

Capturing the Digital Economy: A Proposed Measurement Framework and its Applications

Asian Development Bank

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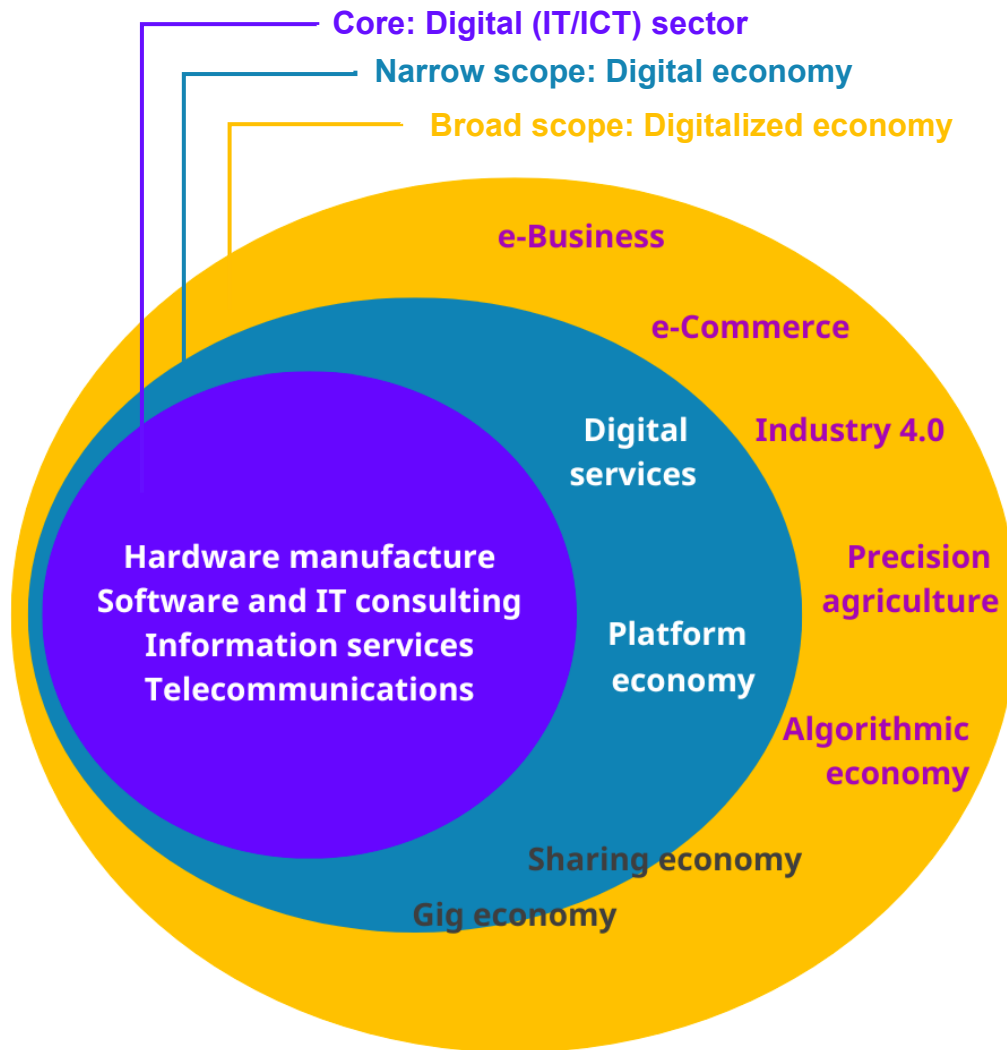
6

