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State of Compute Access 2024: *Annex*

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01

Summary

The State of Compute Access data explorer measures the computing ecosystem maturity of 67 countries around the world, measuring them against 21 indicators. These indicators are split into five categories.

- **Existing compute capacity:** includes server installed base (in both absolute and per capita terms), access to quantum computing, local supercomputer capacity and access to parallel computing.
- **Compute capacity buildout:** includes server investment growth, data-centre investment and quantum-computing investment.
- **Connectivity and infrastructure:** includes power availability, power-grid maturity, subsea-cable landing and internet-exchange points.
- **Software and programming:** includes cloud-service availability and software-engineering professionals in each country.
- **Local talent pool:** includes participation in the open-source community, number of job postings (including AI skills) and availability of training programmes.
- **Policy and governance:** includes data governance, AI strategy and taxation.

The following overview of each indicator details data source, the method used to transform data into a measurable indicator and the metric displayed in the index. To provide maximum value we have adhered to some guiding principles while preparing the index.

1. For all indicators based on an annual recurring metric, 2023 has been used as the baseline year. Where the metric is a snapshot in time, such as availability of a service or solution, the snapshot has been taken within the first half of 2024 and can reflect launched services and solutions within that period.

2. While we use 2023 as the base period in the index, we have been able to build a historic database for many of the indicators, including local supercomputing capacity.

3. Data sources that minimise reporting gaps have been selected. For Russia specifically we have been unable to build an indicator for data-governance policy and found it difficult to corroborate data points where reporting exists, due to verification difficulty. For China we have not been able to fully update the local supercomputing capacity indicator as the country no longer reports new projects to the Top500 Supercomputers list.

4. In the collection of data on new quantum-computing investment, number of data centres (within the cloud-service availability score) and data-centre investment, where no recorded investments or builds were recorded, a value of 0 is assumed.

5. We have purposely focused on the investment of key market makers, such as the buildout of data centres by leading cloud-service providers Amazon, Google, Microsoft, Oracle and so on. These companies lead the market from the perspective of portfolio comprehensiveness and time to market, enabling early access to new compute hardware and software.

6. We have striven to keep our methodology consistent with the first edition of this index but in some cases have updated our processes to improve the value of the index. Where possible we have added 2022 historic data to enable cycle-on-cycle comparisons.

02

Compute Capacity

Compute capacity is the foundational indicator category in this index. It is built using a mixture of proprietary Omdia data and third-party data (with links to the source provided below). The former is based on data directly provided to Omdia by key market players or collected by Omdia using a mixture of public sources and private interviews. Omdia measures general-purpose and specialised computing capacity and the pace of change, using five key indicators.

1. **Server installed base** looks at the number of deployed servers in a country.

    a. Source: Omdia's Data Center Server Tracker[1] and Data Center Building Tracker.[2] To populate the first tracker, Omdia collects server-shipments data directly from original equipment manufacturers and original design manufacturers by country and verifies the reports using processor-shipments guidance provided by the largest semiconductor suppliers. This information is then applied to useful-life data gathered through data-centre operator interviews and surveys. Omdia then checks the server installed base figure against its data-centre capacity tracker and against third-party data-centre trackers such as the Data Center Map. To confirm the server installed base for China, Omdia also used data from the National Bureau of Statistics of China.

    b. Methodology: Omdia's useful-life analysis and, therefore, installed-base estimation considers server refurbishment, which became more common in 2020 when the semiconductor shortage prolonged order-fulfilment times. Omdia has accounted for server re-export and sales made through unofficial channels.

    c. Metric: Absolute number of deployed servers.

2. **Server installed base per capita** expands on the first indicator by comparing the number of deployed servers to each country's population.

a. Source: The source for population data is S&P Global.[3]

b. Methodology: Calculated by dividing the number of deployed servers in each country by one-thousandth of its population.

c. Metric: Absolute number of servers per 1,000 people.

