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The Digital Drivers of the Transatlantic Economy

More data was generated over the last two years than in the entirety of human history.

The crisis has sped the adoption of a wide range of digital technologies by three to four years

The Covid-19 pandemic was a digital turbocharger. It accelerated the adoption of a wide range of digital technologies by three to four years. The digital experiences most of us gained are likely to have a lasting effect on the ways we work, move, buy, sell, learn and play.

As lockdowns ended, the extraordinary digital boom subsided. Companies adjusted once more as people again began to travel and return to shops, cafes and restaurants. Firms battered by the pandemic saw their fortunes improve. The food, travel and hospitality industries began to recover. Physical stores once again beat electronic commerce in the United States and many other countries in 2021 and 2022.[1]

Now, in a reversal of fortunes, once thriving digitally-driven companies are struggling to survive. Companies previously on hiring sprees have been forced to shed workers and cut costs. The combined value of the five biggest tech companies – Alphabet, Amazon, Apple, Meta and Microsoft – fell by nearly $3.7 trillion last year. Global information communication technology (ICT) spending fell to $4.38 trillion – a slight contraction of 0.2% from 2021, but a rare instance of companies deciding to spend less on digital transformation. Gartner expects ICT spending to increase 2.4% in 2023, less than half earlier estimates, as companies face inflationary pressures, higher interest rates, currency fluctuations, and weaker consumer and business spending.[2]

In most cases, digitally-driven companies are simply readjusting to post-pandemic realities and sharpening their focus on opportunities and challenges to come. Despite major job cuts, most digitally-driven companies still have more workers than they did when the pandemic began. The ten companies announcing the largest layoffs have only undone about 10% of the jobs they created during the pandemic.[3] The ICT sector overall continues to record net employment gains, and scores of thousands of jobs remain unfilled.

In short, the digital jet stream may no longer be stratospheric, but it is still flying high. More data was generated over the last two years than in the entirety of human history. By 2025, global data creation is projected to grow to more than 180 zettabytes. That's 180 followed by 21 zeros – over 2 billion times the Internet's size in 1997. Only about 2% of that data survives year-to-year. Still, 2% of 180 zettabytes is huge. By 2026, monthly global data traffic is expected to surge to 780 exabytes – more than three times data usage rates in 2020. [4]

Global internet bandwidth has tripled since 2017, even as growth slowed from a torrid pandemic-driven surge of 34% in 2020 to a more "normal" pace of 29% in 2021.[5] Over 5 billion people typically spend more than 40% of their waking life online.[6] More than 2 billion digital payments are made every day.[7] This year, 1 in 2 companies will generate more than 40% of their revenues from digital products and services.[8] GSMA Intelligence forecasts that 37.4 billion devices will be connected to the internet by 2030, up from 15.1 billion in 2021.[9] The global Internet of Things (IoT) market, valued at $690.3 billion in 2021, is projected to grow to $1.5 trillion in 2026 and $1.85 trillion in 2028.[10]

Over the next three years, global spending on digital transformation is forecast to reach $3.4 trillion, with a five-year compound annual growth rate (CAGR) of 16.3%.[11] The United States is the largest market for such spending, accounting for nearly 35% of the worldwide total. Western Europe is the second largest region, accounting for nearly a quarter of all spending on digital transformation.[12] The World Economic Forum estimates that 70% of the new value created in the whole economy over the next ten years will be digitally enabled.[13]

Digital Twinning, Digital Money, and Generative AI

For the transatlantic economy a number of digital transformations bear watching. In previous surveys, we have discussed opportunities for small- and medium-sized enterprises, the evolution of 3-D printing, the emergence of Web3, and the promise of the connected factory. Each of these developments remains significant.

We also discussed the metaverse, which much popular commentary treats as a fusion of virtual gaming, social networking, and entertainment. Substantial additional economic value, however, is likely to be generated by the "industrial" or "enterprise" metaverse, a world in which the distinctions between physical and digital work environments blend. In that world, nearly any

aspect of work could be performed and tested digitally before it is done physically. Employees could train on 3-D virtual replicas of equipment before using physical tools. Executives could employ more precise tools to predict what's next for their organization. As McKinsey has noted, this world is still aspirational. But its pathfinder is already here: digital twinning technology.[14]

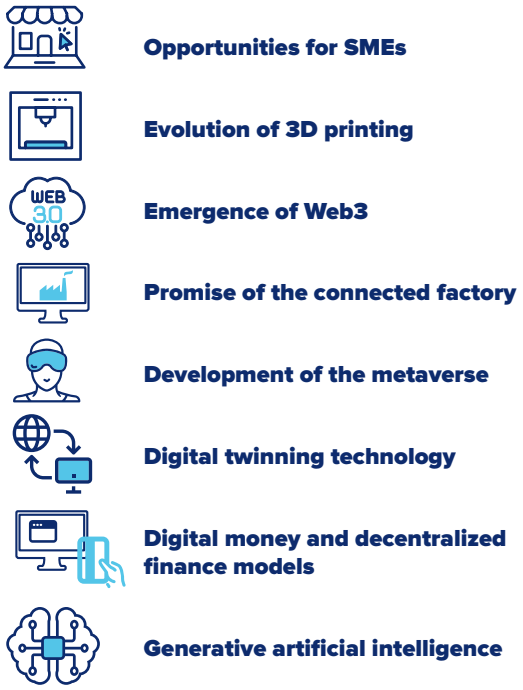
Digital twins are already being employed in fields ranging from architecture, engineering and construction, hospitals and medical facilities, and automobiles to insurance, banking, and wastewater management. The digital twin market is forecast to grow from $6.9 billion in 2022 to $126 billion in 2030.[15]

In our annual surveys, we have also noted the disruptive potential of digital money. Roller-coaster cryptocurrency markets hit an all-time high of $3 trillion in November 2021 before crashing to half that size in February 2022. They were further rocked by the implosion of the TerraUSD stablecoin and the collapse of its twin coin Luna in May, the failure of crypto hedge fund Three Arrows Capital in June and Celsius Network in July, and then the collapse of the FTX exchange and related crypto funds in November. The result is a new "crypto ice age".[16]

At the same time, nine out of ten of the world's central banks are working to create digital versions of their own currencies. Some are already in circulation, such as The Bahamas' Sand Dollar and Nigeria's eNaira. China has been testing a digital renminbi, or e-CNY; India has launched a digital scheme; the European Central Bank plans a pilot phase for a "digital euro" in 2023; and Mexico is slated to launch a "digital peso" by 2024. The G20 has prioritized cross-border payments using central bank digital currencies, and experiments led by the Bank for International Settlements have shown that such platforms could lead to faster, cheaper, and more transparent cross-border payments. The test now is to scale such experiments to real-world use, and to address ongoing concerns regarding privacy, governance, legal uncertainties, and whether such digital linkages could lead to more rapid contagion effects in the event of a digital financial crisis.[17]

Given the dollar's central role in the international monetary system, prospects for a digital dollar are central to any consideration of central bank digital currencies. The U.S. Treasury and the Federal Reserve have stated that the issue is important, but not necessarily urgent. "It's more important to get it right than to be first" says Fed Chairman Jerome Powell.[18]

Digital transformations impacting the transatlantic economy



Opportunities for SMEs

Evolution of 3D printing

Emergence of Web3

Promise of the connected factory

Development of the metaverse

Digital twinning technology

Digital money and decentralized finance models

Generative artificial intelligence

Even as digital transformations envelop all of these fields, the new digital buzz is all about generative artificial intelligence (AI), which is now giving computers the ability to enter realms once reserved for humans. They can churn out original prose, images, sounds and even code in response to human prompts. Open AI's ChatGPT, Google's LaMDA and Bard, and AI models such as Stable Diffusion, DALL·E 2, and GPT-3, to name a few, promise to open these general-purpose technologies beyond specially-trained developers to potentially all users, ushering in a next new wave of digital transformation equivalent in impact to the introduction of the smartphone. Hundreds of start-ups are engaged in the field, and venture capital is pouring in, despite the relative digital investment downturn, and ongoing concerns related to bias, safety, and mis- and disinformation.[19]

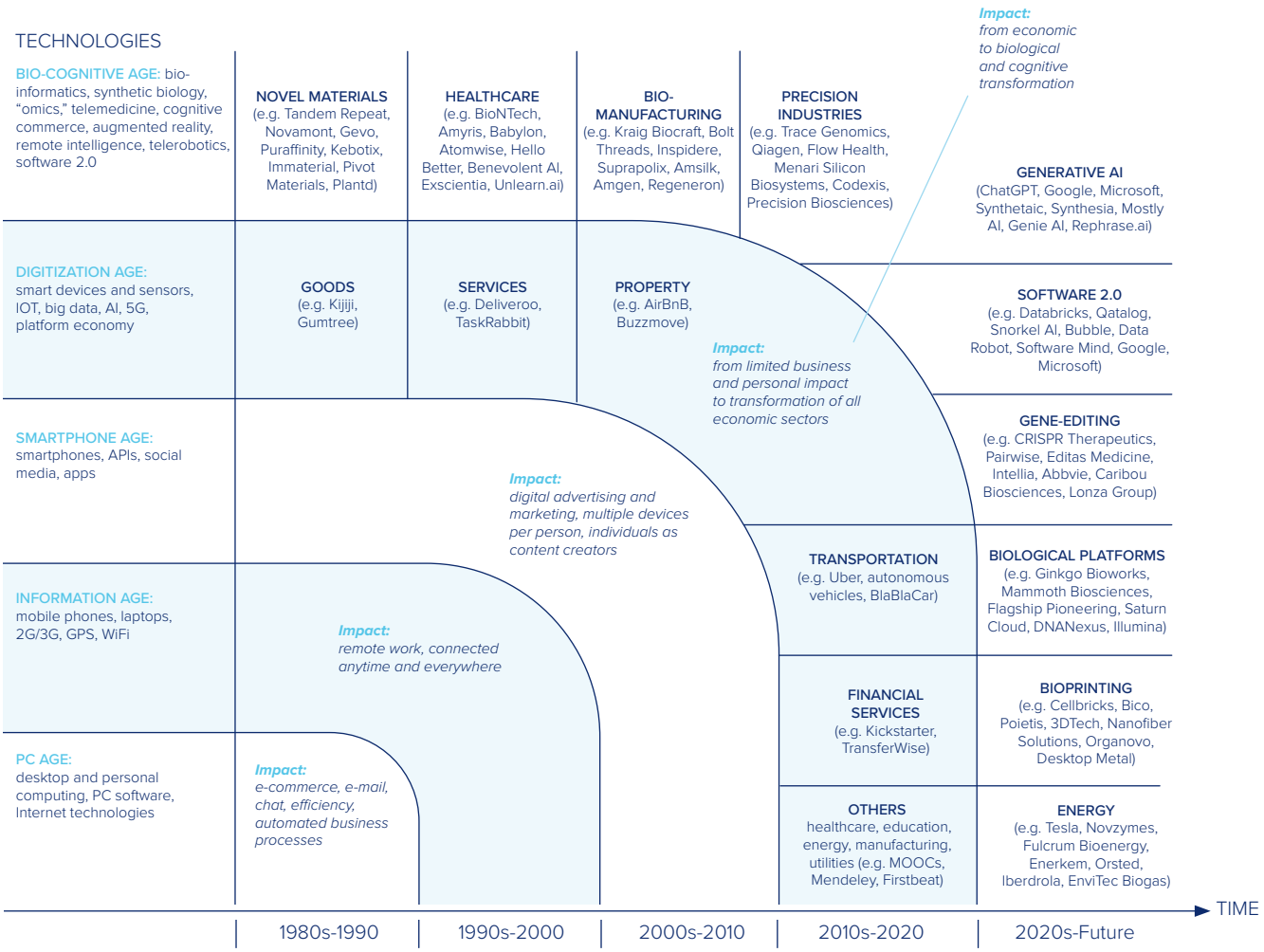
Stepping Into The Bio-Cognitive Age

Even as we grapple with the possibilities and challenges posed by digital transformation, breakthrough advances in the cognitive and biological sciences are combining to usher in a Bio-Cognitive Age, led by pioneering companies on both sides of the Atlantic.[20] Table 1 offers an updated view of this digital frontier.

The pandemic was a major accelerant of the biological revolution. A decade ago, mRNA vaccines were a dream. In 2020, they changed the world. BioNTech, Moderna, Merck, and other companies are already applying mRNA technology to deal with diseases such as malaria, tuberculosis, and HIV. In the future, mRNA drugs could be used for allergies, autoimmune conditions, individualized cancer therapies, regenerative medicine, and for a wide variety of illnesses, from flu and heart disease to yellow fever and the Zika virus. BioNTech believes that in 15 years, one-third of all newly approved drugs will be based on mRNA.[21]

Many biotech firms have also been affected by post-pandemic adjustments. Many face tighter capital inflows and have had to lay off workers. Nonetheless, the current stepback is more a filtering process and course correction than a secular downturn. Digital transformations continue to redefine health in all areas of life. 3D printing is poised to revolutionize reconstructive surgery, from knee replacements to new ears. The rapid advancement of genome-editing techniques holds much promise for the field of human gene therapy. Telemedicine, telepresence, and telesurgery are transforming medical techniques and generating greater cross-border trade in healthcare services.[22]

Table 1 The Expanding Digital Frontier



Sources: GSMA Intelligence; McKinsey Global Institute; Author's own estimates.

By 2025, 40% of the global datasphere will be in health – the largest of any sector or industry. This explosion of genetic and health data – and increasing abilities to process it – hold significant potential for scientific and medical achievement worldwide, assuming the ability to transfer data across borders, subject to certain privacy and data protection standards, is not undermined. The digital health industry is booming, with some estimates valuing the sector at more than $550 billion by 2027 and 16.5% CAGR.[23]

Biological breakthroughs are proceeding alongside, and sometimes interacting with, cognitive advances, led by the transformation of software and artificial intelligence. AI technologies are helping companies supercharge their online advertising, cut energy costs, predict customer behaviors, anticipate stock market movements, improve supply chains, build websites and fill in tax forms. They are approaching or surpassing human levels of performance in vision, image and speech recognition, language translation, skin cancer classification, breast cancer detection, and other domains. Over the next few years, major advances in deep learning and foundation models will lead to even more impressive AI-based applications. Over half of European and U.S. companies have adopted AI applications in their operations.[24]

The potential of transatlantic innovation is underscored by London-based AI company DeepMind, owned by Google parent Alphabet, which has used artificial intelligence to predict the shape of almost every known protein, a breakthrough that will significantly accelerate the time required to make biological discoveries.[25] Recent findings show that AI can slash early drug discovery timelines by four years, and generate cost savings of 60%.[26] BioNTech recently purchased UK AI start-up InstaDeep to augment its efforts to use AI to design next-generation immunotherapies.[27] AI-designed drugs have entered human testing. The healthcare AI-powered tools market is expected to exceed $34 billion by 2025.[28]

While AI's positive effects could be revolutionary, it has also generated substantial concern about potential risks, ranging from automation of jobs, violations of privacy, discrimination, and the spread of fake news, to authoritarian social control and to autonomous weapons.[29] The EU and the United States have each advanced legislation to address AI risks. The EU's AI Act could go into effect in 2024; the U.S. Algorithmic Accountability Act has yet to pass the Congress. The two parties have used their Trade and Technology Council (TTC) to underscore their opposition to AI that does not respect human rights, and to highlight their joint concern "that authoritarian governments are piloting social scoring systems with an aim to implement social control at scale".[30] At the December 2022 TTC Ministerial meeting, the two parties issued a first Joint Roadmap on Evaluation and Measurement Tools for Trustworthy AI and Risk Management. They are also developing a pilot project to assess the use of privacy-enhancing technologies and synthetic data in health and medicine, and to conduct a joint study on the impact of AI on the workforce.[31]

Share of health in the global datasphere by 2025

40%

Digital Apples and Oranges

Given data's peculiar qualities, economists and governments have struggled to devise quality metrics to measure the digital economy. Some recent efforts are relevant to this year's survey.