Other Applications

1

Definition of Core of Digital Economy

Figure 1. Scope of Digital Economy Definitions

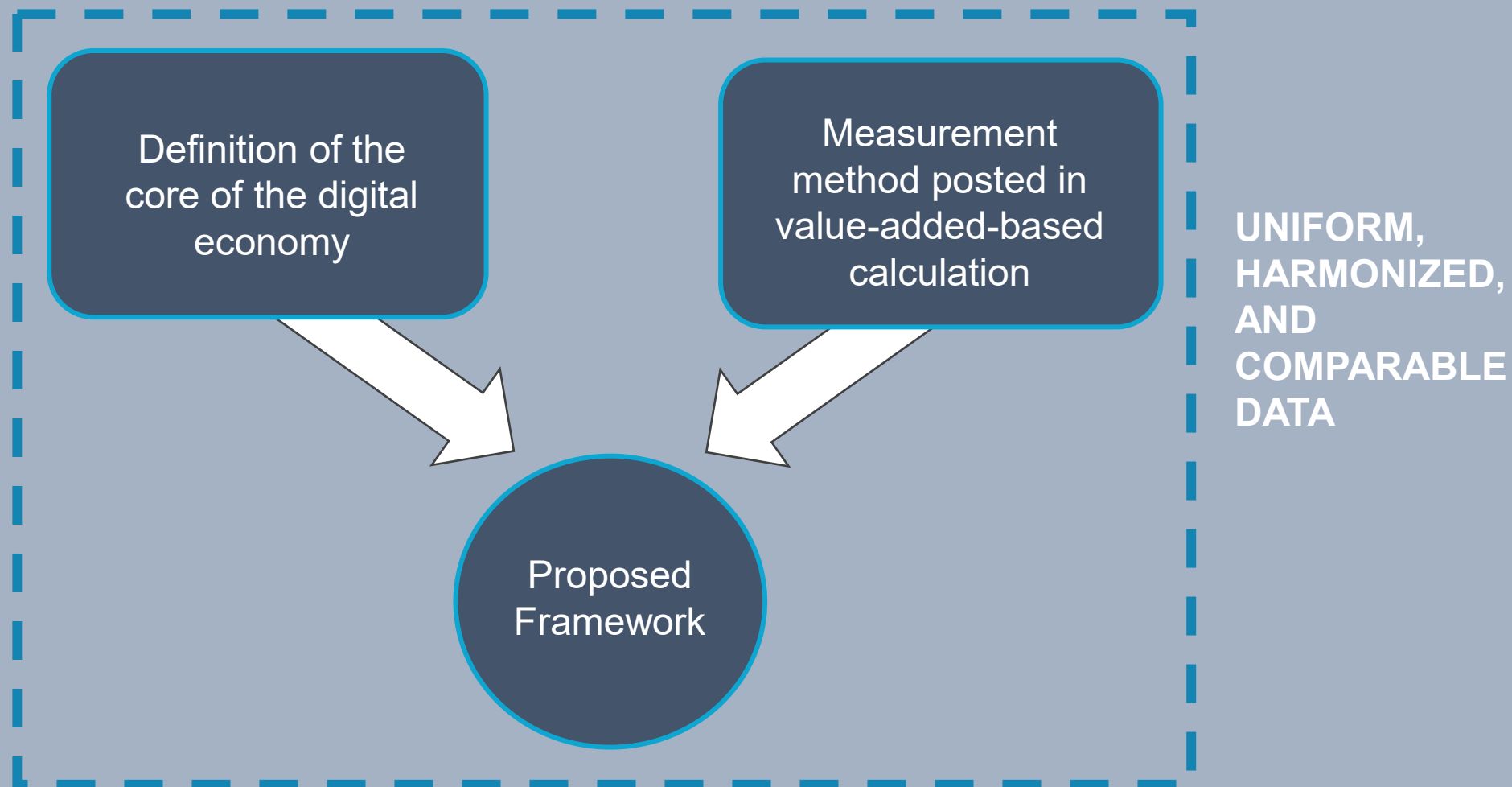


ADB Digital Economy Measurement Framework study team identifies **5 core digital products**: hardware, software, web publishing, telecommunications services, and specialized and support services

Barefoot et al. (2018) – BEA defines the scope of the Digital economy as composed of **digital-enabling infrastructure**, **e-commerce**, and **digital media**; classified using NAICS. On the other hand, digital-enabling infrastructure include computer hardware, software, telecommunications, IoT, and support services.

Source: adapted by the UNCTAD from Bukht and Heeks (2017)

The Digital Economy



Source: Graphics generated by the Digital Economy Measurement Framework study team.

Main Digital Product Groups, Central Product Classification 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).

2

Measuring Digital Economy

Methodological Requirements

Principal Data Source

**National Supply and Use
Tables(SUTs)**

1

National Input Output Table(NIOTs)

2

World Input Output Database(WIOD)

44 economies, 56 sectors, years 2000 to
2014

3

**Asian Development Bank Multiregional
Input-output Tables(ADB-MRIOTs)**

63 economies, 35 sectors, years 2000 and
2007 to 2019

4

Data Sources for Disaggregating Sectors

| Source of Data | Merits | Drawbacks and/or Caveats |
|---|---|--|
| National statistics office | Highly reliable data consistent with the construction of SUT | Dependent on public availability of data or the NSO's responsiveness to queries |
| Relevant journals and published reports | Alternative of sourcing out if primary data are not available | Finding consistent and reliable data may be time-consuming, if even available |
| Supply table | Readily available in the SUT | Applies only if the desired degree of disaggregation among sectors is present |
| Operating revenue data from credible data resources | Readily available given permissions to access certain databases | May be limited by the amount of data collected by the resource |
| Data from donor economy | Based on an actual economy's industry disaggregation | Requires some degree of similarity in terms of structure between the two economies |
| Number of establishments from credible data resources | Readily available given permissions to access certain databases | Bias from an assumption of homogeneity |

NSO = national statistics office, SUT = supply and use table.

Source: R. Consing III, M. Barsabal, J. Alvarez, and M. Mariasingham. 2020. *The Wellness Economy, A Comprehensive System of National Accounts Approach*. *Asian Development Bank Economics Working Paper Series*. No. 631. Manila: Asian Development Bank.

Data Used for Digital Economy Estimations per Economy

| Economy | Year(s) Used for Estimation | Source(s) of IOT, SUT and/ or Related Data | Disaggregation Data Source(s) | No. of Industries | No. of Digital Industries Identified (Total or disaggregated from total) |
|----------------------------|-----------------------------|---|--|---|--|
| Australia | 2010, 2018 | Australian Bureau of Statistics | Orbis, OECD | 114 | 4 |
| Canada | 2012, 2016 | Statistics Canada | Statistics Canada | 236 (2012), 240 (2016) | 7 |
| Denmark | 2010, 2016 | Statistics Denmark | Orbis, Statistics Denmark | 117 | 5 |
| Fiji | 2011 | Fiji Bureau of Statistics | Orbis, Fiji Bureau of Statistics | 50 | 4 |
| Germany | 2010, 2016 | Federal Statistical Office of Germany | Orbis | 72 | 4 |
| India | 2010, 2014 | World Input-Output Database | Orbis, Ministry of Statistics & Programme Implementation (Government of India) | 56 | 4 |
| Indonesia | 2010, 2014 | World Input-Output Database | Orbis, Thailand data, SUT | 56 | 4 |
| Japan | 2000, 2005, 2011, 2015 | e-Stat - Statistics Bureau, Ministry of Internal Affairs and Communications | None | 104 (2000), 108 (2005 and 2011), 107 (2015) | 4 (2000), 5 (2005-2015) |
| Kazakhstan | 2001, 2010, 2018 | Committee on Statistics of the Republic of Kazakhstan | Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan | 72 | 3 |
| Malaysia | 2010, 2015 | Department of Statistics Malaysia | SUT, Thailand data | 86 (2010), 124 (2015) | 5 (2010), 5 (2015) |
| People's Republic of China | 2012 | National Bureau of Statistics of China | Orbis, National Bureau of Statistics of China | 64 | 5 |
| Republic of Korea | 2010, 2018 | Economics Statistics System - Bank of Korea | Statistics Korea | 161 (2010), 165 (2018) | 5 (2010), 5 (2018) |
| Singapore | 2000, 2016 | Singapore Department of Statistics | Orbis, SUT | 152 (2000), 105 (2016) | 3 (2000), 5 (2016) |
| Taipei, China | 2016 | Directorate-General of Budget Accounting and Statistics | None | 164 | 4 |
| Thailand | 2010, 2015 | National Statistics Office of Thailand | Orbis | 180 | 5 |
| United States | 2010, 2019 | U.S. Bureau of Economic Analysis | U.S. Bureau of Economic Analysis, Canada IOTs | 71 | 5 |

IOT = input-output table, OECD = Organisation for Economic Co-operation and Development, SUT = supply and use table, US = United States

Source: Construction of the Digital Economy Measurement Framework study team.

