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Measuring the Digital Economy

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Asian Development Bank

23 June 2021 | Asian Impact Webinar

The Core of the Digital Economy: A Proposed Framework

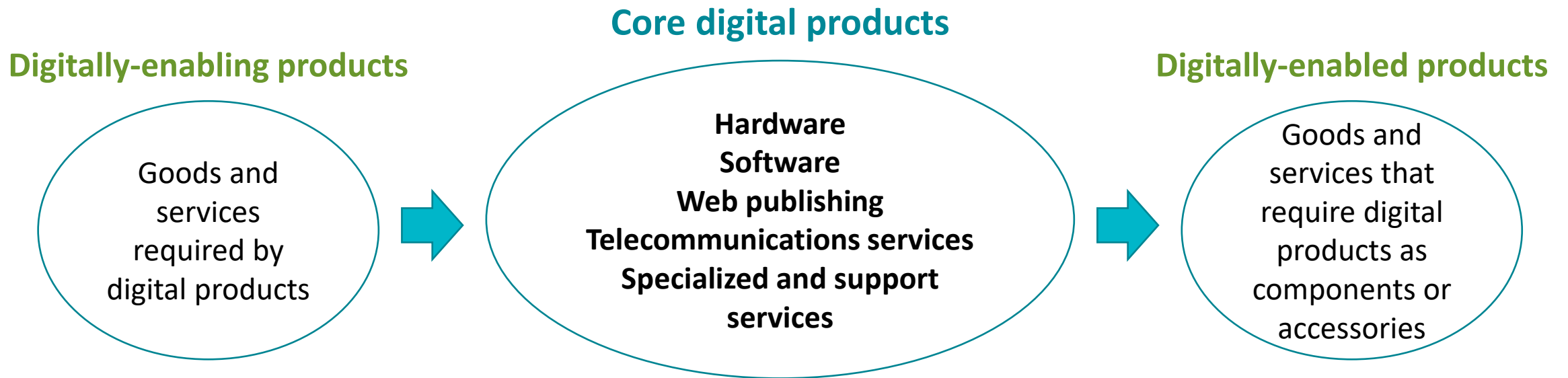
The Digital Economy

- Lack of consensus on an established framework to estimate the digital economy
- Our Framework:
 - Defines the digital economy
 - Measures % of GDP attributable to the digital economy
 - Requires National Accounts data

The Digital Economy

Digital economy - GDP involving digital products / industries

Digital products / industries - main function of generating, processing and/or storing digitized data



Methodological Requirements

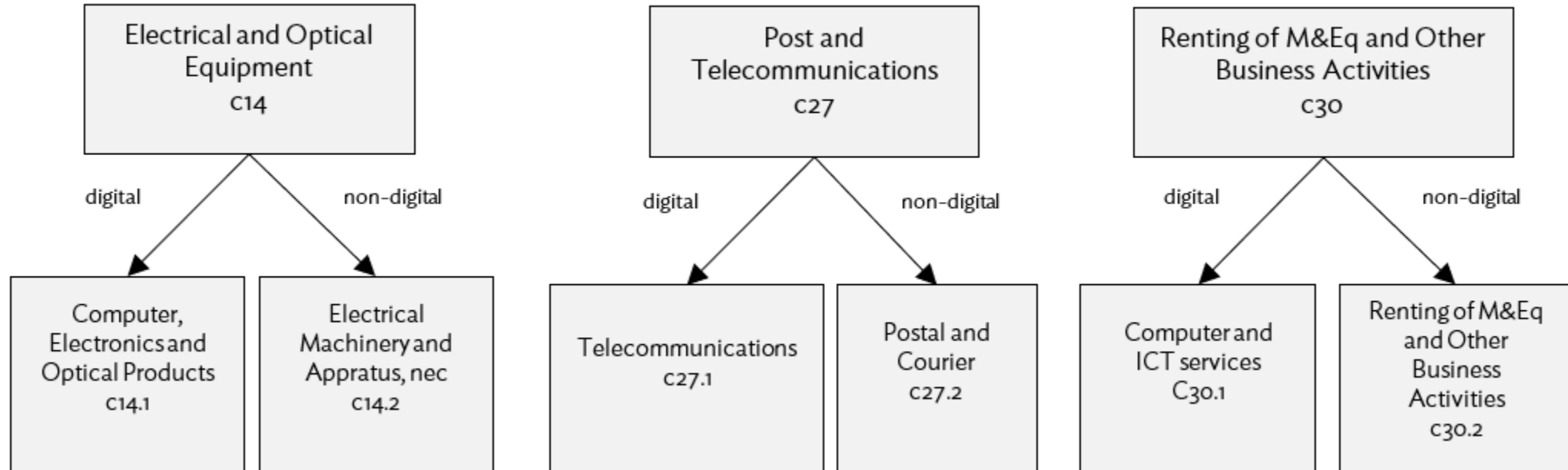
National estimates:

- Input-output tables (IOTs) or supply-and-use tables (SUTs)
- Uniformity across national tables
- Disaggregating products and industries

Methodological Requirements

Regional/ global estimates:

- ADB Multiregional input-output tables (MRIOs) with digital sectors



Theoretical Framework

- Rooted in input-output analysis, using the $\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}$ matrix:
 - \mathbf{v} – direct value-added coefficient vector
 - \mathbf{B} – Leontief inverse matrix $(\mathbf{I} - \mathbf{A})^{-1}$ (the total output requirements from each industry in order to meet final demand for a specific time period)
 - \mathbf{y} – final demand vector
- Digital GDP equation:

$$\text{GDP}_{\text{digital}} = \mathbf{i}^T \hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\boldsymbol{\varepsilon}_1 + \mathbf{i}^T (\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})^T \boldsymbol{\varepsilon}_1 - [\text{diag}(\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})]^T \boldsymbol{\varepsilon}_1 + (\mathbf{i} - \boldsymbol{\varepsilon}_1)^T \hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\hat{\mathbf{r}}\boldsymbol{\varepsilon}_2$$

Theoretical Framework

- Assume that industry 1 is the digital sector
- Term 1: $\mathbf{i}^T \hat{\mathbf{v}} \mathbf{B} \hat{\mathbf{y}} \boldsymbol{\varepsilon}_1$
- Represents the backward linkage of the digital sector

$$\hat{\mathbf{v}} \mathbf{B} \hat{\mathbf{y}} = \begin{bmatrix} v_1 b_{11} y_1 & v_1 b_{12} y_2 & \dots & v_1 b_{1n} y_n \\ v_2 b_{21} y_1 & v_2 b_{22} y_2 & \dots & v_2 b_{2n} y_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n b_{n1} y_1 & v_n b_{n2} y_2 & \dots & v_n b_{nn} y_n \end{bmatrix}$$

Theoretical Framework

- Assume that industry 1 is the digital sector
- Term 2: $\mathbf{i}^T (\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})^T \boldsymbol{\varepsilon}_1$
- Represents the forward linkage of the digital sector

$$\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}} = \begin{bmatrix} v_1 b_{11} y_1 & v_1 b_{12} y_2 & \dots & v_1 b_{1n} y_n \\ v_2 b_{21} y_1 & v_2 b_{22} y_2 & \dots & v_2 b_{2n} y_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n b_{n1} y_1 & v_n b_{n2} y_2 & \dots & v_n b_{nn} y_n \end{bmatrix}$$

Theoretical Framework

- Assume that industry 1 is the digital sector
- Term 3: $-\text{diag}(\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})^T \boldsymbol{\varepsilon}_1$
- Represents the double-counted term

$$\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}} = \begin{bmatrix} \mathbf{v}_1 \mathbf{b}_{11} \mathbf{y}_1 & v_1 b_{12} y_2 & \dots & v_1 b_{1n} y_n \\ v_2 b_{21} y_1 & v_2 b_{22} y_2 & \dots & v_2 b_{2n} y_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n b_{n1} y_1 & v_n b_{n2} y_2 & \dots & v_n b_{nn} y_n \end{bmatrix}$$

