts of the Covid-19 pandemic on trade in the digital economy. UNCTAD Technical Notes on ICT for Development. https://unctad.org/system/files/official-document/tn_unctad_ict4d19_en.pdf

2 International Telecommunication Union. (n.d.). The economic impact of broadband and digitization through the Covid-19 pandemic. https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.COV_ECO_IMPACT_B-2021-PDF-E.pdf

3 Oberlo. (April, 2022). Most popular devices in the US. https://www.oberlo.com/statistics/most-popular-devices

4 Kang, M. (13 September 2022). China Accounted for 67% of Global Handset Production in 2021. Counterpoint Technology Market Research. https://www.counterpointresearch.com/insights/global-handset-production-2021/#:~:text=China%20contributed%20to%2067%25%20of,for%20Huawei's%20decline%20in%20production.

5 Textor, C. (December 14 2022). Number of notebook computers produced in China between 2011 and 2022. Statista. https://www.statista.com/statistics/279235/production-of-notebooks-in-china/#:~:text=This%20statistic%20shows%20the%20number,computers%20were%20produced%20in%20China

6 Canalys. (12 January 2022). Global PC shipments pass 340 million in 2021 and 2022 is set to be even stronger. https://www.canalys.com/newsroom/global-pc-market-Q4-2021

7 Chatterjee S. Lee Y. Esposito A. (24 August 2020). Exclusive: Foxconn, other Asian firms consider Mexico factories as China risks grow. Reuters. https://www.reuters.com/article/us-mexico-china-factories-exclusive-idUSKBN25K17X

8 Team Counterpoint (11 May 2023). Counterpoint Technology Market Research. https://www.counterpointresearch.com/insights/global-semiconductor-foundry-market-share/

9 Seagate Technology Thailand (30 July 2017). A global leader in data storage systems. https://www.boi.go.th/upload/Seagate_44480.pdf

10 Kang, M. (13 September 2022). China Accounted for 67% of Global Handset Production in 2021. Counterpoint Technology Market Research. https://www.counterpointresearch.com/insights/global-handset-production-2021/#:~:text=China%20contributed%20to%2067%25%20of,for%20Huawei's%20decline%20in%20production

11 Textor, C. (14 December 2022). Number of notebook computers produced in China between 2011 and 2022. Statista. https://www.statista.com/statistics/279235/production-of-notebooks-in-china/#:~:text=This%20statistic%20shows%20the%20number,computers%20were%20produced%20in%20China.

12 Canalys. (12 January 2022). Global PC shipments pass 340 million in 2021 and 2022 is set to be even stronger. https://www.canalys.com/newsroom/global-pc-market-Q4-2021

13 Well PCB. (n.d.). 10 Factors to Achieve Low-Cost PCB In China. https://www.wellpcb.com/low-cost-pcb-2.html

14 Jones, L.; Kobza, C.; Lowery, F.;Peters, C. (April 2020). The Rising Role of Re-exporting Hubs in Global Value Chains. Journal of International Commerce and Economics. https://www.usitc.gov/staff_publications/jice/rising_role_re_exporting_hubs_global_value_chains

15 Statista. (n.d.). Semiconductor foundries revenue share worldwide from 2020 to 2022, by country. https://www.statista.com/statistics/1230946/semiconductor-foundries-market-share-by-country-worldwide/

16 Barnes, Mark. (8 February 2023). Where are Samsung's Factories in Viet Nam? Viet Nam Briefing. https://www.vietnam-briefing.com/news/where-are-samsungs-factories-in-vietnam.html/#:~:text=According%20to%20Samsung's%20Supplier%20List,were%20located%20in%20southern%20Vietnam.

17 The China Project. (2023). China's top 10 semiconductor firms. https://thechinaproject.com/2023/02/03/chinas-top-10-semiconductor-firms/

18 UNESCO. (n.d.). TVETipedia Glossary. UNESCO-UNEVOC. https://unevoc.unesco.org/home/TVETipedia+Glossary/lang=en/show=term/term=Digital+divide

19 United Nations Conference on Trade and Development. (2022). ASYCUDA Report 2021/22. https://unctad.org/publication/asycuda-report-202122

20 United Nations Conference on Trade and Development. (2022). ASYCUDA Report 2021/22. https://unctad.org/publication/asycuda-report-202122

21 United Nations Conference on Trade and Development. (2020). ASYCUDA Partnerships for Sustainable Development. https://unctad.org/publication/asycuda-compendium-2020

