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MEASURING THE DIGITAL ECONOMY: LESSONS AND CHALLENGES FOR PERUVIAN POLICYMAKERS

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Executive Summary

Developing economies see digital technology to achieve prosperity and inclusivity. A 10% increase in broadband penetration boosts economic growth by 1.3%, particularly in developing nations. Digital technology drives productivity, especially in manufacturing and routine-intensive fields, contributing up to 86% of the labour productivity surge in the United States. Digital transformation has benefits and drawbacks. It can promote growth and innovation but may result in unemployment for unskilled workers. Policies should support the development of the digital economy with complementary measures such as regulations, training, and institutions. The digital economy is changing how sectors interact. To analyse policy, we need to elaborate on relationships not yet captured. The post-pandemic productivity and competitiveness can benefit from the digital economy.

The digital transformation can help emerging economies by improving financial inclusion, productivity, and transitioning to a formal economy. The pandemic sped up the shift to online services. Measuring the digital economy is difficult for these countries due to a lack of consensus on its definition and gathering data. Public organizations, such as central banks, require this information to analyse the digital economy's status and aid policy decisions for inclusivity. Measuring the digital economy is a challenge for central banks as errors can affect national benchmarks like GDP. Replacing physical goods with free digital platforms may lower estimated GDP. Measuring intangible investments, which are increasingly digital, and offshoring of cloud computing services negatively impact fixed capital investment.

Digital product improvements affect inflation measurements. Measuring quality adjustments of digital products is a challenge for national statistics offices and international organizations improving digital economy measures. The role of technology in daily life and business has become significant. The pandemic has increased the importance of the digital economy because of mobility restrictions and changes in consumer behaviour. These changes impact price stability, finance, and payment systems, requiring central banks to understand the digital sector's dynamics for implementing their mandates. The digital economy needs more evaluation. International organizations and national statistics offices are working together to define it. Developing economies prioritize digital transformation for economic growth and sustainability. Subsequently, this report aims to address the subject of how to measure a nation’s digital economy effectively, with the Peruvian economy being the main target of this study.

This report examined Canada, Australia, and the Philippines and ADB's research for Indonesia and Malaysia to assess two main methods of estimating the digital economy using national accounts. Supply and use tables yield simpler outcomes, while the input-output framework allows for tracing transmission channels due to its linkages with other sectors. This level of detail aids policymaking. Accurate data is vital for effective policymaking on legislative, fiscal, and monetary measures related to the digital economy's estimate. The study, done in partnership with Banco Central de Reserve del Peru with support from the Asian Development Bank, estimated Peru's digital economy. It found that the digital economy experienced growth in 2020 and 2021, increasing its share of Peru's gross domestic product from just over 5% to nearly 7%. Real growth rate also increased from 6% to almost 15%. These results emphasize the digital economy's significance as a central bank policy transmission channel and a crucial sector for economic progress.

Table of Contents

1. INTRODUCTION 1

2. REVIEW OF LITERATURE 3

2.1. DEFINING THE DIGITAL ECONOMY 4

2.2. MEASURING THE DIGITAL ECONOMY 5

3. METHODOLOGY 9

4. SELECTED COUNTRY EXPERIENCES: CASE STUDIES ON MEASURING THE DIGITAL ECONOMY 10

4.1. LESSONS 12

4.2. CHALLENGES 13

5. THE DIGITAL ECONOMY OF PERU: AN APPLICATION OF THE INPUT-OUTPUT MODEL 14

5.1. ESTIMATING THE DIGITAL ECONOMY OF PERU 18

6. CONCLUSION 21

REFERENCES 22

APPENDIX A. CASE STUDIES ON DIGITAL ECONOMY ESTIMATION FOR SELECTED COUNTRIES 25

A. SUPPLY AND USE TABLE-BASED ESTIMATION 30

B. INPUT-OUTPUT TABLE-BASED ESTIMATION 32

APPENDIX B. FIGURES 37

APPENDIX C. TABLES 39

APPENDIX D. MANUAL FOR MEASURING PERU'S DIGITAL ECONOMY USING THE STEPS IMPLEMENTED BY THE ADB DIGITAL ECONOMY TEAM 41

1. Introduction

Evidenced by the numerous national roadmaps and blueprints for digital transformation, we see that many developing economies have reached the conclusion that leveraging on digital technologies, or the Fourth Industrial Revolution, would allow them to leapfrog to a more prosperous, and more inclusive status.

Empirical evidence from analysis using data for 120 countries shows that a 10-percentage point increase in broadband penetration results in a 1.3 percentage point increase in economic growth. This result is significant and stronger for developing economies compared to advanced economies. (World Bank 2009) Meanwhile, Gal et al. (2019) confirm that adoption of digital technologies and improvement in productivity are associated, and the relationship is stronger for manufacturing and sectors that are characterised by processes that are routine-intensive. Finally, van Ark, de Vries, and Erumban (2019) find that industries that adopted digital technologies heavily experienced labour productivity growth. In the United States, digital technologies account for as much as 86 percent of the growth in labour productivity.

Nonetheless, World Bank (2020) warns that digital transformation is a double-edged sword. While it can bring inclusive growth, efficiency, and innovation, it can also widen inequality when ill-equipped workers and unskilled labour are made redundant. Thus, it is imperative that the growth of the digital economy be accompanied by policies that promote "analogue complements" such as regulations, skills training, and strong institutions. (p.14)

Economies experienced swift speed of digital innovation and progress in digital technologies in recent history. As these innovations got adopted by consumers, producers and even governments, they altered how these sectors interact with each other. Such change requires that these yet uncaptured (see Watanabe et al. 2018) or yet invisible relationships be elaborated to aid policy analysis. Meanwhile, post-pandemic "a transformative solution is needed to increase the economy's productivity and competitiveness. That transformative growth solution lies in harnessing the potential of the digital economy." (World Bank 2020, p.13)

For emerging economies, these changes offer the prospect of fostering financial inclusion, access to services, productivity, and formal economy transition. The COVID-19 pandemic reinforced this digital transformation, forcing many services to go online. Yet, despite its increasing importance, measuring the digital economy remains a challenge. On one hand, there is no clear consensus regarding the scope of the "digital economy". Different definitions would have different implications in the extent of data gathering, assumptions used, and reliability of the resulting estimate. Gathering relevant data can be especially challenging for emerging economies.

Public organisations are interested in this information to analyse the state of the economy, both to promote digital inclusion and to facilitate policy decisions. Central banks are interested in measuring the digital economy for monetary, financial stability and payment policy considerations.

Challenges arising from the mismeasurement of the digital economy can be significant for central banks. The Bank of Canada points out that errors in the measurement of the digital economy may affect benchmark measures of national productive capacity and growth. For example, estimated GDP could be lower than actual because of substitution away from expensive physical goods to free digital platforms. At the same time, fixed capital investment is negatively impacted by growing offshoring of cloud computing services and difficulties in measuring intangible investments (which are increasingly digital).

Measures of inflation are affected by improvements in quality and features of digital products. How to capture the quality adjustments of digital products is another challenge that national statistics offices and international organisations working on improving digital economy measures must tackle.

The main contribution of this research project is answering the following fundamental questions through the point of view of central banks:

- What are the current good practices to measure the digital economy?
- How might these be applied to the case of Peru?

We find these questions relevant given the proliferation of the use of technology not just in the daily lives of ordinary citizens but in businesses. During the pandemic, limitations on mobility and physical interactions highlighted these integral roles of the digital economy. At the same time, changes in consumer behaviour, business processes, laws, and fiscal policies affect price stability, the financial system, and even the dynamics of the payment system (e.g., faster progress of financial digitalisation during the pandemic). A greater understanding of the dynamics of the digital sector has been cited by our survey respondent-central banks as important in the implementation of their mandates.

It is, therefore, through the foregoing lens that we base our prior belief that the digital economy requires more intensive assessment. Furthermore, it is evident that fiscal and legislative authorities are not blind to the need for a more accurate understanding of the digital economy. For instance, the World Bank, Organisation for Economic Cooperation and Development (OECD), International Monetary Fund (IMF), and the United Nations have been working with national statistics offices since at least the last couple of decades towards defining, estimating, and understanding the digital economy. Developing economies have also incorporated digital transformation as a crucial part of their economic development and sustainable development plans.

To assess the two main strands of estimation practices that rely on national accounts, we investigate the experiences of Canada, Australia, and the Philippines, as well as ADB (2021)'s findings for Indonesia and Malaysia. We find that although the results using the supply and use tables in estimating the digital economy are easier to communicate as they are more straightforward, the input-output framework is more flexible in allowing for tracing the transmission channels of the changes in the economy since it features the backward and forward linkages of the core digital sector to the other sectors of the economy. Such granularity is useful in policymaking. Policy decisions need to be guided by good quality data. Thus, a reliable measure of the digital economy is vital. Legislative, fiscal, and monetary measures gain effectiveness when based on a reliable estimate of the digital economy.

Finally, we present estimates of Peru's digital economy arrived at by the ADB's Digital Economy Team based on the collaboration of the authors with the Banco Central de Reserve del Peru and the Asian Development Bank teams. The results indicate resilience of the digital economy of Peru through 2020 and 2021, both in terms of growth rates and share to total economy. From a share of just above 5 percent in 2017, Peru's digital economy grew to almost 7 percent of Peru's overall gross domestic product, while its real growth rate increased from 6 percent to almost 15 percent during the same period. These findings resonate with our prior belief of the important role of the digital economy both as transmission channels of central bank policies and as a vital sector for economic growth.

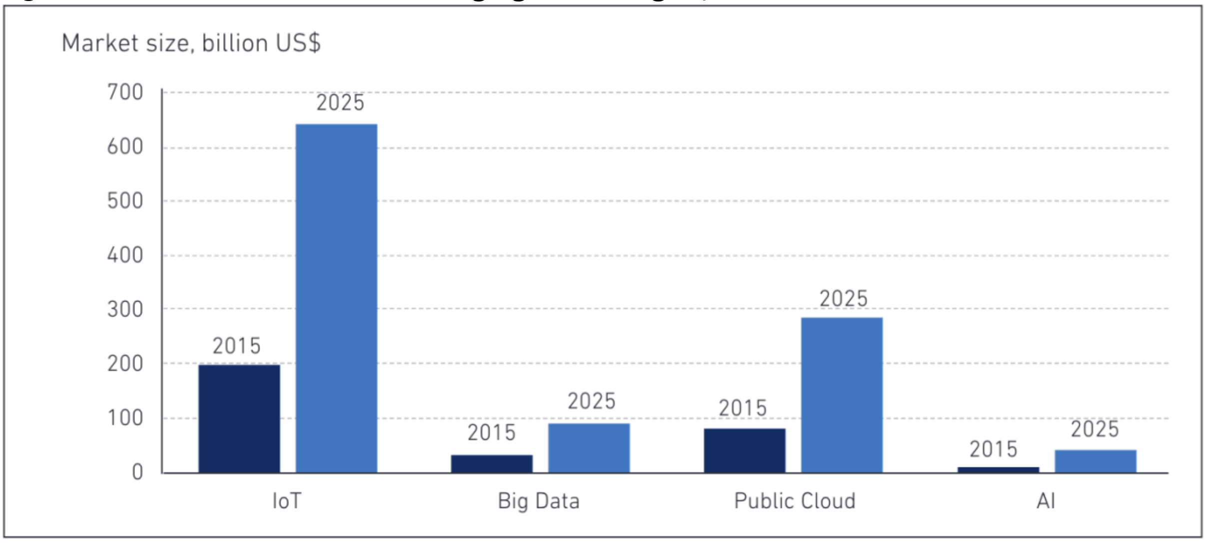
2. Review of Literature

In OECD (2022), ten action plans are laid out towards the measurement of the digital economy as follows:

- Action 01: Make the digital economy visible in economic statistics.
- Action 02: Understand the economic impacts of digital transformation.
- Action 03: Encourage measurement of the digital transformation's impacts on social goals and people's well-being.
- Action 04: Design new and interdisciplinary approaches to data collection.
- Action 05: Monitor technologies underpinning the digital transformation, notably the Internet of Things, AI and Blockchain.
- Action 06: Improve the measurement of data and data flows.
- Action 07: Define and measure skills needs for the digital transformation.
- Action 08: Measure trust in online environments.
- Action 09: Establish an impact assessment framework for digital governments; and
- Action 10: Expand the collection and accessibility of gender statistics.

These action plans are important in understanding better the digital economy and its effects given the significant growth of the digital sector. The internet of things, cloud computing, big data analytics, and artificial intelligence (AI) have been identified as the four revolutionary technologies that will propel the digital transformation. Their market sizes are all forecasted to grow significantly from 2015 to 2025." (Figure 1) Chen et al. (2022) describes the range of digital transformation in society as the "transition from a classic organisation that relies on real-world resources to a digital organisation that relies on information and virtual resources". This transformation can take the form of "(i) changing organizational processes and culture […]; (ii) enabling and optimising the use of information and communication technology (ICT) to improve public service […]; and (iii) new value-added creation." Harnessing the dividends of digital technology is crucial to reaching the Sustainable Development Goals. (p.2)

Figure 1. Global market size of emerging technologies, 2015 versus 2025 estimates



AI = artificial intelligence, IoT = internet of things.

Source: Figure 1.1 in Chen et al. (2022, p.2) citing Bauer (2017).

2.1. Defining the digital economy

The literature on measuring the size of the digital economy is still at its nascent phase. There is still no set definition for a digital economy. The lack of a commonly agreed illustration of the "digital economy" or "digital sector" and the dearth of industry and product classification for internet platforms and associated services pose as challenges to its measurement.

The International Monetary Fund (2018) defines the digital economy as all activities that use digitized data are part of the digital economy. This implies focus on a digital sector comprising the producers at the core of digitalization: online platforms, platform-enabled services, and suppliers of ICT goods and services.