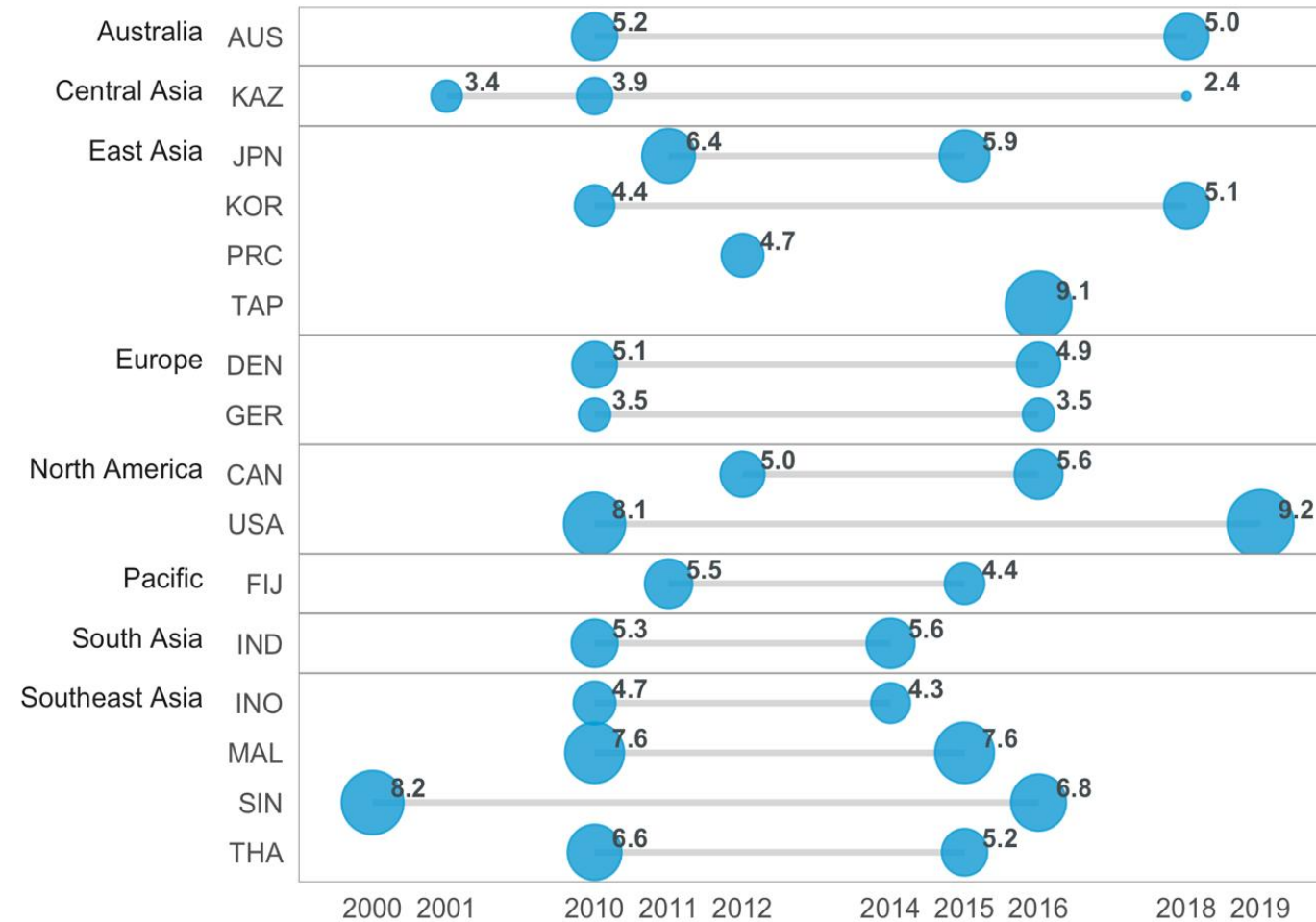
Theoretical Framework

- Assume that industry 1 is the digital sector
- Term 4: $(\mathbf{i} - \boldsymbol{\varepsilon}_1)^T \hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\hat{\mathbf{r}}\boldsymbol{\varepsilon}_2$
- Represents fixed capital investments by the digital sector for goods produced by non-digital industries
- $\hat{\mathbf{r}}$ – diagonalized vector of ratios of gross fixed capital formation (GFCF) used by the digital industry to the corresponding final demand

$$\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\hat{\mathbf{r}} = \begin{bmatrix} v_1 b_{11} y_1 r_1 & v_1 b_{12} y_2 r_2 & \dots & v_1 b_{1n} y_n r_n \\ v_2 b_{21} y_1 r_1 & v_2 b_{22} y_2 r_2 & \dots & v_2 b_{2n} y_n r_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n b_{n1} y_1 r_1 & v_n b_{n2} y_2 r_2 & \dots & v_n b_{nn} y_n r_n \end{bmatrix}$$

Digital Economy Estimates

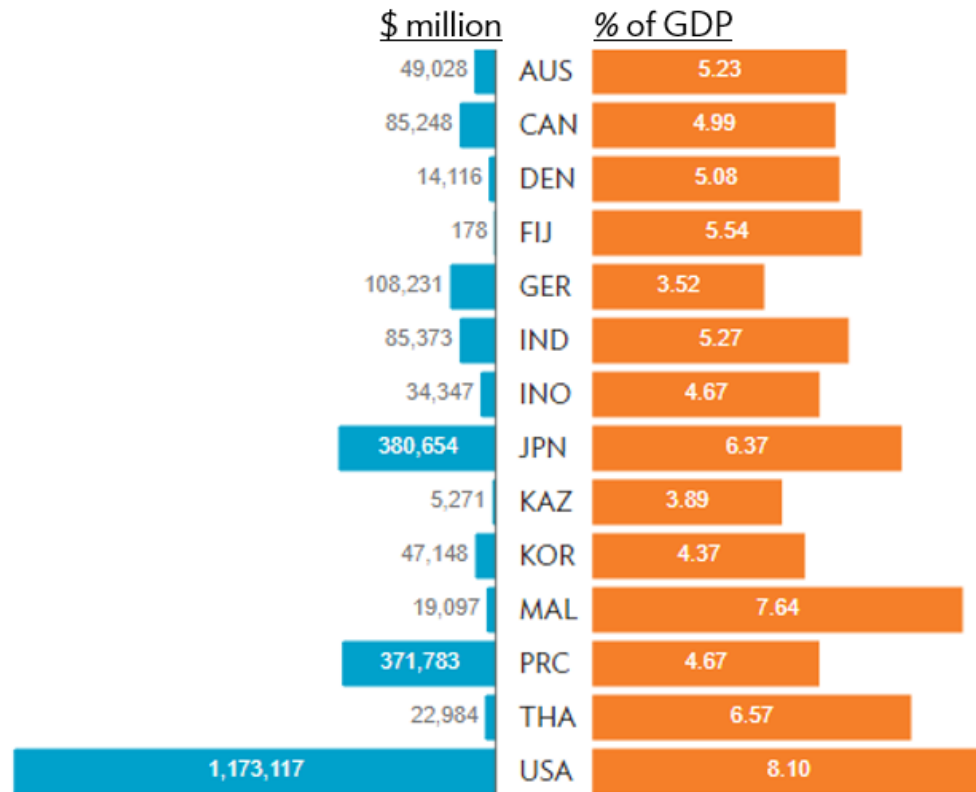
Digital GDP as a percentage of GDP



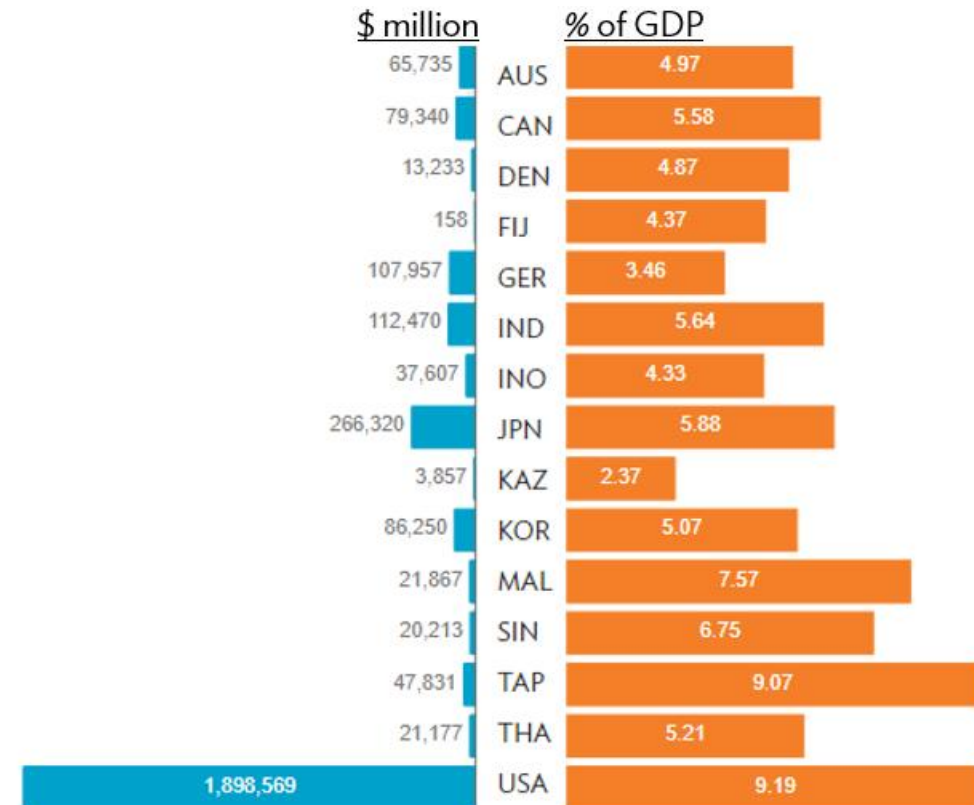
AUS = Australia; CAN = Canada; PRC = People's Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei, China; THA = Thailand; USA = United States.
Note: Point size reflects size of the digital economy.

Size of the digital economy

Period 1
(data within 2007 to 2012)



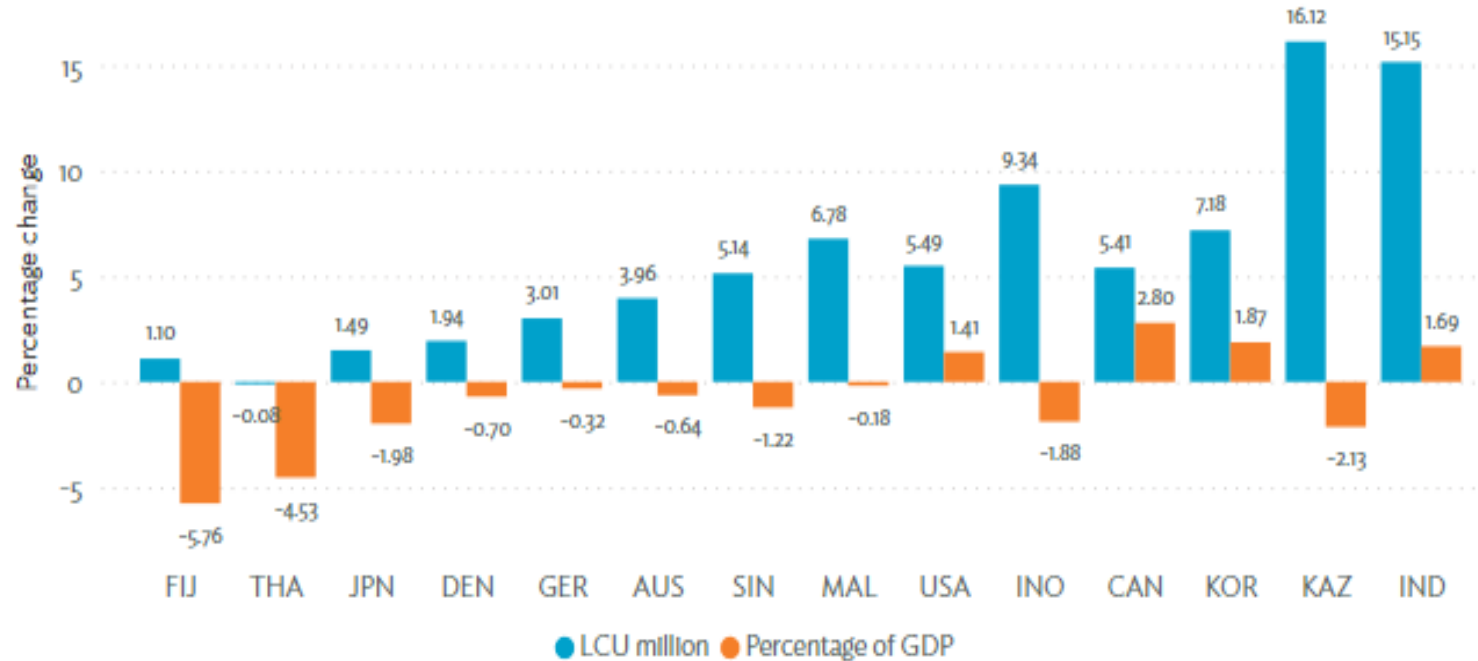
Period 2
(data within 2014 to 2019)