3. **Access to quantum computing** measures the number of quantum computing vendors and institutional adopters in each country.

    a. Source: Omdia's Quantum Computing Market Tracker,[4] published in May 2024, which features data on 276 quantum computing vendors and 259 institutions that have adopted quantum computing. Analysts rely on public announcements, making the dataset subject to data gaps.

    b. Methodology: Based on the total number of institutions.

    c. Metric: Sum of the number of institutions with access to quantum computing and the number of quantum vendors.

4. **Access to parallel computing** looks at cloud services optimised for artificial intelligence, as well as machine-learning techniques, available from the top four cloud-service providers.

    a. Source: The data were obtained from the cloud-service providers' respective websites: AWS,[5] Google,[6] Microsoft[7] and Oracle.[8]

    b. Methodology: Calculated by checking if AWS, Google, Microsoft and Oracle provide a cloud service optimised for machine learning inside each country. Points were distributed based on the number of providers present in each country.

    c. Metric: Using an additive system, each cloud-service provider in each country resulted in an award of 25 points, enabling a maximum score of 100 per country.

5. **Local supercomputer capacity** measures the number of supercomputers in each country.

    a. Source: TOP500[9] and secondary research.

    b. Methodology: Takes into account the number of supercomputers in each country within the TOP500 supercomputer list and the total floating-point operations per second (FLOPS) of these supercomputers in each country. After awarding points for total number of supercomputers and total number of FLOPS in the TOP500 supercomputer list, Omdia calculates an average score. This approach was chosen to recognise the value in both a distributed network of supercomputers and the value of a smaller number of high-performance supercomputers. Countries that started investing in supercomputing infrastructure more recently are likely to have a smaller number of high-performance supercomputers because they are built using the latest processors, which boast superior performance. For countries with supercomputers that did not make it into the TOP500 supercomputer list, Omdia has awarded points for existing installations and for announcements of new installations.

    c. Metric: Points awarded as follows:

A score out of 100 was created by combining a score for teraflops and a score for the number of supercomputers:

$$SC\ score_x = 0.5\ teraflops_x + 0.5\ SCs_x$$

The number of petaflops was normalised between 0 and 100 as follows:

$$teraflops_x = 100 * \frac{ln\ (tflops_x + 1)}{ln\ (\max(tflops))}$$

The number of supercomputers was also normalised between 0 and 100 as follows:

1. If a country had computers outside the TOP500, they received an additional four points.

2. All countries that had announcements for supercomputers in the coming year were awarded an additional two points.

Number of supercomputers was then normalised as follows:

$$SCs_x = 94 * \frac{\ln SCs_x}{\max(SCs)} + 4y + 2z$$

Where:

$$y = \begin{cases} 1, & SCs \text{ outside top500} = True \\ 0, & SCs \text{ outside top500} = False \end{cases}$$

And:

$$z = \begin{cases} 1, & SC \text{ announcement} = True \\ 0, & SC \text{ announcement} = False \end{cases}$$

6. **Data-centre investment** looks at the announced data-centre building activity by 103 of the top cloud and co-location service providers. These companies are responsible for the majority of global data-centre building activity.

    a. Source: Omdia's Data Center Building Tracker.[10]

    b. Methodology: Calculated as the sum of announced data-centre builds in each country and the total number of megawatts (MW) capacity this will contribute once completed.

    c. Metric: Number of MW announced for data-centre builds from 2024 to 2026. For this year's index, 103 cloud and co-location service providers have been used. For year-on-year comparison, the top 41 providers have been used due to lack of data availability for 2022.

7. **Quantum-computing investment** looks at the announced private- and public-sector investment in quantum-computing operations.

    a. Source: Omdia's Quantum Computing Market Tracker,[11] published in May 2024, which features data on 254 individual funding activities. This includes both public and private funding dedicated to the buildout of a quantum-computing ecosystem.

    b. Methodology: Cumulative announced funding by country.

    c. Metric: US dollars (millions).