Bukht and Heeks (2017) focus on conceptualising the notion of a digital economy with an overview of different definitions and elaborating in depth on the various facets of the digital economy. However, they use the idea of a "digitalised" economy instead of the conventional digital economy. This arises from the differentiation between "digitisation": conversion of data from analogue to digital form; and "digitalisation": application of digitisation to organisational and social processes (including economic activity) (Brennen and Kreiss 2014). This broad-scope definition covers e-business (ICT-enabled business transactions) and its sub-set, e-commerce (ICT-enabled external business transactions), algorithmic decision-making in business, use of digitally automated technologies in manufacturing and agriculture including Industry 4.0 and precision agriculture, among others.

Similarly, the Bureau of Economic Analysis (BEA) defines the digital economy primarily in terms of the Internet and related information and communications technologies (ICT) (Barefoot et al. 2018). BEA's ICT sector served as a starting point for its explanation of the digital economy.

While not all ICT goods and services are fully in scope, the ICT sector and the digital economy largely overlap. BEA referenced the Organization for Economic Cooperation and Development's (OECD) digital economy measurement literature.

Barefoot et al. (2018) was recently updated by Highfill and Surfield (2022) as the U.S. BEA update its analysis of the digital economy to include four major types of goods and services: (1) digital-enabling infrastructure (i.e., hardware and software); (2) business-to-business and business-to-consumer e-commerce; (3) priced digital services (e.g., cloud services, telecommunications, internal and data services); and (4) federal nondefense digital services. Nevertheless, this definition still excludes digital intermediary services (e.g., ride-sharing platforms) in the digital economy measurement framework.

Still, the U.S. BEA's definition does not consider digital intermediary services (e.g., ride-sharing platforms) in measuring the digital economy (Highfill and Surfield 2022). Working on inclusion of such services, given their increasing role in consumption patterns would improve the estimates of the digital economy. Another item that needs further consideration is finding ways to reflect imports in the estimation of the digital economy. Meanwhile, not all national statistics offices release supply and use tables and input-output tables in real terms. If the data are in nominal terms, then this makes it difficult to compare the evolution of the size of the digital economy temporally since the price effects would be embedded in the estimation.

World Bank (2020) stresses that although international organisations do not have a common definition of the digital economy, they agree with respect to the crucial role the sector plays in stimulating growth, innovation, productivity, and social welfare. (p.13)

For this research, the authors will tackle the research question using the definition of Asian Development Bank (2021) of digital economy as the "the digital economy is ultimately defined as the contribution of any economic transaction involving both digital products and digital industries to GDP" (p.5). This definition is flexible enough to incorporate digital and digital business model innovation over time. It includes in the digital economy not only those core industries that directly contribute to value-added of digital industries and but also those nondigital industries that enable or support these core digital industries in their production.

2.2. Measuring the digital economy

Methodologies that are based on accounts used to generate country Gross Domestic Products (GDP) allow for the resulting estimates of share of digitalization in the economy to be more easily comparable across countries. Australian Bureau of Statistics (2021) emphasises that using accounts consistent with the System of National Accounts in measuring the digital economy facilitates greater participation in policy discussions and easier international comparability of digital activities. More importantly, with the use of these accounts—the Input-Output Tables (IOTs) and the Supply-Use Tables (SUTs)—policymakers can simulate the impacts of policies on digital-oriented policies or digital shocks.

Meanwhile, Quiggin (2014) posits that with the increasing importance of the digital economy, a rethink of the current methods of national accounting and measurement of value-added is also needed. Relevant work on how to use official statistics to capture the digital economy have already started at both the international and domestic levels.

The Supply-Use Tables (SUTs) classify goods and services as (a) either supplied through domestic production or via importation, and (b) used within the economy as final consumption, intermediate consumption, or investments or used by the rest of the world as the domestic economy's exports. The SUT is a powerful framework that "combines in a single framework the three approaches to measuring GDP, namely, the production approach, the income approach and the expenditure approach" (p.5). (Mahajan et al. 2018)

Mahajan et al. (2018) explain how SUTs can be transformed into IOTs using four ingredients, (a) supply table at basic prices; (b) use table at basic prices; (c) Domestic use table at basic prices; and (d) imports use table at basic prices. Thereafter, four transformation models are applied, each with their own underlying assumptions. These four transformation models can be classified into two categories depending on whether one is building a product-by-product IOT (uses technology assumptions) or an industry-by-industry IOT (based on sales structure assumptions). (See Figure B-1 for an overview of the transformation from SUTs to IOTs)

The Organisation for Economic Co-operation and Development (OECD) and the United States Bureau of Economic Analysis (BEA) both propose using the SUT framework in measuring the digital economy. (Asian Development Bank 2021) Economies like Canada, Australia, and the Philippines in our case studies have estimate their digital economies using their respective SUTs.

Table 1. Prototype for calculating the digital economy using supply and use tables.

	Industry A	Industry B	Total economy
		number	
Output			
Product A: fully digital product	5,000	10,000	15,000
Product B: partially digital product	3,000	0	3,000
Product B.1: digital portion	2,000	0	2,000
Product B.2: non-digital portion	1,000	0	1,000
Product C: all other products (non-digital)	12,500	2,000	14,500
Total output	**23,500**	**12,000**	**35,500**
Digital output (product A + product B.1)	7,000	10,000	17,000
Digital output ratio (digital output ÷ total output)	0.29	0.83	0.48
Total GDP	**12,750**	**8,000**	**20,750**
Digital economy GDP (total GDP × digital output ratio)	3,570	6,640	10,210
Total jobs	**1,000**	**2,500**	**3,500**
Digital economy jobs (total jobs × digital output ratio)	280	2,075	2,355

Note: Above are some hypothetical data that are used as examples to illustrate the method used for calculating digital output, GDP, and jobs using the supply and use tables.
Source: Statistics Canada.

Source: Table 1 in Statistics Canada (2019, p.8)

In essence, this method isolates the digital portion of products or industries. For example, in Table 1, Product B is only partially digital, thus, it is decomposed into B.1 (digital portion), and B.2 (non-digital portion). Then, to derive the digital output ratio, the digital portions are divided by total output. This ratio is then multiplied by the total GDP to arrive at the estimate of the digital economy.

For instance, New Zealand's estimates are based on categorising products from its SUT as digitally ordered, platform enabled, and digitally delivered. Millar and Grant (2019) find that among the three, those digitally delivered are the simplest to pinpoint "when attempting to estimate the digital economy from existing macroeconomic data in the national accounts. At an aggregate level, there are few indicators of digital businesses and transactions. [Nevertheless, comparing] the gross output of digitally delivered products with those that are digitally ordered leads us closer to a representation of the gross output directly attributable to the digital economy and the value indirectly attributable to the digital economy." (p.7)

New Zealand analyses its measurement between direct and indirect measures. Contributions of the digital economy that can be directly measured are those "activities only made possible through digital means…which cannot be produced though non-computerised mechanism" Examples of these are those products that are digitally delivered: packaged software; mobile telecommunications services; telecommunications services and online content; and licensing services for the right to use computer software and databases (Millar and Grant 2019, p.8). Millar and Grant (2019), however, point out that the direct contribution of those classified digitally ordered are probably significantly smaller relative to their indirect share in the digital economy.

Table 2. Composition of the core digital sector using industry codes from Central Product Classification (CPC) Version 2

Main Activity Group	Code	Product
Hardware	452	Computing machinery and parts and accessories thereof
	475	Disks, tapes, solid-state nonvolatile storage devices, and other media, not recorded
Software publishing	38582	Software cartridges for video game consoles
	478	Packaged software
	83143	Software originals
	8434	Software downloads
	84391	Online games
	84392	Online software
Web publishing	83633	Sale of internet advertising space (except on commission)
	843	Online content[a]
Telecommunications services	841	Telephony and other telecommunications services
	842	Internet telecommunications services
Specialized and support services	8313	IT consulting and support services
	83141	IT design and development services for applications
	83142	IT design and development services for networks and systems
	8315	Hosting and IT infrastructure provisioning services
	8316	IT infrastructure and network management services

IT = information technology.
[a] Excluding items under Central Product Classification Version 2, 843 already counted under Software Publishing – 8434, 84391, 84392.
Source: Methodology of the Digital Economy Measurement Framework study team, using United Nations' Central Product Classification: Version 2 (2008).

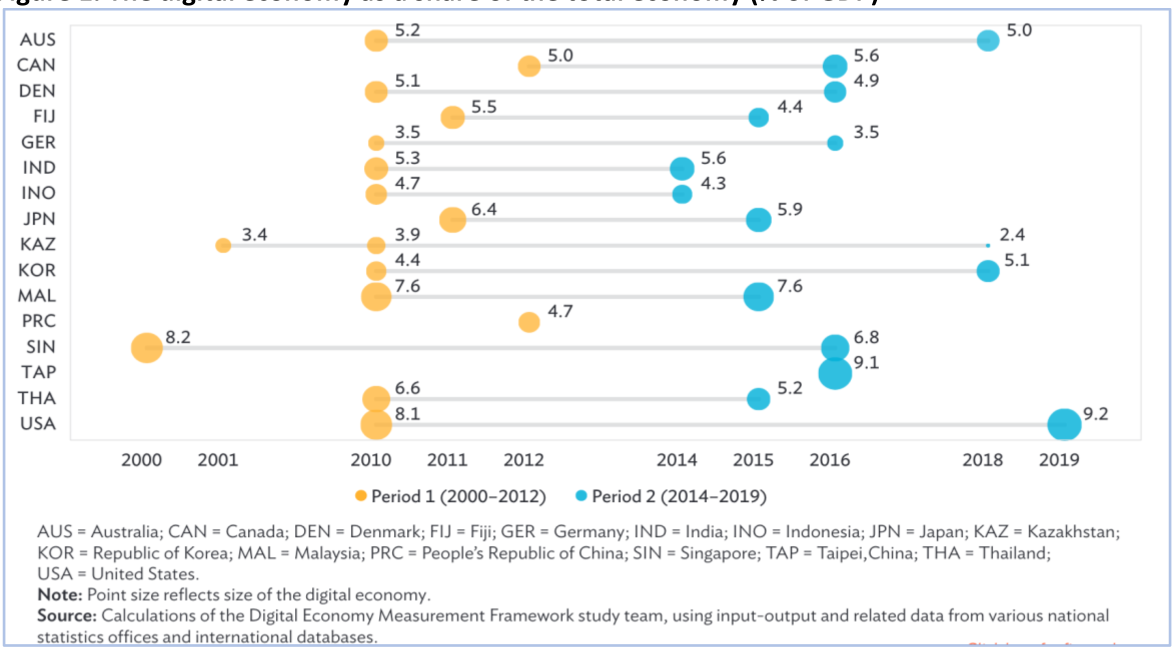
Source: Table 1 in Asian Development Bank (2021, p.6)

Meanwhile, in the case where the estimates are based on the input-output tables, the first step is identifying the sectors that comprise the core digital economy, and then trace these sectors linkages with the rest of the economy. ADB (2021) defines the core digital sector as the industries that produce digital products, i.e., "goods and services with the main function of generating, processing, and/or storing digitized data. The primary producers of such products (i.e., industries that supply these products more so than any other industry in the economy) are considered as the digital industries. The framework identifies core digital products that can be summarized into five main product groupings: (i) hardware, (ii) software publishing, (iii) web publishing, (iv) telecommunications services, and (v) specialized and support services." (p.5). Table 2 lists the products belonging to these main groupings with their corresponding industry codes from the United Nations Statistical Commission's Central Product Classification (CPC) Version 2.

Asian Development Bank (2021) categorises three primary actors in the digital economy value chain. The first are "digital enabling industries'' – industries serving as sources of value-added to digital sectors, providing components such as semiconductors that support core digital products. The second are digital sectors themselves, serving as the primary producers of core digital products – hardware, software and web publishing, telecommunications, specialized and support services (p. 5). The third are "digital enabled industries" – industries enabled by digital sectors, serving as destinations for the latter's value-added in products such as highly digitised cars. Examples include wholesale and retail, construction, financial intermediation, and electronic or optical equipment.

ADB's assessment yield estimates of the share of the digital economy's gross value added to GDP from 2% to 9% for the 16 economies in their sample (Figure 1). (Asian Development Bank 2021) Note that the ADB's estimate for Canada (5.6%) is quite close to the figure calculated by Statistics Canada for 2019 (5.5%).

Figure 1. The digital economy as a share of the total economy (% of GDP)



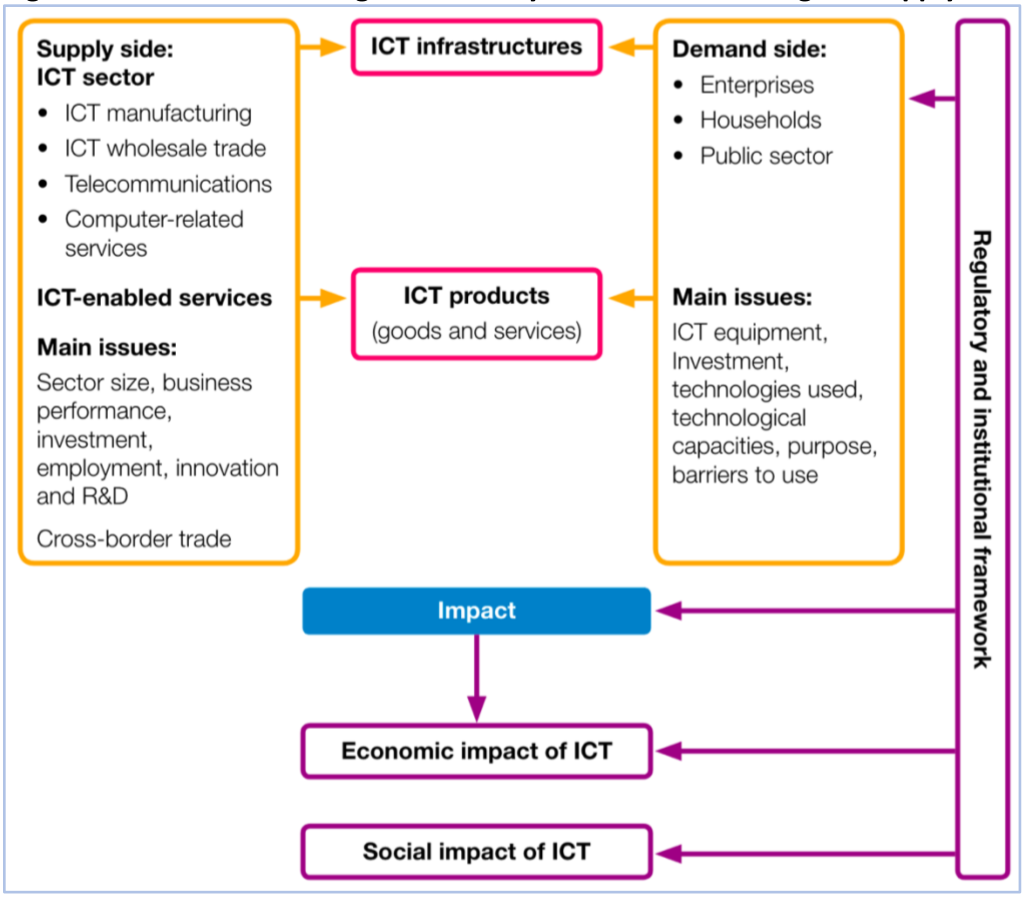
Source: Asian Development Bank 2021

From the foregoing and despite challenges in data coverage, we see the growth rates and shares to GDP of the digital economy have been significant. Accordingly, using either the SUT or the IOT is useful to monetary and fiscal authorities because these frameworks allow for tracing, in different degrees, the transmission channels of shocks to price, output, factor incomes, and employment; and, thus, intervene more appropriately. Technological changes and digitalization affect product quality, employment, prices, and profit margins, and policy interventions that do not consider the digital economy could turn out sub-optimal and derail not just recovery and growth but could also worsen inequality between and among the factors of production.