22 Coutinhom G. Eduardo,J. (n.d.). Brazil's new integrated risk management solutions. WCO News. https://mag.wcoomd.org/magazine/wco-news-86/brazils-new-integrated-risk-management-solutions/

23 World Customs Organization; World Trade Organization. (June 2022). WCO/WTO Study Report on Disruptive Technologies. https://www.wto.org/english/res_e/publications_e/wco-wto22_e.htm

24 IMDA. (n.d.). Tradetrust: A Trusted Global Network For Digitally Interconnected Trade Documents. https://www.imda.gov.sg/-/media/Imda/Files/News-and-Events/Media-Room/Media-Releases/2021/08/TradeTrust-Factsheet.pdf

25 WCO/WTO Study Report on Disruptive Technologies. (June 2022). https://www.wto.org/english/res_e/publications_e/wco-wto22_e.htm

26 IMDA. (n.d.). Tradetrust: A Trusted Global Network For Digitally Interconnected Trade Documents. https://www.imda.gov.sg/-/media/Imda/Files/News-and-Events/Media-Room/Media-Releases/2021/08/TradeTrust-Factsheet.pdf

27 WCO/WTO Study Report on Disruptive Technologies. (June 2022). https://www.wto.org/english/res_e/publications_e/wco-wto22_e.htm

28 Inter-American Development Bank. (n.d.). Blockchain and International Trade. Integration on and Trade Journal, 24(46). https://publications.iadb.org/publications/english/viewer/Integration--Trade-Journal-Volume-24-No.-46-December-2020-Blockchain-an-International-Trade-New-Technologies-for-a-Bigger-and-Better-Latin-American-International-Insertion.pdf

29 Nguyen T. (19 January 2023). 4 Emerging Technologies You Need to Know About. https://www.gartner.com/en/articles/4-emerging-technologies-you-need-to-know-about

30 House, W. (February 2022). Critical and emerging technologies list update - The White House. Critical & Emerging Technologies List Update.https://www.whitehouse.gov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf

31 Infocomm Media Development Authority. (n.d.). Tech Pillars. https://www.imda.gov.sg/about-imda/research-and-statistics/sgdigital/tech-pillars

32 Ministry of Science and ICT (n.d.). The Digital New Deal is to Lead Digital Transition in the World After Covid-19. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=443&searchOpt=&searchTxt=#:~:text=Ministry%20of%20Science%20and%20ICT,-Open%2FClose%20Search&text=Korea%20aims%20to%20lead%20digital,903%2C000%20new%20jobs%20by%202025.

33 Government of Japan. (2021). Science, Technology and Innovation Basic Plan. https://www8.cao.go.jp/cstp/english/sti_basic_plan.pdf

34 Canada Excellence Research Chairs. (7 April 2022). Science, Technology and Innovation Priorities for the Canada Excellence Research Chairs Program and the Canada First Research Excellence Fund. https://www.cerc.gc.ca/program-programme/priority_areas-domaines_prioritaires-eng.aspx

35 United Nations Conference on Trade and Development. (n.d.). Technology and Innovation Report 2023 https://unctad.org/system/files/official-document/tir2023_en.pdf

36 World Trade Organization. (2017). 20 Years of the Information Technology Agreement – Boosting trade, innovation and digital connectivity. https://www.wto.org/english/res_e/booksp_e/ita20years_2017_chap1_e.pdf

37 Anderson, M. & Mohs, J. (January 2010). The Information Technology Agreement: An Assessment of World Trade in Information Technology Products. United States International Trade Commission – Journal of International Commerce and Economics. https://www.usitc.gov/journals/05_AndersonMohs_ITAgreement.pdf

38 Anderson, M. & Mohs, J. (January 2010). The Information Technology Agreement: An Assessment of World Trade in Information Technology Products. United States International Trade Commission – Journal of International Commerce and Economics. https://www.usitc.gov/journals/05_AndersonMohs_ITAgreement.pdf

39 Ezell, S., Long,T. (2023). How Expanding the Information Technology Agreement to an “ITA-3” Would Bolster Economies’ Economic Growth. https://www2.itif.org/2023-ita3-impact.pdf

40 Henn, C. & Gnutzmann-Mkrtchyan. (2015). The Layers of the IT Agreement’s Trade Impact. World Trade Organization. https://www.wto.org/english/res_e/reser_e/ersd201501_e.pdf

41 Tokarick. (2010). A Method for Calculating Export Supply and Import Demand Elasticities. International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2010/wp10180.pdf

42 Australian Government. (May 2021). Digital Economy Strategy 2030. Digital Economy Strategy (apo.org.au). https://apo.org.au/sites/default/files/resource-files/2021-05/apo-nid312247.pdf