3

Measuring Digital Economy

Measuring Framework

Measurement 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 $(\mathbf{I} - \mathbf{A})^{-1}$
 - \mathbf{y} – final demand vector

- Digital GDP equation:

$$\text{GDP}_{\text{digital}} = \underbrace{\mathbf{i}^T \hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\boldsymbol{\varepsilon}_1}_{1} + \underbrace{\mathbf{i}^T (\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})^T \boldsymbol{\varepsilon}_1}_{2} - \underbrace{[\text{diag}(\hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}})]^T \boldsymbol{\varepsilon}_1}_{3} + \underbrace{(\mathbf{i} - \boldsymbol{\varepsilon}_1)^T \hat{\mathbf{v}}\mathbf{B}\hat{\mathbf{y}}\hat{\mathbf{r}}\boldsymbol{\varepsilon}_2}_{4}$$

Measurement 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

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

Digitally enabling industries

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

Measurement 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

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

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

Measurement 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**

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

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

Measurement 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

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

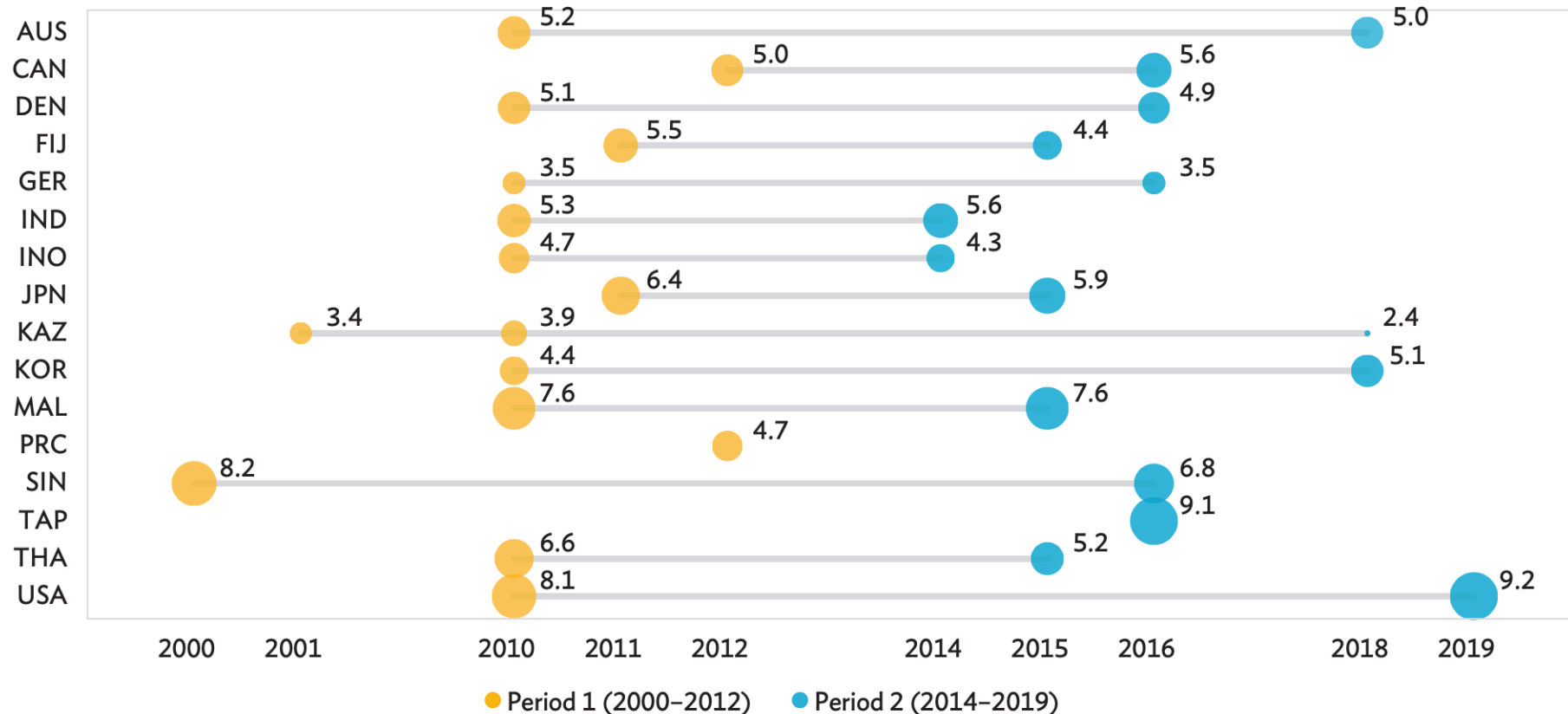
$\hat{\mathbf{r}}$ – diagonalized vector of ratios of gross fixed capital formation (GFCF) used by the digital industry to the corresponding final demand

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

4

Primary Applications

Digital Economy as a Proportion of Total Economy (% of gross domestic product)

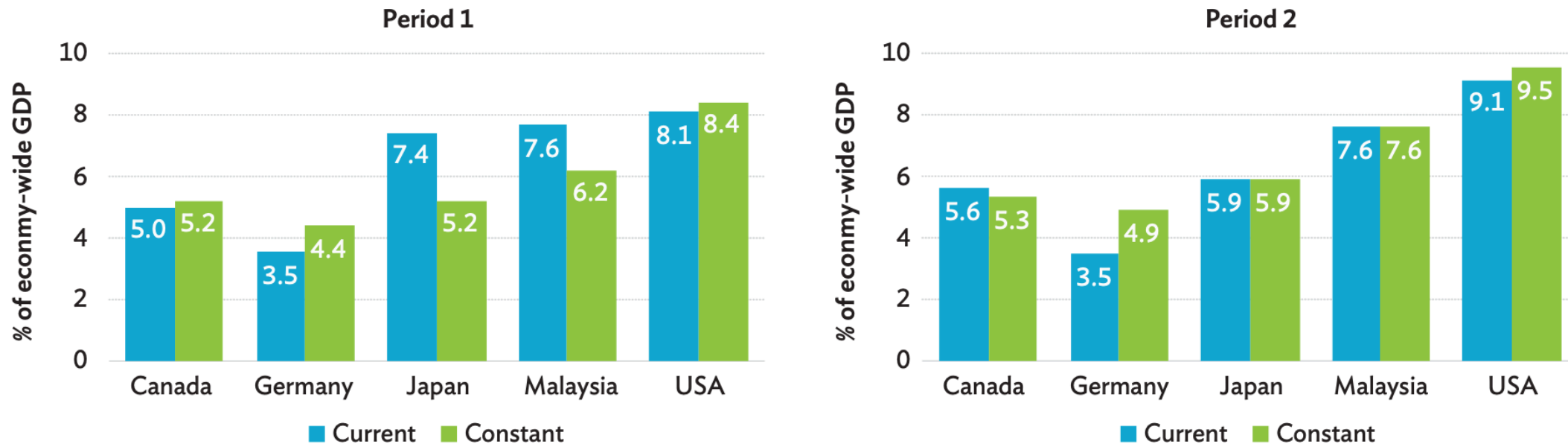


AUS = Australia; CAN = Canada; DEN = Denmark; FIJ = Fiji; GER = Germany; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; MAL = Malaysia; PRC = People's Republic of China; SIN = Singapore; TAP = Taipei, China; THA = Thailand; USA = United States.