3. Methodology

We look at country experiences in estimating their digital economy as well as the methodology of the ADB in estimating the digital economy for selected developing economies. The first set of country cases (Canada, Australia, and the Philippines) show official estimates of the digital economy following the OECD/US BEA methodological concept. Meanwhile, the second set of cases are developing economies Indonesia, and Malaysia that are included in ADB (2021). The estimates for Indonesia and Malaysia are primarily from ADB (2021), except for those gathered from World Bank reports, think tank research, and official government websites and documents. Finally, the ADB (2021) methodology is applied to Peru's 2017-2021 data and the results are presented.

Figure 2. Framework for digital economy measurement using the supply and use tables.

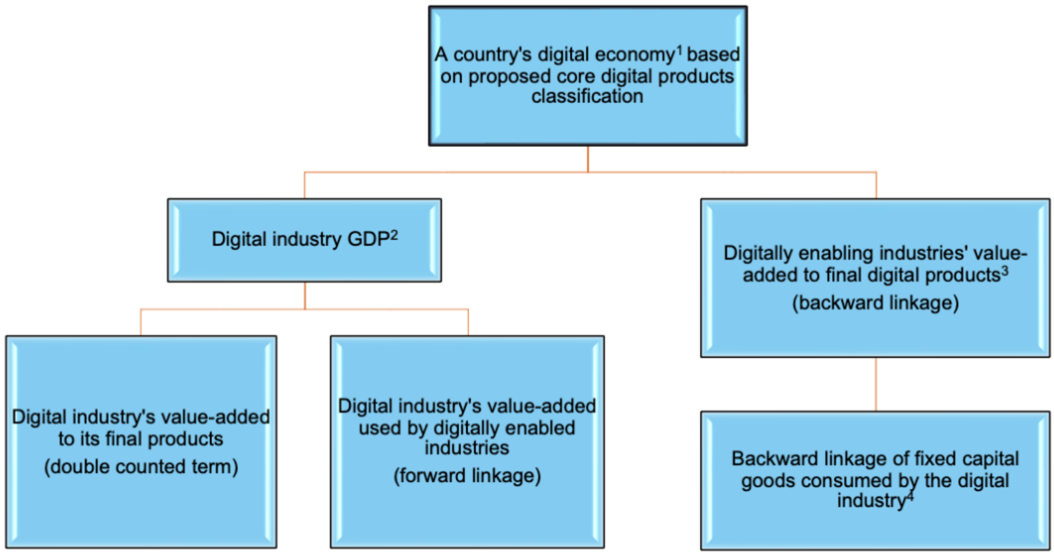


Source: Figure 2 in UNCTAD (2020, p.22)

UNCTAD (2020) presents the digital economy's principal "building blocks". In general, the digital economy can be captured by measuring the building blocks of supply and demand for ICT and ICT infrastructure. From the supply side, data on ICT manufacturing, ICT trade, telecommunications, and computer-related services are gathered. On the other hand, the measurement from the demand side is concerned about access by enterprises, households, and the government sector. (Figure 2)

Meanwhile, Figure 3 illustrates the measurement framework when the IOT is used. First, the core digital sector is defined. Then, the IOT model is used to account for the backward and forward linkages of the core digital sector to the non-digital sectors of the economy.

Figure 3. ADB's Digital Economy Measurement Framework



GDP = gross domestic product.
1 Given by the $GDP_{digital}$ equation, $\mathbf{i}^{T}\hat{\mathbf{V}}\mathbf{B}\hat{\mathbf{Y}}\boldsymbol{\varepsilon}_1 + \mathbf{i}^{T}(\hat{\mathbf{V}}\mathbf{B}\hat{\mathbf{Y}})^{T}\boldsymbol{\varepsilon}_1 - [\mathrm{diag}(\hat{\mathbf{V}}\mathbf{B}\hat{\mathbf{Y}})]^{T}\boldsymbol{\varepsilon}_1 + (\mathbf{i} - \boldsymbol{\varepsilon}_1)^{T}\hat{\mathbf{V}}\mathbf{B}\hat{\mathbf{Y}}\hat{\mathbf{r}}\boldsymbol{\varepsilon}_2$.
2 Given by the second term of the $GDP_{digital}$ equation.
3 Given by the first term of the $GDP_{digital}$ equation.
4 Given by the fourth term of the $GDP_{digital}$ equation.
Source: Methodology of the Digital Economy Measurement Framework study team, using Leontief (1936) coefficients.

Source: Figure 2 in Asian Development Bank (2021)

In practice, the US BEA methodology decompose the digital economy into three: digitally enabling sectors, e-commerce, and digital contents. On the other hand, the ADB framework, which relies on national Input-Output Tables, estimates four blocks of the digital economy in addition and in relation to the core digital economy: forward linkages of the digital sector, backward linkages of the digital sector, the digital sectors consumption of its own output, and the digital sector's use of non-digital sector's output in its capital formation.

Finally, with the collaboration with the Digital Economy Team of the Asian Development Bank, in addition to the 2017-2021 model estimation files, the authors can turn over to the Banco Central de Reserva del Peru a model template that will allow them to extend the estimates presented in this report. Annex C accompanies the files to provide guidance on how to manipulate the model. For this purpose, expertise in input-output analysis and the systems of national account are not required, but some comfort and proficiency in working with Excel would be most useful.

4. Selected country experiences: Case studies on measuring the digital economy

There are five economies included in our case study: two are advanced economies, while three are emerging market economies. The digital economy estimates for Canada, Australia, and the Philippines are done by their respective national statistics office based on the US BEA framework while the estimates for Indonesia and Malaysia are from the Asian Development Bank (2021).

The calculation of the digital economies of Canada, Australia, Philippines, Indonesia, and Malaysia are based on the components in Table 3. The main difference between the two methodologies lies in the capacity of the IOT framework to be used for simulating the impacts of and transmission of shocks through the interlinkages of the sectors. Having said that, estimations that take off from the IOTs inherit the advantages and disadvantages of Leontief (1936)'s model. While Leontief matrices allow for policy simulations using matrix algebra (thus, it can easily be done in MS Excel), they also assume that production technology and consumption patterns remain constant until the next input-output tables are constructed.

Table 3. Summary of components of the digital economy

Components of the digital economy estimation	
Based on Supply-Use Tables Canada, Australia, Philippines	**Based on Input-Output Tables** Indonesia, Malaysia
E-commerce	***Core digital sector***
Data and advertising driven digital platforms	Hardware
E-Tailers	Software publishing
Digital only firms providing finance and insurance services	Web publishing
	Telecommunications
Other producers only operating digitally	Specialized and support services
Digital media/content	***Linkages to the core digital sector:***
Digital intermediary platforms charging a fee	*Digitally enabled or forward linkages (1st term)*
Dependent on intermediary platforms, Incorporated	*Digitally enabling sectors or backward linkages (2nd term)*
Dependent on intermediary platforms, Unincorporated	*Digital sector's inputs to its own final product (3rd term)*
Digital-enabling infrastructure	*Backward linkage of fixed capital goods (4th term)*
Hardware	
Software	
Telecommunications	
Other services	

Sources: Ghanem 2021; Australian Bureau of Statistics 2021, 2022; Asian Development Bank 2021, 2023; Philippine Statistics Authority 2023

The shares of the digital economy shown in Table 4 indicate stable proportions for the five economies. However, it is good to note that capacity and quality improvements of digital technology are not easily captured by their prices. Therefore, the capabilities of a host of gadgets costing $10 two to five years ago might be possible to be done by a gadget that cost only a fraction after a couple of years. Furthermore, economies in our sample have also grown during the sample period, thus, despite largely stable or even slightly declining shares, their digital economies have generally grown.

Table 4. Share of Digital Economy to GDP (in percent)

	Canada	Australia	Philippines	Indonesia	Malaysia
2010				7.6	4.7
2011					
2012		5.4			
2013		5.4			
2014		5.5			4.3
2015		5.6		7.6	
2016		5.8			
2017	5.2	5.7			
2018	5.4	5.6	10.1		
2019	5.5	5.6	10.0		
2020		5.9	9.7		
2021		6.1	9.6		
2022			9.4		

Sources: Ghanem 2021; Australian Bureau of Statistics 2021, 2022; Asian Development Bank 2021, 2023; Philippine Statistics Authority 2023

For the economies in our case study that use the SUT methodology to estimate their digital economies, the digital-enabling infrastructure sector is the biggest component, ranging from 68 percent (Australia in 2021) to 92 percent (Canada in 2017). As for Indonesia and Malaysia, the biggest share depends on whether the digital sector is a net demander or net supplier to the non-digital sectors. In the case of Indonesia, its backward linkages are greater than its forward linkages, while it is the opposite for Malaysia. For both economies, the use of the digital sector of fixed capital is the smallest component of the digital economy. (See Appendix A for more details)

4.1. Lessons

The landscape of statistical compilation and institutional mandates relevant to gathering data from private institutions and households are vital in getting data inputs that reflect economic realities. For instance, in the case of using surveys to gather data, laws and regulations that empower the survey implementors conduct the surveys and data privacy regulations that protect survey participants are important.

Secondly, compilation standards that allow for easier benchmarking and comparison among similarly situated economies would be helpful. At the same time, the setting and finetuning of such international statistical standards imply the need for consultation and collaboration. These venues allow data analysts, compilers, and policymakers to conduct dialogues thereby improving the information content of the statistics being gathered and compiled.

Finally, for the purpose of central banking, the facility for matrix analyses and economic theoretical foundation provided by Leontief (1936), learning to translate SUTs and to manipulate IOTs to assess the digital economy estimates would be quite useful. That is, if the national statistics offices release to the general public digital economy estimates framed within the SUT perspective, there are advantages for central bank policy analysts to reframe the matrices through the input-output table point of view.

In general, the periodic releases of GDP estimates are based on the supply and use tables, therefore, it is less “work” to estimate the digital economy this way. According to Australia’s ASB, using the SUT helps it gauge and communicate the resulting estimates through the National Accounts perspective. The ABS finds that presenting the analysis of the digital economy vis-à-vis GDP facilitates policy discussions. (Australian Bureau of Statistics 2021)

However, input-Output tables allow a more granular analysis of the impacts of shocks. For example, an empirical assessment of the transmission of the economic shocks brought on by the COVID pandemic on the Peruvian economy finds that the most affected sectors are those in trade and services which have significant links to other sectors. Input-output modelling allows for the estimation of not only the direct response to a shock but also of the indirect effects. (Carrera 2023) During times of competing needs and limits in resources, this kind of insight is remarkably useful to policymakers in deciding the kind, timing, and magnitude of interventions to deploy.

4.2. Challenges

With respect to the Canadian experience, Ghanem (2021) points out two main areas of challenges: (a) the need for a more nuanced “differentiation in the production functions of digital and non-digital units in industries outside the digitally enabling sector” (p.14); and (b) non-existent measures for both the market and non-market outputs of the public administration, education, and health sectors. The first one is problematic since assuming similar production functions for digital and non-digital units could lead to inability to capture differences in impacts of shocks and other changes, among other things. Ghanem (2021) stresses the importance of capturing the public administration, education, and health sectors since they are sectors that have been seen to be digitalizing significantly, and, most importantly, together these sectors represent a fifth of Canada’s economy. In other cases of data gaps, though, e-commerce surveys were used as a proxy for the share of digitally ordered products by industry.

In the case of Australia, the Australian Bureau of Statistics (2021) explains that their approach excludes activities like “peer-to-peer transactions and emerging digitalised products (such as Uber transport services, financial services, and “smart” household electronic goods). While the production of these digitalised products is embedded in the supply-use source data under existing product classifications, they are not separately identified, and it would be resource intensive to unembed. Also, digital trade is not visible from the production approach. Exports and imports through digital networks can be estimated with components of final demand” (p.4). The ABS acknowledges the limitation of its approach and concludes that such limited scope provides the “lower bound” of the digital economy of Australia. Such lower bound benchmark is still a useful anchor for policy simulations and deliberations.

In their assessment of the US BEA methodology, Chen et al. (2022) point out that the framework excludes in the measurement ‘partially digital’ items like peer-to-peer e-commerce. Moreover, an ideal measurement framework must be able to capture investments related to the digital economy, such as “physical infrastructure (e.g. information technology (IT) equipment including computers, telephone lines, switches, fibre optic cables, satellites, wireless networks, and local area network (LAN) equipment); investment in software infrastructure; other internet capacity in communication networks; actual traffic on information systems; and depreciation in infrastructure (IT equipment, software, or hardware)” (Chen et al. 2022, p.81).