AUS = Australia; CAN = Canada; PRC = People's Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei, China; THA = Thailand; USA = United States. Period 1 = years 2007 to 2012. Period 1 for AUS is 2010; CAN, 2012; PRC, 2012; GER, 2010; DEN, 2010; FIJ, 2011; IND, 2010; INO, 2010; JPN, 2011; KAZ, 2010; KOR, 2010; MAL, 2010; THA, 2010; and USA, 2010. Period 2 = years 2014 to 2019. Period 2 for AUS is 2018; CAN, 2016; GER, 2016; DEN, 2016; FIJ, 2015; IND, 2014; INO, 2014; JPN, 2018; KAZ, 2018; KOR, 2018; MAL, 2015; SIN, 2015; TAP, 2016; THA, 2015; and USA, 2019

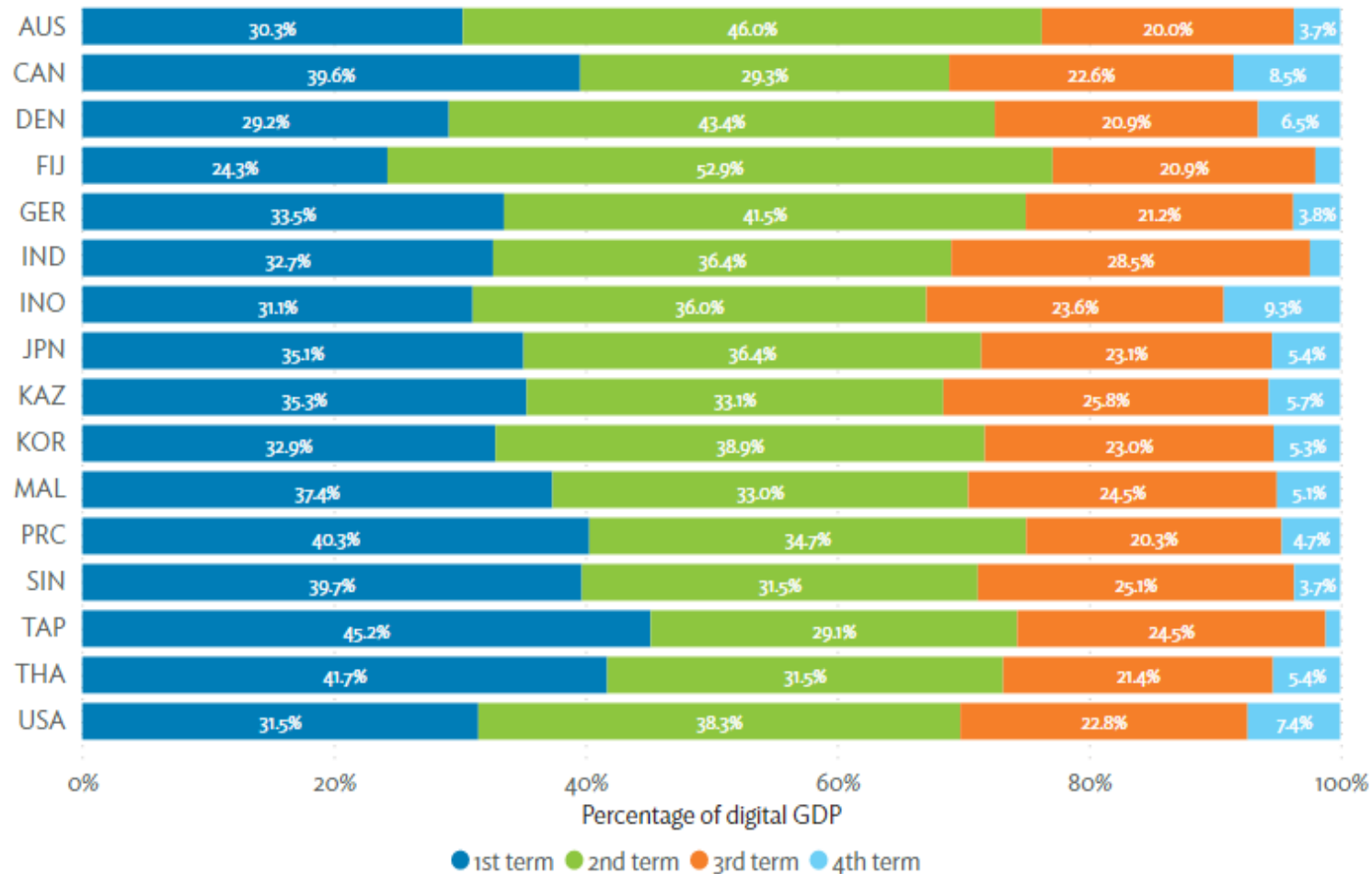
Note: The average is presented in economies for which calculations were made for multiple years

Compound annual growth rates



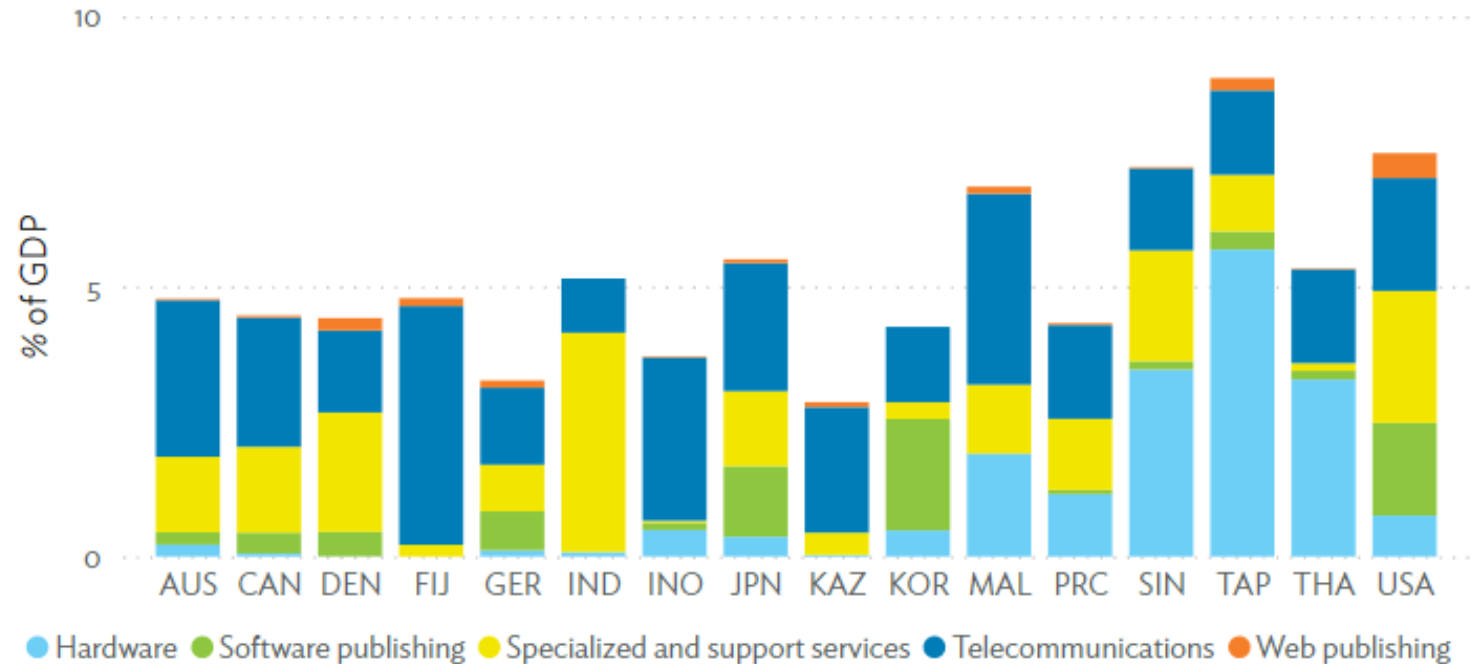
AUS = Australia; CAN = Canada; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; LCU = local currency unit; MAL = Malaysia; SIN = Singapore; THA = Thailand; USA = United States. First and latest years used to compute CAGR for AUS are 2010 and 2018; CAN, 2012, 2016; GER, 2010, 2016; DEN, 2010, 2016; FIJ, 2011, 2015; IND, 2010, 2014; INO, 2010, 2014; JPN, 2011, 2015; KAZ, 2001, 2018; KOR, 2010, 2018; MAL, 2010, 2015; SIN, 2000, 2016; THA, 2010, 2015; USA, 2010, 2019.

Digital economy structure by term



AUS = Australia; CAN = Canada; PRC = People's Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei, China; THA = Thailand; USA = United States. Years included for AUS are 2010 and 2018; CAN, 2012, 2016; PRC, 2012; GER, 2010, 2016; DEN, 2010, 2016; FIJ, 2011, 2015; IND, 2010, 2014; INO, 2010, 2014; JPN, 2011, 2015; KAZ, 2010, 2018; KOR, 2010, 2018; MAL, 2010, 2015; SIN, 2016; TAP, 2016; THA, 2010, 2015; USA, 2010, 2019. 1st term = backward linkage of the digital sector, 2nd term = forward linkage of the digital sector, 3rd term = double counted term or the digital sector's value-added contribution to its own final goods, 4th term = the non-digital products capitalized by the digital sector.

Digital economy structure by industry



AUS = Australia; CAN = Canada; PRC = People’s Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei,China; THA = Thailand; USA = United States. Years included for AUS are 2010 and 2018; CAN, 2012, 2016; PRC, 2012; GER, 2010, 2016; DEN, 2010, 2016; FIJ, 2011, 2015; IND, 2010, 2014; INO, 2010, 2014; JPN, 2011, 2015; KAZ, 2001, 2010, 2018; KOR, 2010, 2018; MAL, 2010, 2015; SIN, 2000, 2016; TAP, 2016; THA, 2010, 2015; USA, 2010, 2019.