First, the U.S. Bureau of Economic Analysis (BEA) has revised its definition of the digital economy to include four major types of goods and services: supportive and enabling infrastructure; electronic commerce; priced digital services charged to customers; and the annual budget of U.S. federal nondefense agencies whose services are directly related to supporting the digital economy. This definition begs many questions, including why the sizable, digitally-intense U.S. defense sector would be excluded. Nonetheless, based on these metrics, the BEA estimates that the U.S. digital economy accounted for $3.70 trillion of gross output, $2.41 trillion of value added (10.3% of U.S. GDP), $1.24 trillion of compensation, and 8 million jobs. Growth of 9.8% in 2021 greatly outpaced growth in the overall economy of 5.9%, and U.S. digital economy growth of 5.6% between 2016 and 2021 far exceeded the 1.6% growth of the overall U.S. real economy.[32]

Table 2. The U.S. Digital Economy: Output and Growth

	Current-Dollar Gross Output ($Billion), 2021	Share of Digital Economy, 2021	Growth, 2020-2021	Growth, 2016-2021
Priced digital services	$1,590	43.10%	9.8%	4.8%
Supportive or enabling infrastructure	$1,170	31.50%	11.1%	7.2%
E-commerce (B2B and B2C)*	$9.42	25.40%	8.7%	5.1%
Federal nondefense digital services	$0.42	0.01%	-0.9%	-1.4%
Total Digital Economy	**$3,700**		**10.0%**	**5.6%****

**B2B: Business-to-business. B2C: Business-to-consumer.*
***U.S. real economy growth 2016-2021: 1.6%.*
Source: U.S. Bureau of Economic Analysis.

The Purpose-Driven Digital Enterprise

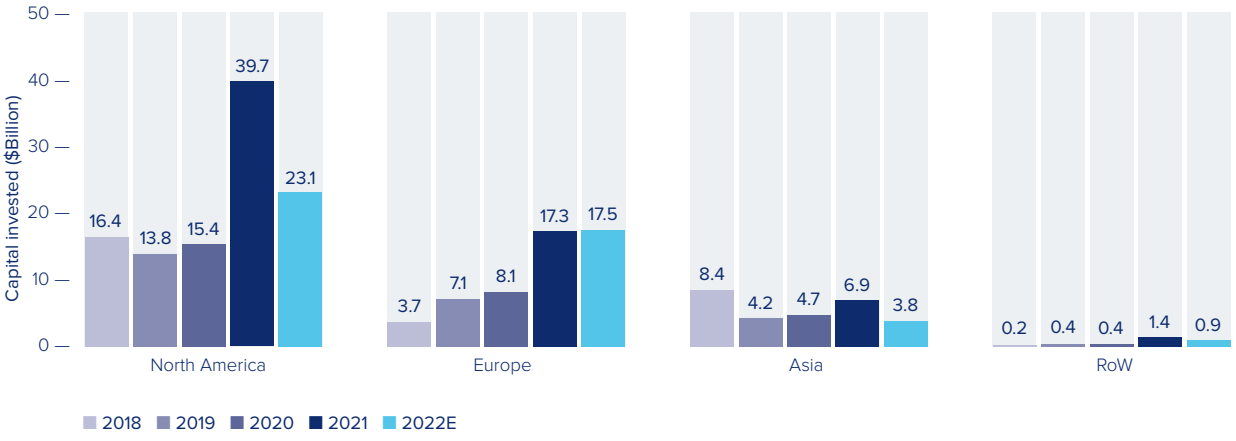
A second lens is offered by European venture capital firm Atomico, which looks more narrowly at information technology and the manufacture of computer, electronic and optical products. It finds that the digital economy (so defined, and excluding biotech) contributed 8.8% of gross value added to the U.S. economy, and 6.3% to the European economy, in 2020.[33]

Within Europe, of course, countries and regions are at different stages of digital maturity. Atomico notes, however, that they all have experienced a rapid growth in value over the past five years. Countries like Sweden, Estonia and Finland are on par with the United States, or close to achieving the same level of gross-value-added contribution from the digital economy. The UK, France, and Germany still capture the greatest share of total ecosystem value, but other regions are growing fast. The total value of private and public tech companies from Central and Eastern Europe, Atomico notes, has reached more than $74 billion, having grown almost 5 times since 2017.[34]

Moreover, total investment in the European digital economy reached a record $100 billion in 2021, and was on track to reach $85 billion in 2022 – the second highest level ever invested, and more than 8 times the level invested in 2015. What's more, investors are sitting on $84 billion worth of dry powder to deploy, up almost 3 times in the last five years.[35]

A particularly bright light on Europe's innovation landscape are purpose-driven digital companies, which Atomico defines as those trying to

Table 3. Capital invested in purpose-driven digital companies by year and region, 2018-2022*



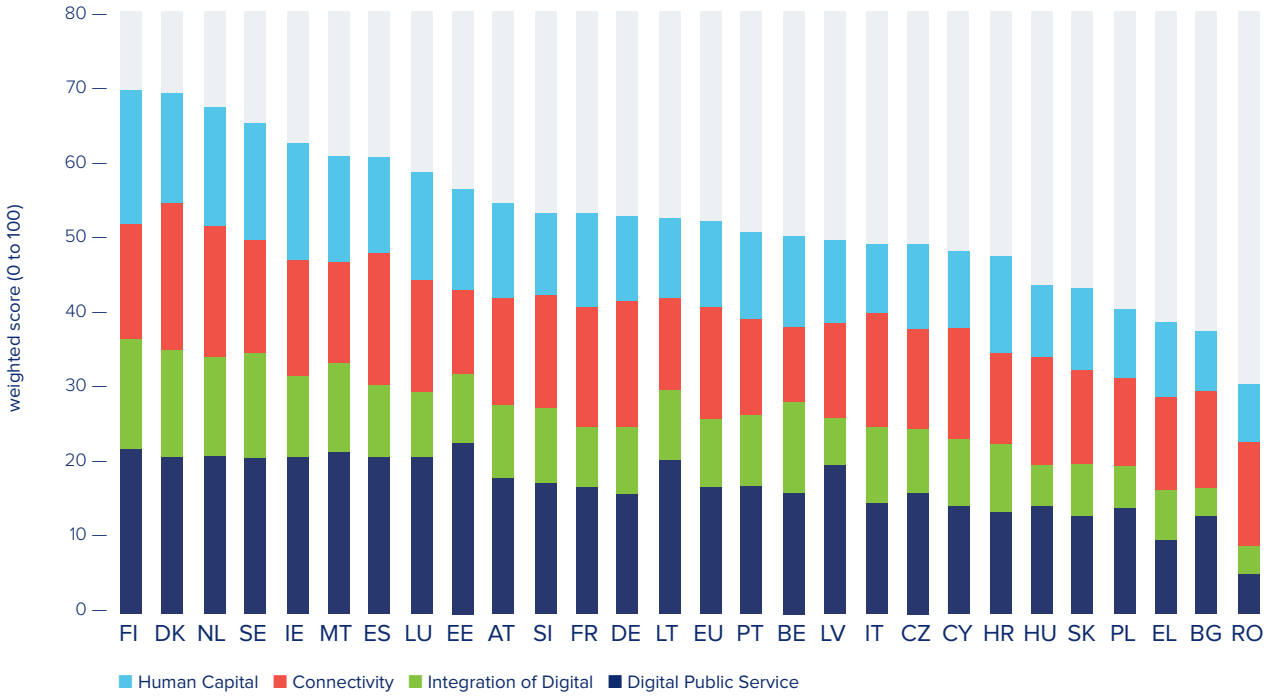
**2022 is annualized based on actuals up to October and annualized on the basis of the three months of August to October. Source: Atomico, State of European Tech 2022, https://stateofeuropeantech.com/1.european-teach-a-new-reality/1.2-tech-motor-for-progress#C1-2-purpose-driven-tech-on-the-rise-again.*

address at least one of the UN's 17 Sustainable Development Goals (SDGs). Over the past five years, investment in these purpose-driven companies has increased at a huge scale globally, but largely in North America and in Europe. Investments in these companies in North America, while still high, flagged somewhat in 2022, whereas investor appetite remained strong in Europe. Capital invested in Europe in these companies has topped $54 billion since 2018, and Europe now accounts for over half (51%) of all investment going into early-stage (up to $20 million) purpose-driven digital companies. This is far greater than Europe's 23% share of overall global investment. For the earliest stages rounds of less than $5 million, Europe's share is even more significant, equating to 69% of all capital invested globally. At later stages, Europe's share of later-stage rounds of $100 million+ global investment into purpose-driven tech companies is 41% – lower, but still significant.

The Digital Economy and Society Index

The European Union takes a different tack. Its flagship annual assessment, the Digital Economy and Society Index (DESI), tracks the digital progress of EU member states according to four metrics: human capital; connectivity; integration of digital technology; and digital public services. Based on this assessment, Finland, Denmark, the Netherlands and Sweden have the most advanced digital economies in the EU, followed by Ireland, Malta and Spain. Romania, Bulgaria and Greece have the lowest DESI scores.

Table 4. The EU Digital Economy: Comparing Member States



Source: Digital Economy and Society Index 2022, European Commission, https://digital-strategy.ec.europa.eu/en/policies/desi.

How Prepared are Europe and the United States for Digital Transformation?

A global assessment is offered by the 2022 Network Readiness Index, which measures how prepared countries are to leverage the opportunities offered by technological innovation. It does so by looking at the state of technology infrastructure, the ability of individuals, businesses, and governments to use ICT productively, how conducive the national environment is for a country's participation in the network economy, and the economic, social, and human impact of a country's participation in the network economy. Based on these metrics, Europe and North America represent 8 of the top 10 countries, and 18 of the top 25, when it comes to technology readiness and adoption (Table 5). Singapore and South Korea were the lone Asian countries in the top ten.[36]

Table 5. **Top Ten Network-Ready Countries, 2022**

Country	NRI Rank	Technology	People	Governance	Impact
United States	1	1	2	7	20
Singapore	2	4	4	10	2
Sweden	3	8	5	5	1
Netherlands	4	3	14	4	4
Switzerland	5	2	11	12	5
Denmark	6	11	7	2	7
Finland	7	13	6	3	3
Germany	8	7	9	14	8
Republic of Korea	9	14	1	22	13
Norway	10	12	12	1	14

Source: Soumitra Dutta and Bruno Lanvin, eds., The Network Readiness Index 2022 (Washington, DC: Portulans Institute, 2022), https://networkreadinessindex.org.[37]

Even though "digital globalization" evokes the image of a seamless global marketplace, digital connections are "thicker" between some continents and "thinner" between others – and they are "thickest" between North America and Europe.

Five Lenses on the Evolving Transatlantic Digital Economy

Due to these apples-and-oranges approaches, it is difficult to come up with a clear estimate of the overall size or value of the transatlantic digital economy. Our interest in this annual survey, however, is more on how North America and Europe connect, rather than on how they compare. With that in mind, we present five ways to look at the transatlantic digital economy. These metrics are not mutually exclusive; they are best understood as different lenses through which one can better understand the importance of transatlantic digital connections.

Together, these five metrics convey one clear message: even though "digital globalization" evokes the image of a seamless global marketplace, digital connections are "thicker" between some continents and "thinner" between others – and they are "thickest" between North America and Europe.

1. Cross-Border Trade and Investment in Digital Services and Digitally-Enabled Services

Digitalization is changing the scale, scope and speed of trade. It has lowered shipping and customs processing times. It offers alternative means of payment and finance. It has boosted trade in software design over trade in final products. It has reduced the cost of creating, copying and accessing text, video content and music. The result: trade in data, digital services, and intellectual property is booming, whereas trade in many traditional goods and services has flagged. According to McKinsey, between 2010 and 2019, trade flows linked to knowledge grew twice as fast as those of traditional goods.[38]

Digitalization has changed the very nature of trade. It blurs the distinction between trade in goods and services. Automakers are now also services providers; online retailers are also manufacturers. 3D-printing generates products that are a mix of goods and services. Digitalization has enhanced our ability to access goods and services without owning them.[39]

The digital economy is dominated by services. Many services sectors that were once non-tradable – because they had to be delivered face-to-face – have become highly tradable – because they can now be delivered over long distances.[40]

Two metrics offer us a clearer picture of transatlantic connections in digital services. A narrow view can be had by looking at cross-border ICT services, or digital services as shorthand, which are services used to facilitate information processing and communication.[41] A broader view can be taken by looking at services that can be, but are not necessarily, delivered remotely over ICT networks. These are called digitally-enabled or digitally-deliverable services: They include digital services as well as "activities that can be specified, performed, delivered, evaluated and consumed electronically."[42] Identifying potentially ICT-enabled services does not tell us with certainty whether the services are actually traded digitally. But the U.S. Commerce Department notes that "these service categories are the ones in which digital technologies present the most opportunity to transform the relationship between buyer and seller from the traditional in-person delivery mode to a digital one," which means a digital transaction is likely and thus can offer a rough indication of the potential for digital trade. [43]

Growth in digitally-deliverable services trade cushioned the pandemic's blow to overall services trade. Global exports of digitally-deliverable services grew from around $3.3 trillion in 2019 to $3.8 trillion in 2021. This 8.4% growth helped to offset a sharp 11.8% decline in exports of other services during this pandemic period. As a result, overall services trade fell by 3.5%, much less than would otherwise have happened. Digitally-deliverable services accounted for about 63% of global services exports.[44]

Germany was the top global importer of digital services in 2021, followed by the United States and France. Ireland was the top global exporter of digital services, followed by India and China (Table 6).

Considering the broader class of digitally-deliverable services, the United States was the largest global exporter and importer in 2021 (Table 7). As with digital services, most of the top 10 exporters and importers of digitally-deliverable services in 2021 were developed countries.

Table 6. Digital Services Trade: Top Exporters and Importers, 2021

Exporters	Value ($Billions)	Importers	Value ($Billions)
1. Ireland	197.7	1. Germany	45.4
2. India	81.7	2. United States	39.2
3. China	77.0	3. France	26.3
4. United States	52.8	4. Singapore	25.2
5. Germany	37.2	5. Japan	24.0
6. United Kingdom	34.0	6. Netherlands	21.4
7. Israel	24.8	7. United Kingdom	14.7
8. France	21.2	8. Belgium	13.7
9. Singapore	18.2	9. India	13.6
10. Sweden	16.9	10. Italy	12.7

Source: UNCTAD.

Table 7. Digitally-Deliverable Services Trade: Top Exporters and Importers, 2021

Exporters	Value ($Billions)	Importers	Value ($Billions)
1. United States	613.0	1. United States	350.4
2. United Kingdom	353.4	2. Ireland	323.8
3. Ireland	316.1	3. Germany	212.5
4. Germany	242.2	4. United Kingdom	170.2
5. China	194.5	5. Netherlands	165.0
6. India	185.2	6. China	164.8
7. Netherlands	164.2	7. Japan	152.5
8. France	163.7	8. France	148.8
9. Singapore	148.4	9. Singapore	135.2
10. Luxembourg	125.4	10. Switzerland	122.8

Source: UNCTAD.