Note: Point size reflects size of the digital economy.

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

The Digital Economy as a Percentage of Economy-Wide Gross Domestic Product (current prices versus constant prices)

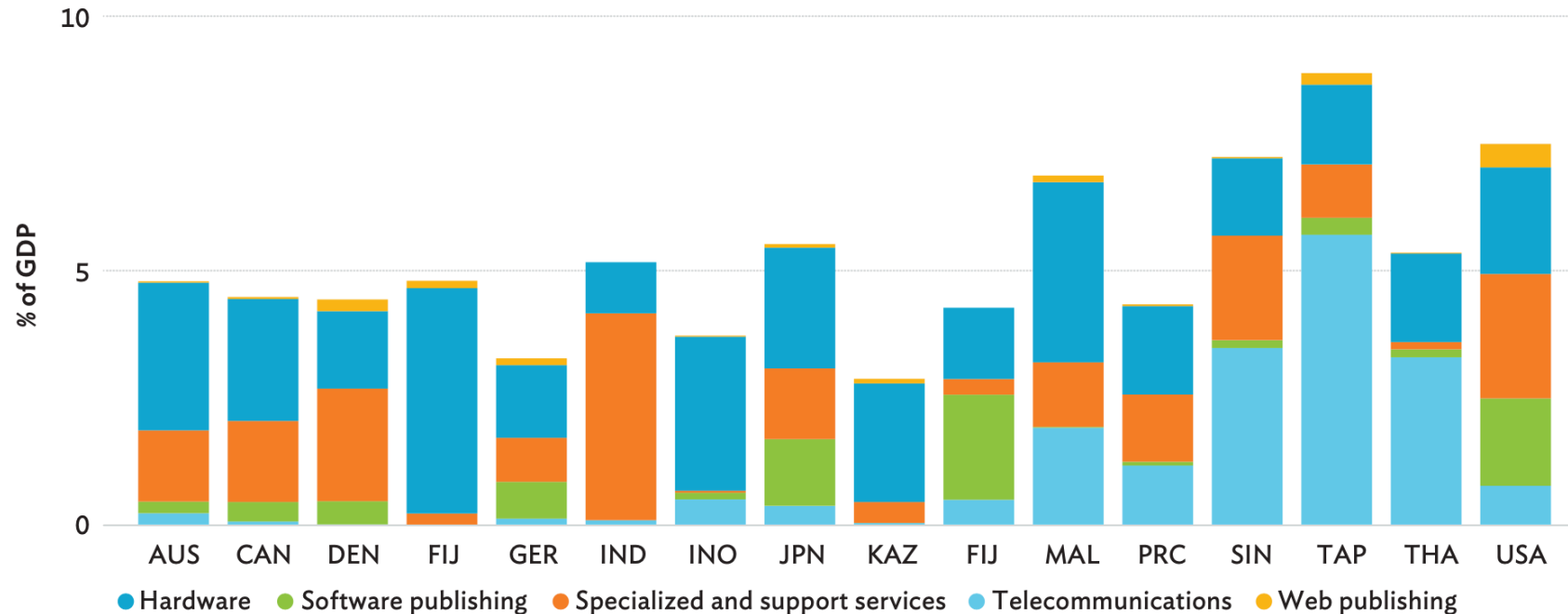


GDP = gross domestic product; USA = United States.

Note: Period 1 and Period 2 are represented by the following years: Canada, 2010, 2016; Germany, 2010, 2016; Japan, 2000, 2015; Malaysia, 2010, 2015; US, 2010, 2016. Base year of constant price estimates is 2015.

Source: Calculations of the Digital Economy Measurement Framework study team, using input-output and related data from various national statistics offices and international databases. Published input-output related data from national statistics offices were stated in constant prices using the double deflation methodology.

Disaggregation of the Digital Economy by Digital Subsector



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

Notes: Years included are AUS, 2010, 2018; CAN, 2012, 2016; DEN, 2010, 2016; FIJ, 2011, 2015; GER, 2010, 2016; IND, 2010, 2014; INO, 2010, 2014; JPN, 2011, 2015; KAZ, 2001, 2010, 2018; KOR, 2010, 2018; MAL, 2010, 2015; PRC, 2012; SIN, 2000, 2016; TAP, 2016; THA, 2010, 2015; USA, 2010, 2019. The average is presented in economies for which calculations include multiple years.