Meanwhile, ADB (2021) finds four limitations of the IOT model in estimating the digital economy of a country. First, granular and up-to-date data are subject to the schedule of releases and publication by the national statistics offices. In addition, to make the data comparable across time or across countries, published data may require significant cleaning and processing since formats, structures, and statistical compilation methods vary or could be updated at subsequent releases.

Secondly, the definition of digital products—and hence the core digital sector—used is intentionally narrow to preclude the use of subjective decision-making on the part of the analyst. For instance, “the entire value of an online sale of a nondigital commodity is not considered. Instead, only the value contribution of the digital products (or the digital industries producing these) involved in such a transaction is captured. […] As the scope of digital products is at the narrowest level, it excludes the digitally dependent economy, which comprises the value-added of the sectors that are critically dependent on digital sectors. Nonetheless, the measurement framework is flexible to accommodate the calculation of this.” (p.29)

Thirdly, the estimates of the digital economy exclude imports and could undervalue the size of the digital economy if it is highly dependent on imported inputs (See for example, Table C-3). Thus, “economies that have high imports of digital products, as well as those with industries heavily reliant on core digital sectors, are likely to have small digital economy estimates relative to others” (p.29).

Finally and, perhaps, most importantly, the matrix of technical coefficients is fixed until a new input-output table is compiled. In the meantime, the changes in the production process and the effects of digital transformation are not captured in the analysis. This can be significant given the nature of digital products and digitalisation process.

5. The digital economy of Peru: An application of the input-output model

Over the past three decades, Peru has made significant strides in digital connectivity, digital literacy, digital rights, and digital government, as well as in its digital economy. In the 1990s, it was one of the pioneers in Latin America in connecting to the internet. Furthermore, Peru is one of the first in Latin America to issue digital financial transactions regulations, thus, providing enhanced e-commerce security. Subsequent policies and reforms over time helped boost mobile phone ownership and stimulated e-commerce, e-governance, and digital financial services. (Corbera et al. 2022)

The foundation of Peru's digital transformation consists of the 2005 Digital Strategy (La Agenda Digital Peruana), 2011 Digital Strategy, the National Plan for Competitiveness and Productivity 2019-2030 (Plan Nacional de Competitividad y Productividad 2019-2030), and the Law of Digital Government of 2018. Digital government development policies and initiative have historically been shared among different agencies in Peru but since 2018, the Digital Government Secretariat (SEGDI) has spearheaded initiatives on governance and digital transformation. (Corbera et al. 2022)

SEGDI was created in 2003 with the aim of supervising the development of electronic government policies. Since then, Peru has implemented numerous programmes targeted at employing technology to improve government services and functions. (Table 6) In 2018, the Digital Government Law (Legislative Decree N° 1410) was issued, mandating SEGDI to be the public leader on digital government.

Table 6. Digital technologies deployed/managed by the Digital Government Secretariat (SEGDI)

GOB.PE	In 2018, Supreme Decree 033-2018-PCM was enacted, creating the GOB.PE platform, a website that seeks to be the only digital point of contact between citizens and the Peruvian State. According to SEGDI, in GOB.PE users can find information on procedures and services; news, norms and publications of public entities; general information about the Peruvian State; and the institutional pages of the different entities of the Executive Branch. During the COVID-19 pandemic, GOB.PE was used as a reference point to provide real-time information on the number of infections nationwide, and the delivery of financial support aids. According to SEGDI, to date this site has had 1.8 billion visits.
ID PERU	The ID Peru Authentication Platform (ID Peru) is the authentication service created by the National Registry of Identification and Civil Status (RENIEC) so citizens have access to online public services, which to date can only be performed face-to-face. In order to use this platform, citizens are required to have the DNIe, an identification card with a chip that includes digital certificates.
FACILITA PERU	The Comprehensive Platform for Digital Applications of the Peruvian State (*Facilita Perú*) is a digital service developed by SEGDI as a support tool for public entities. *Facilita* will speed up the management of citizen requests for access to public procedures and services.
NATIONAL INTEROPERABILITY PLATFORM	This technological infrastructure allows the implementation of online public services by electronic means, and the electronic exchange of data between public entities through the internet, mobile telephone, and other technological means available. It was created on October 18, 2011, through Supreme Decree No. 083-2011-PCM and is currently used by more than 450 entities of the Executive Branch, regional, and local governments.
THE GOVERNMENT AND DIGITAL TRANSFORMATION LABORATORY	The Government and Digital Transformation Laboratory was created through Resolution No. 003-2019-PCM / SEGDI. It is a space for co-creation, enabling academia, civil society, the public and private sectors, where citizens can participate in the design, redesign, and digitization of public services and the digital transformation of the State.

Source: Table 4 in Corbera et al. (2022, p.40)

Since then, SEGDI has released "drafts of National Strategies on Artificial Intelligence, Digital Talent, Open Data, a Digital Agenda (2021), and several online services and informative websites" and markedly altered "the way of producing digital policy and the deployment of online services". (Corbera et al. 2022, p.39-40)
Using the elements in Sabbagh et al. (2012), Katz, Koutroumpis, and Callorda (2013) estimate digitalization indices for 184 countries, including Peru, from 2004-2011. The results, classify economies according to four phases of increasing digitalization: constrained, emerging, transitional, and advanced stage. Katz, Koutroumpis, and Callorda (2013) find that Peru is in the emerging phase. (See Table C-2.) It has fulfilled the affordability target but has a "significantly low" score in infrastructure reliability, human capital, network capacity, and usage making these elements primary targets. Meanwhile, network access was identified by the authors as a secondary development target for Peru.

More recently, Calderón (2021) finds that digital transformation in Peru is "still in the development stage". Citing 2017 data, Calderón (2021) cites that it is possible to initiate only 15 percent of government transactions online, while it is possible to initiate and complete only 5 percent of transactions with the government. Thus, there is significant room for digital transformation in government. (p.6)

OECD (2020a) illustrates the digital frontiers of Peru post-pandemic along seven dimensions: enhancing access, strengthening the effective use of digital technology, enabling digital innovation, ensuring quality jobs for all, promoting inclusive digital society, strengthening trust, and fostering market openness. From 2008 to 2017, indicators of digital access have shown marked improvements, albeit remaining below Latin America average numbers. It is the same with most of the indicators of effective use of digital technology. The share of research and development expenditures as a proportion of GDP has improved from 2011 to 2016 but remains lower at 0.12 percent versus 0.42 percent Latin America average. On the other hand, trust in online privacy and e-commerce safety indicators are higher in 2019 for Peru compared to Latin America and OECD averages even though the country's Global Security Index lags relative to its neighbors and the OECD. (See Table C-1.)

Meanwhile, the USAID's Digital Ecosystem Country Assessment (DECA) was conducted from July 2021 to February 2022 in Peru. The assessment considered (1) digital infrastructure and adoption; (2) digital society, rights, and governance; and (3) digital economy. (Corbera et al. 2022).

Corbera et al. (2022) find that in 2021, a significant portion of Peru's population lacks access to the internet. This situation is more prevalent in rural areas. "During the COVID-19 pandemic, virtualization of classes in basic education was impossible in many parts of the country, especially in the Andean and Amazon regions, not only due to connectivity issues, but also due to the lack of […] computers, [and] tablets" (p.9).

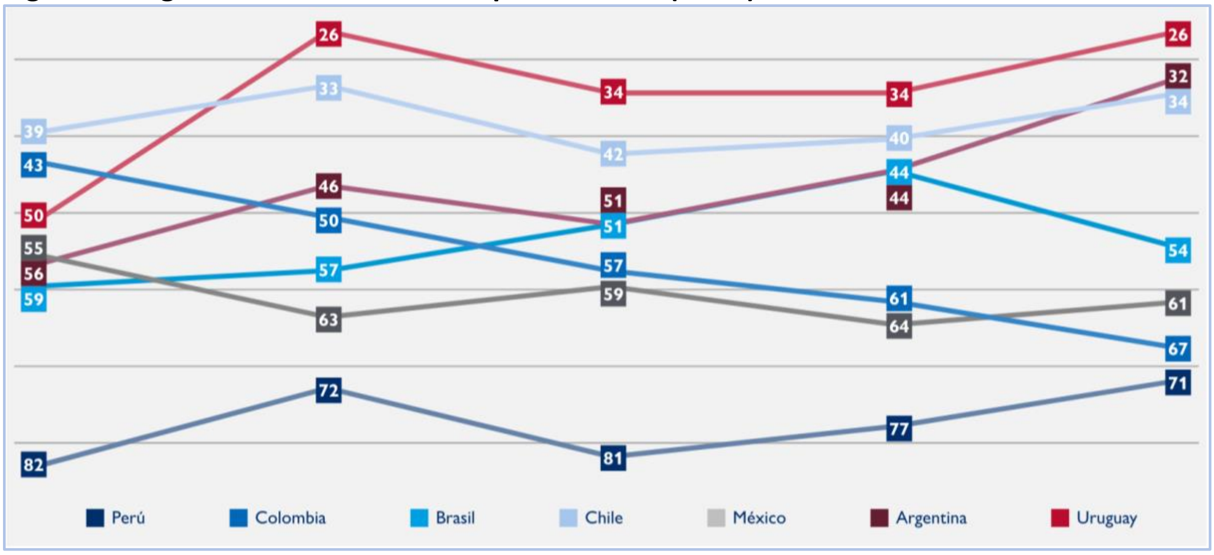
Meanwhile, in addition to the government's drive to improve internet infrastructure with the launch of the Red Dorsal, the national fiber optic network, there are efforts to close the digital divide by promoting inclusive digital transformation. Development of digital literacy is a key element of the government's interventions for inclusiveness. For example, during the height of the pandemic, the distribution of laptops and tablets was accompanied by online learning modules and resources for both the students and their parents, as well as online training on best practices in remote learning for the teachers. (Corbera et al. 2022)

In the e-commerce arena, Corbera et al. (2022) find that although the sector has been growing, it is dominated by international and regional companies. Furthermore, e-commerce is mostly concentrated in urban areas but the far from ideal logistics infrastructure prevents the rural population from benefiting from e-commerce. There is much growth potential in e-commerce in rural areas. Data from the Instituto Nacional de Estadística e Informática (INEI) indicate that mobile and internet penetration in rural areas have been improving and stood at 38 percent in 2016. More importantly, the gap in mobile phone ownership between rural and urban areas have narrowed from 36 percent in 2010 to 18.6 percent in 2015.

Data from the Alliance for Affordable Internet (A4AI) also show that mobile broadband costs less in Peru compared to its neighbors. In 2020, 1GB of data costs only 1.5 percent of gross national income, earning for Peru an Affordability Drivers Index (ADI)[1] rating of 83.9. (See Figure B-2.)

Nevertheless, citing indicators from the Government of Peru's report on progress in government and digital transformation (Government of Peru n.d.), the DECA report by Corbera et al. (2022) show Peru's Digital Government Development Index (DGDI) below other Latin American countries in the area of general digital government development. (Figure 4) Consequently, Corbera et al. (2022) see a bigger role by SEGDI in the digital economy in terms of "sectoral regulations, such as those related to consumer rights, employment platforms, and the collaborative economy" (p.42).

Figure 4. Digital Government Development Index (DGDI)



Source: Figure 9 in Corbera et al. (2022, p.39) citing the Government of Peru (n.d.)

[1] "The Affordability Drivers Index (ADI) is a composite measure that summarizes in a single score an assessment of the drivers of internet affordability in various countries. Benefiting from the research framework established by the Web Index, the 2020 ADI covers 72 countries and focuses on two key aspects driving affordability: telecommunications infrastructure and access to the internet." (Corbera et al. 2022, p.15)

5.1. Estimating the digital economy of Peru

Despite the limits of input-output model, it is a powerful framework in estimating the direct and indirect effects of shocks, and allows policymakers to trace the transmission channels of the shocks and identify whether such shocks are supply- or demand-driven (Carrera 2023). This ability is crucial for policymakers so that the chosen policy interventions could be those that are most effective and efficient in view of the constraints the government are facing at the time.

Upon collaboration with the Asian Development Bank's Digital Economy Team, the digital economy of Peru was estimated by using the input-output tables methodology in employed in Asian Development Bank (2021).

The estimates are based on the data on Supply (Matriz de Producción) and Use (Cuadros de Oferta y Utilización) in constant 2007 prices published by the INEI. (Instituto Nacional de Estadística e Informática n.d.; n.d.). From these two matrices, the national IOT of Peru is derived. Then, using the definition of the core digital economy in Asian Development Bank (2021), the industries in the core digital sector of Peru are identified. These are the following 11 industries:

1. Computers and peripheral equipment
2. Magnetic and optical media
3. Transmission and communication equipment
4. Fixed telephone service
5. Mobile phone service
6. Internet Service
7. Data transmission service
8. Other telecommunication services
9. Computer programming services
10. IT consulting service, computer media management and other IT activities and IT services
11. Data Processing Service, hosting (server), related activities and Web Portals

Once the core digital sector components are identified, their backward (digital enabling sectors) and forward (digitally enabled sectors) linkages can be identified. In 2017, about 74 percent of the core digital sector's inputs are sourced from among the industries in the core digital sector, i.e., only 26 percent of the inputs of the core digital sector is provided by the non-digital sector. In the meantime, 22 percent of the core digital sector's outputs are used by the non-digital sector. By 2021, the backward linkage to the non-digital sector as a portion of the core digital sector's inputs has not changed but the share of its outputs used by the non-digital sector has declined to 19 percent from the 22 percent in 2017.