43 Canada Excellence Research Chairs. (7 April 2022). Science, Technology and Innovation Priorities for the Canada Excellence Research Chairs Program and the Canada First Research Excellence Fund. https://www.cerc.gc.ca/program-programme/priority_areas-domaines_prioritaires-eng.aspx

44State Council. (2021). The State Council issued the “14th Five-Year Plan” Digital Economy Plan. [Press Release]. Central People’s Government of China. (中华人民共和国中央人民政府). https://www.gov.cn/zhengce/content/2022-01/12/content_5667817.htm

45 Hong Kong, China Innovation and Technology Development Blueprint. (December 2022). Innovation, Technology and Industry Bureau. https://www.itib.gov.hk/en/publications/I&T%20Blueprint%20Book_EN_single_Digital.pdf

46 Broeckaert. L. (2022). Digital Transformation in Japan. EU-Japan Center for Industrial Cooperation, Tokyo. https://www.eu-japan.eu/sites/default/files/publications/docs/Digital-Transformation-Japan-Assessing-opportunities-forEU-SMEs.pdf

47 Ministry of Science and ICT. (28 September 2022). Republic of Korea to Come up with the Roadmap of Digital ROK, realizing the New York Initiative. [Press Release]. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&bbsSeqNo=42&nttSeqNo=742

48 Prime Minister Department - Economic Planning Unit. (2021). Malaysia Digital Economy Blueprint. https://www.ekonomi.gov.my/sites/default/files/2021-02/malaysia-digital-economy-blueprint.pdf

49 New Zealand Digital Government. (14 September 2022). 2022–23 Action Plan for the Digital Strategy for Aotearoa. https://www.digital.govt.nz/dmsdocument/238~202223-action-plan-for-the-digital-strategy-for-aotearoa/html

50 Government of the Russian Federation. (28 July 2017), Digital Economy of the Russian Federation. http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf

51 Smart Nation Gov. (November 2018). Smart Nation: The Way Forward. https://www.smartnation.gov.sg/files/publications/smart-nation-strategy-nov2018.pdf

52 House, W. (February 2022). Critical and emerging technologies list update - The White House. Critical & Emerging Technologies List Update .https://www.whitehouse.gov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf

53 Australian Government. (2021). Australia’s AI Action Plan. https://webarchive.nla.gov.au/awa/20220816053410/https://www.industry.gov.au/data-and-publications/australias-artificial-intelligence-action-plan

54 Australian Government. (3 May 2023). National Quantum Strategy. https://www.industry.gov.au/publications/national-quantum-strategy

55 Australian Government. (2020). The National Blockchain Roadmap: Progressing towards a blockchain-empowered future. https://apo.org.au/sites/default/files/resource-files/2020-02/apo-nid276541.pdf

56 Australian Government. (n.d). Australia’s Blockchain Roadmap. https://www.dfat.gov.au/about-us/publications/trade-and-investment/business-envoy-april-2021-digital-trade-edition/australias-blockchain-roadmap

57 Government of Canada. (2017). Pan-Canadian Artificial Intelligence Strategy. https://ised-isde.canada.ca/site/ai-strategy/en

58 Government of Canada. (2022). Canada’s Quantum Strategy. https://ised-isde.canada.ca/site/national-quantum-strategy/en/canadas-national-quantum-strategy#s4

59 Development of International Cooperation Ministry of Science and Technology. (2017). Next Generation Artificial Intelligence Development Plan: Issued by State Council. China Science and Technology Newsletter, 17, http://fi.china-embassy.gov.cn/eng/kxjs/201710/P020210628714286134479.pdf

60 Ministry of Industry and Information Technology. (1 November 2022). Interpretation of the “Virtual Reality and Industry Application Integration Development Action Plan (2022-2026)” [Press Release]. Central People’s Government of China. (中华人民共和国中央人民政府). https://www.gov.cn/zhengce/2022-11/01/content_5723274.htm

61 Ministry of Industry and Information Technology. (10 September 2021). Notice on Issuing the “Three-Year Action Plan for the Construction of New Infrastructure for the Internet of Things (2021-2023)” [Press Release]. Central People’s Government of China. (中华人民共和国中央人民政府). https://www.gov.cn/zhengce/zhengceku/2021-09/29/content_5640204.htm

62 Ministry of Industry and Information Technology. (5 July 2021). Notice from ten departments on the issuance of the "5G Application "Sail" Action Plan (2021-2023)". [Press Release]. Central People’s Government of China. （中华人民共和国中央人民政府）. https://www.gov.cn/zhengce/zhengceku/2021-07/13/content_5624610.htm