Ireland's high rankings underscore both its preferred location for many multinational companies, and its high reliance on digital trade. Its imports of digitally-deliverable services were equivalent to 64%, and its exports 63%, of its GDP.

Digitally-enabled services are not just exported directly, they are used in manufacturing and to produce goods and services for export. Over half of digitally-enabled services imported by the United States from the European Union (EU) is used to produce U.S. products for export, and vice versa, thus generating an additional value-added effect on trade that is not easily captured in standard metrics.[45]

In 2021, U.S exports of digital services totaled $89.4 billion, while U.S. digital services imports were $51.2 billion, resulting in a trade in a U.S. digital services trade surplus of $38.2 billion. U.S. trade in digitally-deliverable services was much higher: exports of $613.0 billion and imports of $350.4 billion. The resulting U.S. digitally-deliverable trade surplus of $262.6 billion was $41 billion (18%) more than in 2020.[46]

The UK was the U.S.' top overall trading partner in digitally-deliverable services, and its largest source of digitally-deliverable services imports. Ireland maintained its position as the top recipient country for U.S. exports of digitally-deliverable services for the third year in a row. Both countries also registered the largest increases in both imports and exports of digitally-deliverable services with the United States.[47]

In terms of world regions, Europe and the U.S. remain each other's main commercial trading partners in digitally-deliverable services. In 2021, the United States exported $283 billion in

digitally-deliverable services to Europe – more than double what it exported to the entire Asia-Pacific region, and more than combined U.S. exports of digitally-deliverable services to the Asia-Pacific ($136 billion), Latin America and other Western Hemisphere ($111 billion), and the Middle East ($17 billion).

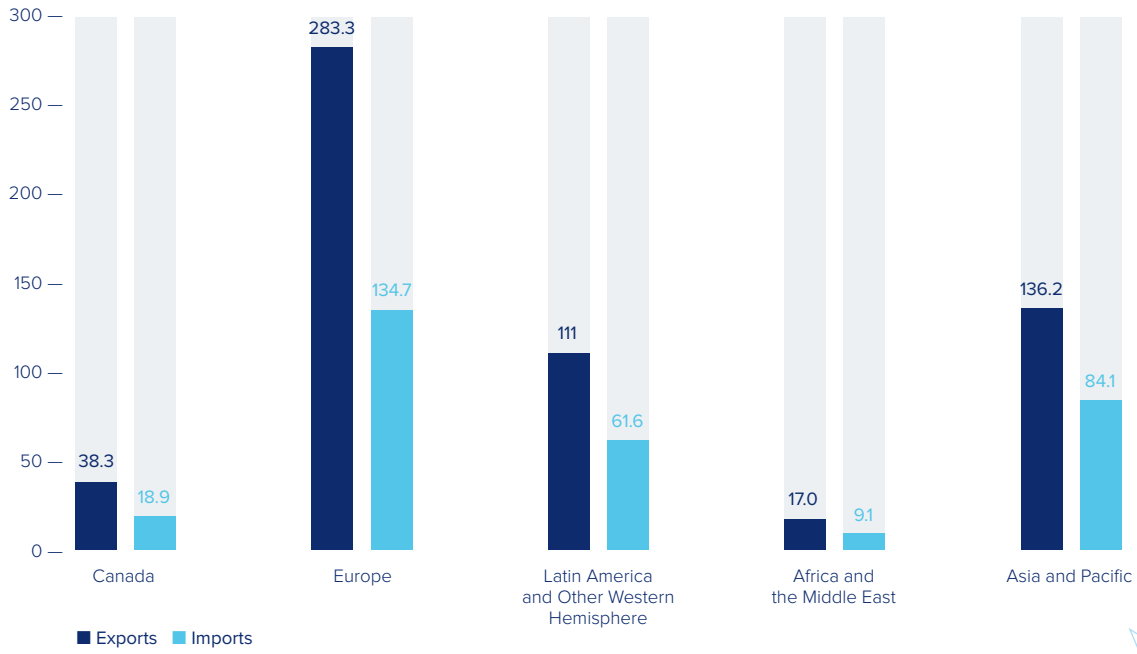
Europe and the U.S. remain each other's main commercial trading partners in digitally-deliverable services.

In 2020, the 27 EU member states collectively exported €1.0 trillion and imported €1.0 trillion in digitally-enabled services to countries both inside and outside the EU (See Tables 9 and 10). Excluding intra-EU trade, EU member states exported €551 billion and imported €594.5 billion in digitally-enabled services, resulting in a deficit of €43.3 billion for these services.

Digitally-enabled services represented 61% of all EU27 services exports to non-EU27 countries and 68% of all EU services imports from non-EU countries.

In 2020, the United States accounted for 22% of the EU27's digitally-enabled services exports to non-EU27 countries, and 34% of EU27 digitally-enabled services imports from non-

Table 8. **U.S. Trade in Digitally-Deliverable Services by Major Area, 2021*** ($Billions)



**Data for 2021 or latest available.*
Source: Bureau of Economic Analysis, Trade in Potentially ICT-Enabled Services Database.
Data as of February 2023.

Table 9. Destination of EU Exports of Digitally-Enabled Services, 2020 (€Billions)

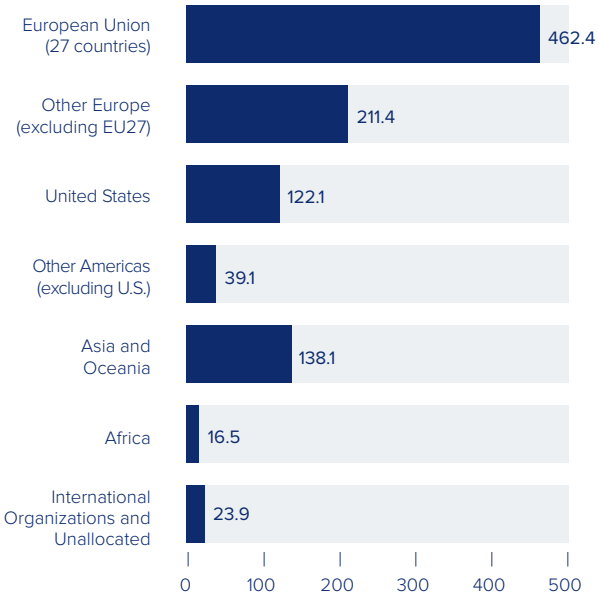
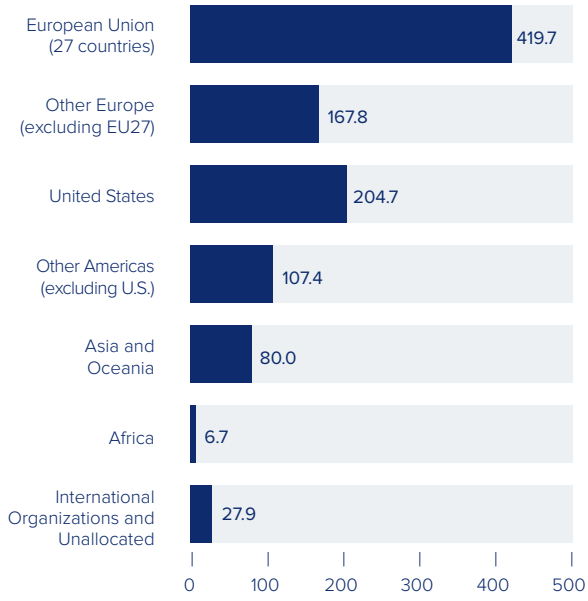


Table 10. Origin of EU Imports of Digitally Enabled Services, 2020 (€Billions)



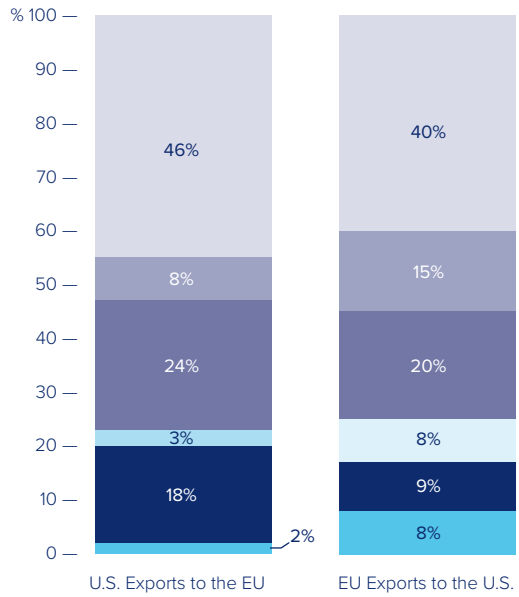
Note: Digitally-Enabled Services includes finance; insurance; IP charges; telecommunications, computer, information services; R&D services; professional and managemet services; architectural, engineering, scientific and other techhnical services; trade-related services; audiovisual services; and other personal, cultural, and recreational services. Asia includes Middle East countries.
Source: Eurostat. Data as of January 2022.

EU27 countries.[48] The United States purchased €122.1 billion, according to Eurostat data for 2020, making it the largest country for imports of EU27 digitally-enabled services exports – ahead of even the United Kingdom (€121.1 billion). The entire region of Asia and Oceania imported just slightly more than the U.S. (€138.1 billion).

In 2020, EU member states imported just over €1.0 trillion in digitally-enabled services, according to Eurostat data. 41% originated from other EU member states (See Table 10). Another 20% (€204.7 billion) came from the United States, making it the largest supplier of these services. The EU imports of these services from the U.S. were almost double imports from the UK (€114.2 billion).

Table 11 categorizes U.S.-EU digitally-enabled services trade into six sectors. For both economies, the most important exports are represented by digitally-deliverable business, professional and technical services, which accounted for 40% of digitally-enabled services exports from the EU to the United States and 46% of digitally-enabled services exports from the United States to the EU in 2021. The second most important category consists of intellectual property. This usually comes in the form of royalties and license fees, most of which are paid on industrial processes

Table 11. U.S.-EU Digitally Enabled Services Trade by Sector, 2021



Sources: U.S. Bureau of Economic Analysis. Data as of July 2022.

and software, underscoring how integral such transatlantic inputs are to production processes in each economy. Financial services comprise the third largest digitally-enabled services export category.

Digitally-Enabled Services Supplied Through Foreign Affiliates

The digital economy has transformed the way trade in both goods and services is conducted across the Atlantic and around the world. Even more important, however, is the delivery of digital services by U.S. and European foreign affiliates – another indicator reinforcing the importance of foreign direct investment, rather than trade, as the major driver of transatlantic commerce.

In 2020, U.S. services supplied by affiliates abroad were $1.65 trillion, roughly 2.3 times U.S. global services exports of $726.43 billion. Moreover, half of all services supplied by U.S. affiliates abroad are digitally-enabled.[49]

Table 12 underscores the relative importance of digitally-enabled services supplied by affiliates of U.S. companies located in Europe and affiliates of European companies in the United States, versus U.S. and European exports of digitally-enabled services. 58% of the $998 billion in services provided in Europe by U.S. affiliates in 2019 was digitally-enabled. In 2019, U.S. affiliates in Europe supplied $585.5 billion in digitally-enabled services, whereas European affiliates in the United States supplied $287 billion in digitally-enabled services. Digitally-enabled services supplied by U.S. affiliates in Europe were more than double U.S. digitally-enabled exports to Europe, and digitally-enabled services supplied by European affiliates in the United States were double European digitally-enabled exports to the United States.

The significant presence of leading U.S. service and technology leaders in Europe underscores Europe's position as the major market for U.S. digital goods and services. Table 13 underscores this dynamic. In 2020, Europe accounted for 72% of the $333 billion in total global information services supplied abroad by U.S. multinational corporations through their majority-owned foreign affiliates. This is not surprising given the massive in-country presence of U.S. firms throughout Europe, with outward U.S. FDI stock in information overwhelmingly positioned in Europe. U.S. overseas direct investment in the "information" industry in the UK alone, for instance, was almost

Digitally-enabled services supplied by affiliates (2019)

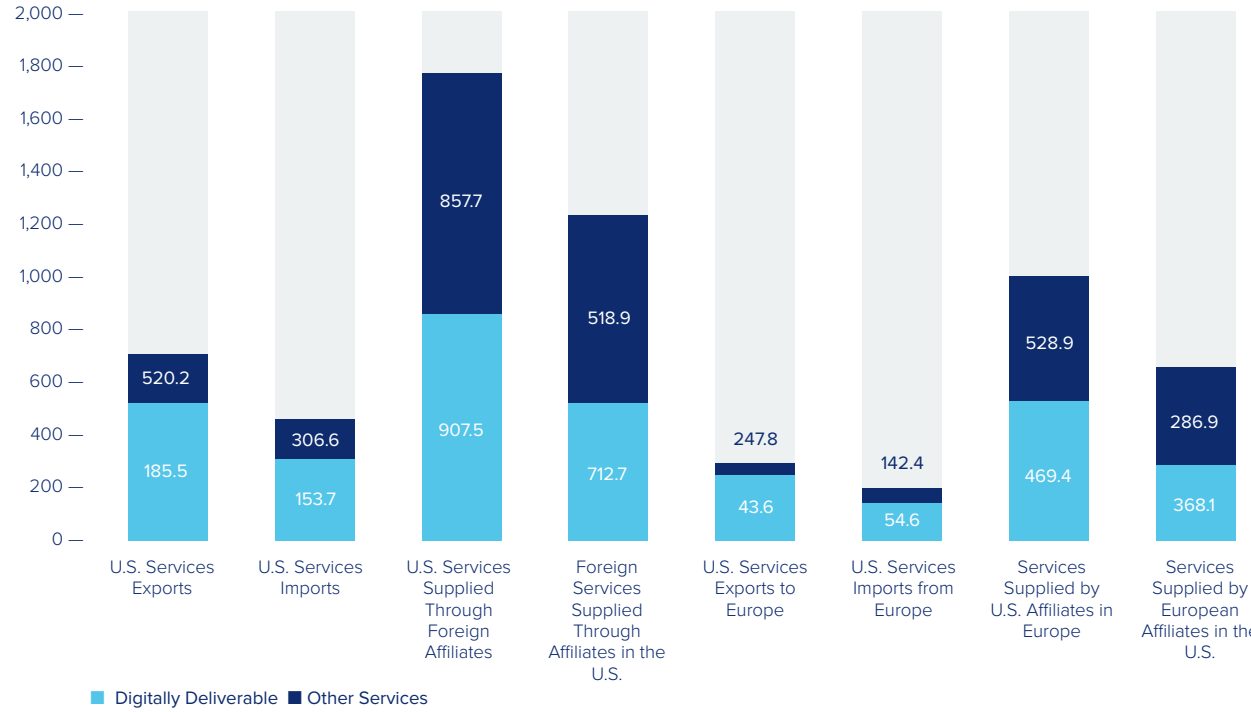
$585.5 billion

U.S. in Europe

$287 billion

Europe in the U.S.

Table 12. **Digitally-Enabled Services Trade and Services Supplied through Affiliates*** ($Billions)



**Trade data are for 2020. Affiliate data are for 2019, the latest available year.*
Source: U.S. Bureau of Economic Analysis.
Data as of October 2021.

