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

Asian Development Bank
Outline of Discussions

1. Defining the Core of the Digital Economy
2. Methodological Requirements
3. Measurement Framework
4. Primary Applications
5. Digital Dependence
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.
The Digital Economy

Definition of the core of the digital economy

Measurement method posted in value-added-based calculation

Proposed Framework

UNIFORM, HARMONIZED, AND COMPARABLE DATA

Main Digital Product Groups,
Central Product Classification Version 2

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

\(^{a}\) Excluding items under Central Product Classification Version 2, 843 already counted under Software Publishing – 8434, 84391, 84392.

Measuring Digital Economy

Methodological Requirements
Principal Data Source

1. National Supply and Use Tables (SUTs)
   - National Input Output Table (NIOTs)

2. World Input Output Database (WIOD)
   - Asian Development Bank Multiregional Input-output Tables (ADB-MRIOTs)

- 44 economies, 56 sectors, years 2000 to 2014
- 63 economies, 35 sectors, years 2000 and 2007 to 2019
# Data Sources for Disaggregating Sectors

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

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

# Data Used for Digital Economy Estimations per Economy

<table>
<thead>
<tr>
<th>Economy</th>
<th>Year(s) Used for Estimation</th>
<th>Source(s) of IOT, SUT and/or Related Data</th>
<th>Disaggregation Data Source(s)</th>
<th>No. of Industries</th>
<th>No. of Digital Industries Identified (Total or disaggregated from total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>2010, 2018</td>
<td>Australian Bureau of Statistics</td>
<td>Orbis, OECD</td>
<td>114</td>
<td>4</td>
</tr>
<tr>
<td>Denmark</td>
<td>2010, 2016</td>
<td>Statistics Denmark</td>
<td>Orbis, Statistics Denmark</td>
<td>117</td>
<td>5</td>
</tr>
<tr>
<td>Fiji</td>
<td>2011</td>
<td>Fiji Bureau of Statistics</td>
<td>Orbis, Fiji Bureau of Statistics</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Germany</td>
<td>2010, 2016</td>
<td>Federal Statistical Office of Germany</td>
<td>Orbis</td>
<td>72</td>
<td>4</td>
</tr>
<tr>
<td>India</td>
<td>2010, 2014</td>
<td>World Input-Output Database</td>
<td>Orbis, Ministry of Statistics &amp; Programme Implementation (Government of India)</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2010, 2014</td>
<td>World Input-Output Database</td>
<td>Orbis, Thailand data</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>Taipei, China</td>
<td>2016</td>
<td>Directorate-General of Budget Accounting and Statistics</td>
<td>None</td>
<td>164</td>
<td>4</td>
</tr>
<tr>
<td>United States</td>
<td>2010, 2019</td>
<td>U.S. Bureau of Economic Analysis, Canada IOTs</td>
<td>U.S. Bureau of Economic Analysis</td>
<td>71</td>
<td>5</td>
</tr>
</tbody>
</table>

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

Measuring Digital Economy

Measuring Framework
Measurement Framework

- Rooted in input-output analysis, using the $\hat{v}B\hat{y}$ matrix:
  - $v$ – direct value-added coefficient vector
  - $B$ – Leontief inverse matrix $(I - A)^{-1}$
  - $y$ – final demand vector

- Digital GDP equation:
  \[
  GDP_{\text{digital}} = i^T\hat{v}B\hat{y}\varepsilon_1 + i^T(\hat{v}B\hat{y})^T\varepsilon_1 - [\text{diag}(\hat{v}B\hat{y})]^T\varepsilon_1 + (i - \varepsilon_1)^T\hat{v}B\hat{y}\hat{r}\varepsilon_2
  \]
Measurement Framework

- Assume that industry 1 is the digital sector.