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

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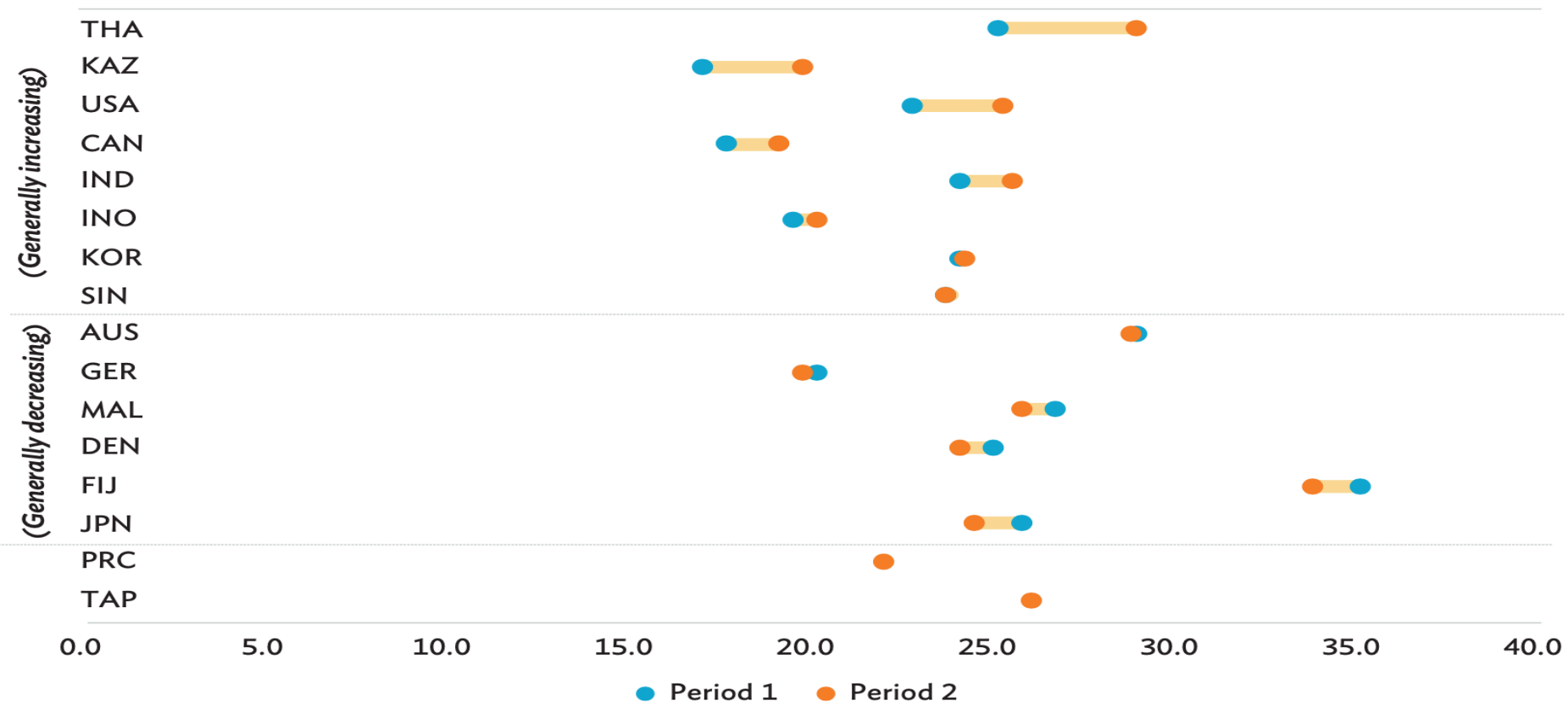
Digital Dependence

Most 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 programme 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 |

Source: Advisory Expert Group on National Accounts (2019).

Degree of Digital Dependence by Economy (% of gross domestic product)

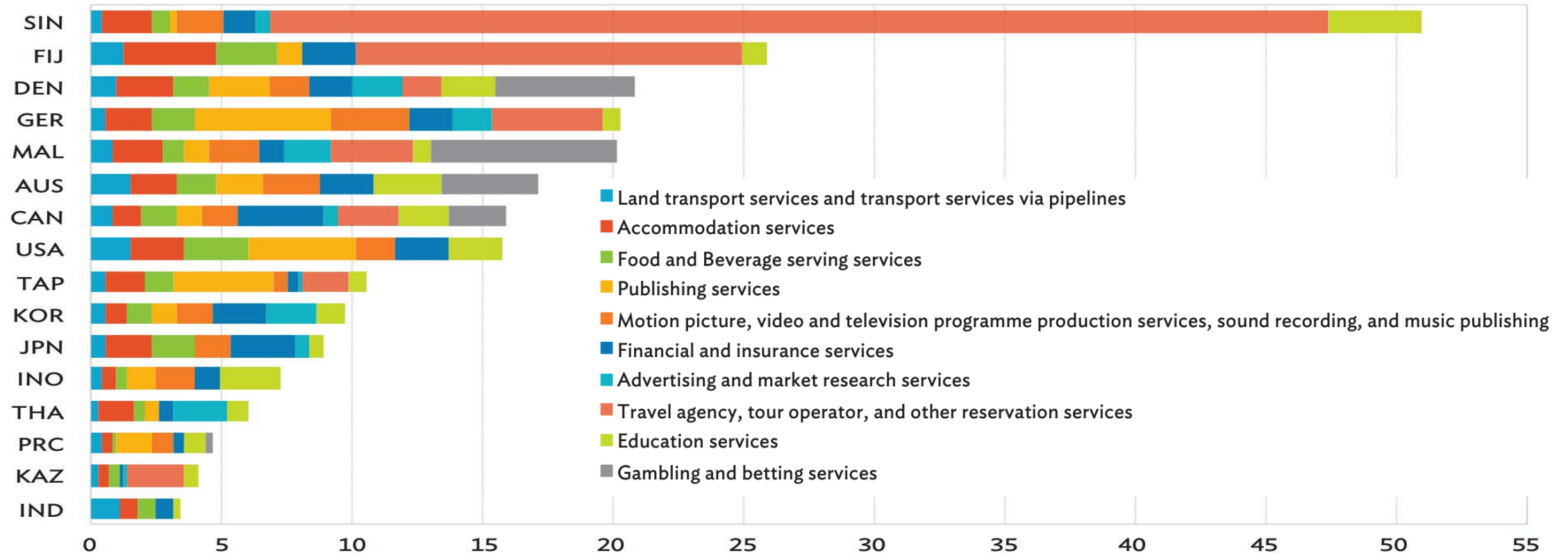


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Notes: Period 1 is AUS, 2010; CAN, 2012; DEN, 2010; FIJ, 2011; GER, 2010; IND, 2010; INO, 2010; JPN, 2011; KAZ, 2010; MAL, 2010; SIN, 2000; THA, 2010; USA, 2010. Period 2 is AUS, 2018; CAN, 2016; DEN, 2016; FIJ, 2015; GER, 2016; IND, 2014; INO, 2014; JPN, 2015; KAZ, 2018; KOR, 2018; MAL, 2015; PRC, 2012; SIN, 2016; TAP, 2016; THA, 2015; USA, 2019.