8. **Server unit growth (five-year compound annual growth rate [CAGR] %)**

    a. Source: Omdia's Data Center Server Tracker and Canalys internal data. Omdia and Canalys both collect server-shipments and revenue data directly from original equipment manufacturers and original design manufacturers by country, and verify the reports using processor-shipments guidance provided by the largest semiconductor suppliers. Omdia projects this forward based on server- and semiconductor-development roadmaps and end-user demand signals.

    b. Methodology: Calculated by taking the five-year CAGR of servers shipped to each country and the future year projections from 2023 to 2028.

    c. Metric: Five-year compound annual growth rate from 2023 to 2028 (percentage)

9. **Server revenue growth (five-year CAGR %)**

    a. Source: Omdia's Data Center Server Tracker and Canalys internal data.

    b. Methodology: Calculated by taking the five-year CAGR of cumulative server sales to each country and the future year projections from 2023 to 2028.

    c. Metric: Five-year compound annual growth rate from 2023 to 2028 (percentage)

03

Connectivity and Infrastructure

This group of indicators measures the infrastructure that can impact or drive compute-capacity expansion.

10. **Power-grid maturity** measures the reliability of a county's power grid over a given year.

    a. Source: The World Bank.[12]

    b. Methodology: The indicator was calculated by taking an average of the power-outage days per country from the two data sources. Due to a lack of recent data, this metric remains unchanged from the previous year.

    c. Metric: Average monthly number of power-outage days per country.

11. **Subsea-cable landing and internet exchange** measure a country's connectivity.

    a. Source: For the subsea-cable landing data, Omdia used the Submarine Cable Map[13] website. For the internet-exchange data, Omdia used the Data Center Map[14] website.

    b. Methodology: Calculated by adding two metrics: the number of subsea cables with connection points to each country, and each country's total internet exchanges.

    c. Metric: Sum of the number of subsea cables and the number of internet exchanges in a country.

12. **Availability of clean energy**

    a. Source: Ember,[15] an independent energy think-tank. To build its database, Ember relied on data from Global Energy Monitor, the International Renewable Energy Agency, Eurostat, the European Network of Transmission Systems Operators for Electricity, the Energy Institute and the US Energy Information Administration.

b. Methodology: This variable combines a country's values on:

   1. Clean energy generated (TWh).
   2. Clean energy generated as a share of total energy demand (%).

c. Metric: A normalised score between 0 and 100 was assigned as follows:

$$normCleanEnergy_x = 100 * \frac{CleanEnergy_x - min(CleanEnergy)}{max(CleanEnergy) - min(CleanEnergy)}$$

Where:

$$CleanEnergy_x = 0.5nornCleanPercentDemand_x + 0.5normCleanTotal_x$$

Clean-energy score is a combination of:

1. A normalised score of the percentage of a country's total demand generated by clean energy

$$normCleanPercentDemand_x = 100 * \frac{CleanPercentDemand_x - min(CleanPercentDemand)}{max(CleanPercentDemand) - min(CleanPercentDemand)}$$

2. A normalised score of the TWh of a country's clean energy generated

$$normCleanTotal_x = 100 * \frac{CleanTotal_x - min(CleanTotal)}{max(CleanTotal) - min(CleanTotal)}$$

13. Energy independence

a. Source: Ember

b. Methodology: Calculated as the net energy imports of a country divided by its total energy demand. Negative net imports indicated the country was a net exporter of electricity.

c. Metric: A normalised score between 0 and 100 was assigned as follows:

If E is the percentage of imports out of total energy demand:

$$normE_X = \begin{cases} 50 * \dfrac{max(E_X) - E_X}{\max(E_X)}, & E_X \geq 0 \\ 50 * \dfrac{-E_X}{|\min(E_X)|} + 50, & E_X \geq 0 \end{cases}$$

Whereby a score of 50 means a country has a trade balance of 0, a score of 100 indicates it is the top exporter and a score of 0 the top importer.