Digital Dependence

Forward linkages of the digital sector (normalized by economy's digital sector size)

Industry	AUS	DEN	INO	JAP	KOR	PRC	THA
Air transport			2.1				
Architectural and engineering activities		3.2				2.6	
Construction	6.5	2.5	11.9	1.7	2.2	12.3	
Education	4.4	3.1	4.7		3.9	2.1	1.9
Electronic, electrical and optical equipment			1.9		4.6	15.3	19.4
Financial intermediation	19.2	3.2	1.8	4.9	5.0		1.6
Food, beverages, and tobacco			3.6	1.3			
Health and social work	5.9	5.5		4.1	1.9	2.0	
Hotels and restaurants				2.6	2.2		1.8
Leather, leather products, and footwear							1.4
Machinery, nec				1.2		5.1	
Manufacturing, nec; recycling							0.7
Pharmaceuticals		3.7					
Post and telecommunications					2.9		
Public administration and defense; compulsory social security	15.5	11.3	3.5	5.5	4.6	5.8	
Real estate activities	5.2	4.9		1.5			
Renting of M&Eq and other business activities	3.8						3.8
Research and development				4.2	3.1		
Textiles and textile products			1.7				
Transport equipment					2.4	2.6	
Wholesale and retail trade	17.5	15.8	3.4	11.7	11.2		2.4

AUS = Australia; PRC = People's Republic of China; DEN = Denmark; INO = Indonesia; JPN = Japan; KOR = Republic of Korea; THA = Thailand

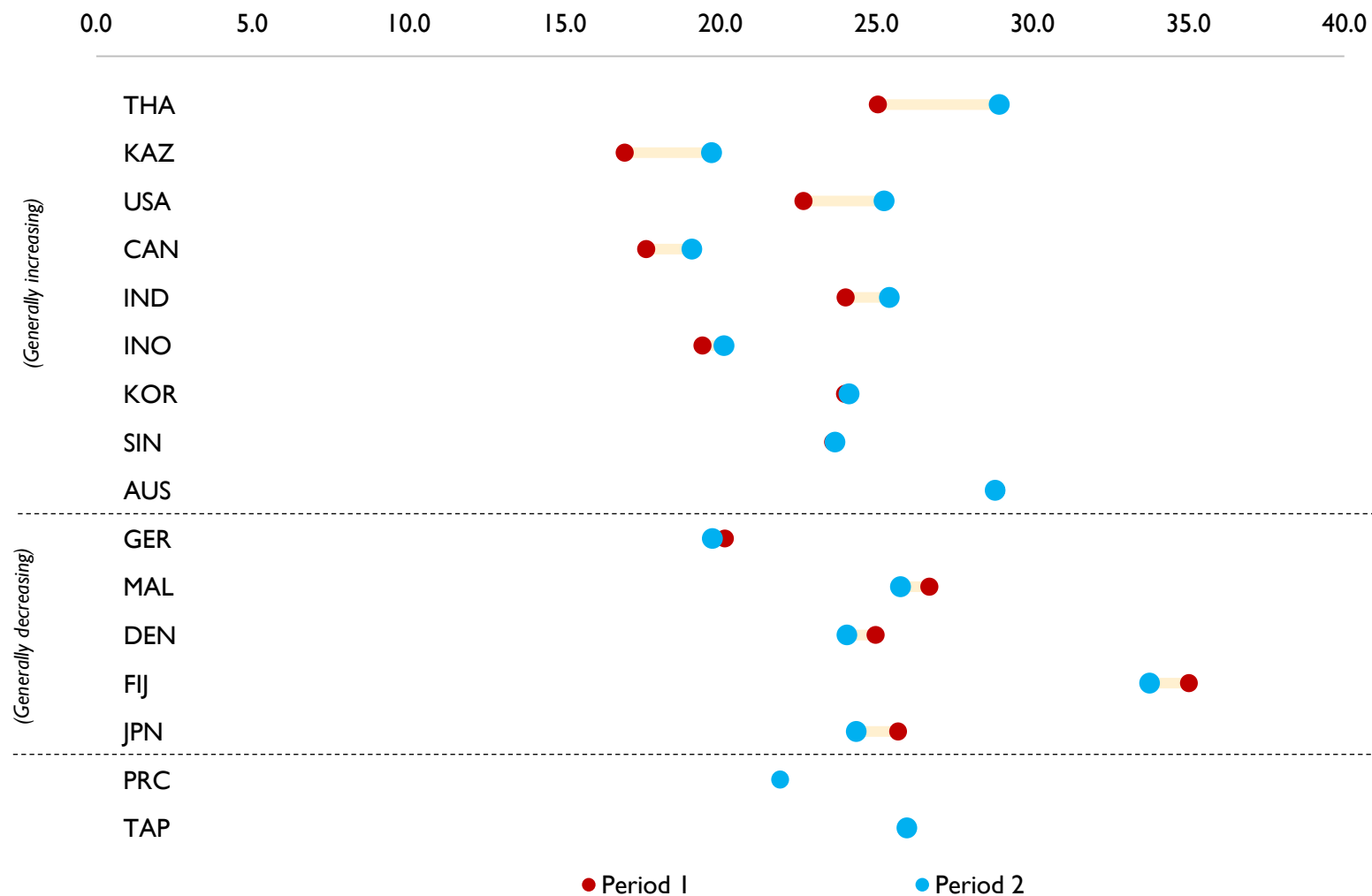
OECD's 10 digitally-disrupted sectors

Classification of Products by Activity

Code	Description
49	Land transport services and transport services via pipelines
55	Accommodation services
56	Food and Beverage serving services
58	Publishing services
59	Motion picture, video and television program production services, sound recording and music publishing
K	Financial and insurance services
73	Advertising and market research services
79	Travel agency, tour operator and other reservation services
P	Education services
92	Gambling and betting services
58	Publishing services

Source: Advisory Expert Group on National Accounts (2019)

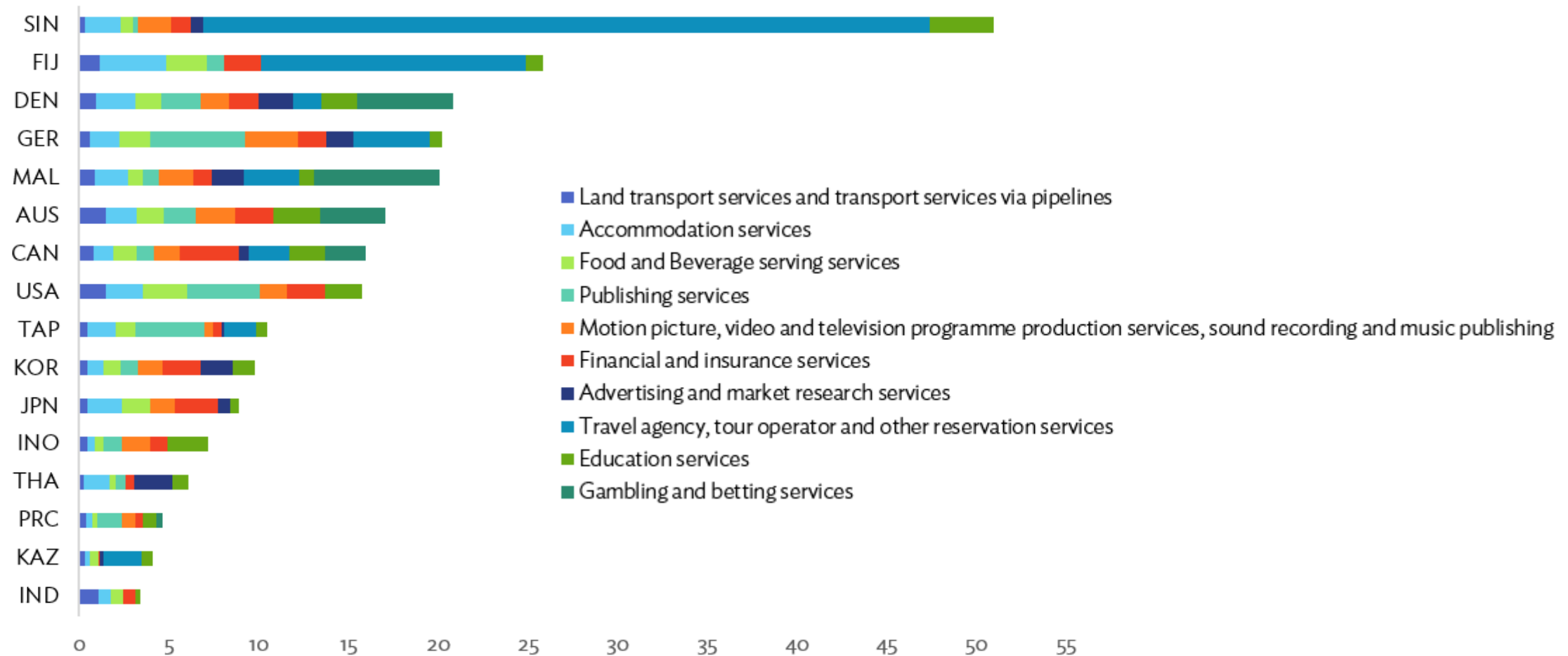
Digitally dependent economy (% of GDP)