Table 7. Top 10 non-digital sector industries with forward linkages to the core digital sector

2017	2021
1. Marketing service 2. Public administration, defence and other services 3. Financial intermediation services indirectly measured (FISIM) 4. Restaurant and mobile food services 5. Cable TV service 6. Accommodation and similar services 7. Other financial services 8. Urban and interprovincial passenger ground transport services 9. Copper mineral 10. Residential buildings (dwellings)	1. Marketing service 2. Public administration, defence and other services 3. Financial intermediation services indirectly measured (FISIM) 4. Restaurant and mobile food services 5. Residential buildings (dwellings) 6. Cable TV service 7. Other financial services 8. Copper mineral 9. Public health services 10. Urban and interprovincial passenger ground transport services

Source: Estimates by the ADB Digital Economy Team, 26 May 2023

Table 8. Top 10 non-digital sector industries with backward linkages to the core digital sector

2017	2021
1. Specialized support services of administrative offices and other business activities 2. Accounting, auditing, and consulting services on business management 3. Real estate service 4. Financial intermediation services indirectly measured (FISIM) 5. Services related to employment agencies 6. Specialized services of design, photography, and other professional, scientific, technical activities n.e.c. 7. Legal service 8. Advertising services 9. Repair of computers and communication equipment 10. Television programming and broadcasting service	1. Specialized support services of administrative offices and other business activities 2. Accounting, auditing, and consulting services on business management 3. Financial intermediation services indirectly measured (FISIM) 4. Services related to employment agencies 5. Real estate service 6. Specialized services of design, photography, and other professional, scientific, technical activities n.e.c. 7. Legal service 8. Advertising services 9. Repair of computers and communication equipment 10. Marketing service

Source: Estimates by the ADB Digital Economy Team, 26 May 2023

Meanwhile, the top 10 non-digital sectors that demand from the digital sector (ranked from highest to lowest) are shown in Table 7. In 2021, public health services replaced accommodation and similar services in the top 10 non-digital sectors being supplied to by the core digital sector. We can surmise that this is a structural change brought about by the pandemic.

The top 10 non-digital industries that supply their inputs of the core digital sector hardly changed from 2017 to 2021. Sorted from highest to lowest in Table 8, we see that marketing service replaced television programming and broadcasting service in 2021 in the list of top non-digital industry supplier to the core digital sector.

The core digital sector is supported in its demand for fixed investments by the industries in Table 9. There is no change from 2017 to 2021. On the other hand, one weakness of the estimates for this item is that it relies on the share of the sector in total output in calculating the gross fixed capital formation for each industry due to lack of actual data on investments by industry. Nevertheless, it is the smallest in magnitude among the four terms in the digital economy equation estimated in Table 10.

Table 9. Top 10 non-digital industries supplying the fixed capital goods consumed by the core digital sector.

2017	2021
1. Residential buildings (dwellings) 2. Marketing service 3. Non-residential buildings 4. Other civil engineering works 5. Roads, streets and paths, railways, bridges, and tunnels (road works) 6. Cement 7. Stone, sand, and concrete 8. Financial intermediation services indirectly measured (FISIM) 9. Urban and interprovincial land freight transport services 10. Other services for building construction	1. Residential buildings (dwellings) 2. Marketing service 3. Non-residential buildings 4. Other civil engineering works 5. Roads, streets and paths, railways, bridges, and tunnels (road works) 6. Financial intermediation services indirectly measured (FISIM) 7. Cement 8. Stone, sand, and concrete 9. Urban and interprovincial land freight transport services 10. Other services for building construction

Source: Estimates by the ADB Digital Economy Team, 26 May 2023.

Finally, Table 10 shows the size of Peru's digital economy from 2017 to 2021. The values are in real terms, with 2007 as the base year. Thus, it is meaningful to compare the figures intertemporally as price effects have been controlled for. From 2018 to 2021, we see higher growth rates of the digital economy relative to the overall economy. The digital economy is also resilient to the downturn in 2020. Moreover, the share of the digital economy has been steadily increasing from 2017 to 2021. Table 10 also gives us insights on the role of the digital economy. It is more of a "demander" from, the other sectors but not by a very wide margin:

backward linkages (that is, other sectors supply to the digital sector) values are greater than the forward linkages (i.e., the digital sector supplies to the other sectors) values. Thus, policies that promote the growth of the digital sector would have multiplier effects in the overall economy in terms of its needs that the non-digital sector will have to supply. It also implies that policymakers will need to identify the bottlenecks and necessary policies to support these digital enabling industries to ensure that the growth of the digital economy runs smoothly and as planned.

Table 10. Digital Economy of Peru (in million soles unless otherwise stated)

Terms	Description	2017	2018	2019	2020	2021
1	Forward linkage	18,652	19,737	21,381	23,239	25,928
2	Backward linkage	19,662	20,912	22,677	25,242	28,286
3	Double-counted terms	(14,614)	(15,554)	(16,924)	(19,011)	(20,948)
4	Backward linkage of digital producers in nondigital assets	2,691	2,876	3,100	3,135	4,095
	Digital GDP	26,391	27,972	30,234	32,605	37,361
	growth rate		6.0%	8.1%	7.8%	14.6%
	Digital, share in GDP, %	**5.1%**	**5.2%**	**5.5%**	**6.7%**	**6.8%**
	GDP	514,215	534,626	546,605	487,191	552,560
	growth rate		4.0%	2.2%	-10.9%	13.4%

Source: Estimates by the ADB Digital Economy Team, 26 May 2023

6. Conclusion

The digital economy is growing worldwide, accelerated by innovations in digital services and changes in user habits. The COVID-19 pandemic resulted in a sudden shift to digital services in all economies. For countries like Peru which is transforming into a more digital economy and with still a significant digital divide among its population, the need to improve connectivity in rural areas and the unserved population together with digital skills and literacy trainings and retooling have never been more primordial. These would improve adoption of productivity-enhancing and equity-improving digital technologies.

However, policymaking needs to be guided by good quality data. It is in this spirit that a reliable measure of the digital economy is necessary. Legislative, fiscal, and monetary measures gain effectiveness when based on a reliable estimate of the digital economy. As pointed out by the Bank of Canada, for central banks, a reliable measure of the digital economy is essential in understanding the dynamics of the labour market and productivity, which in turn are important in interest rate decisions. A good measurement framework helps policymakers understand better the impacts of shocks on demand and supply for skills and inputs to production, on employment, and on inequality. Having such insights, policy interventions can be more effective and efficient.

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APPENDIX A. Case Studies on Digital Economy Estimation for Selected Countries

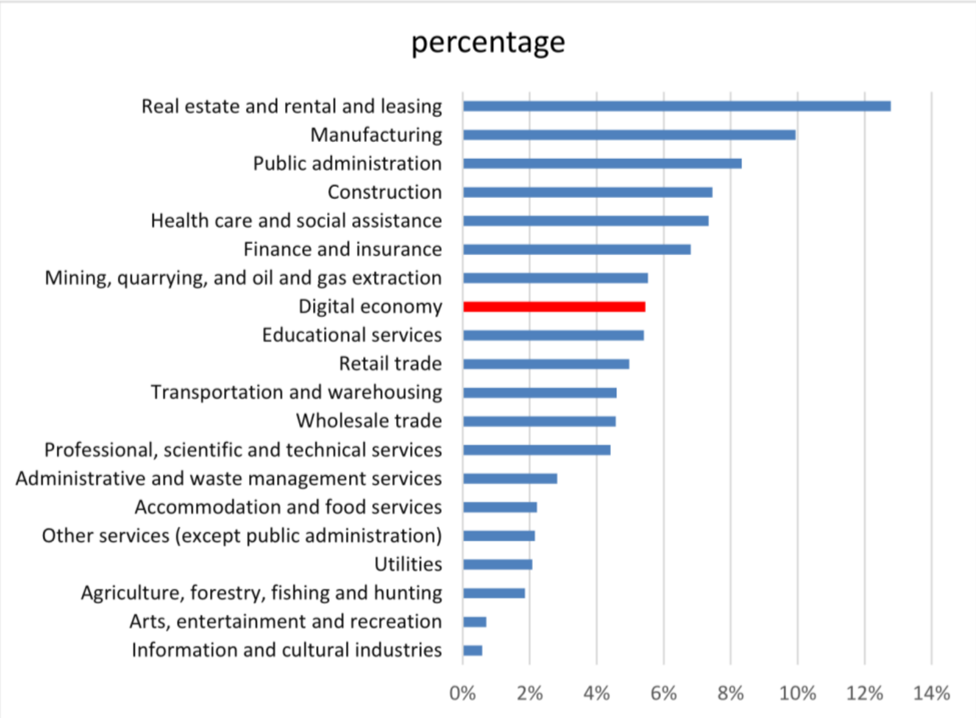
We have two sets of case studies that may be useful to Peru in its efforts to estimate its digital economy using the System of National Accounts. Depending on data availability, the purpose for coming up with the estimates, and the kinds of policy analyses desired, each methodology has its strengths and challenges.

Canada

Statistics Canada's method in its estimation adheres to the OECD framework, i.e., a measurement method that is based on an extended SUT. To measure its digital economy, the data from the standard SUT were disaggregated according to available indicators and simplifying assumptions. In particular, the digital SUT (DSUT) split the transactions in the standard SUT according to two elements: (a) digital, or (b) non-digital component. From there, Statistics Canada applies an integrated analytical framework for the relative roles of these components in production, consumption, and international trade. The resulting SUT with more detailed or "granular indicators" then enables deeper analyses of the digital economy that is consistent with the national accounts. Statistics Canada then calls this new tables the Canadian digital Supply and Use Table (DSUT). (see Government of Canada 2021; Statistics Canada 2021; Sinclair 2019)

The digital economy of Canada is estimated at 5.5 percent of the 2019 GDP (Figure **A-1**), an increase from 2017's 5.2 percent share in total GDP. (Ghanem, 2021)

Figure A-1. Shares of different sectors to Canada's GDP, 2019, in percent



Source: Statistics Canada, Digital Supply and Use Tables, 2019

One notable limitation of Canada's digital SUT is that it does not include digital activities in the education, health care and public administration sectors, principally due to unavailability of data sources. (Ghanem 2021, p.2)

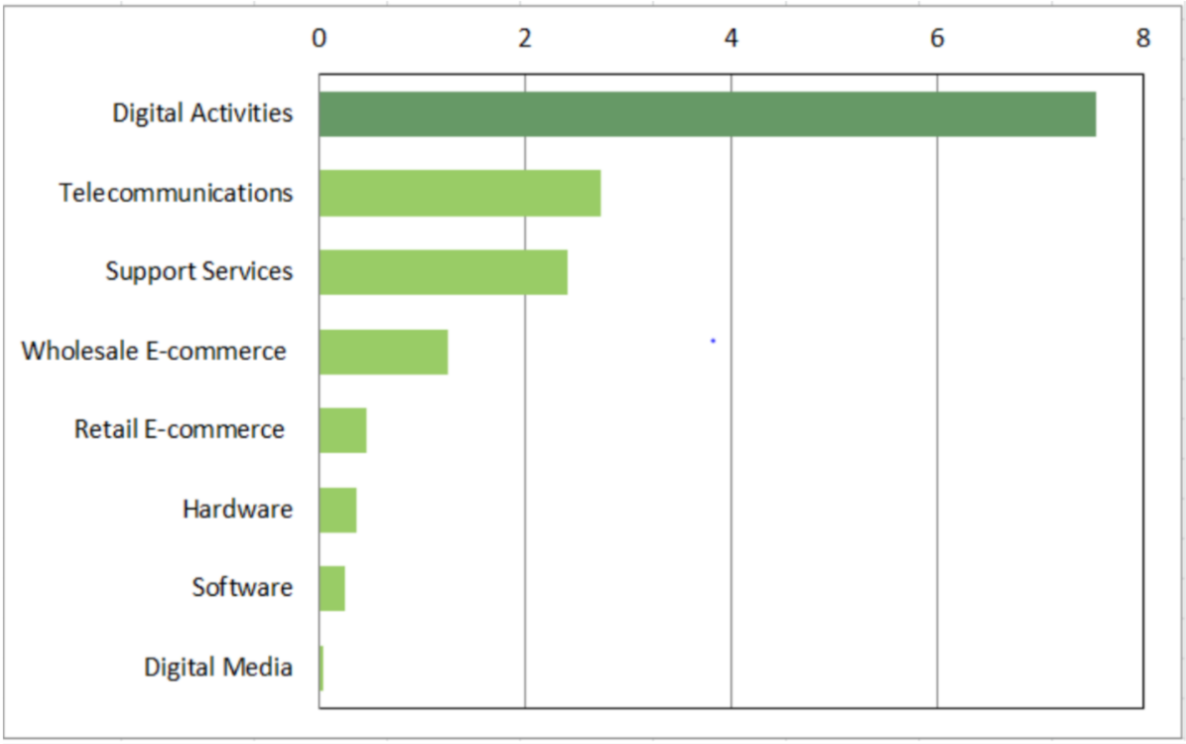
Australia

Australia also adheres to the OECD framework. The Australian Bureau of Statistics (ABS) applies the US Bureau of Economic Analysis methodology in estimating its digital economy. (see Australian Bureau of Statistics 2019a; 2019b; 2021; 2022a; 2022b)

In practical terms, ABS decided to focus on "products that were primarily digital in nature" and at the same time already distinctly identifiable in the SUT. Digital activities were estimated as the production of three sectors, to wit, (Australian Bureau of Statistics 2021, p.4)

- "Digital enabling infrastructure: computer hardware, software, telecommunications equipment, and support services that form and facilitate the use of computer networks.
- "Digital media: digital audio, video and advertisement broadcasting services that can be created, accessed, stored, or viewed on digital devices; and
- "E-commerce: retail and wholesale services and margins from digitally ordered or platform enabled online transactions."