04

Software and Programming

14. Cloud-service availability measures a country's access to cloud services using the number and size of data centres operated by 103 of the top cloud and co-location companies. This measure was chosen because it provides a high-accuracy insight into the availability of industry-leading cloud services.

a. Source: Data Center Building Tracker,[16] which covers all data centres for 103 of the largest cloud and co-location data-centre operators. These companies represent about 60 per cent of the global data-centre power capacity.

b. Methodology: Cumulative number of cloud and co-location data centres in a country and cumulative size of the data-centre capacity (space measured in square feet), represented per capita x10^5. The square-feet measure was chosen in addition to the data-centre count to give credit to less distributed environments, where there are fewer but larger data centres in a country. This can often be the case in a quickly developing market. Representing the metric per capita is intended to provide context for the demand of a country.

c. Metric: Points awarded as follows (based on average of the two indicators):

A normalised score between 0 and 100 was assigned as follows:

Where *CS* is the cloud-service availability score:

$$normCS_x = 100 * \frac{CS_x - \min(CS)}{\max(CS) - \min(CS)}$$

Where cloud-service availability is:

$$CS_x = 0.5normDS_x + 0.5normSqFt_x$$

And where *DS* is number of data centres:

$$normDS_x = 100 * \frac{DS_x — min (DS)}{max(CS) — min (DS)}$$

And where *DS* is number of data centres:And SqFt is the square foot of data centres per capita in a country:

$$normSqFt_x = 100 * \frac{SqFt_x — min (SqFt)}{max(SqFt) — min (SqFt)}$$

15. **Software-engineering professionals in each country** is an indicator that takes into account the total number of suitably skilled professionals in a country.

    a. Source: LinkedIn.[17]

    b. Methodology: The total number of people with the job role of “software engineer” in each country, based on experiences listed in LinkedIn profiles.

    c. Metric: Total number of software engineers in each country.

05

Local Talent Pool

16. **AI skills** is an indicator that captures the availability of AI professionals in each country through a tracker on job postings as a measure of labour shortages.

    a. Source: Omdia's AI Skills Tracker, which provides an ongoing curated collection of job postings specific to the development of enterprise AI solutions. Every six months, Omdia publishes a snapshot of AI-hiring activity and charts the distribution of job openings across several measures, including technologies, skills, regions and industry verticals.

    b. Methodology: To build this database, Omdia collects job postings every week from three major job sites: LinkedIn, Glassdoor and The Muse. These sources were chosen for their global coverage and complementarity. All collected postings are scrutinised before inclusion according to a set of requirements designed to focus the final dataset on all relevant AI-practitioner roles. Omdia culled approximately 1 million entries down to 275,216 across the globe (including countries not covered in this index). Omdia employed a GenAI tool – OpenAI GPT-4 Turbo – to prepare data for this report and generate select data-processing elements.

    c. Metric: Cumulative number of AI job postings in a country.

17. **Availability of training programmes** is a country's access to tech education provided by industry leaders. To best represent the mix of skills required by compute professionals, a mix of large cloud-service providers, as well as IT hardware and software companies, was included. In the following description we refer to these companies as training leaders.

    a. Source: Training leaders' websites, namely AWS,[18] HPE,[19] Linux,[20] Microsoft[21] and Red Hat.[22]

b. Methodology: Data from the World Bank[23] on the size of the labour force were also included. To find the number of training programmes relative to the labour force, the number of programmes per million within the labour force was used. Due to missing data for Taiwan, a data point from Moody's[24] was used instead.

c. Metric: 20 points were awarded for the presence of a training leader (maximum of 100).

For each of the five training partners, a country received a score as follows:

$$\text{training score}_x = 20Score_{Linux\ x} + 20Score_{AWSx} + 20Score_{Microsoft\ x} + 20Score_{RedHat\ x} + 20Score_{HPE\ x}$$

Within each training programme score:

- A total of 0.5 points was awarded based on the raw number of training partners.
- A total of 0.5 points was awarded based on the number of training partners per working age population.

$$Score_x = 0.5Score_{percapita\ x} + 0.5Score_{total\ x}$$

For both $Score_{percapita\ x}$ and $Score_{total\ x}$ the following approach was taken:

The number of training partners each country had was divided into quartiles. A maximum of 1 point was awarded for those in the top quartile; the bottom quartile received 0.25 and those with no programmes received 0.