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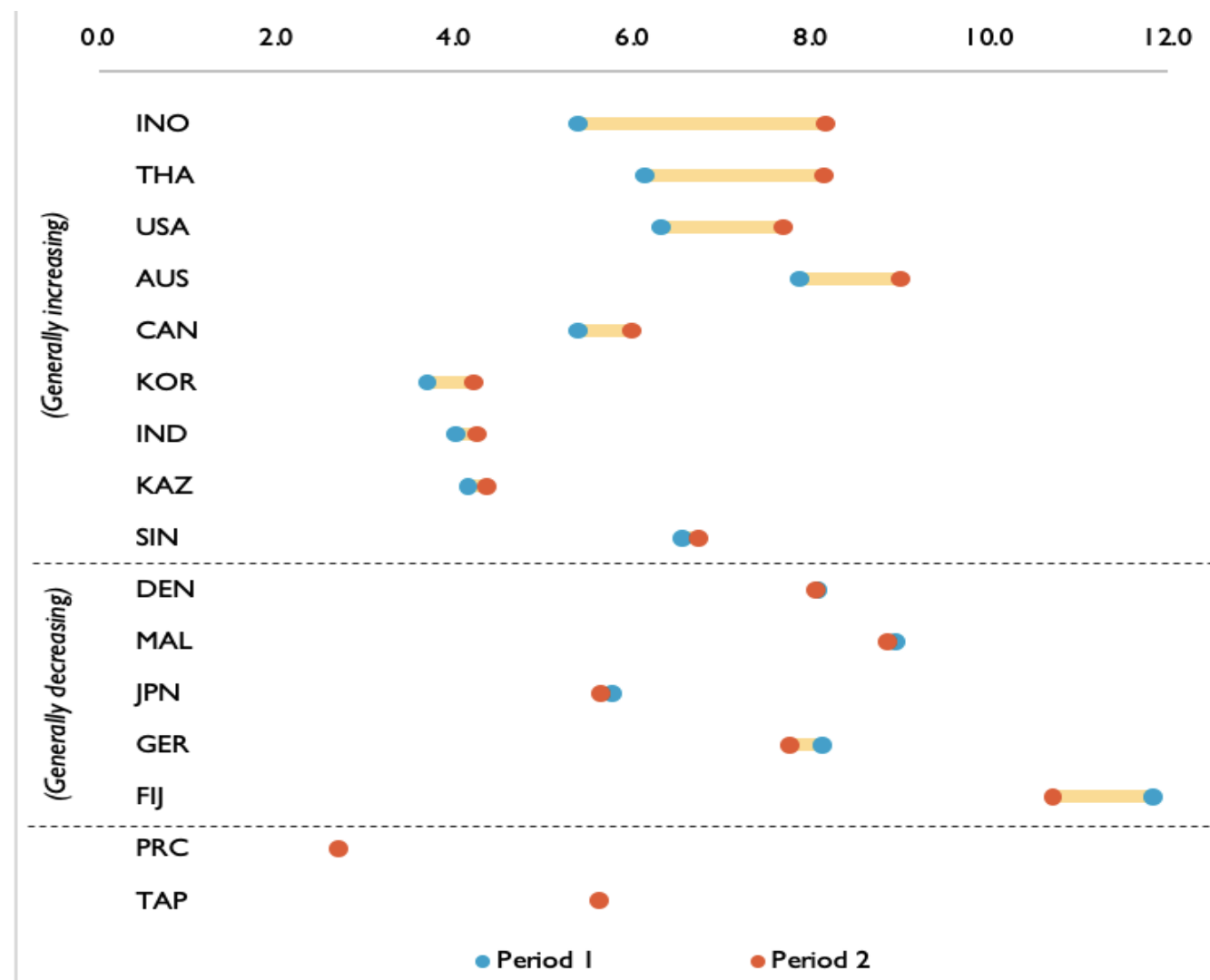
Digitally dependent economy

(% of respective sector size averaged across two periods)



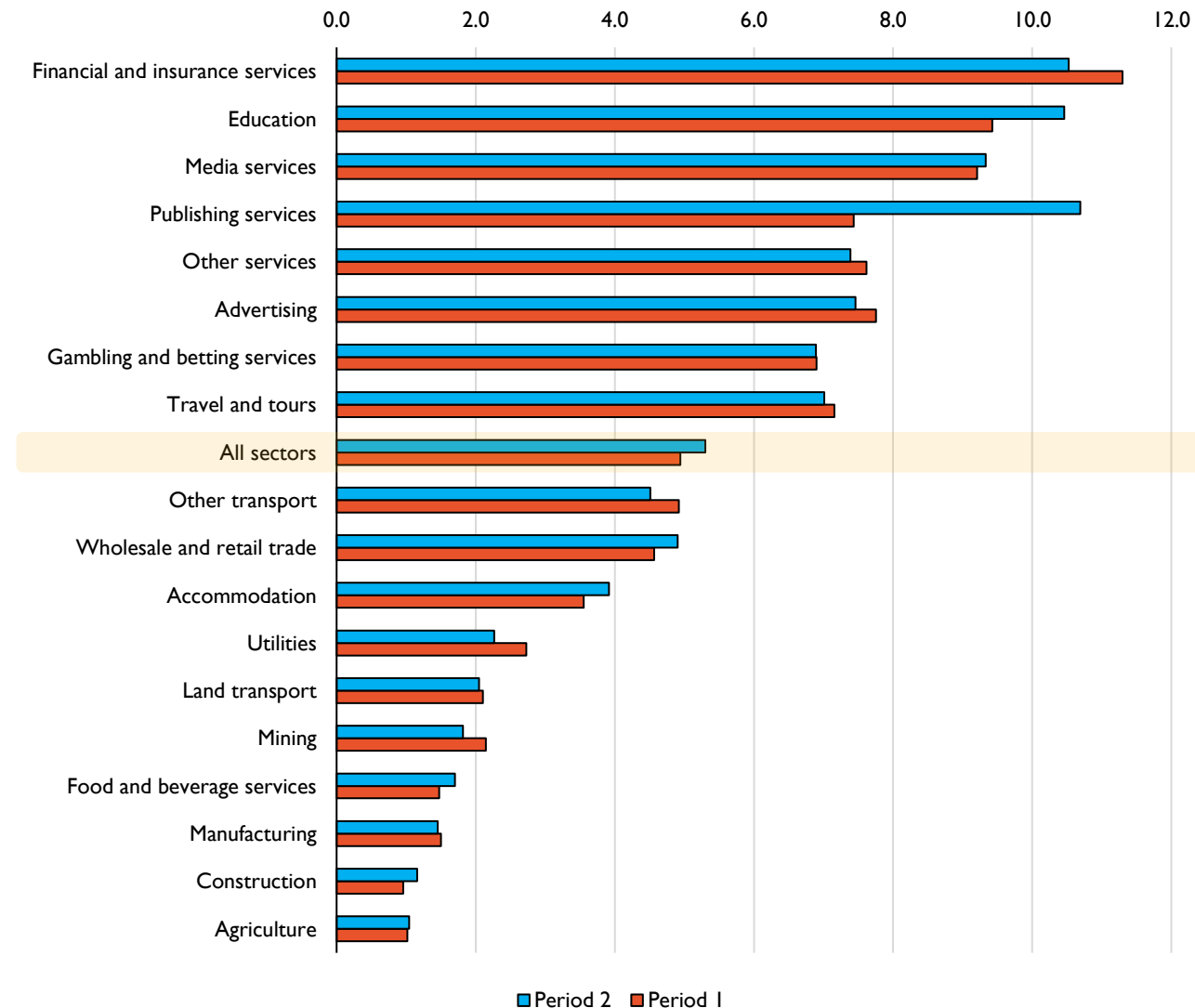
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Share of Digital Inputs to Total Intermediate Inputs (%)



AUS = Australia; CAN = Canada; PRC = People's Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei, China; THA = Thailand; USA = United States; Period 1 for AUS is 2010; CAN, 2012; GER, 2010; DEN, 2010; FIJ, 2011; IND, 2010; INO, 2010; JPN, 2011; KAZ, 2001; KOR, 2010; MAL, 2010; SIN, 2000; THA, 2010; USA, 2010; Period 2 for AUS is 2018; CAN, 2016; PRC, 2012; GER, 2016; DEN, 2016; FIJ, 2015; IND, 2014; INO, 2014; JPN, 2015; KAZ, 2018; KOR, 2018; MAL, 2015; SIN, 2016; TAP, 2016; THA, 2015; USA, 2019.

Average Shares of Digital Inputs to Total Intermediate Inputs by Sector (%)



“Free” digital services and its links to data

Investments in ‘data’, ‘databases’, and ‘data science’ in India
select years, in current billion rupees

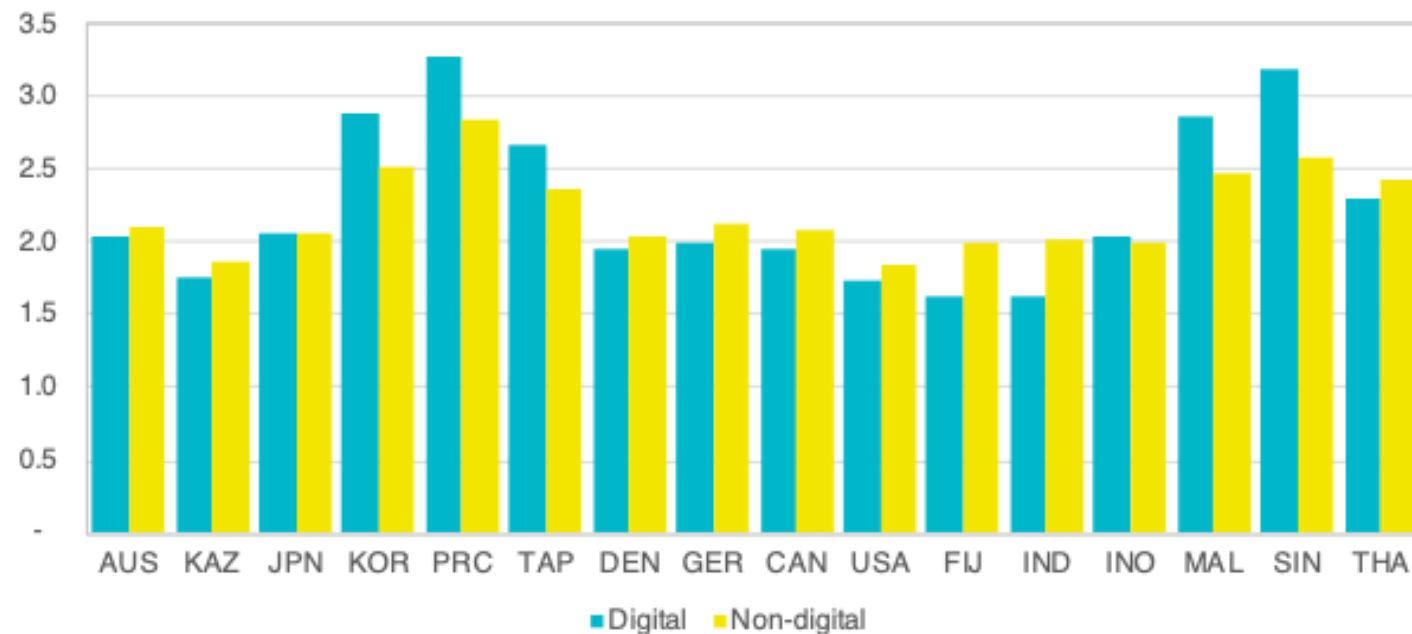
	2011	2013	2015	2017	2019
Total of all data-related categories					
Lower range value	914	867	1,040	1,407	1,663
Upper range value	1,102	1,045	1,256	1,702	2,004
‘Data’					
Lower range value	496	466	567	811	980
Upper range value	624	587	715	1,021	1,225
‘Databases’					
Lower range value	201	189	217	267	373
Upper range value	225	211	243	299	418
‘Data science’					
Lower range value	217	212	256	329	310
Upper range value	253	247	298	383	361
Net capital stock of all data-related categories					
Lower range value	2,944	3,392	3,802	4,540	5,511
Upper range value	3,631	4,189	4,701	5,610	6,794
Gross fixed capital formation*	29,977	35,156	39,571	48,156	58,513
<i>of which: Intellectual property products</i>	2,169	3,577	4,853	5,627	7,627