Figure A-2. Australia's digital activities value-added growth, in volumes, in percent, 2012-13 to 2016-17

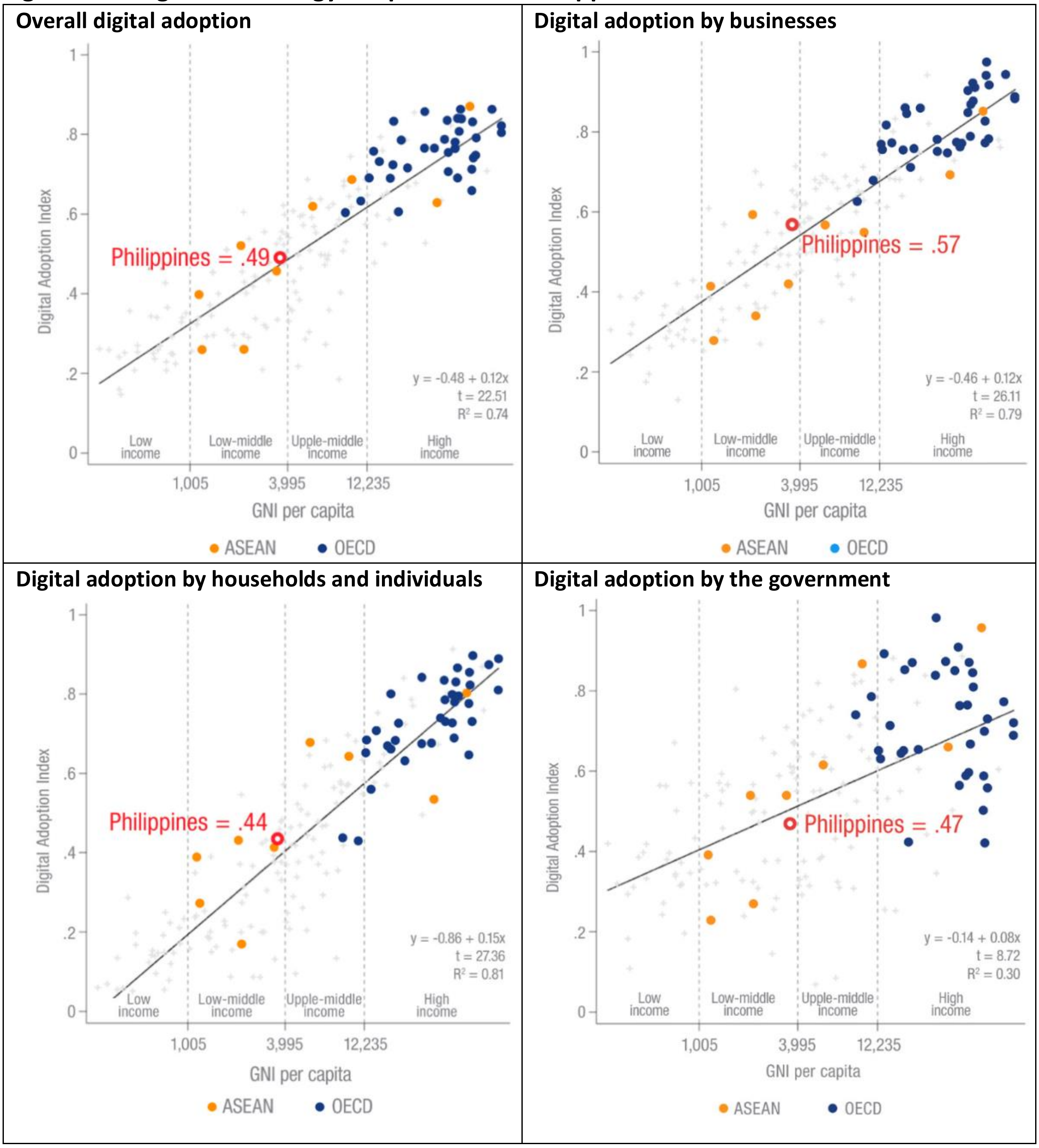


Source: Figure 8 in Australian Bureau of Statistics 2021, p. 12.

According to the Australian Bureau of Statistics (2021), the results of Australia's estimation exercise indicates that the aggregate digital GVA increased per year by 7.5 percent from 2012-

2017. This growth was driven by the following sectors: telecommunications (2.7 percent), support services (2.4 percent), and wholesale e-commerce (1.3 percent). (Figure **A-2**)

Figure A-3. Digital technology adoption in the Philippines



Source: Figures 1.8-1.11 in World Bank (2020, p.22)

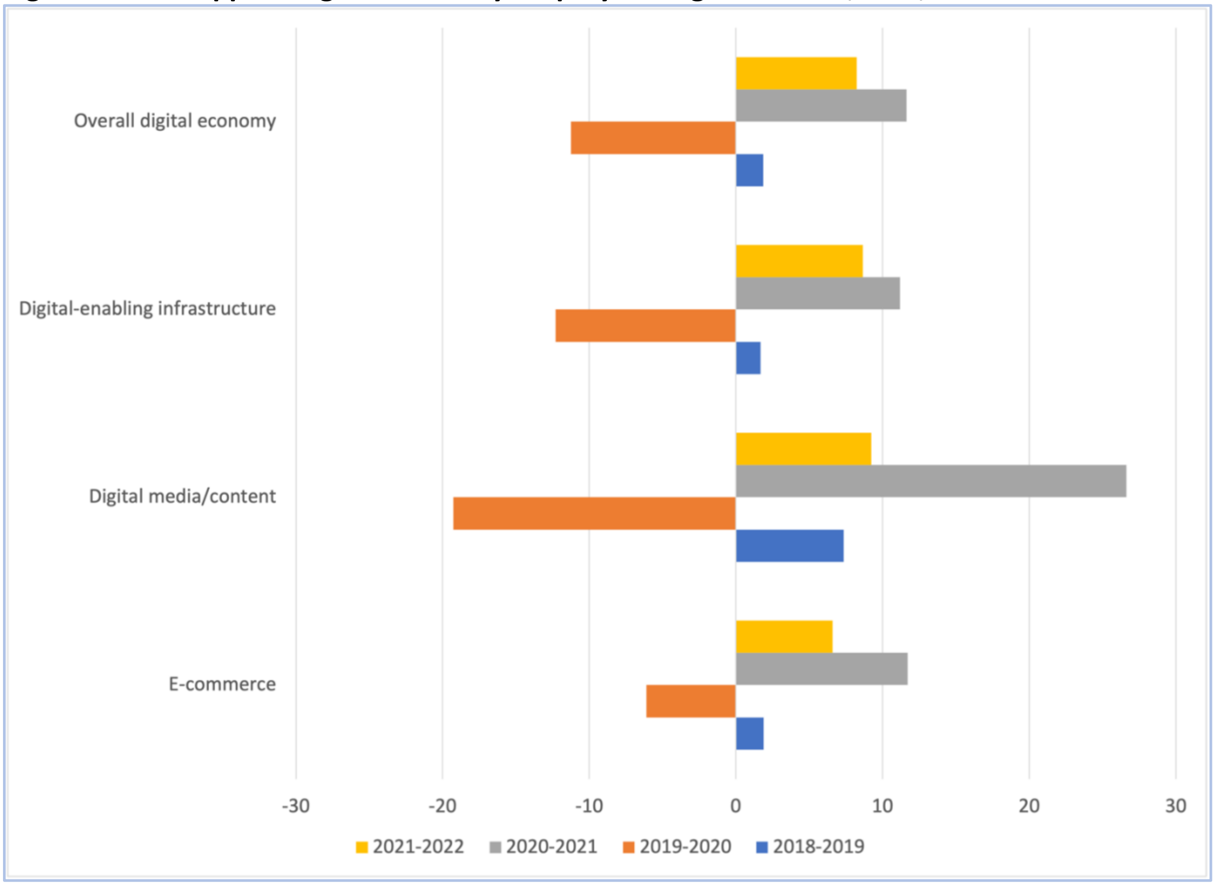
Philippines

Though its digital adoption remains commensurate to its economic development status, the World Bank Digital Adoption Index (DAI) and its three sub-indices on people, government and business indicate that the Philippines is below world average on digital adoption. Adoption of digital technology by businesses is at par with neighbors like Malaysia, Thailand, and Vietnam. Businesses performs above median of regional and income group peers in terms of the percent of business establishments with a website and the international internet bandwidth per user. Similarly, individuals also have wide adoption of digital technologies. On the other hand, government adoption lags. (Figure **A-3**) Challenges in adoption are attributed to "problems of digital infrastructure and connectivity, high cost of broadband and internet services, and uneven quality of internet service". (World Bank 2020, p.21)

Given the consistent empirical findings on the impacts of digital economy on productivity and growth, digitization of the micro-, small-, and medium-sized enterprises (MSMEs) is among the strategies in improving the competitiveness of the country's businesses (See Chapter 6 of the Philippine Development Plan 2023-2028, National Economic and Development Authority 2023).

In the meantime, like Canada and Australia, the Philippine official statistics agency also bases its digital economy estimates on the OECD and US BEA framework. The Philippine Statistics Authority (PSA) defines the digital economy as "a broad range of activities, which include the use of knowledge and information as factors in production, information networks as a platform for action and how the information and communication technology (ICT) sector spurs economic growth." Conceptually, the US BEA's definition of the digital economy consists of the following sectors: (1) digital-enabling infrastructure needed for a computer network to exist and operate; (2) digital transactions that take place using that system ("e-commerce"); and (3) the content that digital economy users create and access ("digital media"). (See Philippine Statistics Authority 2022; 2023; Ilarina 2018)

Figure A-4. Philippine digital economy employment growth rate, in %, 2018-2022



Source: Philippine Statistics Authority (2023)

Philippine Statistics Authority (2023) finds that the digital economy represents 9.4 percent of nominal gross domestic product in 2022. This represents an 11 percent increase in nominal value relative to 2021. The number of people employed by the digital economy also increased by 8.2 percent year-on-year to more than 6 million in 2022. Although among the three main categories of the digital economy, employment in digital media/content grew the fastest at 11.6 percent, the bulk of employment is in digital-enabling infrastructure, averaging 77.5 percent of total employment in the digital economy from 2018 to 2022. Figure **A-4** shows notable declines in employment growth rates across all components of the digital economy in 2000 (orange bars) at the strictest period of the pandemic lockdowns. Swift recovery in 2021 and 2022 are seen however with total employment in the digital economy hitting 6.1 million in 2022—more than the pre-pandemic employment of 5.6 million in 2019.

Indonesia

In 2018, the Indonesian government launched the blueprint for "Making Indonesia 4.0". (Ministry of Industry 2018) While Indonesia has successfully improved in internet connectivity in the last ten years, more than half of its adult population remains with no internet access. The top two reasons for having no internet connectivity are the costs, and the quality of internet connection. Nonetheless, data show that consumers have been benefiting from e-commerce and that Indonesia is the fifth most internet-engaged country in the world. (World Bank 2021)

World Bank (2021) enumerates three key policies that could increase inclusion in Indonesia. First, it is critical that digital connectivity is enhanced, and universal access is supported. Second, it is important to ensure that the digital economy benefits everyone. Finally, digital technologies must be leveraged to improve government services and elevate the quality of the interaction of its citizens with the bureaucracy. (World Bank 2021)

According to Aprilianti and Dina (2021), Indonesia has the largest digital economy among ASEAN economies. It accounts for 41 percent of the US$100 billion worth of digital economy transactions in the ASEAN region. In particular, its business-to-consumer (B2C) e-commerce is valued at US$13.6 billion in 2019. Indonesia's B2C market is supported by travel bookings (58.9 percent share), and online shopping and retail categories (14.6 percent). Meanwhile, during the first six months of 2020, 630 digital service providers handled US$41 billion worth of transactions, of which more than half is from e-commerce, 24 percent from online travel, 15 percent from ride hailing service, and 10 percent from online media. (p.7)

Aside from e-commerce, Indonesia's digital economy is also dominated by fintech companies. The development in digital payment systems, particularly its Quick Response Code Indonesian Standard (QRIS), has been a critical stimulus in the digitisation in trade. Micro and small enterprises are the majority users of the QRIS digital payment system. (Sapulette and Muchtar 2023, p.3)

The Indonesian government is working towards the faster progress in the nation's digital transformation by accelerating the development of digital infrastructure, implementing a comprehensive human resource development for the digital sector, and formulating digital transformation blueprints for key sectors (such as the government sector, public services, social welfare support, education, health, trade, industry, and broadcasting). (Chen et al. 2022, p.12)

Malaysia

From 1960-2016, Malaysia's economy posted an average annual growth rate of 6.3 percent, elevating it to upper middle-income status. During this period, growth was founded on structural reforms that stimulated the rise of microelectronics and the birth of new industries that pushed Malaysia up the global value chains. Policies targeted broadening the stock of human capital by improving the skillsets of the labor force and equipping women to participate in the labor force (Record et al. 2018).

Malaysia's digital transformation began with the launch in 1996 of the Multimedia Super Corridor programme, which incentivised domestic and foreign information and communication technology (ICT) firms to locate in economic zones. By 2019, Malaysia's ICT sector was worth RM289 billion. In February 2021, the government launched MyDIGITAL, an initiative that aims to "transform Malaysia into a digitally enabled and technology-driven high-income nation, and a regional leader in digital economy". Subsequently, the Digital Economy Blueprint was prepared to "set the direction, outline the strategies, initiatives and targets to build the foundation to drive the growth of digital economy, including bridging the digital divide." (Malaysia Economic Planning Unit 2021)

Malaysia enjoys high internet penetration rate that is surpassed only by Japan, S. Korea, and Singapore in the Asian region. Furthermore, Malaysians, on average, also have more than one mobile phone subscription. However, fixed broadband quality is poor (Record et al. 2018, p.13).

Without going into the details of the estimates and the estimation methodology, Department of Statistics Malaysia (2019) discloses that Malaysia's digital economy grew by 6.9 percent in 2018, with the ICT industry and e-commerce for non-ICT industries contributing 12.6 percent and 5.9 percent to total GDP, respectively. Telecommunications services were the main driver of ICT services, while the production of electronic components and boards, communication equipment, and consumer electronics buoyed ICT manufacturing.

In 2017, 78.9 percent of business establishments used computer while 76.3 percent are connected to the internet. Meanwhile, 70.5 percent of individuals were using computers while 81.2 percent were using the internet in 2018 (Department of Statistics Malaysia 2019).