63 Ministry of Industry and Information Technology. (n.d.). Main Indicators of 5G Application Development. [Press Release]. Central People’s Government of China.（中华人民共和国中央人民政府）. https://www.gov.cn/zhengce/zhengceku/2021-07/13/5624610/files/cd32c1bd1ca2493eb23ae188313b013d.pdf

64 Research Office, Legislative Council Secretariat. (2023). Development of Web 3.0 technologies in selected places. https://app7.legco.gov.hk/rpdb/en/uploads/2023/IN/IN10_2023_20230614_en.pdf

65 Innovation, Technology and Industry Bureau. (2022). Hong Kong, China Innovation and Technology Development Blueprint. https://www.itib.gov.hk/en/publications/I&T%20Blueprint%20Book_EN_single_Digital.pdf

66 Office of the Communications Authority. (2023). List of Wireless Internet of Things licensees https://www.coms-auth.hk/en/licensing/telecommunications/wiot/list_of_licensees/index.html

67 Hong Kong, China Productivity Council. (n.d.). IIOT. https://www.hkpc.org/en/our-services/iiot

68 Office of the Privacy Commissioner for Personal Data, Hong Kong, China. (2021). Guidance on the Ethical Development and Use of Artificial Intelligence. https://www.pcpd.org.hk/english/resources_centre/publications/files/guidance_ethical_e.pdf

69 Integrated Innovation Strategy Promotion Council. (2022). AI Strategy 2022. https://www8.cao.go.jp/cstp/ai/aistratagy2022en_ov.pdf

70 Integrated Innovation Strategy Promotion Council. (2023). Strategy of Quantum Future Industry Development. https://www8.cao.go.jp/cstp/ryoshigijutsu/230414_mirai.pdf, https://www8.cao.go.jp/cstp/english/strategy_r08.pdf

71 Integrated Innovation Strategy Promotion Council. (2022). Vision of Quantum Future Society. https://www8.cao.go.jp/cstp/ryoshigijutsu/ryoshimirai_220422.pdf, https://www8.cao.go.jp/cstp/english/outline_vision.pdf

72 Integrated Innovation Strategy Promotion Council. (2020). Quantum Technology and Innovation Strategy. https://www8.cao.go.jp/cstp/tougosenryaku/ryoushisenryaku.pdf, https://www8.cao.go.jp/cstp/english/outline_quantum.pdf

73 Institute of Information and Communications Technology. (n.d.). Beyond 5G R&D Promotion Project. https://b5g-rd.nict.go.jp/en/B5G_pamphlet_en_202204.pdf

74 Ministry of Science and ICT. (n.d.). The Digital New Deal Is to Lead Digital Transition in the World after Covid-19. [Press Release].

https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=443&searchOpt=&searchTxt=

75 The Government of the Republic of Korea. (n.d.). National Strategy for Artificial Intelligence. https://wp.oecd.ai/app/uploads/2021/12/Korea_National_Strategy_for_Artificial_Intelligence_2019.pdf

76 Ministry of Science and ICT. (n.d.). MSIT Launches the K-Network 2030 Strategy. [Press Release]. https://www.msit.go.kr/bbs/view.do?sCode=eng&mId=4&mPid=2&bbsSeqNo=42&nttSeqNo=783

77 Ministry of Science and ICT. (n.d.). 6G, Republic of Korea takes the lead once again – 6G R&D implementation plan established. [Press Release]. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=18&bbsSeqNo=42&nttSeqNo=517&searchOpt=ALL&searchTxt=

78 Ministry of Science and ICT. (27 June 2023). In 2035, Republic of Korea becomes the Global Hub for Quantum Economy. [Press Release]. https://www.korea.net/Government/Briefing-Room/Press-Releases/view?articleId=6930&insttCode=A110439&type=O

79 Ministry of Science and ICT. (19 November 2022). MSIT to announce the pan-government strategy on metaverse. [Press Release]. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=621&searchOpt=ALL&searchTxt=

80 Ministry of Science and ICT. (28 February 2022). MSIT supports the creation of a metaverse ecosystem. [Press Release]. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=657&searchOpt=ALL&searchTxt=

81 Malaysia Applied Research and Development Centre. (2014). National Internet of Things (IoT) Strategic Roadmap. http://www.mimos.my/iot/National_IoT_Strategic_Roadmap_Book.pdf

82 Ministry of Science, Technology and Innovation. (n.d.). National Blockchain Roadmap 2021-2025. https://www.mosti.gov.my/wp-content/uploads/2022/08/National-Blockchain-Roadmap-2021-2025.pdf