*official published figures from India’s Ministry of Statistics and Programme Implementation (MOSPI)

Source: ADB Staff Estimates following the approach of Statistics Canada (2019) and using 2011 Census data from India’s Office of the Registrar General and Census Commissioner, International Labor Organization, ADB Multi-Regional Input-Output Database, and India’s MOSPI

Other Applications and Analyses

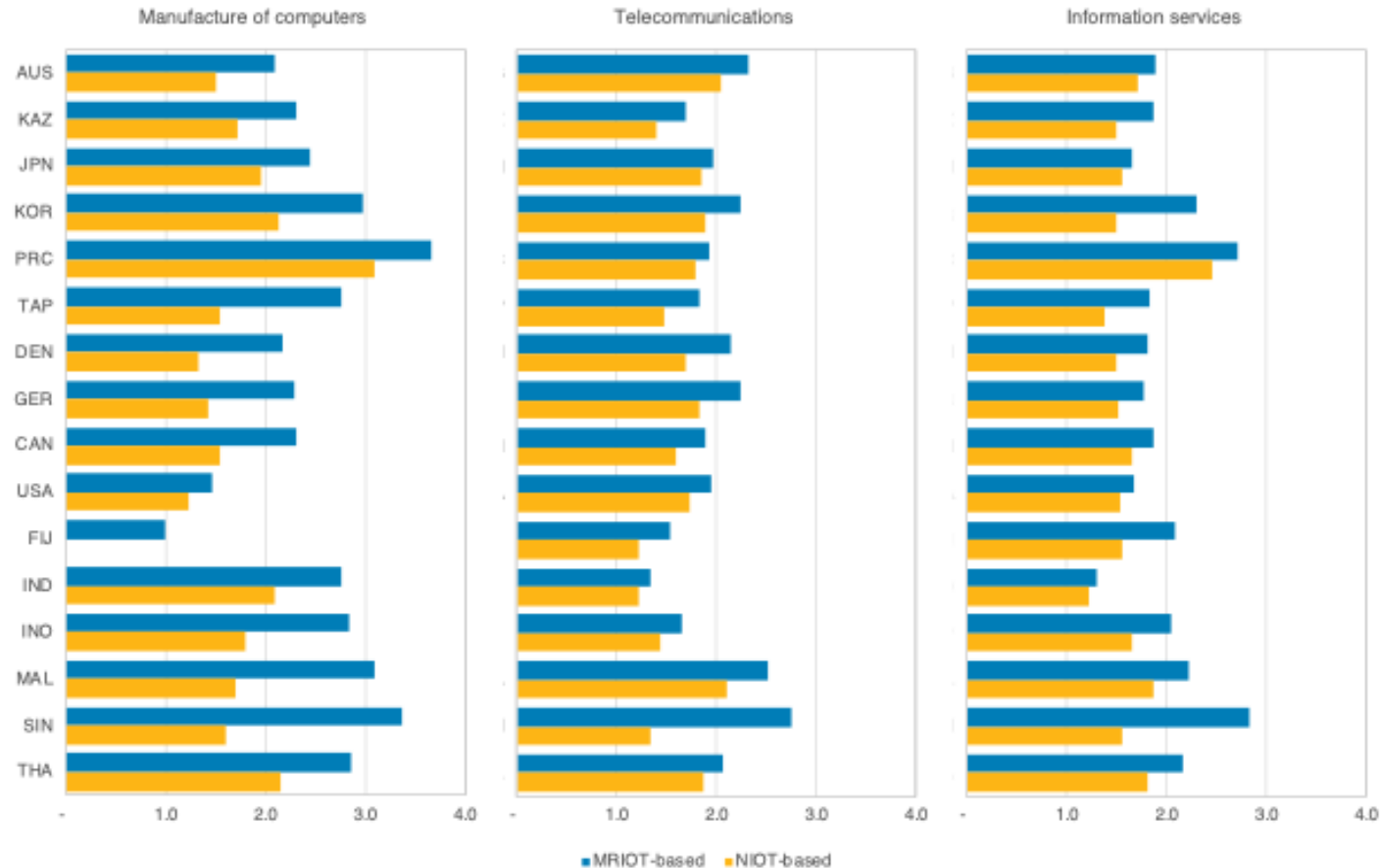
Weighted Average MRIOT-Based Output Multipliers of Digital and Non-Digital Sectors, 2019



AUS = Australia; CAN = Canada; PRC = People's Republic of China; GER = Germany; DEN = Denmark; FIJ = Fiji; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; SIN = Singapore; TAP = Taipei,China; THA = Thailand; USA = United States.

Source: Authors' calculations using 2019 38-sector Asian Development Bank Multiregional Input-Output Table (ADB MRIOT).

Digital Sector Output Multipliers MRIOTs vs. NIOTs, 2019

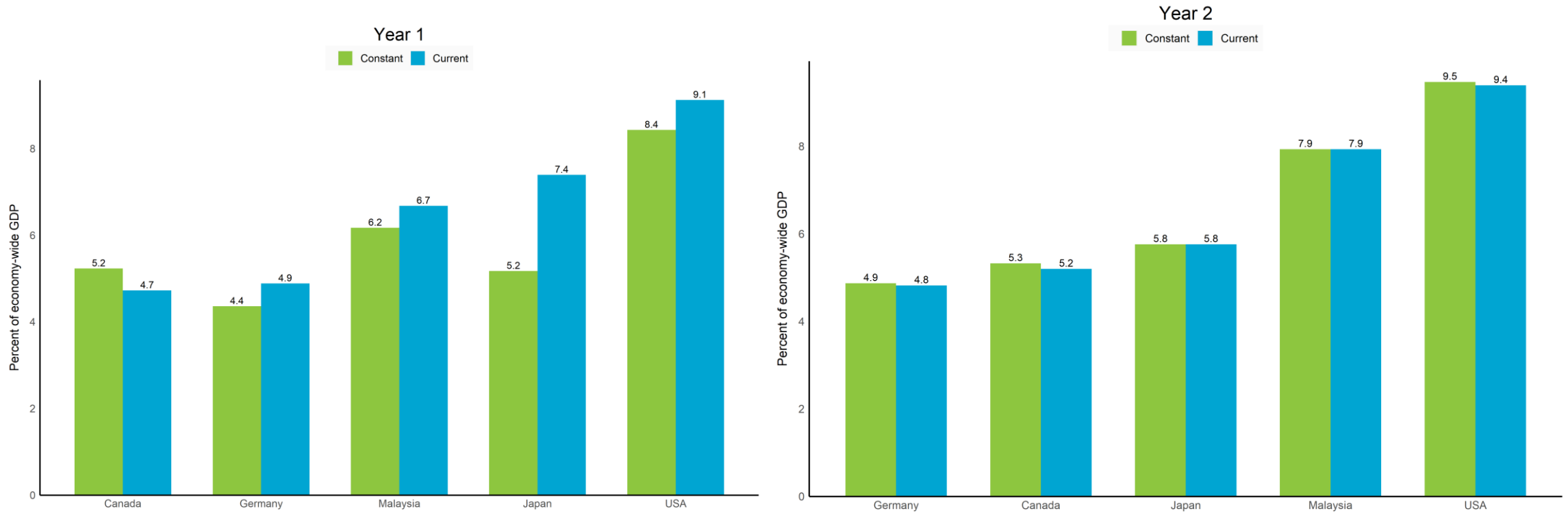


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Source: Authors' calculations using 2019 38-sector Asian Development Bank Multiregional Input-Output Table (ADB MRIOT). NIOT-based multipliers are computed using the NIOT extracted from the 2019 38-sector ADB MRIOT for sectoral and temporal comparability to MRIOT-based multipliers.

Temporal Comparative Analysis

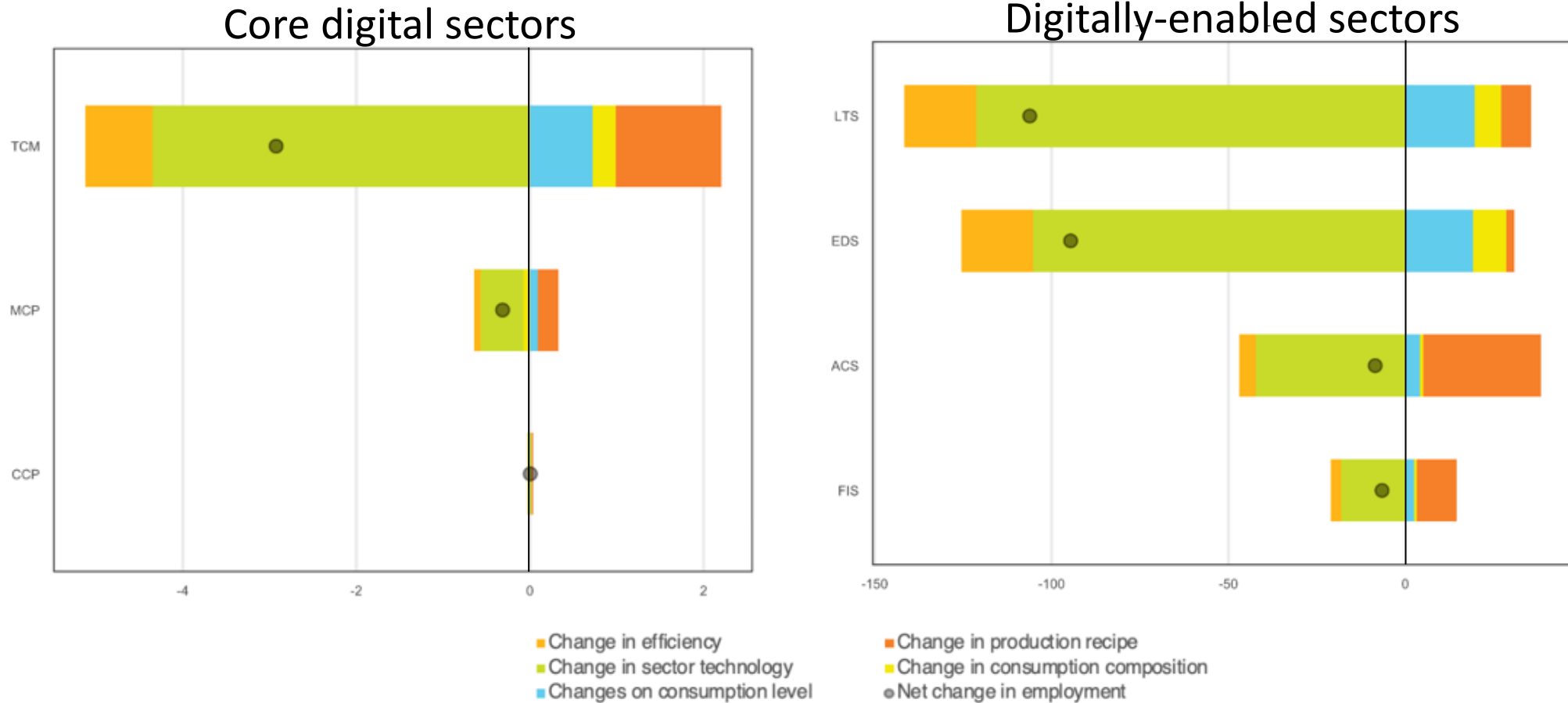
Digital Economy as a Percentage of Economy-Wide GDP



Source: SNA data from statistics offices; Asian Development Bank estimates.