A. Supply and Use Table-based estimation

This method is primarily based on the OECD and the US BEA framework. Nevertheless, each economy faces different data challenges and, thus, each of the three main component of the digital economy will not necessarily reflect the same details as will be discussed below. However, it is apparent that digital-enabling sectors compose more than half of the digital economies of Canada, Australia, and the Philippines, with e-commerce a far second. Even for the two advanced economies, digital media/content is the smallest component of the digital economy. (Table **A-1**)

Table A-1. Share to total digital economy, in % unless otherwise indicated

	E-commerce	Digital media/content	Digital-enabling infrastructure	Digital Economy (in million domestic currency)
Canada				
2017	7.1	1.7	91.5	103,298
2018	7.6	2.1	90.3	111,384
2019	8.8	2.7	88.5	117,788
Australia				
2012	15.0	8.1	76.9	75,666
2013	13.2	8.3	78.5	78,186
2014	16.5	8.2	75.4	82,404
2015	16.0	8.0	76.1	85,405
2016	18.7	7.7	73.6	89,051
2017	20.0	7.1	72.8	92,925
2018	19.7	7.0	73.4	96,898
2019	22.9	5.9	71.1	101,733
2020	24.7	5.1	70.1	109,448
2021	27.0	5.3	67.9	118,030
Philippines				
2018	22.1	2.7	75.2	1,842,860
2019	22.7	2.7	74.6	1,955,281
2020	17.6	2.7	79.8	1,734,590
2021	17.6	2.7	79.7	1,871,822
2022	20.0	2.8	77.2	2,077,258

Sources: Authors' estimates; Ghanem 2021; Australian Bureau of Statistics 2021, 2022; Asian Development Bank 2021, 2023; Philippine Statistics Authority 2023

Digitally enabling sectors

In Canada, the digitally enabling sectors consist of hardware, software, telecommunications, and other services. (Statistics Canada 2019)

In the Philippines, the digital enabling infrastructure sector is composed of computer, electronic and optical products, wholesale trade (except of motor vehicles and motorcycles), telecommunication services, professional and business services, and repair of computers and communication equipment. (Philippine Statistics Authority 2023)

In Australia, its digital-enabling infrastructure includes "computer hardware, software, telecommunications equipment and support services that form and facilitate the use of computer networks" (Australian Bureau of Statistics 2022b).

E-commerce

For Canada, we summed their data for "E-tailers", "Data and advertising driven digital platforms", "Digital only firms providing finance and insurance services", and "Other producers only operating digitally" to arrive at the e-commerce figures in Table A-1. Meanwhile, Australia's e-commerce sector is split into retail e-commerce and wholesale e-commerce. Finally, the Philippines reports its e-commerce data in the aggregate.

Digital media and digital contents

Canada's digital media sectors are composed of "Digital intermediary platforms charging a fee", "Dependent on intermediary platforms, Incorporated", and "Dependent on intermediary platforms, Unincorporated". (Statistics Canada 2021) In Australia, digital media covers "digital audio, video and advertisement broadcasting services that can be created, accessed, stored or viewed on digital devices". (Australian Bureau of Statistics 2022b) For the Philippines, the digital media/content component is reported in the aggregate. (Philippine Statistics Authority 2023)

B. Input-Output Table-based estimation[2]

This sub-section uses the input-output table (IOT) based methodology and findings of ADB (2021). We use the cases of Indonesia and Malaysia to illustrate the how this estimation methodology is implemented for emerging economies like Peru. According to Table 4 at the main report, Indonesia's digital economy was 4.7 percent (US$34.3 billion) of its total economy in 2010 but declined to 4.3 percent (US$37.6 billion) in 2014. On the other hand, the share of Malaysia's digital economy was steady at 7.6 percent (US$19.1 billion in 2010, and US$21.9 billion in 2015). Note, however, that these figures are based on nominal values and, therefore, are affected by price movements. (ADB 2021) Inflation rates based on the GDP deflator were 7.3 percent (2010) and 5.4 percent (2014) for Indonesia, while they were 3.8 percent (2010) and -0.1 percent (2015) for Malaysia. However, in the future, it would be more helpful if specific price indices for the digital economy are used rather than the overall price deflator given that the price behaviour of technology is likely much different from the overall picture. At the same time, from experience, we know that digital technologies have improved in quality and functionalities which may not be reflected in prices.

The core digital sector

The core digital sector are the industries that are the primary producers of "goods and services with the main function of generating, processing and/or storing digitized data", which are hardware, software publishing, web publishing, telecommunications, and specialised and support services. For both Indonesia and Malaysia, the subsector with the biggest contribution to GDP is telecommunications. The contributions of hardware, and specialised and support services are also significant for Malaysia, where, in 2015, specialised and support

[2] This sub-section reports on the details of estimation for Indonesia and Malaysia in Asian Development Bank (2021) unless otherwise cited.

services overtook hardware in terms of the magnitude of its contribution to overall GDP illustrating the growing influence of digital services in Malaysia. (Table **A-2**)

Table A-2. Disaggregation of the core digital sector by subsector, as % of GDP

	Year	Hardware	Software publishing	Web publishing	Telecommunications	Specialized and support services
Indonesia	2010	0.503	0.133	0.022	3.122	0.041
	2014	0.485	0.129	0.020	2.922	0.038
Malaysia	2010	2.330	0.006	0.178	3.260	0.917
	2015	1.468	0.028	0.084	3.811	1.619

Source: ADB (2021)

ADB (2021) also estimates the compounded annual growth rates (CAGR) of the digital economy as measure in their respective domestic currencies. For each economy, the CAGR of the digital economy measured in levels (i.e., in Indonesian rupiah and in Malaysian ringgit) and the CAGR of digital GDP as a percentage of GDP in domestic currency units. Malaysia's absolute level CAGR is 6.8 percent, while Indonesia's is 9.3 percent. However, when the CAGR is calculated using digital GDP that is normalised by the total GDP, both economies registered negative growth rates: -0.2 percent for Malaysia and -4.9 percent for Indonesia. According to ADB (2021), such negative growth of the latter measure is not necessarily an indication of diminishing role of the digital economy. Rather, the roots could be (1) falling prices of digital products, and (2) improvement in quality or productivity of digital products through the years. Citing OECD (2019), ADB (2021) explains that, in particular, "the digital economy in more recent years is characterized by cheaper digital products that can process information more efficiently, contributing to its declining share in economy-wide GDP. In addition, the transition of business models toward offering goods-as-services in recent years is further exacerbating this phenomenon. This is particularly apparent in digital products, such as software, conventionally capitalized but now increasingly sold as services (e.g., cloud computing services), and subsequently recorded as intermediate consumption in national accounts. This leads to a lower value-added for corresponding industries" (p. 36).

Indonesia's core digital sector is a net user of outputs by the non-digital sector as its backward linkage is greater than its forward linkage. Digitally enabling sectors grew by 11 percent to US$25.87 billion from 2010 to 2014 in Indonesia, while they expanded by 31 percent to US$15.14 billion from 2010 to 2015 for Malaysia. (Table **A-3**)

Table A-3. Estimates of the components of digital economy for Indonesia and Malaysia

	Year	1st term ($mil)	2nd term ($mil)	3rd term ($mil)	4th term ($mil)	Total ($mil)
Indonesia	2010	20,204	23,319	15,431	6,253	34,345
	2014	22,158	25,874	16,794	6,369	37,607
Malaysia	2010	12,523	11,548	7,349	2,375	19,097
	2015	17,765	15,136	12,652	1,618	21,867

Source: ADB (2021)

Digitally enabled or forward linkages of the digital sector (1st term)

According to ADB (2021), digitally enabled industries (or the backward linkages of the core digital sector) are products or services that use digital products as components, but their primary function is not changed compared to when their inputs are just analog products. The study cites as an example car manufacturers, which are "increasingly adding digital components into their vehicles, which includes connected in-car entertainment experiences, vehicle systems management, and self-driving capabilities, among others. Despite these novel features, highly digitalized cars are still considered to be transportation equipment, not digital hardware" (p.6).

In contrast to Indonesia, Malaysia's core digital sector is more of a supplier to its non-digital sectors than customers. Malaysia's digitally enabled sector is bigger than its digitally enabling sectors. For Indonesia, the top users of its output are construction; education; food, beverage, and tobacco; public administration; trade; air transport; electronic, electrical, and optical equipment; textiles; and financial intermediation. Meanwhile, electronic, electrical, and optical equipment; public administration; trade; community, social, and personal services; and food, beverage, and tobacco are the main users of the digital sectors outputs in Malaysia. Unlike in Indonesia where the users of the digital sector's outputs remain essentially the same between 2010 and 2014, in Malaysia, the users became less concentrated between 2010 and 2015, that is, Malaysia's digital sector is less dependent on a few industries as destinations of its outputs. (Table **A-4**)

Table A-4. Top domestic digitally enabled sectors, based on forward linkages (normalized %)

	Year	Value (in Local Currency Units)	Industry	Percent
Indonesia	2010	15,431	DIGITAL SECTOR	100.00
	2010	1,753	Construction	11.36
	2010	699	Education	4.53
	2010	543	Food, beverages, and tobacco	3.52
	2010	532	Public administration and defense; compulsory social security	3.45
	2010	410	Wholesale and retail trade	4.21
	2010	285	Electronic, electrical, and optical equipment	1.85
	2010	260	Textiles and textile products	1.68
	2010	258	Financial intermediation	1.67
	2014	16,794	DIGITAL SECTOR	100.00
	2014	2,092	Construction	12.46
	2014	831	Education	4.95
	2014	614	Food, beverages, and tobacco	3.66
	2014	588	Public administration and defense; compulsory social security	3.50
	2014	445	Wholesale and retail trade	2.65
	2014	358	Air transport	2.13
	2014	337	Electronic, electrical, and optical equipment	2.01
	2014	317	Financial intermediation	1.89

	Year	Value (in Local Currency Units)	Industry	Percent
	2014	279	Textiles and textile products	1.66
Malaysia	2010	23,681,378	DIGITAL SECTOR	100.00
	2010	3,727,355	Electronic, electrical, and optical equipment	15.74
	2010	1,087,903	Public administration and defense; compulsory social security	4.59
	2010	1,050,448	Financial intermediation	4.44
	2010	659,531	Food, beverages, and tobacco	2.79
	2010	541,187	Other community, social, and personal services	2.29
	2010	485,586	Wholesale and retail trade	3.89
	2010	371,118	Education	1.57
	2010	311,838	Construction	1.32
	2015	49,402,480	DIGITAL SECTOR	100.00
	2015	1,432,340	Electronic, electrical, and optical equipment	3.46
	2015	1,202,330	Wholesale and retail trade	2.43
	2015	605,650	Other community, social, and personal services	1.23
	2015	547,080	Renting of M&Eq and other business activities	1.11
	2015	432,373	Food, beverages, and tobacco	0.88
	2015	259,917	Hotels and restaurants	0.53
	2015	255,830	Construction	0.52
	2015	253,513	Architectural and engineering activities	0.51

Source: ADB (2021) citing Calculations of the Digital Economy Measurement Framework study team, using input-output and related data from various national statistics offices and international databases.

Table A-5. Digitally disrupted sectors by size of digital forward contribution (% of respective sector size)

	Indonesia	Malaysia
Land transport services and transport services via pipelines	0.418	0.849
Accommodation services	0.467	1.845
Food and Beverage serving services	0.467	0.858
Publishing services	1.019	0.880
Motion picture, video and television programme production services, sound recording and music publishing	1.558	1.911
Financial and insurance services	1.010	1.003
Advertising and market research services	0.000	1.798
Travel agency, tour operator and other reservation services	0.000	3.134
Education services	2.263	0.769
Gambling and betting services	0.000	7.002

Source: ADB (2021) citing Calculations of the Digital Economy Measurement Framework study team, using input-output and related data from various national statistics offices and international databases.

Table **A-5** shows education services as the most digitally disrupted in Indonesia with 2 percent of inputs supplied by the digital sector. In Malaysia, it is gambling and betting services that is the most digitally disrupted sector (i.e., 7 percent of inputs of gambling and betting services in Malaysia is supplied by the digital sector).