83 Ministry of Science, Technology and Innovation. (n.d.). Malaysia National Artificial Intelligence Roadmap 2021-2025. https://airmap.my/

84 Ministry of Science, Technology and Innovation. (n.d.). National Robotics Roadmap 2021-2030. https://www.mosti.gov.my/en/dasar/#flipbook-df_65254/1/

85 New Zealand Government. (2021). Government Data Strategy and Roadmap 2021. https://www.data.govt.nz/assets/Uploads/4e-government-data-strategy-and-roadmap.pdf

86 AI Forum NZ. (May 2018). Artificial Intelligence – Shaping a Future New Zealand. Ministry of Business, Innovation & Employment. https://www.mbie.govt.nz/dmsdocument/5754-artificial-intelligence-shaping-a-future-new-zealand-pdf

87 Ministry of Business, Innovation and Employment. (24 July 2023). Minute of Decision – Additional Item: Artificial Intelligence (AI) Update. https://www.mbie.govt.nz/dmsdocument/27416-additional-item-artificial-intelligence-update-minute-of-decision-proactiverelease-pdf

88 Ministry of Business, Innovation and Employment. (n.d.). Digital Technologies Industry Transformation Plan – Future Focus Areas https://www.mbie.govt.nz/business-and-employment/economic-development/industry-policy/industry-transformation-plans/digital-technologies/digital-technologies-industry-transformation-plan/future-focus-areas/

89 New Zealand Government. (2022). 2022-23 Action Plan for the Digital Strategy for Aotearoa. https://www.digital.govt.nz/dmsdocument/238~202223-action-plan-for-the-digital-strategy-for-aotearoa/html

90 Ministry of Business, Innovation and Employment. (16 December 2022). PlantTech Research Institute. https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/regional-research-institutes/planttech/

91 Ministry of Business, Innovation and Employment. (19 August 2022). NZD 5.1 million (USD 3 million) for research into artificial intelligence to improve health outcomes. https://www.mbie.govt.nz/about/news/5-1-mil-for-research-into-artificial-intelligence-to-improve-health-outcomes/

92 Ministry of Business, Innovation and Employment. (Deceber 2022,). Lifting Connectivity in Aotearoa New Zealand. https://www.mbie.govt.nz/assets/lifting-connectivity-in-aotearoa-new-zealand-december-22.pdf

93 The Russian Federation.(28 October 2019). Decree of the President of the Russian Federation on the Development of Artificial Intelligence in the Russian Federation – Translated Version. Center for Security and Emerging Technology. https://cset.georgetown.edu/wp-content/uploads/Decree-of-the-President-of-the-Russian-Federation-on-the-Development-of-Artificial-Intelligence-in-the-Russian-Federation-.pdf

94 The Russian Federation.(14 July 2021). Decree of the President of the Russian Federation on the Strategic development of Additive Technologies in the Russian Federation for the period up to 2030. http://static.government.ru/media/files/ogvdrJAzZEx7roHJAZwVEGZw6yTxBaJu.pdf

95 The Russian Federation. (2019). Roadmap for the Development of End-to-End Digital Technology – Quantum Technologies. Ministry of Digital Development, Communications and Mass Media of the Russian Federation. https://digital.gov.ru/uploaded/files/07102019kvantyi.pdf

96 The Russian Federation. (2019). Roadmap for the Development of End-to-End Digital Technology – Robotics. Ministry of Digital Development, Communications and Mass Media of the Russian Federation. https://digital.gov.ru/uploaded/files/07102019robototehnika-i-sensorika.pdf

97 The Russian Federation. (2019). Roadmap for the Development of End-to-End Digital Technology – Virtual and Augmented Reality. Ministry of Digital Development, Communications and Mass Media of the Russian Federation. https://digital.gov.ru/uploaded/files/07102019vrar.pdf

98 Smart Nation Singapore. (November 2019). AI Strategy. https://www.smartnation.gov.sg/media-hub/publications/national-ai-strategy/

99 Beowulf. (2023). Home - AI Singapore. AI Singapore. https://aisingapore.org/

100 IMDA. (n.d.). Internet of Things. https://www.imda.gov.sg/about-imda/research-and-statistics/sgdigital/tech-pillars/internet-of-things

101IMDA. (n.d.). Internet of Things (IoT) – Available standards. https://www.imda.gov.sg/regulations-and-licensing-listing/ict-standards-and-quality-of-service/it-standards-and-frameworks/internet-of-things