Jobs in the Digital Economy

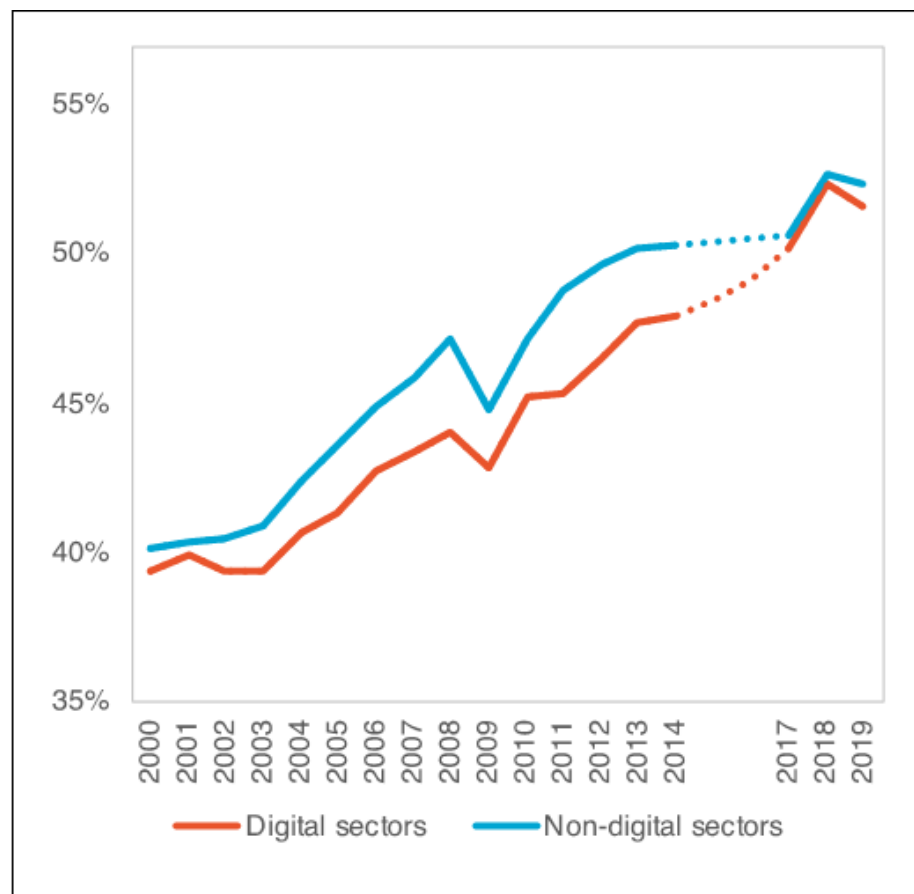
Change in employment in India's sectors, 2010 & 2014 (thousands)



TCM = Telecommunications; MCP = Manufacture of computers and peripheral equipment; CCP = Computer consultancy and related activities; information service activities.
 LTS = Land transport services and transport services via pipelines; EDS = Education services; ACS = Accommodation services; FIS = Financial and insurance services.

Digital Sectors in GVCs

Evolution of Total GVC Participation Rates of Digital and Non-Digital Sectors, World Average



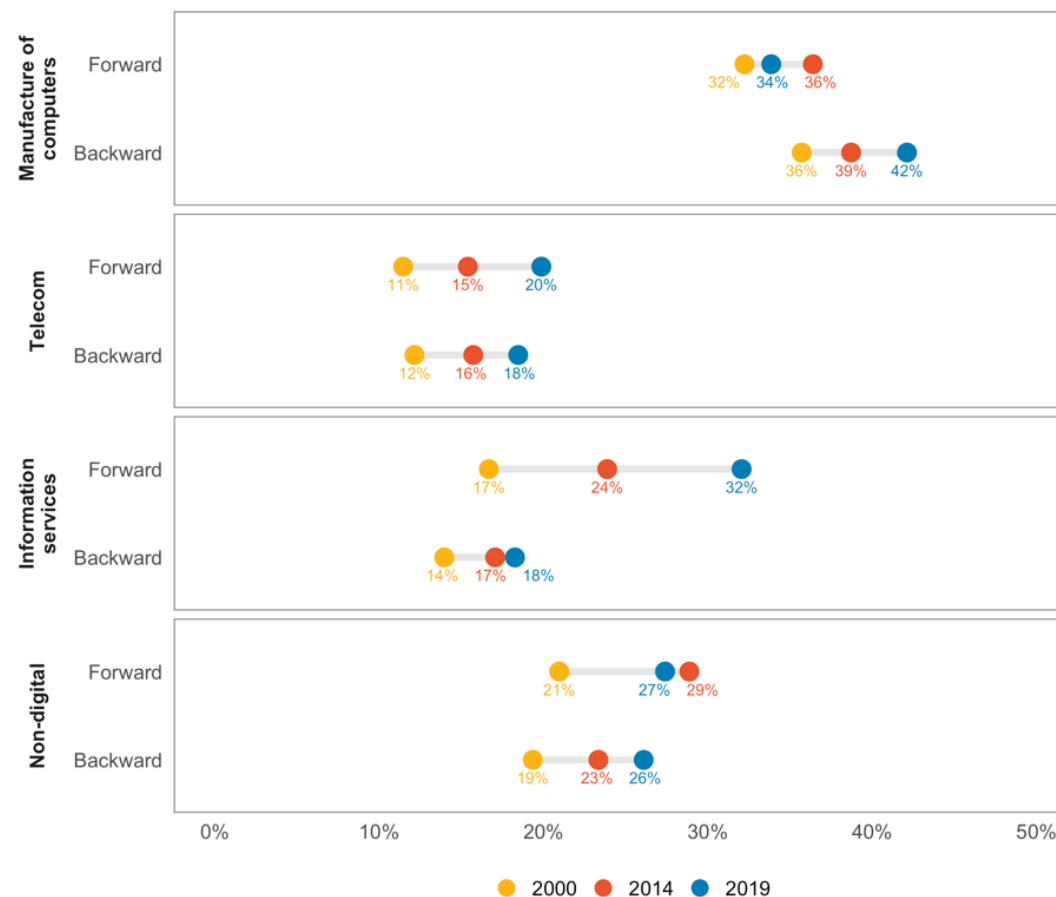
GVC = Global value chain; Digital sector = manufacture of computer, electronic and optical products sector, telecommunications sector, and computer programming, consultancy and related activities and information service activities sectors.

Note: ADB estimates are based on the methodology by Wang, Wei, Yu, and Zhu (2017). The world average of total GVC participation is computed by taking the sum of the world average of forward GVC participation and backward GVC participation. Certain economy-sectors were excluded in computing for the world average because of mathematical inconsistencies.

Source: World Input-Output Database Tables, 2000-2014; 38-sector Asian Development Bank Multiregional Input-Output Table 2017-2019

Digital Sectors in GVCs

GVC Participation Rates by Digital Sector, World Average



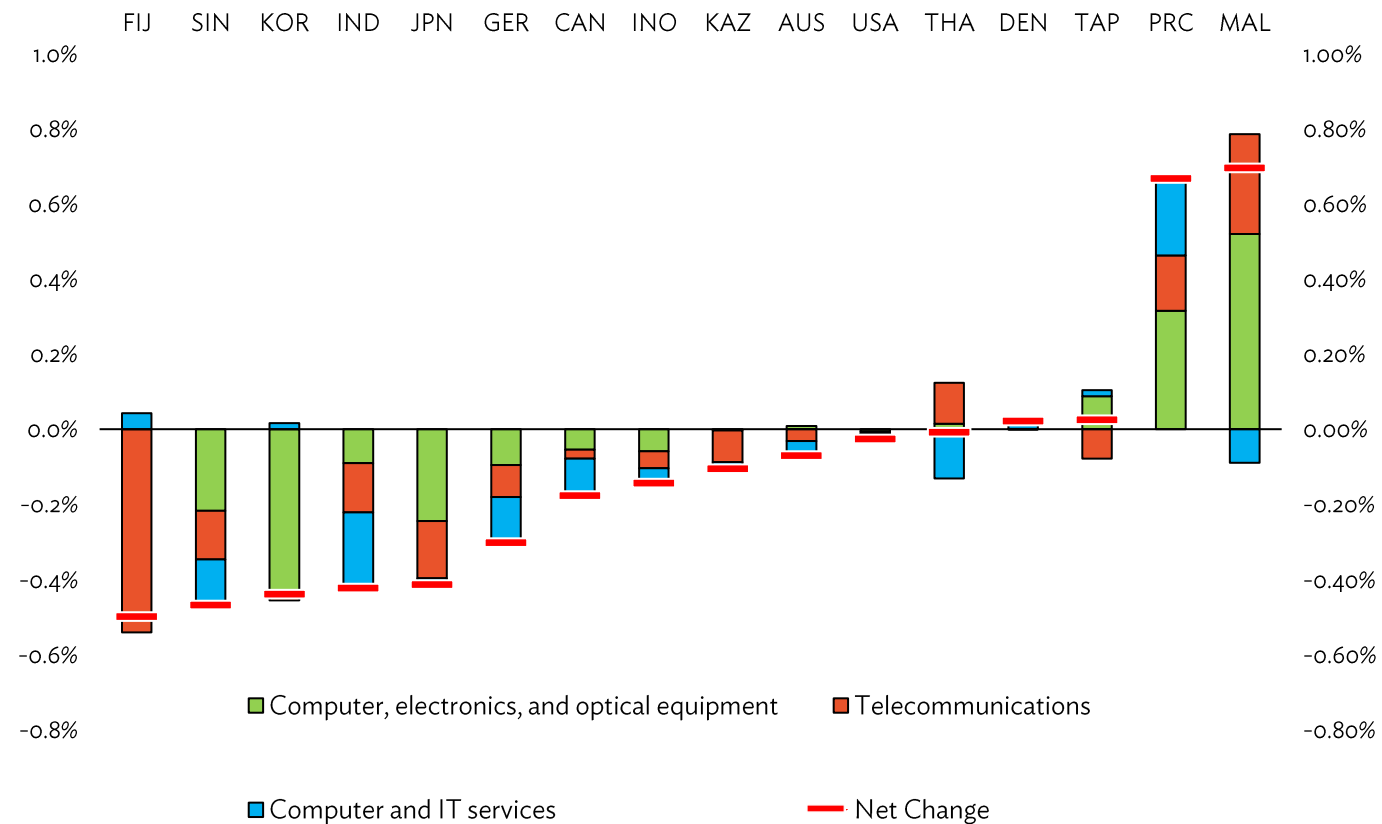
GVC = Global value chain; Manufacture of computers = Manufacture of computer, electronic and optical products sector; Telecom = Telecommunications sector; Information service = Computer programming, consultancy and related activities and information service activities sectors; Digital sector = manufacture of computer, electronic and optical products sector, telecommunications sector, and computer programming, consultancy and related activities and information service activities sectors.