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

Digitally Disrupted Sectors by Size of Digital Forward Contribution (averaged % of respective sector size)

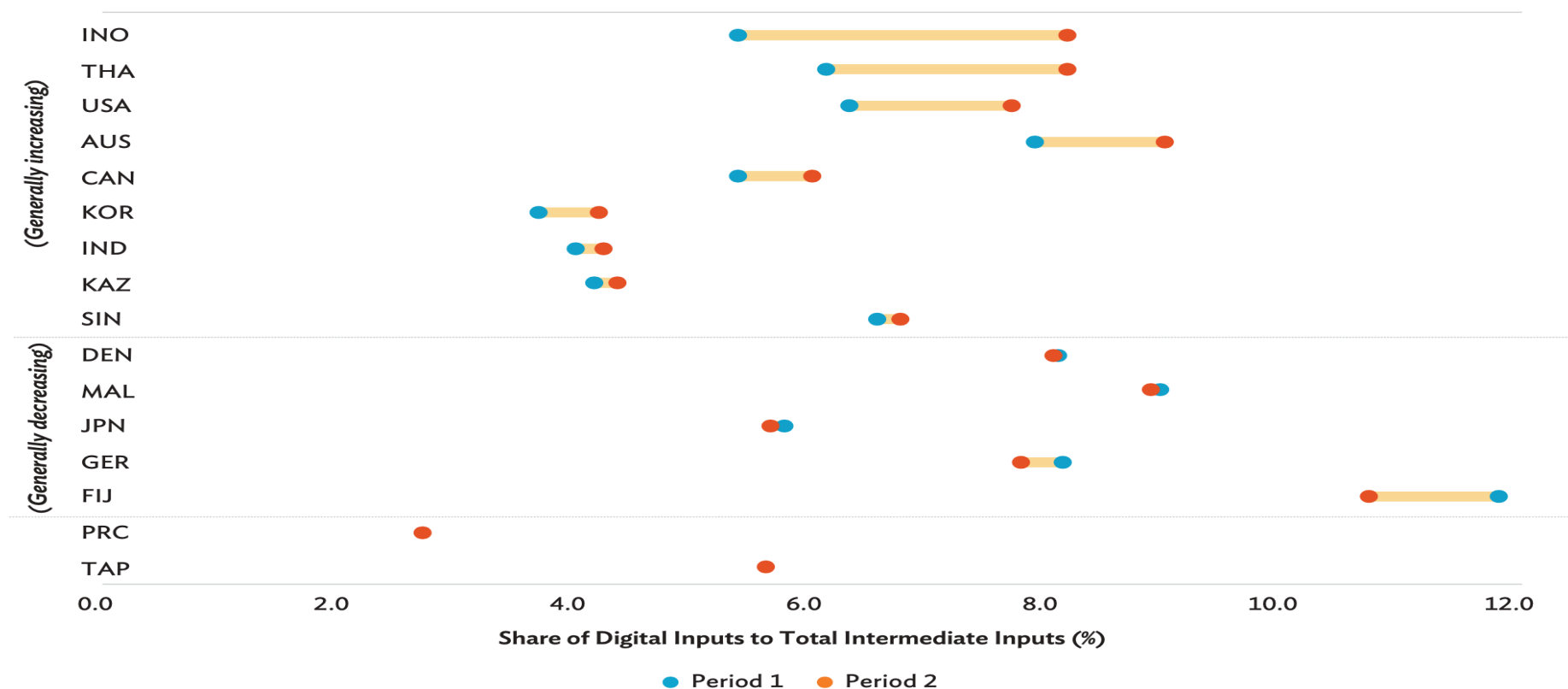


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Note: Years included are AUS, 2010, 2018; CAN, 2012, 2016; DEN, 2010, 2016; FIJ, 2011, 2015; GER, 2010, 2016; IND, 2010, 2014; INO, 2010, 2014; JPN, 2011, 2015; KAZ, 2010, 2018; KOR, 2010, 2018; MAL, 2010, 2015; PRC, 2012; SIN, 2000, 2016; TAP, 2016; THA, 2010, 2015; USA, 2010, 2019.

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

Average Share of Digital Inputs to Total Intermediate Inputs for Digitally Dependent Sectors