102 Robotics Program. (n.d.). Who we are. https://www.nrp.gov.sg/who-we-are/

103 Robotics Program. (n.d.). Overview. https://www.nrp.gov.sg/research/.

104 Ministry of Finance. (n.d.). Budget 2016. https://www.mof.gov.sg/docs/default-source/default-document-library/singapore-budget/budget-archives/2016/fy2016_budget_statement.pdf?sfvrsn=5d80a545_2

105 Science and Technology Council. (May 2023). Artificial Intelligence Research and Development Strategic Plan 2023 Update https://www.whitehouse.gov/wp-content/uploads/2023/05/National-Artificial-Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf

106 The White House (2023). FACT SHEET: Biden-Harris Administration Announces New Actions to Promote Responsible AI Innovation that Protects Americans' Rights and Safety. https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/04/fact-sheet-biden-harris-administration-announces-new-actions-to-promote-responsible-ai-innovation-that-protects-americans-rights-and-safety/

107 The White House. (n.d.). Artificial intelligence for the American people. (n.d.). https://trumpwhitehouse.archives.gov/ai/executive-order-ai/

108 The White House. (11 February 2020). President Trump's FY 2021 Budget Commits to Double Investments in Key Industries of the Future – The White House. https://trumpwhitehouse.archives.gov/briefings-statements/president-trumps-fy-2021-budget-commits-double-investments-key-industries-future/

109 Congress. (26 June 018,). National Quantum Initiative Act. https://www.congress.gov/bill/115th-congress/house-bill/6227

110 Wong, T. (2022). Quantum in the CHIPS and Science Act of 2022. Quantum Initiative. https://www.quantum.gov/quantum-in-the-chips-and-science-act-of-2022/

111 Quantum Coordination Office. (15 May 2023). About the National Quantum Initiative – National Quantum Initiative. National Quantum Initiative. https://www.quantum.gov/about/

112 Science and Technology Council. (September 2018,). National Strategic Overview for Quantum Information. https://www.quantum.gov/wp-content/uploads/2020/10/2018_NSTC_National_Strategic_Overview_QIS.pdf

113 Quantum Coordination Office. (6 January 2023). National Quantum Strategy - National Quantum Initiative. National Quantum Initiative. https://www.quantum.gov/strategy/

114 Science and Technology Council. (October 2022). National Strategy for Advanced Manufacturing https://www.whitehouse.gov/wp-content/uploads/2022/10/National-Strategy-for-Advanced-Manufacturing-10072022.pdf

115 Science and Technology Council. (May 022,). Future Advanced Computing Ecosystem Strategic Plan FY2022 Implementation Roadmap. https://www.nitrd.gov/pubs/FACE-SP-FY22-Implementation-Roadmap.pdf

116 GSMA. (n.d.). How China Mobile Is Harnessing IoT Big Data Solutions to Create Value in Strawberry Production. https://www.gsma.com/iot/wp-content/uploads/2019/09/China-Mobile-Case-Study-BC-1.pdf

117 Relief Web. (19 November 2019). Information and Communication Technology for Disaster Risk Management in Japan : How Digital Solutions are Leveraged to Increase Resilience through Improving Early Warnings and Disaster Information Sharing - Japan. https://reliefweb.int/report/japan/information-and-communication-technology-disaster-risk-management-japan-how-digital

118 The Government of Republic of Korea. (15 April 2020). How the Republic of Korea responded to a pandemic using ICT Flattening the curve on COVID-19. https://english.seoul.go.kr/covid/wp-content/uploads/2020/04/2_Flattening-the-curve-on-COVID-19.pdf

119 Smart Nation Singapore. (n.d.). Smart Nation Singapore. https://www.smartnation.gov.sg/

120 3-D printed parts and new materials help Rolls-Royce to engine test success | Rolls-Royce. (11 October 2018). 3-D Printed Parts and New Materials Help Rolls-Royce to Engine Test Success | Rolls-Royce. https://www.rolls-royce.com/media/press-releases/2018/11-10-2018-3-d-printed-parts-and-new-materials-help-rolls-royce-to-engine-test-success.aspx

121 Goehrke, S. (19 February 2015). Rolls-Royce to Get Largest-Ever 3D Printed Component Off the Ground, Flight-Testing Engine Later This Year - 3DPrint.com | The Voice of 3D Printing / Additive Manufacturing. 3DPrint.com | the Voice of 3D Printing / Additive Manufacturing. https://3dprint.com/45820/rolls-royce-largest-3d-printed/