Note: ADB estimates are based on the methodology by Wang, Wei, Yu, and Zhu (2017).

Source: World Input-Output Database Tables, 2000 and 2014; 38-sector Asian Development Bank Multiregional Input-Output Table 2019.

Digital in the Time of COVID-19

Changes in the Digital Economy in 2020, as % of 2019 GDP
By Digital Product

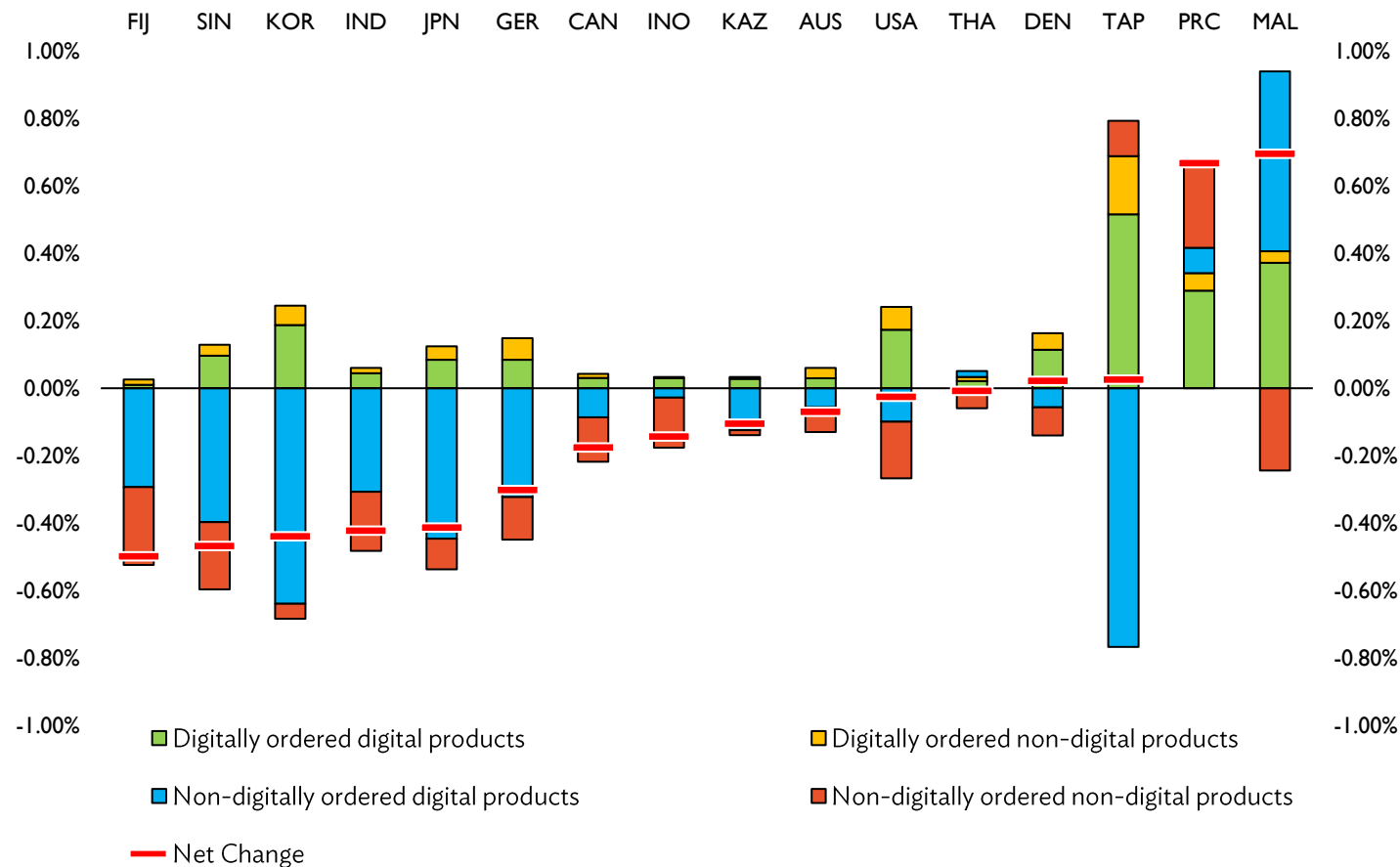


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 Source: Authors' calculations using 2019 38-sector Asian Development Bank Multiregional Input-Output Table (ADB MRIO) and 2020 35-sector ADB MRIO, national accounts, and various sources of digitally ordered shares to total sales.

Digital in the Time of COVID-19

Changes in the Digital Economy in 2020, as % of 2019 GDP

By Type of Demand

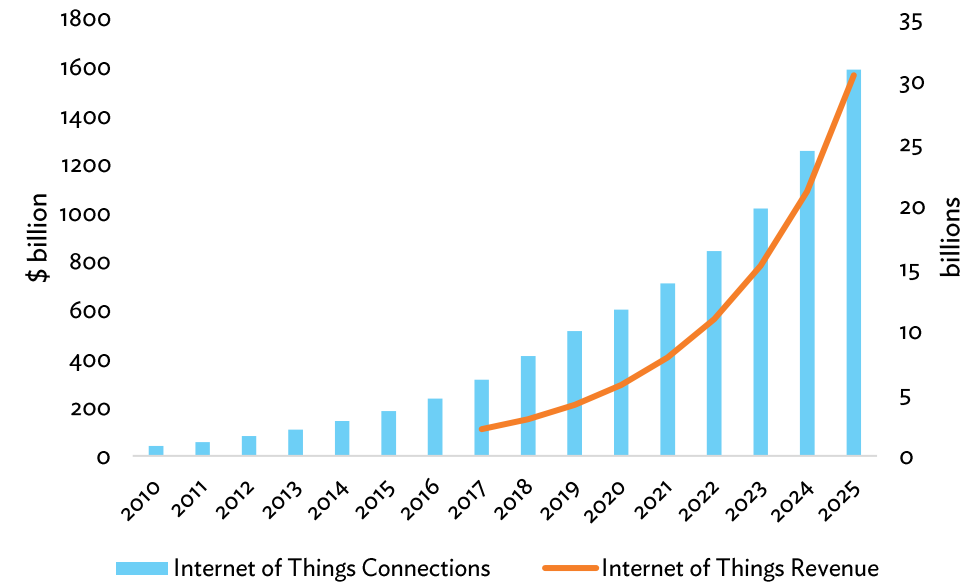
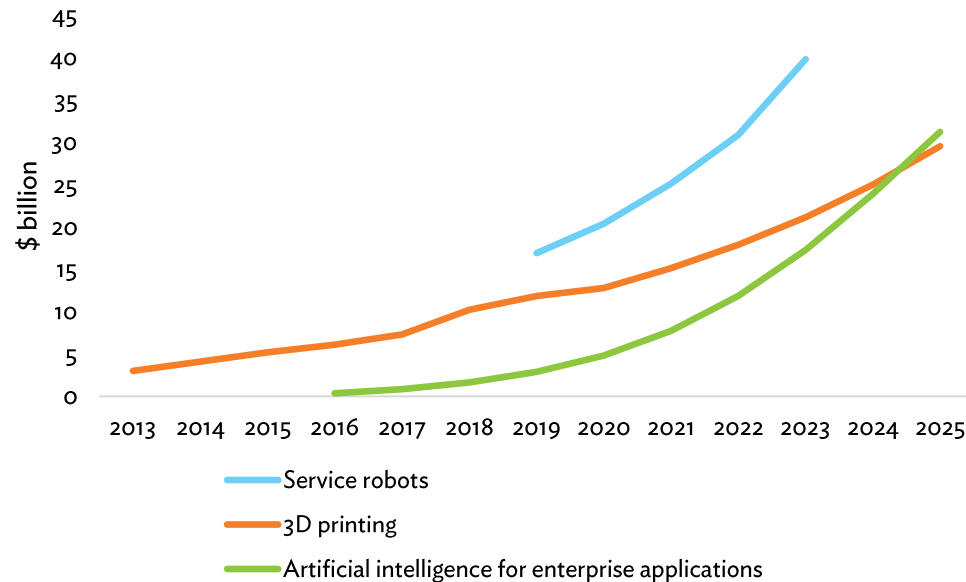


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Source: Authors' calculations using 2019 38-sector Asian Development Bank Multiregional Input-Output Table (ADB MRIO) and 2020 35-sector ADB MRIO, national accounts, and various sources of digitally ordered shares to total sales.

Industry 4.0

Global Industry 4.0 technology revenues



Note: Estimated CAGR was used to compute values for 2021-2022 of Service robots, 2021-2025 of 3D printing, and 2020-2025 of AI for enterprise applications.
 Sources: International Federation of Robotics 2020b, Autonomous Manufacturing 2020, Wohler's Associates 2021, Statista 2018, Global Industry Analysts 2021

Sources: K. Lueth, IoT Analytics 2020 (connections), K. Lueth, IoT Analytics 2018 (revenues)

Conclusion

Conclusion

- We defined the digital economy and devised a practical measurement framework rooted in input-output analysis and national accounts.
- Data requirements and framework application are relatively simple and proves to be feasible for any domestic or multiregional IOT.
- We applied the methodology to several economies which provided insightful results and allowed for various statistical analyses to support evidence-based decision making.
- Various additional economic and regional applications and analyses will still be conducted in the future.

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Thank you!

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