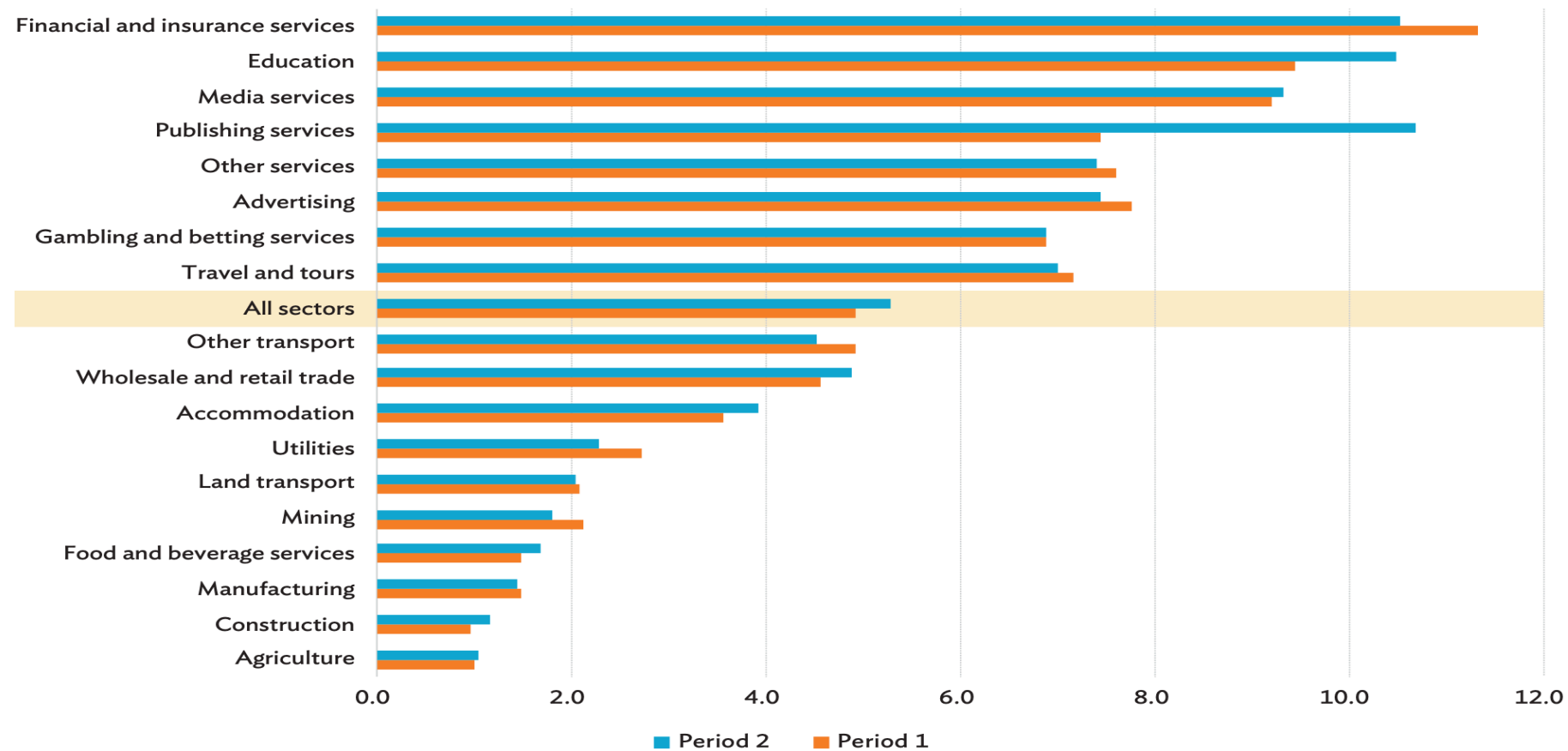


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Notes: Period 1 is AUS, 2010; CAN, 2012; DEN, 2010; FIJ, 2011; GER, 2010; IND, 2010; INO, 2010; JPN, 2011; KAZ, 2001; KOR, 2010; MAL, 2010; SIN, 2000; THA, 2010; USA, 2010. Period 2 is AUS, 2018; CAN, 2016; DEN, 2016; FIJ, 2015; GER, 2016; IND, 2014; INO, 2014; JPN, 2015; KAZ, 2018; KOR, 2018; MAL, 2015; PRC, 2012; SIN, 2016; TAP, 2016; THA, 2015; USA, 2019.

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

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



Notes: Economies covered and their years for Period 1 and Period 2 are Australia (2010, 2018); Canada (2012, 2016); Denmark (2010, 2016); Fiji (2011, 2015); Germany (2010, 2016); India (2010, 2014); Indonesia (2010, 2014); Japan (2011, 2015); Kazakhstan (2001, 2018); Republic of Korea (2010, 2018); Malaysia (2010, 2015); People's Republic of China (2012); Singapore (2000, 2016); Taipei, China (2016); Thailand (2010, 2015); and the United States (2010, 2019). Sectors' digital input shares are averaged across sectors for Period 1 and Period 2.

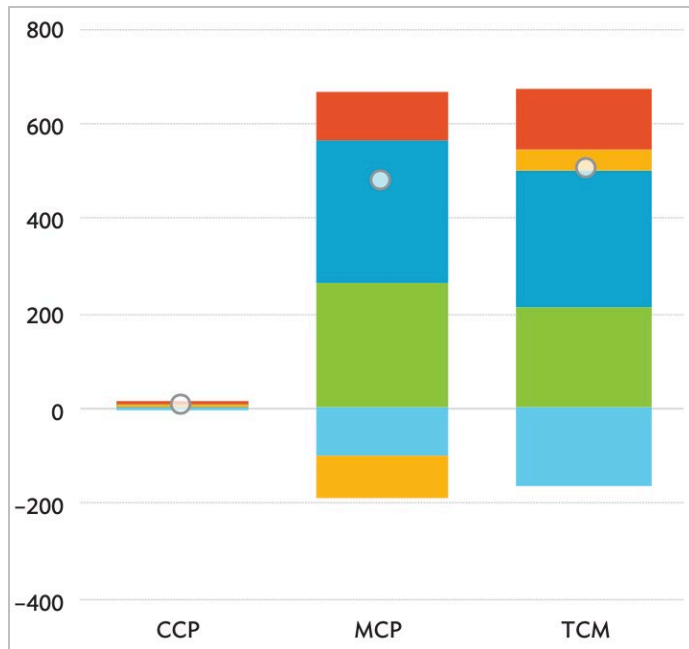
Source: Calculations of the Digital Economy Measurement Framework study team, using input-output and related data from various national statistics offices and international databases.

6

Other Applications and Analyses

Change in Employment in India, 2010 and 2014 (in thousands of persons)

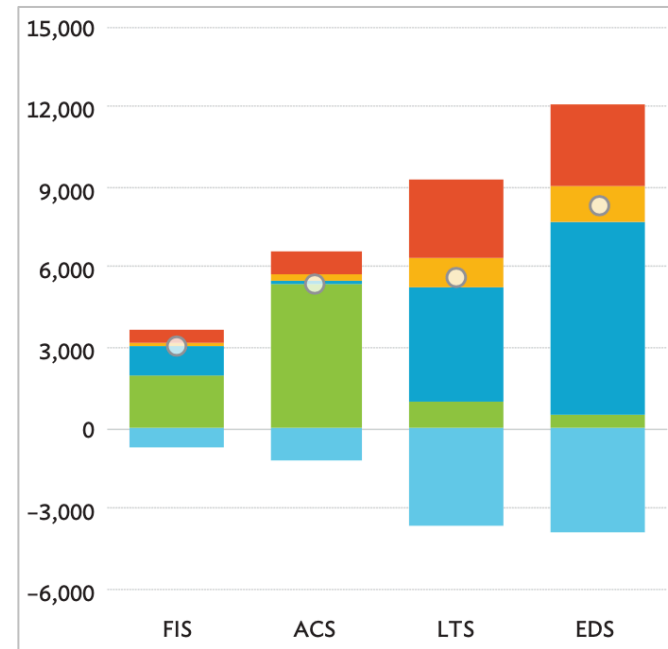
Core digital sectors



CCP = computer consultancy and related activities; information service activities. MCP = manufacture of computers and peripheral equipment; TCM = telecommunications.

Source: Calculations of the Digital Economy Measurement Framework study team, using data from the Ministry of Statistics and Programme Implementation, CEIC database, and Organisation for Economic Co-operation and Development Multifactor Productivity.