Table 13. Information Services Supplied Abroad by U.S. Multinational Corporations through their MOFAs ($Millions)

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Canada	3,595	4,140	3,971	5,996	6,316	7,135	7,595	7,401	8,487	8,342	9,161	8,991	9,403	9,875	10,301
Europe	67,270	76,156	85,450	84,117	96,310	110,525	119,123	120,796	157,811	162,409	175,105	174,396	200,600	224,475	238,610
France	4,045	3,794	4,475	4,713	4,582	5,013	4,768	5,258	6,085	5,894	5,927	6,265	7,036	7,904	8,519
Germany	5,260	6,031	6,104	6,456	7,143	7,798	7,970	10,599	12,018	11,191	11,394	12,589	13,624	14,379	14,546
Netherlands	5,925	8,152	9,980	8,674	8,719	9,313	10,196	9,117	12,686	13,590	13,938	16,617	20,252	19,137	21,585
Switzerland	2,871	2,527	3,197	3,747	4,034	4,419	5,243	4,778	(D)	5,452	5,435	5,404	5,733	8,155	7,342
United Kingdom	33,512	35,711	31,479	29,906	24,941	26,446	25,996	23,876	30,228	33,512	35,854	37,684	38,426	54,173	55,598
Latin America and Other Western Hemisphere	7,255	10,845	13,165	13,798	17,578	20,943	21,887	21,751	22,457	20,672	20,320	21,698	23,822	23,575	19,657
Australia	5,722	6,365	6,369	5,961	6,852	6,960	5,531	7,735	7,045	6,266	6,431	7,018	8,349	12,267	13,214
Japan	3,447	(D)	6,224	7,856	4,575	4,828	5,204	5,807	7,796	7,821	11,252	9,856	11,416	12,862	14,273
China	n/a	n/a	n/a	1,252	1,633	1,627	1,581	1,656	3,016	2,675	2,726	3,250	3,620	4,475	4,070
Other Asia-Pacific, Middle East and African Countries	5,217	(D)	(D)	7,623	8,582	10,320	11,663	14,226	33,461	36,891	36,293	30,498	32,363	31,441	32,841
TOTAL	92,507	(D)	(D)	126,603	141,846	162,338	172,583	179,372	240,073	245,076	261,288	255,707	289,573	318,970	332,966

MOFA: Majority-owned foreign affiliate.
(D) indicates that the data in the cell have been suppressed to avoid disclosure of data of individual companies.
Source: Bureau of Economic Analysis.
Data as of February 2023.

double U.S. information industry investment in the entire Western Hemisphere outside the United States, and almost 14 times such investment in China. Equivalent U.S. investment in Germany was 3.6 times more than in China.

Jobs in the App Economy

Digitally-enabled services have catalyzed the growth of the App Economy on both sides of the Atlantic. During the pandemic the App Economy was critical as individuals and companies suddenly had to turn to the digital world for work, school, shopping and communications. App developers responded to these unexpected needs by launching over 2 million new apps in 2021 alone.[50] Even as the pandemic subsides, the App Economy remains vibrant.

The Progressive Policy Institute (PPI) estimates that as of January 2022 Europe had generated 3.034 million App Economy jobs, a 28% rise over three years.[51] App Economy employment in the United States totaled 2.378 million, up 14% since April 2019.[52] Those are important figures, but not overwhelming in terms of overall employment on either side of the Atlantic. Yet PPI points to the App Economy's outsized contribution to job growth since Apple opened the first App Store in July 2008. For example, from July 2008 to early 2022 the U.S. nonfarm economy added roughly 13 million jobs, while the App Economy generated 2.564 million jobs – about 20% of nonfarm job growth since its inception.[53] And as other parts of the economy have stumbled, the App Economy keeps on going. According to Statista, total revenue in the App market reached $430.90 billion in 2022, and is slated to grow to $614.40 billion by 2026.[54]

Table 14 shows App Economy jobs in Europe and the United States. Roughly half of Europe's App Economy jobs are in just three countries – the UK, Germany, and France – although the smaller Nordic countries and Switzerland are relatively "app intensive," in terms of App Economy jobs as a percentage of all jobs in the country. App Economy jobs in the United States are less concentrated, despite anecdotes about the overwhelming importance of Silicon Valley. California still leads other U.S. states in terms of App Economy jobs,

Table 14. App Economy Jobs: Top 30 European Countries and U.S. States

	Job (Thousands)	Share of European App Economy Jobs		Jobs (Thousands)	Share of U.S. App Economy Jobs
Country			State		
United Kingdom	558	18.4	California	408	15.9
Germany	504	16.6	Texas	239	9.3
France	484	16.0	Washington	137	5.3
Netherlands	267	8.8	New York	136	5.3
Spain	159	5.2	Florida	129	5.0
Sweden	134	4.4	Pennsylvania	114	4.4
Italy	127	4.1	Illinois	90	3.5
Poland	121	4.0	Virginia	83	3.2
Finland	71	2.3	Georgia	81	3.2
Switzerland	68	2.2	Massachusetts	81	3.2
Portugal	57	1.9	Colorado	75	2.9
Denmark	54	1.8	Ohio	74	2.9
Norway	53	1.7	North Carolina	74	2.9
Czech Republic	52	1.7	New Jersey	69	2.7
Belgium	43	1.4	Minnesota	62	2.4
Romania	35	1.2	Michigan	52	2.0
Austria	33	1.1	Maryland	52	2.0
Hungary	31	1.0	Oregon	44	1.7
Ireland	31	1.0	Missouri	44	1.7
Greece	19	0.1	Tennessee	43	1.7
Luxembourg	5	0.0	Arizona	40	1.6
Remaining 9*	128	4.2	Indiana	35	1.4
			Wisconsin	35	1.4
			Utah	28	1.1
			Remaining 21**	339	13.2
Total 30 countries	**3,034**		**Total 50 states**	**2,564**	

*As of December 2021. *Includes estimates for Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia, and Slovenia. **20 states plus the District of Columbia. Sources: Michael Mandel, "Europe App Economy Update 2021," Progressive Policy Institute, May 25, 2022, https://www.progressivepolicy.org/blogs/europe-app-economy-update-2021/; Michael Mandel and Jordan Shapiro, "US App Economy Update 2021," Progressive Policy Institute, May 25, 2022, https://www.progressivepolicy.org/wp-content/uploads/2022/05/PPI_US-App-Economy-Update-2022_V4.pdf. Data: ILO, Eurostat, Indeed, PPI.*

but its lead is diminishing. The Golden State, which accounts for 12% of the U.S. population, accounted for 15.9% of U.S. App Economy jobs in 2022, down from 29% in 2012. New York, Illinois, and Massachusetts have also lost share, whereas states such as Texas, Washington, Florida and Pennsylvania have all gained. Some smaller U.S. states like Colorado, Minnesota, Maryland and Oregon are also relatively "app intensive".

2. E-Commerce

Electronic commerce (e-commerce), which usually refers to transactions in which goods or services are ordered over a computer network (e.g., over the Internet), offers a second window into transatlantic digital connections.[55] Here again we run into some definitional and data challenges. Most estimates of e-commerce do not distinguish whether such commerce is domestic or international. Many metrics do not make it clear whether they cover all modes of e-commerce or only the leading indicators of business-to-business (B2B) and business-to-consumer (B2C) e-commerce. Finally, there are no official data on the value of cross-border e-commerce sales broken down by mode; official statistics on e-commerce are sparse and usually based on surveys rather than on real data.[56]

Nevertheless, we can evaluate and compare many different estimates and surveys that have been conducted. According to UNCTAD, global e-commerce was worth $26.7 trillion globally in 2020 – equivalent to 30% of global gross domestic product.[57]

When most people hear the term 'e-commerce,' they think of consumers buying things from businesses via websites, social networks, crowdsourcing platforms, or mobile apps. These business-to-consumer transactions (B2C), however, pale in comparison to business-to-business (B2B) e-commerce. In 2022 B2B e-commerce was estimated to exceed $22 trillion and account for the vast majority of global e-commerce.[58] By 2028 the global B2B e-commerce market is slated to reach a value of $25.65 trillion, over three times more than the B2C market, which is expected to total $7.65 trillion.[59] B2B e-commerce sales were estimated to total $1.67 trillion in the United States and $1.33 trillion in Europe in 2022, and are projected to reach $2.25 trillion and $1.8 trillion, respectively, in 2025.[60]

While B2B e-commerce accounts for the bulk of global e-commerce, most B2B e-commerce does not cross a border. Most B2B e-commerce users are manufacturers or wholesalers who are dependent on physically moving goods, and often heavy freight; the lack of freight digitalization ultimately poses a barrier to cross-border B2B e-commerce. The sheer volume of B2B e-commerce, however, means it still is the most important component of cross-border e-commerce sales.[61]

Including all types of e-commerce, the United States was the top market in the world in the pre-pandemic year of 2019, for which there is the latest comparable data. U.S. online sales

Table 15. Top 10 Countries by E-Commerce Sales

Rank	Economy	Total ($Billion)	As % of GDP	B2B ($Billion)	% of all e-commerce	B2C ($Billion)
1	United States	9,580	45	8,319	87	1,261
2	Japan	3,416	67	3,238	95	178
3	China	2,604	18	1,065	41	1,539
4	Korea (Rep.)	1,302	79	1,187	91	115
5	United Kingdom	885	31	633	72	251
6	France	785	29	669	85	116
7	Germany	524	14	413	79	111
8	Italy	431	22	396	92	35
9	Australia	347	25	325	94	21
10	Spain	344	25	280	81	64
	Top 10 Total	*20,218*	*36*	*16,526*	*82*	*3,691*
	World	**26,673**	**30**	**21,803**		**4,870**

Source: UNCTAD. Data for 2019, latest available. B2B: Business-to-Business. B2C: Business-to-Consumer.

Table 16. Cross-Border B2C Sales of Top Ten Merchandise Exporters

Rank	Economy	Total ($Billion)	As % of merchandise exports	% of B2C e-commerce sales
1	China	105	4.2	6.8
2	United States	90	5.5	7.1
3	United Kingdom	38	8.2	15.2
4	Hong Kong	35	6.2	94.3
5	Japan	23	3.3	13.2
6	Germany	16	1.1	14.7
7	France	12	2.2	10.6
8	Italy	5	0.9	13.9
9	Korea (Rep.)	5	0.9	4.4
10	Netherlands	1	0.2	4.3
	Top 10 Total	*332*	*3.4*	*9.0*
	World	**440**	**2.3**	**9.0**

Source: UNCTAD. Data for 2019, latest available B2C: Business-to-Consumer.

there were 2.8 times higher than in Japan and 3.7 times higher than in China. North America and Europe accounted for six of the top 10 e-commerce countries (Table 15). China's large B2C e-commerce market reflects its billion-plus population. China is underweight, however, when it comes to B2B e-commerce.

When it comes to cross-border B2C e-commerce sales, China and the United States led in terms of total value, while the UK led in terms of B2C e-commerce as a share of overall goods exports (Table 16).[62]

Cross-border e-commerce revenues (excluding travel) in Europe reached €171 billion in 2021, an increase of 17% compared to 2020. Among 16 prominent European ecommerce markets, 25.5% of total B2C turnover was cross-border in 2020, for which there is the latest comparable data. Cross-border turnover accounted for 35% or more of total ecommerce turnover for Austria, Denmark, Finland, Ireland, Luxembourg, Norway, Portugal and Switzerland.[63]

One likely effect of Brexit, with its accompanying cross-border complications related to new tax provisions, import duties, and logistics adjustments, was that UK cross-border B2C e-commerce sales dropped by 12% in 2021, falling to €29 billion from €33 billion in 2020. The UK lost its traditional position to Germany as Europe's top cross-border B2C e-commerce country. Whereas UK retailers accounted for one of every five of the top 500 European cross-border e-commerce companies in 2020, they accounted for only one in 68 in 2021 – a decline of 32%.[64]

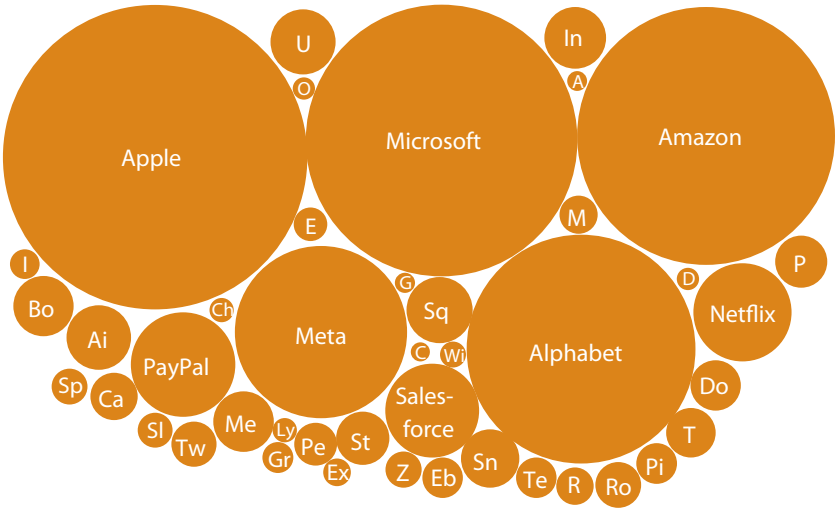
3. The Platform Economy

Platform companies that connect individuals and companies directly to each other to trade products and services continue to reshape the U.S. and European economies, as well as the commercial connections between them. Platforms have swiftly become a prominent business model in the transatlantic and global economy, both by matching supply and demand in real time and at unprecedented scale, and by connecting code and content producers to develop applications and software such as operating systems or technology standards.[65] Platform models have risen so quickly over the past two decades that by 2019, platform companies accounted for 7 of the 10 most valuable global firms.[66] By 2025, platform models are projected to expand to around $60 trillion, or nearly one-third of all global commerce.[67]

Size matters in the platform economy. The biggest are U.S. companies, which account for about two-thirds of the global platform economy. Next come Chinese companies. European platform companies on average are markedly smaller than their U.S. and Chinese counterparts, and together represent only 3% of global market value (Table 17).

Table 17. **Geographical Distribution of the Top Global Platforms.** Based on MarketCap/last-known venture round valuation. (December 2021)

America

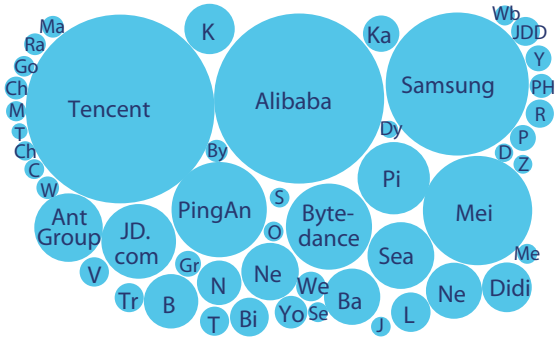


Airbnb
Alteryx
Booking
Carvana
Chegg
Doordash
Dropbox
Ebay
Etsy
Expedia
Grainger
Grubhub
Instacart
Intuit
Lyft
Match
MercadoLibre
Opendoor
Palantir
Peloton
Pinterest
Roblox
Roku
Slack
Snap
Splunk
Square
Stripe
Teladoc
Twilio
Twitter
Uber
Wish
Zillow

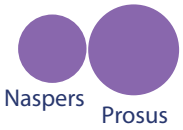
Europe

Adyen
Auto1
Checkout
Delivery Hero
Edenred
Hellofresh
Farfetch
Klarna
Spotify
Just Eat T.
Yandex

Asia-Pacific



Africa



Baidu
Beike
Bilibili
BYJU
Chehaoduo
Coupang
Dada Nexus
Didi Chuxing
Go-Jek
Grab
JD Digits
Kakao
Kuaishou
Lufax
Manbang
Meicai
Meituan
Mercari
Naver
Netease
Ola
OYO
Paytm
Pinduoduo
PindAn **H**ealth
Rakuten
Rea
Sea Group
Seek
Sensetime
Tokopedia
Trip.com
VipShop
WeBank
WeDoctor
Weibo
YonYou
Yuanfudao

Share in total value, by region (%)

Number of top 100 platforms, by region

Source: Holger Schmidt, available at www.netzoekonom.de/vortraege/#tab-id-1 (data as of May 2021).