Digitally enabling sectors or backward linkages of the digital sector (2nd term)

Digitally enabling sectors are those that produce "components and accessories supporting digital goods and services" that are essential in the manufacture and creation of digital products. They are not part of the core digital sector because absent the "assembly process, such products cannot generate, process, and store data by themselves." (ADB 2021, p.6)

Digital sector's inputs to its own final product (3rd term)

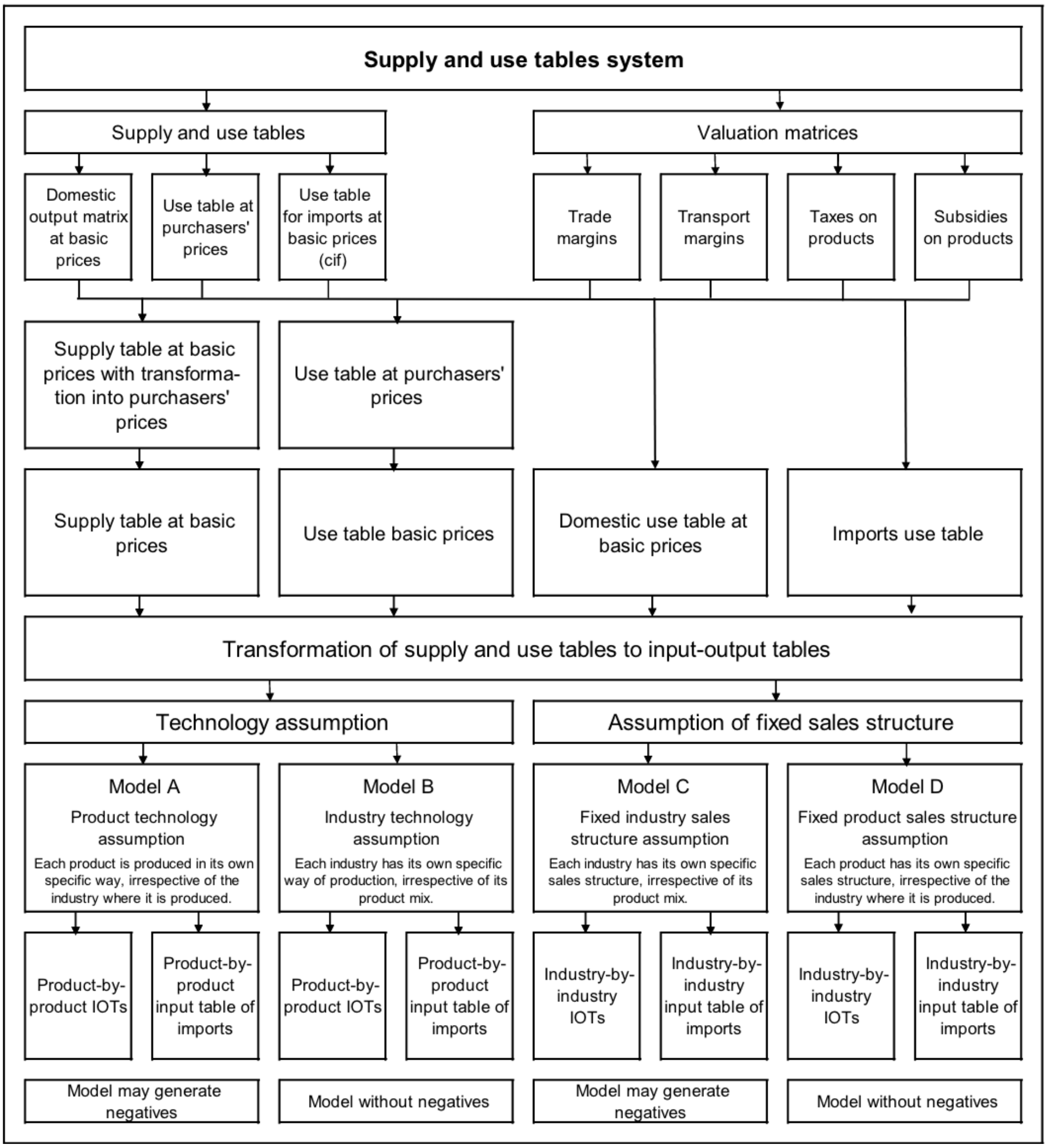
This term represents the core digital sector's value added to its own final output. This term is double counted since it is included in both the first and the second term, i.e., the sector's inputs to its own production is also counted when we sum up its outputs that it is supplying to itself. Thus, this term is deducted.

Backward linkage of fixed capital goods to the digital sector (4th term)

This term represents the fixed capital goods used by the core digital sector. It increased by 1.9 percent for Indonesia from 2010 to 2014, but it declined by 31.9 percent for Malaysia from 2010 to 2015. (ADB 2021) This does not necessarily imply a slowdown in capacity building but may reflect price effects since our data are in nominal terms.

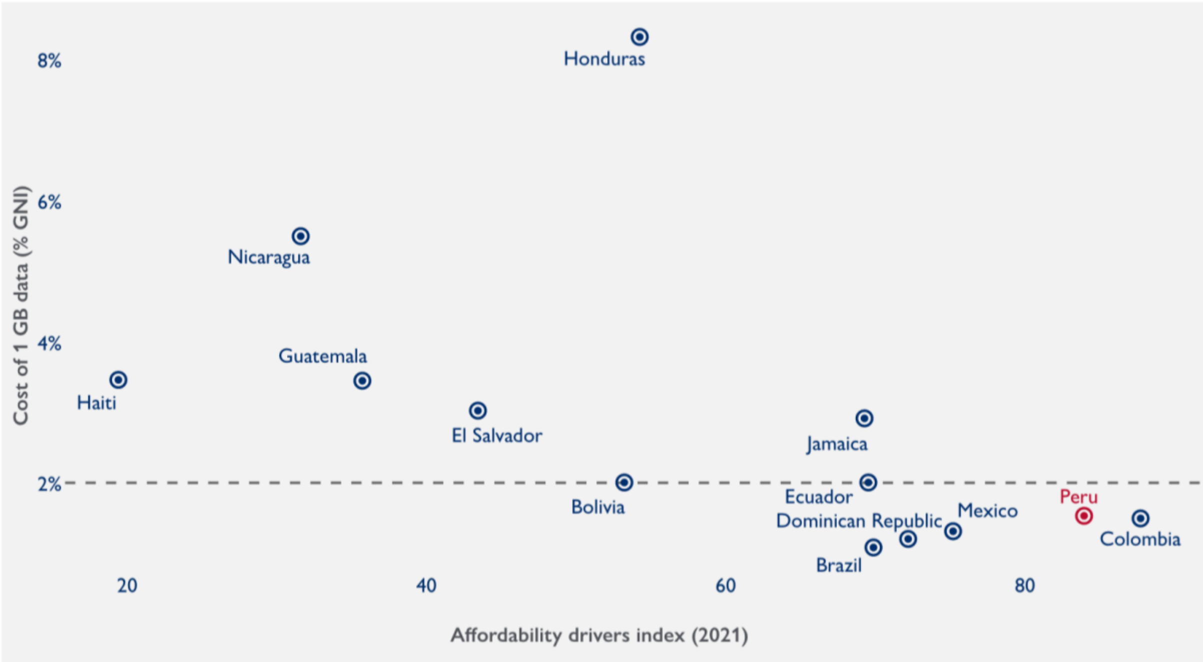
APPENDIX B. Figures

Figure B-1. From Supply and Use Table (SUT) to Input-Output Table (IOT)



Source: Figure 12.1 in Mahajan et al. (2018, p.372)

Figure B-2. Internet affordability scores



Source: Figure 2 in Corbera et al. (2022, p.17) citing the Alliance for Affordable Internet (A4AI)

APPENDIX C. Tables

Table C-1. Digital Indicators for Peru

Digital indicators - Peru	Peru		LAC		OECD	
Enhancing access	**2008**	**2017**	**2008**	**2017**	**2008**	**2017**
Fixed broadband subscriptions (per 100 inhabitants)	2.5	7.3	4.1	12.0	22.7	32.2
	2009	**2017**	**2009**	**2017**	**2009**	**2017**
Active mobile-broadband subscriptions (per 100 inhabitants)	0.29	65.7	1.8	66.8	29.8	97.3
	2015	**2017**	**2015**	**2017**	**2015**	**2017**
Proportion of population covered by at least 3G network	70.8	73.9	86.1	93.2	98.2	99.0
	2008	**2017**	**2008**	**2017**	**2008**	**2007**
Fixed broadband speed (in Mbit/s)	0.40	2.0	0.58	5.1	2.2	27.7
Strengthening their effective use	**Peru**		**LAC**		**OECD**	
	2008	**2018**	**2008**	**2018**	**2008**	**2018**
E-Government Development Index (EGDI)	0.53	0.65	0.52	0.65	0.72	0.82
Share of Internet users (% of population)	30.6	52.5	25.3	67.7	65.0	84.3
	2015	**2019**	**2015**	**2019**	**2015**	**2019**
UNCTAD B2C E-Commerce Index	43.1	47.8	46.4	51.5	73.9	85.0
	2017		**2017**		**2017**	
Share of individuals engaging in online shopping	13.2		14.8		N/A	
Enabling digital innovation	**Peru**		**LAC**		**OECD**	
	2008	**2018**	**2008**	**2018**	**2008**	**2018**
High-technology exports (% of manufactured exports)	2.9	4.6	9.3	8.6	15.6	15.1
	2008	**2017**	**2008**	**2017**	**2008**	**2017**
Share of ICT service imports, as % of total trade in services	2.3	3.7	3.1	3.8	4.6	6.6
	2012	**2016**	**2012**	**2016**	**2012**	**2016**
ICT patent applications filed under the Patent Cooperation Treaty (per million people)	0.00	0.09	0.14	0.34	30.9	38.2
	2011	**2016**	**2011**	**2016**	**2011**	**2016**
R&D expenditures, as % of GDP	0.08	0.12	0.33	0.42	1.9	1.9
	2019		**2019**		**2019**	
OECD OURdata Index	N/A		0.43		0.61	
Ensuring quality jobs for all	**Peru**		**LAC**		**OECD**	
	2006-15		**2006-15**		**2006-15**	
Contributions to changes in total employment, by digital intensity of sectors, 2006-16	N/A		6.9		4.8	
	2017		**2018**		**2018**	
Share of informal employment to total employment	68.9		54.9		N/A	
	2006	**2017**	**2006**	**2017**	**2006**	**2017**
Tertiary gross enrolment rate (%)	34.2	70.7	39.9	60.5	64.3	74.3
	2016		**2016**		**2016**	
Tertiary graduates by field (%) - Education	9.1		16.0		9.8	
Tertiary graduates by field (%) - Health	16.3		13.8		14.5	
Tertiary graduates by field (%) - Engineering	16.0		12.5		14.6	
Promoting an inclusive digital society	**Peru**		**LAC**		**OECD**	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**
E-waste generated, kilograms per inhabitant	5.6	5.8	6.9	7.2	17.7	17.7
	2015	**2018**	**2015**	**2018**	**2015**	**2018**
Number of students per computer	2.2	1.4	2.4	1.6	1.8	1.1
	2018		**2018**		**2018**	
Percentage of women scoring at Level 2 or 3 in problem solving in technology-rich environments	6.3		7.7		27.7	
Strengthening trust	**Peru**		**LAC**		**OECD**	
	2020		**2020**		**2020**	
CAF GovTech Index	4.0		4.4		N/A	
	2016	**2018**	**2016**	**2018**	**2016**	**2018**
Global Cybersecurity Index (ITU)	0.32	0.40	0.36	0.43	0.56	0.79
	2018	**2019**	**2018**	**2019**	**2018**	**2019**
E-commerce safety (%)	64.6	72.5	72.0	63.1	61.7	58.3
Trust in online privacy (%)	52.0	75.5	52.8	54.9	41.7	45.6
Fostering market openness	**Peru**		**LAC**		**OECD**	
	2015	**2019**	**2015**	**2019**	**2015**	**2019**
OECD Digital Services Trade Restrictiveness Index	N/A	N/A	0.24	0.24	0.13	0.15
	2018		**2018**		**2018**	
OECD FDI RRI	0.08		0.07		0.06	

Source: OECD (2020a, p.301)

Table C-2. Stage of digitalization in Latin America, 2011

Stage	Country	Index
Transitional	Chile	45.33
	Panama	44.29
	Uruguay	42.78
	Argentina	41.32
	Colombia	38.33
	Costa Rica	37.33
	Mexico	37.05
	Brazil	36.61
Emerging	Ecuador	32.75
	Venezuela	32.60*
	Peru	32.20
	Dominican Republic	29.93
	El Salvador	29.56
	Paraguay	28.68
	Honduras	22.98*
Constrained	Cuba	19.87
	Bolivia	19.85*
	Nicaragua	17.70*

Note: *Computed out of five rather than six components due to missing data

Source: Table 5 in Katz, Koutroumpis, and Callorda (2013, p. 13)

Table C-3. Imports of the digital sector, 2019

	Imports as % of digital sector gross value-added	Imports as % of digital sector gross output
Singapore	1.750	0.407
Malaysia	0.997	0.285
S. Korea	0.458	0.149
China	0.326	0.086
Indonesia	0.210	0.114
Canada	0.165	0.093
Thailand	0.133	0.057
Australia	0.088	0.045
Japan	0.088	0.043
USA	0.075	0.046
India	0.047	0.033

Source: ADB (2021) citing Calculations of the Digital Economy Measurement Framework study team, using the 38-sector Asian Development Bank Multiregional Input-Output Tables 2019.

APPENDIX D. Manual for Measuring Peru's Digital Economy Using the Steps Implemented by the ADB Digital Economy Team

Step 1. Download the files Matriz de Producción (Nivel 365, Valores a Precios Constantes) and the Cuadro de Oferta y Utilización (Nivel 365, Valores a Precios Constantes de 2007) from the INEI website.

Step 2: Paste in the appropriate worksheet in the ADB Digital Economy's **Excel template**: Matriz de Producción in the Supply worksheet, and the Cuadro de Oferta y Utilización in the Use worksheet. The information in these two worksheets will be called by the other worksheets to transform the SUT into an IOT. **NB:** Ensure that the matrix size, and column and row headings of the downloaded files are similar to those of the template; otherwise, adjust as one would Excel cell functions for the size of the matrices and revise the headings in the template to be consistent with the actual supply and use matrices being used.

Step 3: The functions in the worksheet "Input Output" will automatically call the worksheets "Margins", "Taxes", "Imports", "Use at bp", and "Transformation".

Step 4: The Input Output worksheet will be reordered wherein the core digital sectors will be presented as a block before the non-digital sector. This is done by identifying the industries comprising the core digital sector in the "Mapping" worksheet. Industries in the core digital sector are assigned values of 1.

Step 5: Reordered presents the IOT which has the industries in the core digital sector presented above/to the left of the non-digital sector.

Step 6: From the Reordered IOT, matrices A, V, B, and Y are calculated. The worksheets of the same name contain the functions to calculate these matrices.

Step 7: With the needed matrices calculated, the worksheet VBY, which contains the total value-added flows, is thus computed.

Step 8: Using the sector shares to total output as the last resort in the absence of data on gross fixed capital formation (GFCF) per industry, the VBYr or the matrix of fixed capital by industry is calculated.

Step 9: The functions in the "Summary" worksheet call the relevant cells in the worksheets VBY and VBYr. The Summary worksheet will calculate the four items in the digital economy equation. The backward linkage will sum up the rows of the first 11 columns of industries. The forward linkage is the sum of the columns of the first 11 rows of industries. The double counted items (corresponding to the 11 row-11 column block of the core digital sectors) are computed. Finally, the backward link to the suppliers of GFCF to the core digital sector is calculated using data from the VBYr worksheet. These backward linkages (as intermediate inputs and as GFCF inputs) and the forward linkages are summed, and the double counted item is deducted to arrive at the value of the digital economy. Since this is in constant value terms, the real gross domestic product is used to arrive at the share of the digital economy to the total economy.