- **Term 1**: $i^T \hat{v}B\hat{y}\varepsilon_1$ represents the **backward linkage** of the digital sector

$$
\hat{v}B\hat{y} = \begin{bmatrix}
v_1b_{11}y_1 & v_1b_{12}y_2 & \ldots & v_1b_{1n}y_n \\
v_2b_{21}y_1 & v_2b_{22}y_2 & \ldots & v_2b_{2n}y_n \\
\vdots & \vdots & \ddots & \vdots \\
v_nb_{n1}y_1 & v_nb_{n2}y_2 & \ldots & v_nb_{nn}y_n
\end{bmatrix}
$$

**Digitally enabling industries**

$$
GDP_{\text{digital}} = i^T\hat{v}B\hat{y}\varepsilon_1 + i^T(\hat{v}B\hat{y})^T\varepsilon_1 - [\text{diag}(\hat{v}B\hat{y})]^T\varepsilon_1 + (i - \varepsilon_1)^T\hat{v}B\hat{y}\hat{e}_2
$$
Measurement Framework

- Assume that industry 1 is the digital sector.

- **Term 2:** $i^T(\hat{v}B\hat{y})^T\epsilon_1$ represents the **forward linkage** of the digital sector.

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

Digitally enabled industries

$$GDP_{digital} = i^T\hat{v}B\hat{y}\epsilon_1 + i^T(\hat{v}B\hat{y})^T\epsilon_1 - [\text{diag}(\hat{v}B\hat{y})]^T\epsilon_1 + (i - \epsilon_1)^T\hat{v}B\hat{y}\hat{\epsilon}_2$$
Measurement Framework

• Assume that industry 1 is the digital sector.

• **Term 3:** $- [\text{diag}(\vec{v}B\hat{y})]^T \varepsilon_1$ represents the double-counted term

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

\[
\text{GDP}_{\text{digital}} = i^T \hat{v}B\hat{y} \varepsilon_1 + i^T (\hat{v}B\hat{y})^T \varepsilon_1 - [\text{diag}(\hat{v}B\hat{y})]^T \varepsilon_1 + (i - \varepsilon_1)^T \hat{v}B\hat{y}\hat{\varepsilon}_2
\]
Measurement Framework

- Assume that industry 1 is the digital sector.
- Term 4: \((i - \varepsilon_1)^T\hat{\mathbf{B}}\hat{\varepsilon}_2\) represents fixed capital investments by the digital sector for goods produced by non-digital industries.

\[
\hat{\mathbf{B}}\hat{\varepsilon} = \begin{bmatrix}
v_1 b_{11} y_1 r_1 & v_1 b_{12} y_2 r_2 & \cdots & v_1 b_{1n} y_n r_n \\
v_2 b_{21} y_1 r_1 & v_2 b_{22} y_2 r_2 & \cdots & v_2 b_{2n} y_n r_n \\
\vdots & \vdots & \ddots & \vdots \\
v_n b_{n1} y_1 r_1 & v_n b_{n2} y_2 r_2 & \cdots & v_n b_{nn} y_n r_n
\end{bmatrix}
\]

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

\[
\text{GDP}_{\text{digital}} = i^T\hat{\mathbf{B}}\hat{\varepsilon}_1 + i^T(\hat{\mathbf{B}}\hat{\varepsilon})^T\varepsilon_1 - [\text{diag}(\hat{\mathbf{B}}\hat{\varepsilon})]^T\varepsilon_1 + (i - \varepsilon_1)^T\hat{\mathbf{B}}\hat{\varepsilon}_2
\]
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.


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.


Source: Calculations of the Digital Economy Measurement Framework study team, using input-output and related data from various national statistics offices and international databases.
Digital Dependence
**Most Digitally Disrupted Sectors, Classification of Products by Activity**

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

**Source:** Advisory Expert Group on National Accounts (2019).
Degree of Digital Dependence by 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.


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)

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.


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

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.


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.

---

---
Other Applications and Analyses
Change in Employment in India, 2010 and 2014 (in thousands of persons)

### Core digital sectors

![Graph showing changes in employment in core digital sectors](image)


### Digitally enabled sectors

![Graph showing changes in employment in digitally enabled sectors](image)


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

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

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

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

Digital Economy Team

Mahinthan J. Mariasingham, mmariasingham@adb.org;
Faith Hyacinth Balisacan, fbalisacan.consultant@adb.org;
John Arvin C. Bernabe, jbernabe.consultant@adb.org;
Ma. Charmaine R. Crisostomo, mccrisostomo.consultant@adb.org;
Michelle Monique A. Sianghio, msianghio.consultant@adb.org;
Ridhima Bahl, rbahl.consultant@adb.org