The dramatic rise of U.S. and Chinese platform companies has generated considerable concern among Europeans that they may be missing out on a major economic transformation. Europe certainly faces some challenges. However, size is not everything. Platform economics have rewarded entrepreneurship and the adoption of new business models. Those who can develop both their digital and their entrepreneurial ecosystems stand to profit greatly from the platform revolution. The Digital Platform Economy Index, which draws on 112 indicators that integrate digital and entrepreneurial ecosystems gauges, goes beyond size to offer a more differentiated view of digital platform-based ecosystem performance (Table 18).

According to this Index, North American and European countries account for 9 of the top 10, and 17 of the top 20, countries when it comes to combined digital and entrepreneurial ecosystem development. China's brand of state-driven capitalism ranks highly in terms of building digital ecosystems, but lags behind the leaders when it comes to digital entrepreneurship.[68] The leading countries not only host digital multi-sided platforms, they rank highly in terms of digital technology entrepreneurship, digital infrastructure governance, and "digital user citizenship".

In the end, it is Europe's larger ecosystem that is likely to shape its future in the platform economy. This underscores the importance of a true European Single Market, including a more integrated Digital Single Market, that would transcend fragmentation of languages, consumer preferences, rules and regulations to facilitate cross-border research, development and commercialization that could introduce new technologies and fresh business models to reach the kind of scale that platform companies have achieved in the large continental markets of the United States or China.[69]

Table 18. Top 20 Countries in the Digital Platform Economy Index

Rankings				
Overall	Multi-Sided Platforms	Digital Technology Entrepreneurship	Digital Infrastructure Governance	Digital User Citizenship
1. United States	1	1	2	6
2. United Kingdom	3	3	4	1
3. Netherlands	2	4	1	4
4. Canada	5	5	6	2
5. Sweden	4	6	5	5
6. Switzerland	9	2	8	7
7. Norway	6	12	3	3
8. Denmark	7	11	9	10
9. Australia	10	18	7	8
10. Finland	11	8	11	9
11. Ireland	14	7	17	15
12. Luxembourg	17	14	10	14
13. New Zealand	8	23	14	11
14. Germany	23	13	12	12
15. France	16	9	15	18
16. Iceland	13	10	16	22
17. Belgium	15	17	18	17
18. Estonia	22	21	19	16
19. Hong Kong	20	19	13	26
20. Austria	28	20	21	19

Source: Zoltan J. Acs, László Szerb, Abraham K. Song, Éva Komlósi, Esteban Lafuente, The Digital Platform Economy Index 2020, Global Entrepreneurship and Development Institute, December 2020, https://thegedi.org/wp-content/uploads/2020/12/DPE-2020-Report-Final.pdf.

Transatlantic data flows account for more than half of Europe's data flows and about half of U.S. data flows globally.

EU-based firms transferring data to and from the U.S. (2020)

Over 90%

4. Cross-Border Data Flows

Another lens through which we can better understand transatlantic digital connections is to appreciate the role of cross-border data flows, which not only contribute more to global growth than trade in goods, they underpin and enable virtually every other kind of cross-border flow.[70]

Transatlantic data flows are critical to enabling the $7.1 trillion EU-U.S. economic relationship. They account for more than half of Europe's data flows and about half of U.S. data flows globally. Over 90% of EU-based firms transfer data to and from the United States.[71]

However, despite the broad recognition of its value, and the need to develop appropriate policy frameworks, there is still no consensus method for empirically determining the value of data.[72] One reason is that data is a special resource different than goods and services. UNCTAD calls cross-border data flows "a new kind of international economic flow, which lead to a new form of global interdependence".[73] Data flows are not necessarily a proxy for commercial links, since data traffic is not always related to commercial transactions.[74] Knowing the volume of data flows does not necessarily provide insight on the economic value of their content. The BEA puts it succinctly: "Streaming a video might be of relatively little monetary value but use several gigabytes of data, while a financial transaction could be worth millions of dollars but use little data".[75]

In addition, commercial transactions do not always accompany data, and data do not always accompany commercial transactions. For instance, multinational companies often send valuable, but non-monetized, data to their affiliates.[76] User-generated content on blogs and on YouTube drives very high volumes of internet traffic both within countries and across borders, but consumers pay for very little of this content. Since it does not involve a monetary transaction, the significant value that this content generates does not show up in economic or trade statistics.[77] In short, data flows are commercially significant, yet their extent, as well as their commercial value, are hard to measure and are in constant flux.

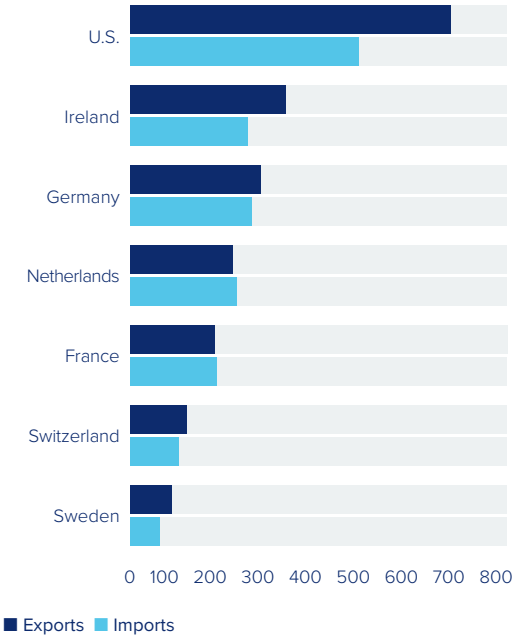
Box 1. Forging a Transatlantic Data Privacy Framework

Data flows are critical to the transatlantic economy, yet U.S.-EU regulatory differences have generated legal uncertainties regarding the transfer of personal data. In July 2020, the Court of Justice of the European Union (CJEU) invalidated the Privacy Shield framework that enabled over 5,000 mostly small- and medium-sized enterprises to transfer personal data for commercial purposes. This prompted renewed negotiations that led to the EU-U.S. Data Privacy Framework (DPF) announced by Presidents Biden and von der Leyen in March 2022. Six months later, President Biden issued an Executive Order that strengthened principles-based privacy and civil liberties safeguards for U.S. intelligence activities, and created an independent and binding mechanism that individuals can use to challenge violations of these principles. In December, the European Commission issued a draft decision that these protections are "essentially equivalent" to those provided within the EU when the personal data of Europeans is transferred to the United States. However, such determinations are based on self-compliance certification schemes similar to those invalidated by the CJEU. As a result, the DPF, like its predecessors, is likely to face legal challenges from within the EU.[78]

Cross-Region Data Flows

Globally, the most intense and valuable cross-region data flows continue to run between North America and Europe. They are also almost certainly the most valuable, even if their worth is difficult to measure. The OECD devised metrics to determine the most active countries when it comes to delivering products across borders through data flows, as opposed to considering all transactions facilitated through data flows. It determined that the United States is a major hub for international trade in products delivered through data flows, and that France, Germany, India, Ireland, the Netherlands, Switzerland, and the United Kingdom also feature heavily in trade underpinned by data, all ahead of China (Table 19).[79]

Table 19. **International Trade Underpinned by Data Flows, Top Countries** (€Billions)



Note: Trade underpinned by data flows includes four categories: (1) "ISIC J production", or trade in products produced by firms classified in ISIC section J (Information and Communication); (2) "ISIC J products," or trade in the products mainly associated with firms classified in ISIC section J but including production by firms classified in other sectors; (3) "Digitally deliverable services," or "potentially ICT-enabled products" per UNCTAD (2015); and (4) "Digitisable products," or products within the WTO HS commodity classification per Banga (2019).
Source: OECD, Perpectives on the Value of Data and Data Flows, December 2020.
Data as of October 2020.

5. Digital Wiring: Land-Based Hubs and Sea-Based Spokes

The Digital Landscape: Hubs and Hyperscalers

The United States and Europe host key land-based hubs and sea-based spokes of the global digital economy. European and U.S. cities are major hubs of cross-border digital connectivity. Europe is the global leader, with tremendous connected international capacity. Frankfurt, London, Amsterdam and Paris – together known as FLAP – substantially outpace North American and Asian cities (Table 20). Frankfurt is home to the largest Internet node in the northern hemisphere. Frankfurt's connected capacity is over three times greater than that of New York and double that of Singapore, the Asian leader.[80] Investments in European data centers are now expanding beyond FLAP to encompass sites like Dublin, Ireland – home to many digital companies – and Marseille, France, which has become a major hub for traffic between Europe, Africa and the Middle East.

Table 20. **10 Highest Capacity International Internet Hub Cities** (€Billions)

Domestic routes omitted. Source: Telegeography, The State of the Network 2022.

The hard-wiring of the transatlantic digital landscape continues to evolve. One key development is the shift in providers of data centers and cloud-like services from European and U.S. telecommunication companies and related data-center management enterprises to "hyperscalers," mainly from the United States. Traditional data centers are centralized facilities that use computing and networking systems and equipment to store data and to enable users to access those resources. Now, the opportunity to use applications that work together via the web and the cloud has given birth to more cost-effective hyperscale data centers that can store more data and scale up or down in quick response to shifting demand for computing tasks.

Many commentators simplify the term "hyperscalers" to refer to the three largest providers: Amazon Web Services (AWS), Microsoft Azure, and Google Cloud. These three firms account for about two-thirds of hyperscale data market share. Nonetheless, other hyperscalers include Meta, Oracle, Apple, IBM, Scaleway, Switch, Alibaba, Huawei, QTS, Digital Realty Trust, Equinix and SAP. [81]

Hyperscale data centers accounted for more than half of all installed data-center servers and total data center traffic in 2021. The global hyperscale data center market is slated to grow by $107.60 billion between 2021-2025. There are now more than 700 hyperscale data centers around the world, double the amount of five years ago. That number is expected to top 1,000 at the end of 2024 and reach 1,200 by the end of 2026.[82]

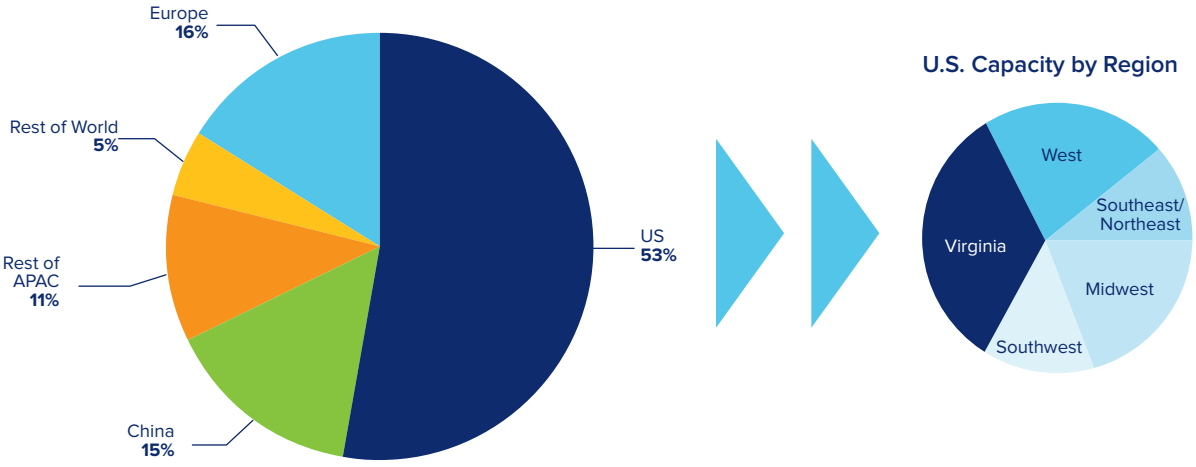
The United States currently accounts for over 53% of the world's operational hyperscale infrastructure, measured by critical IT load.[83] More than one-third of U.S. hyperscale capacity is located in one state – Virginia.[84] Virginia has far more hyperscale data center capacity than either China or all of Europe. Much of that is in Northern Virginia, along the border with Washington, DC. The second-largest concentration of hyperscale infrastructure is in the western United States, primarily Oregon and California. The U.S. Midwest follows, with large concentrations of hyperscale infrastructure in Iowa and Ohio.[85]

The other half of global hyperscale infrastructure is relatively evenly split between China, Europe, and the rest of the world.

In Europe, the leading country markets for hyperscale infrastructure are Ireland and the Netherlands, followed by Germany and the UK. The Western Europe and Nordic hyperscale data center market is expected to be generating revenues of around $29 billion in 2023.[86]

While many U.S. and European regions have embraced this torrid pace of investment, others have raised concerns about data centers' size and heavy energy and water use. By 2030, data centers are projected to account for 3.2% of electricity demand within the EU – an 18.5% jump from 2018, at a time when Europe is under severe pressure to cut its energy demand. The Netherlands issued a nine-month moratorium on new hyperscale sites in February 2022. Authorities in Ireland and in cities such as

Table 21. Hyperscale Data Center Capacity (Q2 2022)



Source: Synergy Research Group. APAC: Asia-Pacific.

Frankfurt and Paris are grappling with related proposals. Similar worries have surfaced across the ocean in Virginia.[87]

These concerns are amplified by related European anxieties about U.S. dominance, which could inhibit some possible avenues for deeper transatlantic cooperation. The European cloud market, for example, is now over five times as big as it was in early 2017, reaching $10.9 billion in the second quarter of 2022. During that time, European providers have grown their cloud revenues by 167%. Their market share in Europe, however, has declined from 27% to under 13%, whereas AWS, Microsoft Azure and Google Cloud now account for 72%.[88] Among the European cloud providers, SAP and Deutsche Telekom are the leaders, each accounting for 2% of the European market.[89]

Two other trends have the potential to mitigate such concerns, depending on how they unfold: migration to the "edge;" and the evolution of "cloud-as-a-service" to "cloud-as-a-product".

Today, most cloud computing still happens in centralized rather than decentralized data centers. By 2025, this trend will reverse: 80% of all data is expected to be processed in smart devices closer to the user, known as edge computing. A few enormous data centers may still be built, but the more pervasive reality will be the emergence of thousands of small data centers distributed more evenly across geographies. This could open opportunities for European providers to offer multi-cloud options that ensure local control over data with the amplified possibilities that come from hyperscaled connections. Cloud/edge computing is likely to be critical to the EU's ability to realize its European Green Deal, particularly in areas such as farming, mobility, buildings and manufacturing.[90]

These opportunities are likely to be influenced by the evolution of the cloud from being a platform on which a business runs, to becoming the product itself. Rather than considering hyperscalers as direct competitors, some European telecoms operators and companies in a range of other businesses now see their biggest opportunities in the cloud building on top of the basic infrastructure already rolled out by U.S. companies. For instance, Siemens is building an ambitious "industrial cloud platform" on top of the basic cloud infrastructure provided by AWS, to enable it to become a key player in digital industrial manufacturing services. Thales, a French defense company, has formed a company in cooperation with Google Cloud to operate three "trusted cloud" hyperscale data centers in France. Other examples include Vodaphone's multi-year strategic partnership with Google, and an alliance between AWS and European digital company Atos.[91]

Submarine cables in the Atlantic already carry 55% more data than transpacific routes.