122 Net Pracharat Initiative. (n.d.). https://npcr.netpracharat.com/Netpracharat_EN/one-page/

123 Asian and Pacific Training Centre for Information and Communication Technology for Development. (n.d.). An Overview of ICTs and Sustainable Development. United Nations Economic and Social Commission for Asia and the Pacific. https://repository.unescap.org/bitstream/handle/20.500.12870/4607/ESCAP-2020-MN-overview-ICTs-sustainable-development.pdf?sequence=1&isAllowed=y

124 Net Pracharat Initiative. (n.d.). https://npcr.netpracharat.com/Netpracharat_EN/Default.aspx

125 Reed, J. (2 August 202). How Transportation Departments Are Using Advanced Drone Technology for Infrastructure Inspections - Avionics International. Avionics International. https://www.aviationtoday.com/2022/08/02/transportation-departments-using-advanced-drone-technology-infrastructure-inspections/

126 Rogers, K. (10 June 2022). When we'll be able to 3D-print organs and who will be able to afford them | CNN. CNN. https://www.cnn.com/2022/06/10/health/3d-printed-organs-bioprinting-life-itself-wellness-scn/index.html

127 GSMA. (n.d.). 2022 Mobile Industry Impact Report: Sustainable Development Goals. https://www.gsma.com/betterfuture/wp-content/uploads/2022/11/2022-SDG-Impact-Report.pdf

128 AT&T. (16 September 2021). Expanding Efforts to Bridge the Digital Divide for Underserved Students and Families Across the Economy. https://about.att.com/story/2021/att_connected_learning_center.html

129 GSMA. (2015). Accelerating Digital Literacy: Empowering women to use the mobile internet. (2015). https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/06/DigitalLiteracy_v6_WEB_Singles.pdf

130 Camba, M. (2013). Telecentre Women: Digital Literacy Campaign. Global Gender. http://www.globalgender.org/en-global/news/detail/11

131 Market capitalization of Technology equipment companies are from Thomson Reuters

132 S&P Capital IQ, Gartner

133 Disk Manufacturer. Discovering the Impact of Singapore's Semiconductor Industry. https://www.diskmfr.com/singapores-surprising-role-in-the-semiconductor-industry/

134 Cayas, A, Grepo, A. & Lachica, D. The Philippines: Your Ally in the Global Chip Race. https://semi.org/sites/semi.org/files/2021-10/The-Philippines-Your-Ally-in-the-Global-Chip-Race.pdf

135 Potkin, F. & Ngui, Y. Chinese firms look to Malaysia for assembly of high-end chips, sources say. https://www.reuters.com/technology/chinese-firms-look-malaysia-assembly-high-end-chips-sources-say-2023-12-17/

136 Semiconductor Industry Association. (2022). 2022 Factbook. https://www.semiconductors.org/wp-content/uploads/2022/05/SIA-2022-Factbook_May-2022.pdf

137 Semiconductor Industry Association (2022). 2022 State of the U.S. Semiconductor Industry. https://www.semiconductors.org/wp-content/uploads/2022/11/SIA_State-of-Industry-Report_Nov-2022.pdf

138 IDN Financials. (20 June 2022). German semiconductor industry ready to invest in Indonesia. https://www.idnfinancials.com/news/43413/german-semiconductor-industry-ready-invest-Indonesia

139 Nilsson, P. (3 August 2023). Infineon spends extra €5bn on Malaysia plant in bet on electric vehicles. Financial Times. https://www.ft.com/content/e987dd0f-6076-4c0e-9650-a59bf2d9a254

140 The Sun Daily. (n.d.). Malaysia to strengthen semiconductor ecosystem, eyes 15% market share by 2030. https://www.thesundaily.my/local/malaysia-to-strengthen-semiconductor-ecosystem-eyes-15-market-share-by-2030-BB11011606

141 Galvez, D. (4 May 2023). Global semiconductor firm to invest US 200 m in PH expansion plans. Global News. https://globalnation.inquirer.net/214433/global-semiconductor-firm-to-invest-200-million-in-ph-for-expansion-plans

142 Writer, S. (26 February 2023). Chip industry doubles down on Singapore as production hub. Nikkei Asia. https://asia.nikkei.com/Business/Tech/Semiconductors/Chip-industry-doubles-down-on-Singapore-as-production-hub

143Writer, S. (6 August 2022). Samsung to begin making semiconductor parts in Viet Nam in 2023. Nikkei Asia. https://asia.nikkei.com/Business/Tech/Semiconductors/Samsung-to-begin-making-semiconductor-parts-in-Vietnam-in-2023