Digitally enabled sectors

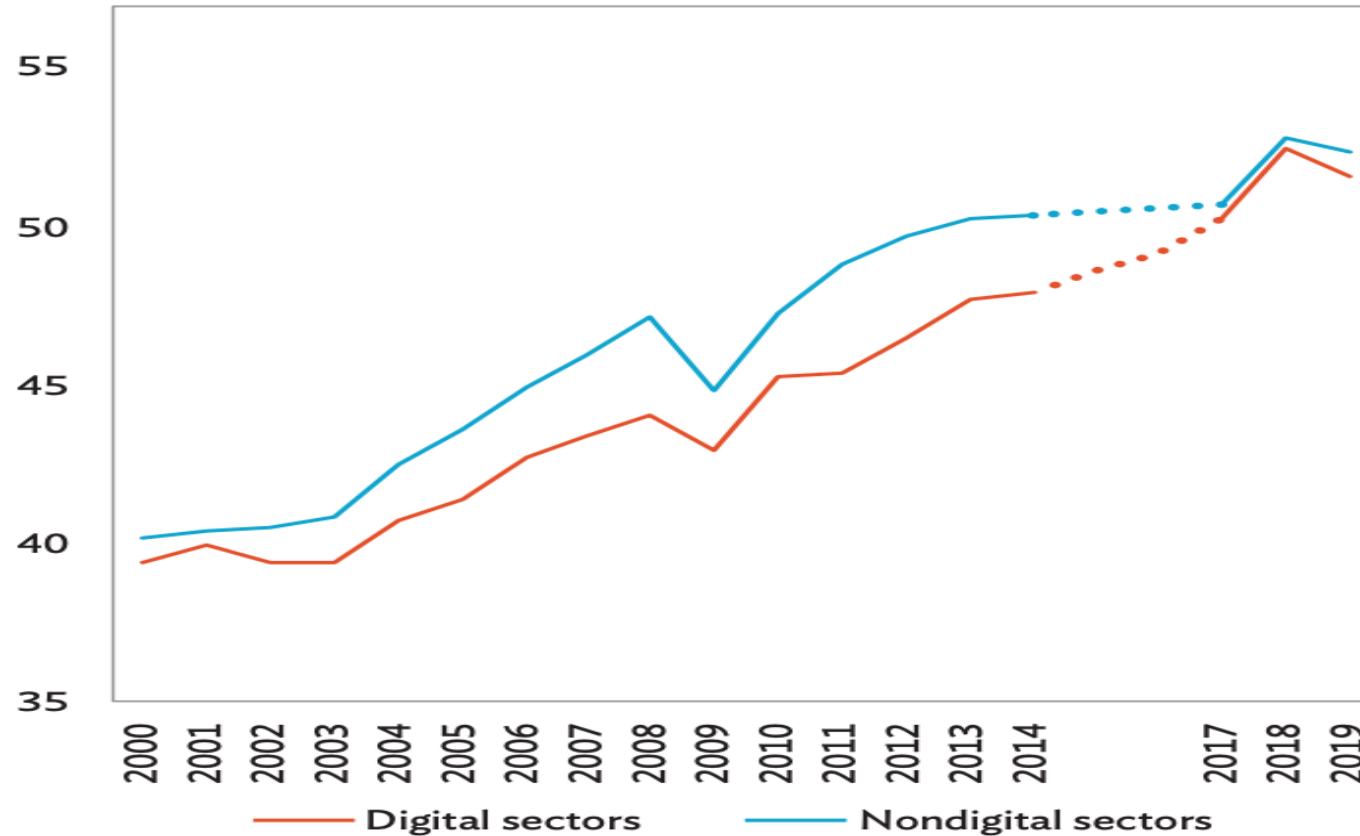


ACS = accommodation services; EDS = education services; FIS = financial and insurance services; LTS = land transport services and transport services via pipelines.

Source: Calculations of the Digital Economy Measurement Framework study team, using data from the Ministry of Statistics and Programme Implementation, CEIC database, and Organisation for Economic Co-operation and Development Multifactor Productivity.

- Changes on consumption level
- Change in consumption composition
- Change in sector technology
- Change in production recipe
- Change in efficiency
- Net change in employment

Total Global Value Chain Participation Rates of Digital and Nondigital Sectors

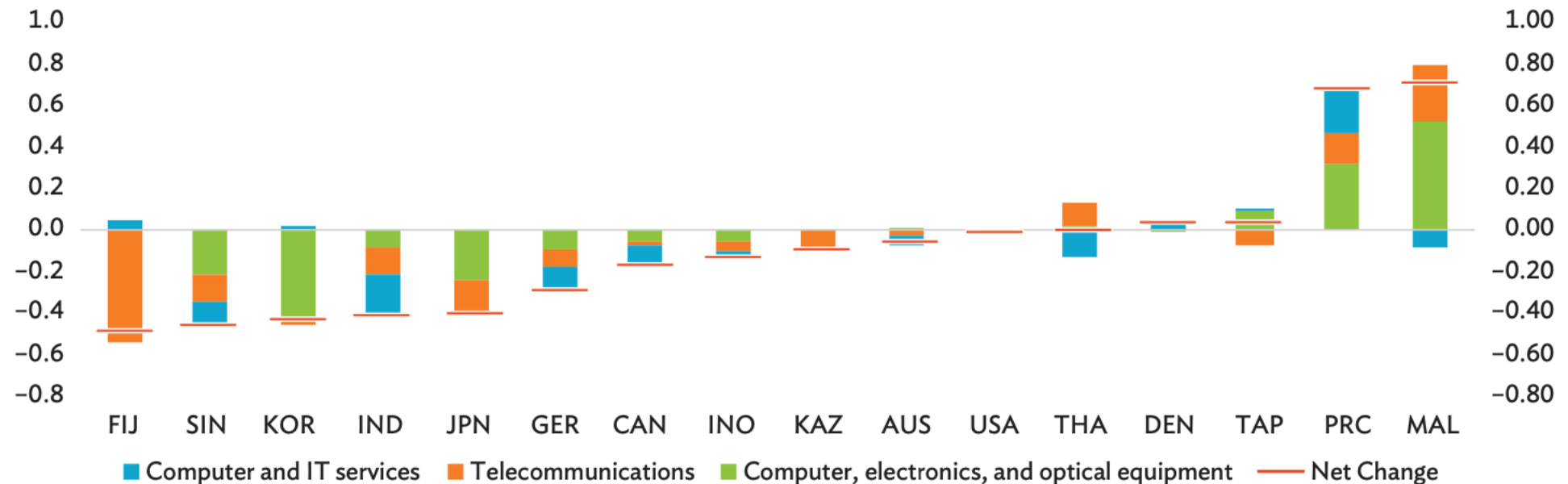


Notes: Digital sector = manufacture of computer, electronic and optical products; telecommunications; and computer programming, consultancy, and related activities, and information service activities. Asian Development Bank estimates are based on the methodology of Wang, Wei, Yu, and Zhu (2017). The world average of total global value chain (GVC) participation is calculated by taking the sum of the world average of forward GVC participation and backward GVC participation. Certain economy-sectors were excluded in calculating for the world average because of mathematical inconsistencies.

Sources: World Input–Output Database Tables, 2000–2014; and the Asian Development Bank’s 38-sector Multiregional Input-Output Table 2017–2019.

Changes in the Digital Economy, 2020 (% of 2019 gross domestic product)

By Digital Product



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

Source: Calculations of the Digital Economy Measurement Framework study team, based on the Asian Development Bank's 38-sector Multiregional Input-Output Table 2019, national accounts, and various sources of digitally ordered business-to-consumer shares to total sales.

Thank You

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