The Digital Atlantic Seascape

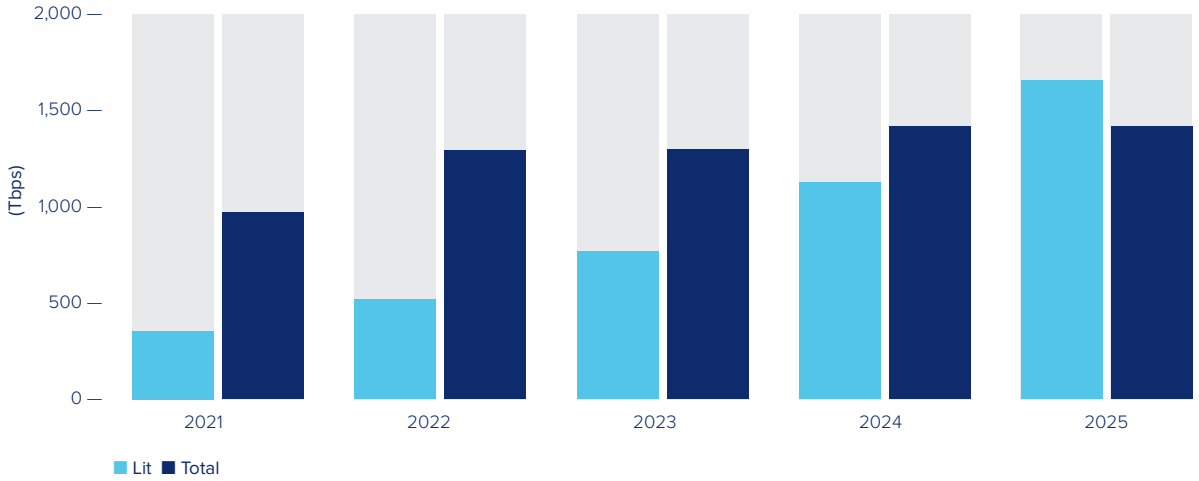
Land-based digital hubs are connected to sea-based digital spokes – roughly 500 undersea fiber optic cables that transmit 95% of all intercontinental telecommunication traffic, carry an estimated $10 trillion worth of financial transactions every day, and serve as the backbone for the global internet.[92] Elon Musk's Starlink may have popularized the idea of satellite internet, but satellites cannot compete with submarine cables when it comes to digital communication capacity, speed, or transaction time (latency). They transmit less than one-half of one percent of such traffic.[93]

Subsea cables serve as an additional proxy for the ties that bind continents. Despite uncertain economic growth prospects for many countries, demand for international bandwidth continues to be strong. Globally, the market for submarine fiber optic cables is estimated to reach $30.8 billion by 2026, growing at an annual rate of 14.3%.[94]

The transatlantic data seaway is the busiest and most competitive in the world. Submarine cables in the Atlantic already carry 55% more data than transpacific routes, and with new capacity buildout, that ratio is tilting further in favor of the Atlantic. North America and Europe are connected via 17 subsea cables. The extend from the U.S. East Coast, primarily from New York, New Jersey, Massachusetts, and Virginia. They land in the UK, France, Denmark, Norway, Ireland, Spain and Portugal.[95]

Transatlantic subsea routes are building out fast, as capacity demands grow from New York across the North Atlantic, and as new connections are built out from the U.S. Mid-Atlantic and across the South Atlantic. Relatively slow buildout of transatlantic bandwidth during Covid year 2020 was replaced by what Telegeography called "scorching" growth in 2021 and 2022. In 2021, 90 Tbps of transatlantic bandwidth was added – equivalent to building all international links from the 2013 internet, for the whole world, in a single

Table 22. Transatlantic Capacity Growth, 2021-2025



Source: Submarine Telecoms Forum.

year. And Telegeography estimates an even greater amount, a record 136 Tbps, was added in 2022.[96]

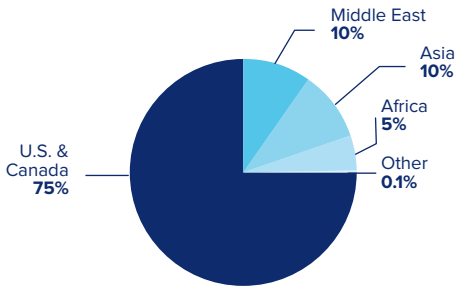
This meteoric rise in transatlantic bandwidth growth is being driven by individuals and businesses switching to cloud and web-based services. Based on current trends, demand could outpace design capacity growth by 2025 (Table 22).[97]

In 2022, total transatlantic capacity was boosted by 70% just by two new powerful transatlantic cables: Grace Hopper, which now extends 6,250 km from New York to the Cornish seaside resort town of Bude in the UK and 6,300 km from New York to Bilbao in Spain; and Amitié, which now connects Massachusetts with Bude and with Le Porge in France across 6,600 km of subsea terrain.[98]

The South Atlantic Express cable, stretching from Virginia Beach, Virginia all the way to South Africa, is slated to begin operations this year. So too is the IRIS cable, which runs 1,700 km from Ballyloughane Strand in Galway, on the Irish west coast, to Thorlakshofen beach in southwest Iceland. It is the first Irish submarine cable not linked to the UK, and the first direct cable link between Ireland and Iceland.[99] The Leif Erikson Cable System, slated for service in 2024, will run 4,200 km from southern Norway to Goose Bay, Canada, and then on Montreal. It will be the first transatlantic cable powered with 100% renewable energy.[100]

The trans-Atlantic route accounted for 75% of Europe's total interregional bandwidth in 2021. The Middle East and Asia each accounted for 10%, Africa 5%, and other regions for 1%. There are land-based networks that link Europe to Asia, but they boast far less capacity than subsea cables – and all of them go through Russia.[101]

Table 23. Share of European Interregional Bandwidth by Region



Data for 2021. Source: Telegeography.[102]

The Digital Arctic may also become reality. The Far North Fiber project, led by Alaskan company Far North Digital, Finland's Cinia, and Japan's Arteria Networks, would extend 14,000 km to connect Scandinavia and Ireland to Japan, passing via the Arctic Northwest Passage, with landings in Greenland, Canada and Alaska. The cable would be the first to be laid on the Arctic seabed and the first to connect Europe to Asia without passing via

the Suez Channel in Egypt, a critical choke point regarding internet infrastructure and international trade. The cable is expected to cut data transmission delays between Frankfurt and Tokyo by around 30%. Russia is preparing to launch its own Arctic cable, Polar Express, in 2026.[103]

Security Concerns

Subsea cables are relatively fragile. On average, 2-4 cables break somewhere in the world every week. Most incidents are caused by shipping or environmental damage. However, recent episodes have prompted suspicions about sabotage. In November 2021, a network of undersea sensors of the Norwegian Ocean Observatory was cut; two months later, the undersea cables connecting Norway's Svalbard Satellite Station to the mainland were cut. Impaired operations at that station, which connects to Europe's Galileo satellite system, could cripple the EU's ability to monitor maritime infrastructure.[104] These indicators of vulnerability, often attributed to human error, took on new meaning following Russia's invasion of Ukraine in February 2022. A trio of explosions that severed both strands of the Nord Stream I and one of the Nord Stream II pipelines in the Baltic Sea in September have heightened fears that subsea cables linking Europe to the rest of the world could be targeted.[105]

Investigators have concluded the Nord Stream incident was clearly an intentional attack, and almost certainly required nation-state capabilities to carry out. As of this writing, there is no substantive proof of attribution. Western officials have hinted that Russia was behind the sabotage, and have pointed to Russian ships and submarines monitoring Atlantic cable crossings and landings. Others point to the possibility of sabotage by pro-Ukrainian individuals without links to the Kyiv government, possibly acting on their own. [106]

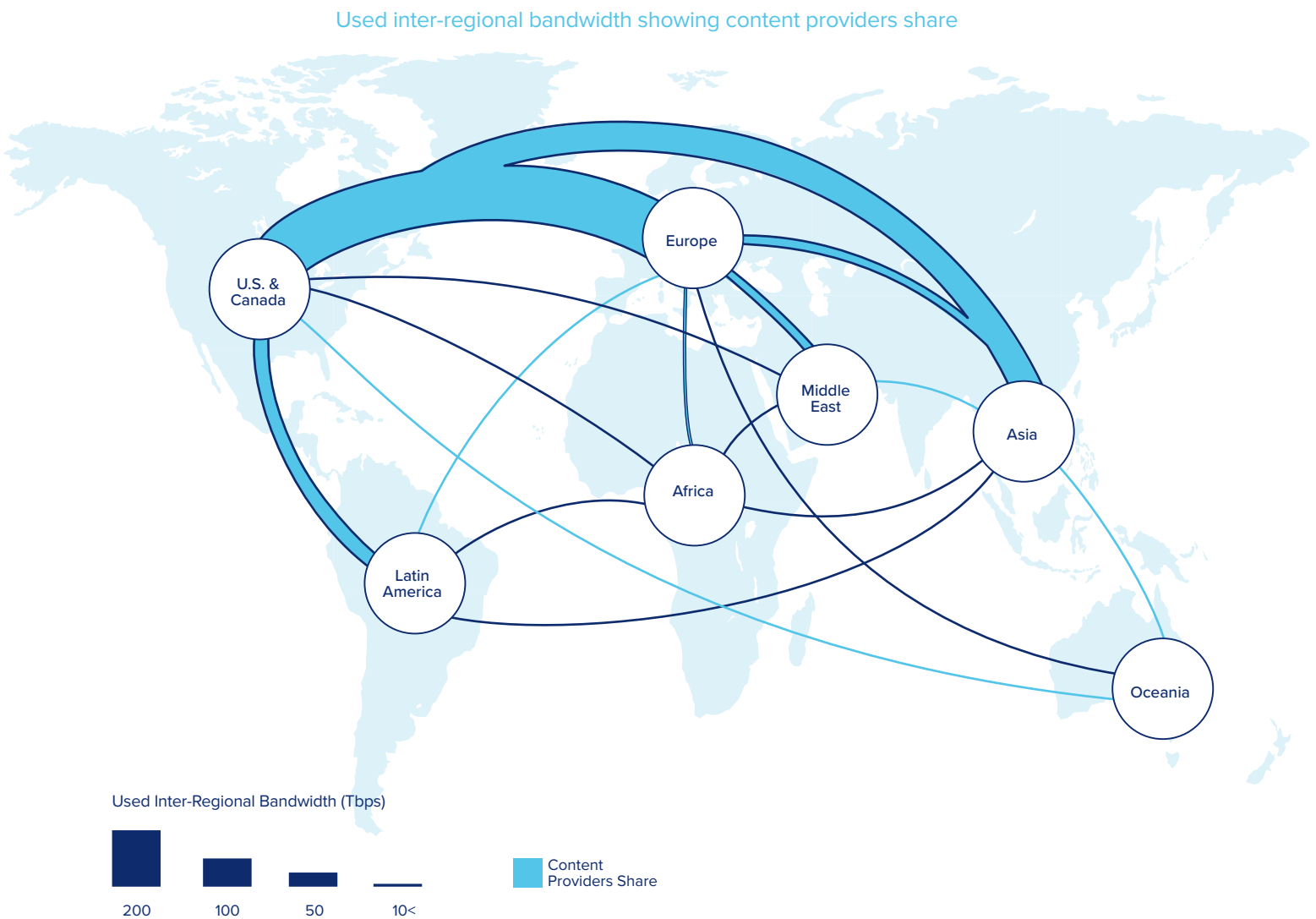
In response, NATO governments are ramping up their own surveillance and deep-sea defensive capabilities to protect maritime infrastructure. Concerns about subsea cable fragility has also prompted subsea cable providers to generate greater redundancy and diversification across their own networks.

Such concerns are not limited to potential Russian activities. The "most vital bottleneck for the EU," according to a European Parliament study, is the passage between the Mediterranean and the Indian Ocean, where sixteen subsea cables converge in Egypt and the Red Sea. The fragility of this major chokepoint was highlighted in March and again in June 2022, when the Asia-Africa-Europe-1 Internet cable connecting Hong Kong to Marseille was severed where it briefly crosses across land in Egypt. Millions were plunged offline; Ethiopia lost 90% of its connectivity; Somalia lost 85%. A number of cable providers are now working to generate cable connections that would cross Israel, bypassing Egypt and the Suez Canal.[107]

The Hyper-Providers

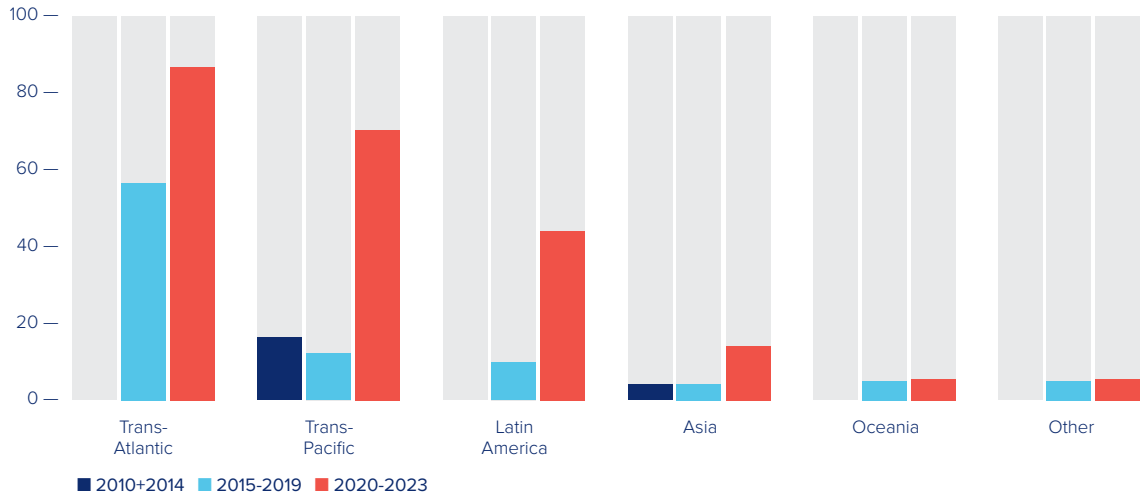
In 2010, the vast majority of international cable capacity was used by telecommunications companies, governments, and research-educational networks. Only 6.3% was consumed by private network providers of content and cloud services. By 2021, the numbers had flipped: content providers accounted for 69% of used international bandwidth globally and for 91% of used capacity on transatlantic routes. Moreover, the content providers now build and either wholly or partially own those cables themselves.[108] They are largely responsible for the new surge in global subsea digital capacity, and their densest connections are between North America and Europe (Table 24).

Table 24. Inter-Regional Capacity and the Cloud



Source: Telegeography.

Table 25. Content Provider Investments Share as % of CAPEX on New Submarine Cables



Source: Telegeography.

Bypassing the Internet

The rise of private content providers as drivers of submarine cable traffic is related to yet another significant yet little understood phenomenon shaping the transatlantic digital economy: more and more companies are working to bypass the public internet as a place to do business in favor of private channels that can facilitate the direct electronic exchange of data among companies.[109]

This move is exponentially increasing demand for "interconnection" – direct, private digital data exchanges that bypasses the public internet – and is another fundamental driver behind the proliferation of transatlantic cable systems. Private interconnection bandwidth is not only distinct from public internet traffic, it is already 9 times larger and is slated to grow much more quickly.[110]

The public internet will remain a pervasive force in most people's lives and a key to digitally-delivered services, e-commerce and the platform economy.[111] Yet private interconnection is rising alongside the public internet as a powerful vehicle for business. And as we have shown here, its deepest links are across the Atlantic.