The score also considered whether programmes were provided in the local language. Each country's quartile score was multiplied by 1 if they had local language and 0.75 if they did not.

$$Score_{per\ capita\ x} = Quartile_{per\ capita\ x} * Language_x$$

$$Score_{total\ x} = Quartile_{total\ x} * Language_x$$

$$Quartile_x = \begin{cases} 1.00 & training\ programmes_x > Q_{3\ training\ programmes,} \\ 0.75 & training\ programmes_x > Q_{2\ training\ programmes,} \\ 0.5 & training\ programmes_x > Q_{1\ training\ programmes,} \\ 0.25 & training\ programmes_x \leq Q_{1\ training\ programme}\ and\ training\ programmes_x > 0 \\ & 0\ ,\ training\ programmes = 0 \end{cases}$$

$$Language_x = \begin{cases} 1, & local\ language_x = \text{“Yes”} \\ 0.75, & local\ language_x = \text{“No”} \end{cases}$$

18. Participation in the open-source community looks at the total number of pushes to GitHub from each country.

a. Source: GitHub.[25]

b. Methodology: Calculated by taking an economy's total number of Git pushes:[26] the number of times developers in a given economy uploaded code to GitHub. Note that a single Git push may contain multiple commits.

c. Data on the size of the labour force were also included also from the World Bank.[27] Due to missing data for Taiwan, a data point from Moody's[28] was used instead.

d. Metric: Total number of Git pushes per million of the labour force.

06

Policy and Governance

19. Data-governance policy is the ability of a country to safeguard information using standards and regulations.

a. Source: This was drawn from the TBI data-governance Dare to Share Data Governance Project Dataset. This is built using desktop research, including data from CNIL,[29] the Data Governance Mapping Project[30] and World Privacy Forum.[31]

b. Methodology: Calculated by taking the average of seven metrics:

1. The presence of a data strategy.
2. The sophistication of data-protection regulation.
3. The presence of personal-data protection.
4. The presence of an open-data portal.
5. The presence of an open-data coordinating body.
6. The presence of trade agreements.
7. Ratification of the Budapest Convention.

c. Metric: Seven different metrics were given equal weight in calculating a country's data-governance score. All are binary variables with the exception of data protection, which is scored out of four by CNIL.[32]

$$\begin{aligned} \textit{strategy}_x = \ & 100/7\ (\textit{Data Strategy}_x + 0.25\textit{Data Protection}_x \\ & + \textit{Personal Data Protection}_x + \textit{Open Data}_x \\ & + \textit{Open Data Coordinating Body}_x + \textit{Trade Agreements}_x \\ & + \textit{Budapest Convention}_x) \end{aligned}$$

20. AI/computing strategy

a. Source: The Organisation for Economic Co-operation and Development (OECD) and secondary research.

b. Methodology: Calculated by recording countries with a "yes" or "no" and allocating 25 points for "yes" if they have:

i. a national AI strategy
ii. a national academic resource
iii. mention of monitoring AI bodies in their national AI strategy
iv. mention of generative AI in their national strategy or mention of generative AI in other government whitepapers.

c. Metric: 25 points were allocated for each “yes”, for a maximum of 100 points

strategy$_x$ = *IF(National AI Strategy ="Yes", 25, 0) + IF(National Academic Resource ="Yes", 25, 0) + IF(AI Bodies="Yes", 25, 0) + IF(Generative AI ="Yes", 25, 0)*

21. **Tax policy** is a measure of the tax placed on computing infrastructure. Due to the increasing complexity of the digital economy and variance in the taxation of goods compared with services, Omdia changed the source from an EY-estimated VAT on digital goods to PwC’s standard VAT rate.

- Source: PwC.[33]
- Methodology: VAT rates for WWTS territories.
- Metric: VAT percentage.

Endnotes

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