144 Intel invests additional USD 475 million in Viet Nam. (n.d.). Intel. https://www.intel.com/content/www/us/en/newsroom/news/invests-additional-475-million-vietnam.html#gs.5l98g5ocal/malaysia-to-strengthen-semiconductor-ecosystem-eyes-15-market-share-by-2030-BB11011606

145 Shilov, A. (11 September 2023). HP to Relocate PC Assembly to Thailand, Mexico, and Viet Nam: Report. Tom's Hardware. https://www.tomshardware.com/news/hp-relocating-pc-assembly

146 UNCTAD. (2010). Non-tariff Measures: Evidence from Selected Developing Economies and Future Research Agenda (United Nations publication, New York and Geneva), p. 99. https://unctad.org/system/files/official-document/ditctab20093_en.pdf

147 UNCTAD. (2019). Asia-Pacific Trade and Investment Report 2019. https://unctad.org/publication/asia-pacific-trade-and-investment-report-2019

148 Rosenberg, J. (2017). Existing Challenges and Opportunities: Non-Tariff Barriers to Trade in Information Technology Products. WTO. https://www.wto.org/english/tratop_e/inftec_e/ita20th_e/19_rosenberg_joshua.pdf

149 WTO. (2018). WTO World Trade Report 2018. https://www.wto.org/english/res_e/publications_e/world_trade_report18_e.pdf

150 MRA for telecommunications conformity assessment is an initiative by IMDA that reduces technical barriers to trade in telecommunications equipment by allowing such equipment to be tested in the exporting country and assured acceptance in the importing country with minimal further regulatory action

151 : International Trade Centre and United Nations Economic and Social Commission for Asia and the Pacific (2023). Making Regional Integration Work: Company Perspectives on Non-Tariff Measures in Asia Pacific. ITC. Geneva. https://repository.unescap.org/bitstream/handle/20.500.12870/2851/ESCAP-2023-RP-Making-regional-integration-work.pdf?sequence=9&isAllowed=y

152 ITI. (2022). ICT Product Safety Regulations and Their Impact on the Ease of Doing Business https://www.itic.org/documents/product-regulatory/EODB2022ReportFV.pdf

153 EUR-LEX - 01998A0817(01)-20130101 - EN - EUR-LEX. (n.d.). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:01998A0817(01)-20130101

154 European Commission. (n.d.). EU-Republic of Korea Free Trade Agreement. https://trade.ec.europa.eu/access-to-markets/en/content/eu-south-korea-free-trade-agreement

155 MOFA.(2011). Agreement Between Japan and The United Mexican States For The Strengthening of the Economic Partnership https://www.mofa.go.jp/region/latin/mexico/agreement/agreement.pdf

156 World Trade Organization. (n.d.). Technical Barriers to Trade (TBT). https://www.wto.org/english/tratop_e/dtt_e/dtt-tbt_e.htm

157 APEC. (2021). Testing Time for APEC Economies: A Guide for Conformity Assessment Bodies to the APEC TEL Mutual Recognition Agreement. https://www.apec.org/docs/default-source/Publications/2001/12/Testing-Time-for-APEC-Economies-A-Guide-to-the-APEC-Telecommunications-and-Information-Working-Group/01_tel_mrm_testin_Oct06.pdf

158 APEC. (2023). Telecommunications and Information. https://www.apec.org/groups/som-steering-committee-on-economic-and-technical-cooperation/working-groups/telecommunications-and-information

159 ASEAN. (n.d.). ASEAN Trade in Goods Agreement. https://asean.org/asean2020/wp-content/uploads/2020/12/ASEAN-Trade-in-Goods-Agreement.pdf

160 International Trade Centre and United Nations Economic and Social Commission for Asia and the Pacific (2023). Making Regional Integration Work: Company Perspectives on Non-Tariff Measures in Asia Pacific. ITC. Geneva. https://repository.unescap.org/bitstream/handle/20.500.12870/2851/ESCAP-2023-RP-Making-regional-integration-work.pdf?sequence=9&isAllowed=y

161 Huawei. (n.d.). Huawei's Glocal Ecosystem: Helping carriers unlock the Golden era of IoT. https://carrier.huawei.com/en/trends-and-insights/iot/huawei-glocal-ecosystem

162 Michaelides, N. (2021). A new operating model for state and local government. Cisco Blogs. https://blogs.cisco.com/government/a-new-operating-model-for-state-and-local-government

163 Shilov, A. (12 September 2023). HP to Relocate PC Assembly to Thailand, Mexico, and Viet Nam : Report. Tom's Hardware. https://www.tomshardware.com/news/hp-relocating-pc-assembly