Notes

1 Shira Ovide, "A Comeback for Digital Stores," *New York Times*, February 25, 2022.
2 Angus Loten, "Global IT Spending Decreased in 2022," *Wall Street Journal*, January 18, 2023; Richard Waters, "Post-pandemic downturn enforces Big Tech 'correction'," *Financial Times*, January 28, 2023.
3 Alex Irwin-Hunt, "Big tech layoffs barely touch pandemic hiring," Fdi Intelligence, February 15, 2023, https://www.fdiintelligence.com/content/data-trends/big-tech-layoffs-barely-touch-pandemicera-hiring-82050.
4 Soumitra Dutta and Bruno Lanvin, eds., "The Network Readiness Index 2022" (Washington, DC: Portulans Institute, 2022), https://networkreadinessindex.org; UNCTAD, *Digital Economy Report 2021*, https://unctad.org/system/files/official-document/der2021_en.pdf; "Worldwide Global DataSphere Forecast, 2021–2025: The World Keeps Creating More Data — Now, What Do We Do with It All?" IDC, 2020; Tom Coughlin, 175 Zettabytes by 2025," *Forbes*, November 27, 2018; Paul Overberg and Kevin Hand, "How to understand the data explosion," Wall Street Journal, December 8, 2021.
5 Telegeography, "The State of the Network 2022," https://www2.telegeography.com/hubfs/LP-Assets/Ebooks/state-of-the-network-2022.pdf.
6 Data.ai, "State of Mobile 2023"; Simon Kemp, "Looking Ahead: Key Digital Themes for 2023," DataReportal, October 7, 2022, https://datareportal.com/reports/looking-ahead-to-what-2023-holds; GSMA Intelligence, "The State of Mobile Internet Connectivity," February 2022; https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf.
7 Bank for International Settlements, "Red Book Statistics," https://stats.bis.org/statx/toc/CPMI.html; Bank for International Settlements, "The future monetary system," June 2022, https://www.bis.org/publ/arpdf/ar2022e3.pdf.
8 "Cross-border data flows: Designing a global architecture for growth and innovation," Zurich Insurance, 2022, https://www.zurich.com/en/knowledge/topics/digital-data-and-cyber/why-cross-border-data-flows-matter.
9 GSMA Intelligence, "Digital transformation in a post-pandemic future," 2022.
10 See Andrew Meola, "A look at examples of IoT devices and their business applications in 2023," Insider Intelligence, December 19, 2022, https://www.insiderintelligence.com/insights/internet-of-things-devices-examples/#:~:text=In%20short%2C%20the%20Internet%20of,be%20connected%20to%20the%20IoT; Angus Loten, "Investors Cool on Internet-of-Things Startups, a Tech Conduit for Retailers," *Wall Street Journal*, November 15, 2022; UNCTAD *Digital Economy Report 2021*.
11 Giulia Carosella, et al., "IDC FutureScape: Worldwide Digital Transformation Predictions," October 2021, https://www.idc.com/getdoc.jsp?containerId=US47115521; Petroc Taylor, "Amount of data created, consumed, and stored 2010-2020, with forecasts to 2025," Statista, September 8, 2022, https://www.statista.com/statistics/871513/worldwide-data-created/
12 IDC Spending Guide Sees Worldwide Digital Transformation Investments Reaching $3.4 Trillion in 2026, ICD, October 26, 2022, https://www.idc.com/getdoc.jsp?containerId=prUS49797222; Errin O'Conner, "Top 50 Digital Transformation Statistics and Trends for 2022," EPC Group, January 24, 2022, https://www.epcgroup.net/top-50-digital-transformation-statistics-and-trends-for-2022/.
13 "Shaping the future of digital economy and new value creation," World Economic Forum; McKinsey Global Institute, "Securing Europe's competitiveness: Addressing its technology gap," September 22, 2022.
14 McKinsey & Co., "Digital twins: The Foundation of the enterprise metaverse," October 22, 2022, https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/digital-twins-the-foundation-of-the-enterprise-metaverse. For more, see Mark Sullivan, "What the metaverse will (and won't) be, according to 28 experts," Fast Company, October 26, 2021, https://www.fastcompany.com/90678442/what-is-the-metaverse; *The Economist*, "22 emerging technologies to watch in 2022," November 8, 2021, https://www.economist.com/the-world-ahead/2021/11/08/what-next-22-emerging-technologies-to-watch-in-2022.
15 Simon Bentley and Tony Murdzhev, "Accelerating Sustainability With Virtual Twins," Accenture, January 26, 2021, https://www.accenture.com/us-en/blogs/industry-digitization/accelerating-sustainability-with-virtual-twins. Also "Top 7 IoT Trends That Will Shape the Digital World in 2023," Emeritus.org, December 9, 2022, https://emeritus.org/blog/technology-program-iot-trends-2023/; Peter Bilello, "Outlook 2023: Digital Twins Will No Longer Be an Option," Engineering.com, November 22, 2022, https://www.engineering.com/story/outlook-2023-digital-twins-will-no-longer-be-an-option; Bishwadeep Mitra, "How Digital Twin Solutions Affect Business: The Next Digital Transformation," Emeritus, November 9, 2022, https://emeritus.org/blog/technology-what-is-a-digital-twin/; Oliver Peckham, "Europe's Digital Twins for Earth Kick Off, Crown Jewel Supercomputers in Tow," HPCWire, October 19, 2022, https://www.hpcwire.com/2022/10/19/europes-digital-twins-for-earth-kick-off-crown-jewel-supercomputers-in-tow/; Julie Pattison-Gordon, "Can a Digital Twin of Earth Give Better Climate Insights? Government Technology, November 14, 2022, https://www.govtech.com/products/can-a-digital-twin-of-earth-give-better-climate-insights. https://www.geospatialworld.net/prime/digital-twin-of-earth-to-aid-climate-change-studies/; Bernard Marr, "The Best Examples Of Digital Twins Everyone Should Know About," *Forbes*, June 20, 2022, https://www.forbes.com/sites/bernardmarr/2022/06/20/the-best-examples-of-digital-twins-everyone-should-know-about/.
16 Pak Yiu, Dylan Loh and Francesca Regaldo, "'Crypto winter' to 'ice age'? What 2023 holds for digital assets," *Nikkei Asia*, December 30, 2022, https://asia.nikkei.com/Business/Business-Spotlight/Crypto-winter-to-ice-age-What-2023-holds-for-digital-assets; Bank for International Settlements, "The future monetary system," June 2022, https://www.bis.org/publ/arpdf/ar2022e3.pdf; David J. Farber and Dan Gillmor, "Cryptocurrencies remain a gamble best avoided," *Nikkei Asia*, February 5, 2022, https://asia.nikkei.com/Opinion/Cryptocurrencies-remain-a-gamble-best-avoided.
17 See Bank for International Settlements, "Using CBDCs across borders: lessons from practical experiments," June 2022, https://www.bis.org/publ/othp51.pdf; Maria Demertzis, "Is there social added value in digital currencies?" Presentation at the 10th Meeting of the Fintech Working Group, Bruegel, November 29, 2022, https://www.bruegel.org/sites/default/files/2022-12/Retail%20CBDCs%20and%20private%20crypto%20solutions%20Presenation%20EP%20November%202022_0.pdf; Siddharth Venkataramakrishnan and Martin Arnold, "Report suggests bright future for central bank digital currencies," *Financial Times*, June 30, 2022.
18 U.S. Federal Reserve, "CBDC: Monetary/Digital – Money and Payments: The U.S. Dollar in the Age of Digital Transformation," January 20, 2022, https://www.federalreserve.gov/publications/files/money-and-payments-20220120.pdf; U.S. Department of the Treasury, "The Future of Money and Payments," September, 2022, https://home.treasury.gov/system/files/136/Future-of-Money-and-Payments.pdf; U.S. Department of the Treasury, "Assessing the Impact of New Entrant Non-bank Firms on Competition in Consumer Finance Markets," Report to the White House Competition Council, November 2022, https://home.treasury.gov/system/files/136/Assessing-the-Impact-of-New-Entrant-Nonbank-Firms.pdf.
19 Steven Levy, "Welcome to the Wet Hot AI Chatbot Summer," *Wired*, January 6, 2023; John Thornhill, "Can generative AI's stimulating powers extend to productivity?" *Financial Times*, January 26, 2023; Erin Griffith and Cade Metz, "A New Area of A.I. Booms, Even Amid the Tech Gloom," *New York Times*, January 7, 2023; Michael Chui, Roger Roberts, and Lareina Yee, "Generative AI is here: How tools like ChatGPT could change your business," McKinsey & Co., December 20, 2022, https://www.mckinsey.com/capabilities/quantumblack/our-insights/generative-ai-is-here-how-tools-like-chatgpt-could-change-your-business.
20 See previous years of this survey. Also Daniel S. Hamilton, *The Transatlantic Digital Economy 2017* (Washington, DC: Center for Transatlantic Relations, 2017); Digital Economy Compass 2018, Statista.com, file:///C:/Users/Owner/Downloads/study_id52194_digital-economy-compass.pdf; International Technology and Innovation Foundation (ITIF), "The Task Ahead of US," http://www2.itif.org/2019-task-ahead.pdf.
21 Ugur Sahin and Ozlem Tureci, "The post-covid future of mRNA therapies," *The Economist*, November 8, 2021, https://www.economist.com/the-world-ahead/2021/11/08/ugur-sahin-and-ozlem-tureci-on-the-future-of-mrna-therapies; Gina Vitale, "Moderna/Merck cancer vaccine shows promise in trials," Chemical and Engineering News, December 20, 2022, https://cen.acs.org/pharmaceuticals/vaccines/ModernaMerck-cancer-vaccine-shows-promise/100/web/2022/12; McKinsey Global Institute, The Bio Revolution: Innovations transforming economies, societies, and our lives, May 2020, https://www.mckinsey.com/industries/life-sciences/our-insights/the-bio-revolution-innovations-transforming-economies-societies-and-our-lives.
22 Nick Webster, "How 3D printing is set to revolutionise reconstructive surgery," The National, October 7, 2022, https://www.thenationalnews.com/weekend/2022/10/07/how-3d-printing-is-set-to-change-the-world-of-reconstructive-surgery/; Paul Hanaphy, "3D Printing Industry Review of the Year," 3D Printing Industry, December 24, 2022, https://3dprintingindustry.com/news/3d-printing-industry-review-of-the-year-december-2022-219144/; Roni Caryn Rabin, "Doctors Transplant Ear of Human Cells, Made by 3-D Printer," *New York Times*, June 2, 2022.

23 Conor Mulcahy, "What is the Future of Digital Healthcare?" Jabil.com, December 21, 2022, https://www.jabil.com/blog/digital-health-infographic.html; Ilona Kickbusch and Anurag Agrawal, "Ungoverned digital advances undermine global healthcare gains," *Financial Times*, October 24, 2021; Markets and Markets, "Synthetic Biology Market Size, Growth by Tools, Applications, and Region – Global Forecasts to 2026," https://www.marketsandmarkets.com/Market-Reports/synthetic-biology-market-889.html McKinsey & Co., "McKinsey Technology Trends Outlook 2022: future of bioengineering," August 2022, https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/the%20top%20trends%20in%20tech%202022/McKinsey-Tech-Trends-Outlook-2022-Bioengineering.pdf.
24 John Thornhill, "Code-generating software can spur a cognitive revolution," *Financial Times*, September 16, 2021; McKinsey and Co., "McKinsey Tech Trends Outlook 2022: next generation software development," August 2022; McKinsey & Co., "McKinsey Technology Trends Outlook 2022: Applied AI," August 2022, https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/the%20top%20trends%20in%20tech%202022/McKinsey-Tech-Trends-Outlook-2022-Applied-AI.pdf; "The new age of AI," *The Economist*, June 12, 2022; Irving Wladawsky-Berger, "The Disruptive Economics of AI," MIT Initiative on the Digital Economy," December 9, 2022, https://medium.com/mit-initiative-on-the-digital-economy/the-disruptive-economics-of-ai-620178817b9a.
25 Nicole Wetsman, "DeepMind found the structure of nearly every protein known to science," *The Verge*, July 28, 2022, https://www.theverge.com/2022/7/28/23280743/deepmind-alphafold-protein-database-alphabet.
26 Michael Reddy, "Digital Transformation in Healthcare in 2022: 7 Key Trends," Digital Authority Partners, December 7, 2022, https://www.digitalauthority.me/resources/state-of-digital-transformation-healthcare/.
27 Hannah Kuchler, "BioNTech buys UK AI start-up InstaDeep in £562m deal," *Financial Times*, January 10, 2023.
28 "Healthcare Artificial Intelligence Software, Hardware, and Services Market to Surpass $34 Billion Worldwide by 2025, According to Tractica," Business Wire, August 27, 2018, https://www.businesswire.com/news/home/20180827005149/en/.
29 Mike Thomas, "7 Dangerous Risks of Artificial Intelligence," Built In, July 6, 2021, https://builtin.com/artificial-intelligence/risks-of-artificial-intelligence.
30 U.S.-E.U. Trade and Technology Council. "US-EU Trade and Technology Council Inaugural Joint Statement." White House Briefing Room Statements and Releases. September 29, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/29/u-s-eu-trade-and-technology-council-inaugural-joint-statement/.
31 TTC Joint Roadmap on Evaluation and Measurement Tools for Trustworthy AI and Risk Management, https://www.nist.gov/system/files/documents/2022/12/04/Joint_TTC_Roadmap_Dec2022_Final.pdf.
32 Tina Highfill and Christopher Surfield, "New and Revised Statistics of the U.S. Digital Economy, 2005–2021, U.S. Bureau of Economic Analysis, November 2022, https://www.bea.gov/system/files/2022-11/new-and-revised-statistics-of-the-us-digital-economy-2005-2021.pdf.
33 Atomico, "State of European Tech 2022," https://stateofeuropeantech.com/1.european-teach-a-new-reality/1.2-tech-motor-for-progress#C1-2-purpose-driven-tech-on-the-rise-again.
34 Atomico.
35 Atomico.
36 Dutta and Lanvin.
37 For a related survey, see IMD World Digital Competitiveness Ranking 2022, https://www.imd.org/centers/world-competitiveness-center/rankings/world-digital-competitiveness/.
38 Jeongmin Seong, Olivia White, Jonathan Woetzel, Sven Smit, Tiago Devesa, Michael Birshan, and Hamid Samandari, "Global flows: The ties that bind in an interconnected world," McKinsey & Co., November 15, 2022, https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/global-flows-the-ties-that-bind-in-an-interconnected-world; OECD, "The impact of digitalisation on trade," https://www.oecd.org/trade/topics/digital-trade/; C. Cadestin and S. Miroudot, "Services exported together with goods," OECD Trade Policy Papers, No. 236, Paris, 2020, https://dx.doi.org/10.1787/275e520a-en; Erik van der Marel, "Globalization Isn't in Decline: It's Changing," ECIPE Policy Brief 6/2020, https://ecipe.org/wp-content/uploads/2020/08/ECI_20_PolicyBrief_06_2020_LY06.pdf; Rachel F. Fefer, Wayne M. Morrison, Shayerah Ilias Akhtar, "Digital Trade and U.S. Trade Policy," Congressional Research Service, May 21, 2019, https://fas.org/sgp/crs/misc/R44565.pdf.
39 OECD, "The impact of digitalisation on trade;" Cadestin and Miroudot; van der Marel.
40 See Martin Smeets, ed., *Adapting to the digital trade era: challenges and opportunities* (Geneva: WTO, 2021); WTO, *World Trade Report 2019*; OECD, *Global Value Chains and Trade*, 2021, https://www.oecd.org/trade/topics/global-value-chains-and-trade/.
41 The U.S. Bureau of Economic Analysis (BEA) defines those services as including three categories of international trade in services: telecommunications services, computer services, and charges for the use of intellectual property associated with computer software. See U.S. Bureau of Economic Analysis, Defining and Measuring the Digital Economy Data Tables 1997-2017, April 2, 2019. For an updated approach, see Highfill and Surfield, also Shari A. Allen and Maryam Fatima, "U.S. International Services: Trade in Services in 2021 and Services Supplied Through Affiliates in 2020," U.S. Bureau of Economic Analysis, October 2022, https://apps.bea.gov/scb/2022/10-october/1022-international-services.htm
42 This approach draws on work by UNCTAD, the OECD, the WTO and the IMF. See Javier López-González, "The changing nature of digital trade, current and future barriers and ideas to overcome them," Woodrow Wilson Center, April 21, 2021, https://www.wilsoncenter.org/article/changing-nature-digital-trade-current-and-future-barriers-and-ideas-overcome-them. Also BEA International Data, https://www.bea.gov/iTable/index_ita.cfm; Jessica R. Nicholson, " New BEA Estimates of International Trade in Digitally Enabled Services," May 24, 2016, Bureau of Economic Analysis, http://www.esa.doc.gov/economic-briefings/new-bea-estimates-international-trade-digitally-enabled-services.
43 The OECD/IMF/WTO Handbook defines digital trade as "trade that is digitally ordered and/or digitally delivered," yet data statistics have not yet been aligned to this definition. That leaves us with digitally-enabled services as the default metric. For more, see IMF/OECD, "How to move forward on measuring digital trade," Thirty-Second Meeting of the IMF Committee on Balance of Payments Statistics, Thimphu, Bhutan October 29–November 1, 2019, https://www.imf.org/external/pubs/ft/bop/2019/pdf/19-07.pdf; Joshua P. Meltzer, "The Importance of the Internet and Transatlantic Data Flows for U.S. and EU Trade and Investment," Brookings Institution, Global Economy and Development Working Paper 79, October 2014; Ryan Noonan, "Digitally Deliverable Services Remain an Important Component of U.S. Trade," Washington, DC. U.S. Department of Commerce, Economics and Statistics Administration, May 28, 2015, available at http://www.esa.gov/economic-briefings/digitally-deliverable-services-remain-important-component-us-trade; U.S. Department of Commerce, "Measuring the Value of Cross-Border Data Flows," September 2016, https://www.ntia.doc.gov/files/ntia/publications/measuring_cross_border_data_flows.pdf ; United States International Trade Commission, "Digital Trade in the U.S. and Global Economies, Part 2", Pub.4485, Investigation No.332-540, August 2014, p.47; Jessica R. Nicholson and Ryan Noonan, "Digital Economy and Cross-Border Trade: The Value of Digitally-Deliverable Services," Washington, DC. U.S. Department of Commerce, Economics and Statistics Administration, ESA Issue Brief # 01-14, January 27, 2014, available at http://www.esa.doc.gov/sites/default/files/digitaleconomyandcross-bordertrade.pdf.
44 UNCTAD, "Supporting countries to measure the digital economy for development," December 2, 2022, https://unctad.org/news/supporting-countries-measure-digital-economy-development; UNCTAD, "International trade in digitally-deliverable services, value, shares and growth, annual," https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=158358; UNCTAD, International trade in ICT services, value, shares and growth, annual, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=158359.
45 Ibid; Meltzer, op. cit.; Ker and Mazzini, op. cit., p. 71.
46 Allen and Fatima.
47 Allen and Fatima.
48 Note that these figures are sourced from Eurostat and can vary from the corresponding U.S.-EU bilateral trade figures reported by the U.S. Bureau of Economic Analysis. Differences can occur in how services are measured, classified, and attributed to partner countries, resulting in asymmetries in the two data sources. For more information on these asymmetries, please see Eurostat report, "Transatlantic Trade in Services: Investigating Bilateral Asymmetries in EU-US Trade Statistics, 2017 edition," https://ec.europa.eu/eurostat/documents/7870049/8544118/KS-GQ-17-016-EN-N.pdf/eaf15b03-5dcf-48dd-976f-7b4169f08a9e.
49 Allen and Fatima.
50 Michael Mandel, "Europe App Economy Update 2021," Progressive Policy Institute, May 25, 2022, https://www.progressivepolicy.org/blogs/europe-app-economy-update-2021/; Michael Mandel and Jordan Shapiro, "US App Economy Update 2021," Progressive Policy Institute, May 25, 2022, https://www.progressivepolicy.org/wp-content/uploads/2022/05/PPI_US-App-Economy-Update-2022_V4.pdf.
51 Mandel.
52 Mandel and Shapiro.
53 Mandel.
54 Statista, "Apps-worldwide," October 2022, https://www.statista.com/outlook/dmo/app/worldwide.
55 UNCTAD, "Measuring the value of e-commerce," October 21, 2022, Non-paper for the third meeting of the Trade and Development Board Working Group on Measuring E-Commerce and the Digital Economy, https://unctad.org/system/files/information-document/Measuring_value_ecommerce.pdf.
56 See UNCTAD, "In Search of Cross-Border E-Commerce Trade Data," Technical Note NO 6 Unedited, April 2016, available at http://unctad.org/en/PublicationsLibrary/tn_unctad_ict4d06_en.pdf.
57 UNCTAD, "Global e-commerce jumps to $26.7 trillion, fuelled by COVID-19," May 3, 2021, https://news.un.org/en/story/2021/05/1091182; UNCTAD, " Estimates of Global E-Commerce 2019 and Preliminary Assessment of Covid-19 Impact and Online Retail 2020," March 2021, https://unctad.org/system/files/official-document/tn_unctad_ict4d18_en.pdf.
58 The Paypers, "Cross-Border Payments and Ecommerce Report 2022–2023," December 2022, https://thepaypers.com/reports/cross-border-payments-and-ecommerce-report-20222023/r1259465.
59 Research and Markets, "Global Business-to-Business E-commerce Market Size, Share & Trends Analysis Report by Deployment Model (Intermediary-oriented, Supplier-oriented), by Application, by Region, and Segment Forecasts, 2021-2028," June 2021, https://www.researchandmarkets.com/reports/5028717/global-business-to-business-e-commerce-market.
60 Mark Brohan, Jason Smith, "More European companies engage in B2B ecommerce," Digital Commerce 360, December 6, 2022, https://www.digitalcommerce360.com/2022/12/06/more-european-companies-engage-in-b2b-ecommerce/; U.S. Department of Commerce, "European Retail eCommerce Consumer Snapshot," https://www.trade.gov/european-retail-ecommerce-consumer-forecast; Ethan Cramer-Flood, "US B2B Ecommerce Forecast 2022–2026: A Rapidly Growing Slice of an Enormous Market," Insider Intelligence, October 18, 2022, https://www.insiderintelligence.com/content/us-b2b-ecommerce-forecast-2022-2026; Forrester, "US B2B E-Commerce Will Reach An Estimated $3 Trillion By 2027," June 8, 2022; "Europe B2C e-Commerce Market Opportunities Report 2022: Market is Expected to Grow by 14.96% to Reach $1,010.0 Billion in 2022 - Forecasts to 2026 - ResearchAndMarkets.com," Business Wire, October 19, 2022, https://www.businesswire.com/news/home/20221019005857/en/Europe-B2C-e-Commerce-Market-Opportunities-Report-2022-Market-is-Expected-to-Grow-by-14.96-to-Reach-1010.0-Billion-in-2022---Forecasts-to-2026---ResearchAndMarkets.com.
61 The Paypers, "Cross-Border Payments and Ecommerce Report 2022–2023," December 2022, https://thepaypers.com/reports/cross-border-payments-and-ecommerce-report-20222023/r1259465; Pymnts, "Cross-Border B2B Payments Account for 26% of UK and US Firms' Annual Sales," March 4, 2022, https://www.pymnts.com/antitrust/2022/uks-cma-ramps-up-apple-google-antitrust-probe/.
62 Statista Digital Market Outlook 2020, eCommerceDB.com. ALSO 2023 http://cbre.vo.llnwd.net/grgservices/secure/CBRE%20Global%20E-Commerce%20Outlook%202022_Update.pdf.
63 Cross-Border Commerce Europe, "TOP 16 Cross-Border EU Countries 2022," https://www.cbcommerce.eu/publication/top-16-cross-border-eu-countries-2022/; Sara Lone, "The European Cross-Border Ecommerce Market – Key Trends and Developments," in The Paypers, ; Cross-Border Commerce Europe, "Top 16 Cross-Border EU Countries 2021," https://www.cbcommerce.eu/product/top-16-cross-border-eu-countries/.
64 Cross-Border Commerce Europe, "4th edition of the "TOP 500 Cross-Border Retail Europe": an annual ranking of the top 500 European cross-border online shops," March 12, 2022, https://www.cbcommerce.eu/press-releases/4th-edition-of-the-top-500-cross-border-retail-europe-an-annual-ranking-of-the-top-500-european-cross-border-online-shops/.
65 The OECD definition of an online platform is "digital services that facilitate interactions between two or more distinct but interdependent sets of users (whether 6 firms or individuals) who interact through the service via the internet." OECD, "Online Platforms: A Practical Approach to Their Economic and Social Impacts," Paris, 2018.

66 Anuj Saush, Mark Fenwick, and Erik P. M. Vermeulen, "The Platform Economy," European Corporate Governance Institute/The Conference Board, 2021, https://www.conference-board.org/pdfdownload.cfm?masterProductID=27309; Jennifer Schenker, "The Platform Economy," The Innovator, January 19, 2019.
67 Digital Economy 2021, op. cit.; OECD, "Digital Enablers of the Global Economy: Background Paper for the CDEP Ministerial Meeting," OECD Digital Economy Papers, November 2022 No. 337, https://www.oecd.org/publications/digital-enablers-of-the-global-economy-f0a7baaf-en.htm.
68 Zoltan J. Acs, Abraham K. Song, László Szerb, David B. Audretsch, and Éva Komlósi, "The evolution of the global digital platform economy: 1971–2021," *Small Business Economics*, November 13, 2021, https://link.springer.com/article/10.1007/s11187-021-00561-x; Zoltan J. Acs, László Szerb, Abraham K. Song, Éva Komlósi, Esteban Lafuente, "The Digital Platform Economy Index 2020," Global Entrepreneurship and Development Institute, December 2020, https://thegedi.org/wp-content/uploads/2020/12/DPE-2020-Report-Final.pdf.
69 Ibid; W. Naudé, "Is European Entrepreneurship in Crisis?" IZA Working Paper, DP 9817 (2016).
70 Janet Bush, ed., "Global flows: The ties that bind in an interconnected world," McKinsey Global Institute, November 2022; Zurich Insurance, "Cross-border data flows."
71 The White House, "FACT SHEET: President Biden Signs Executive Order to Implement the European Union-U.S. Data Privacy Framework," October 7, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/07/fact-sheet-president-biden-signs-executive-order-to-implement-the-european-union-u-s-data-privacy-framework/; Rachel F. Fefer and Kristin Archick, "U.S.-EU Trans-Atlantic Data Privacy Framework," Congressional Research Service, June 7, 2022, https://crsreports.congress.gov/product/pdf/IF/IF11613; Emily Benson and Elizabeth Duncan, "Temporarily Shielded? Executive Action and the Transatlantic Data Privacy Framework," CSIS, October 7, 2022, https://www.csis.org/analysis/temporarily-shielded-executive-action-and-transatlantic-data-privacy-framework; Digital Europe, "Schrems II Impact Survey Report," November 20, 2020, https://www.digitaleurope.org/resources/schrems-ii-impact-survey-report/.
72 See Diane Coyle and Annabel Manley, "What is the Value of Data? A review of empirical methods," Bennett Institute, University of Cambridge, July 2022, https://www.bennettinstitute.cam.ac.uk/wp-content/uploads/2022/07/policy-brief_what-is-the-value-of-data.pdf; OECD, "Cross-border Data Flows: Taking Stock of Key Policies and Initiatives," October 2022, https://www.oecd-ilibrary.org/science-and-technology/cross-border-data-flows_5031dd97-en.
73 *Digital Economy Report 2021*, op. cit.
74 James Manyika, Susan Lund, Jacques Bughin, Jonathan Woetzel, Kalin Stamenov, and Dhruv Dhingra, "Globalization: The new era of global flows," McKinsey Global Institute, February 24, 2016, https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/Digital-globalization-The-new-era-of-global-flows,.
75 See "Measuring the Value of Cross-Border Data Flows," Economics and Statistics Administration and the National Telecommunications and Information Administration, U.S. Department of Commerce, September 2016, p. 21, https://www.ntia.doc.gov/files/ntia/publications/measuring_cross_border_data_flows.pdf. D. Coyle, et al., "The Value of Data: Policy Implications," Bennett Institute, University of Cambridge, February 26, 2020, https://www.bennettinstitute.cam.ac.uk/media/uploads/files/Value_of_data_Policy_Implications_Report_26_Feb_ok4noWn.pdf.
76 Coyle, et al.; Manyika, et al.; Michael Mandel, "Data, Trade and Growth," Progressive Policy Institute, April 2014, http://www.progressivepolicy.org/wp-content/uploads/2014/04/2014.04-Mandel_Data-Trade-and-Growth.pdf.
77 Manyika, et al.
78 For more on the implications of this decision, see Daniel S. Hamilton, "Europe's new privacy ruling will help fragment the global economy," *Washington Post*, July 22, 2020, https://www.washingtonpost.com/politics/2020/07/22/europes-new-privacy-ruling-will-help-fragment-global-economy/.
79 Ker and Mazzini, pp. 71, 78, 79.
80 Michael Rasch, "Der grösste Internet-Knotenpunkt der nördlichen Hemisphäre ist in Frankfurt – würde er einen Atomschlag überstehen?" *Neue Zürcher Zeitung*, October 15, 2022, https://www.nzz.ch/wirtschaft/groesster-internet-knotenpunkt-was-waere-nach-einem-atomschlag-ld.1703243; Telegeography, The State of the Network 2022; Telegeography Workshop, Pacific Telecommunications Council, January 19, 2022, https://www2.telegeography.com/hubfs/2022/Presentations/2022%20PTC%20Workshop.pdf; On land, the United States accounts for about 40% and Europe for an additional 35% of so-called colocation data centers.
81 Synergy Research Group, "Pipeline of Over 300 New Hyperscale Data Centers Drives Healthy Growth Forecasts," March 23, 2022, https://www.srgresearch.com/articles/pipeline-of-over-300-new-hyperscale-data-centers-drives-healthy-growth-forecasts; John Edwards, "What You Need To Know About Hyperscalers," Information Week, December 19,2022, https://www.informationweek.com/cloud/what-you-need-to-know-about-hyperscalers.
82 Reegan Barnett, "Hyperscale Data Centers - What Are They and Why Should You Care," Raritan Blog, February 1, 2018, https://www.raritan.com/blog/detail/hyperscale-data-centers-what-are-they-and-why-should-you-care; Mark Haranas, "10 Data Center Companies You Need To Watch In 2022," CRN, January 10, 2022, https://www.crn.com/slide-shows/data-center/10-data-center-companies-you-need-to-watch-in-2022/11; Fortinet, "What is Hyperscale?" https://www.fortinet.com/resources/cyberglossary/hyperscale; LD Investments, "Hyperscale: Opportunity Or Threat For Data Center Operators?" Seeking Alpha, January 29, 2021, https://seekingalpha.com/article/4401956-hyperscale-opportunity-threat-for-data-center-operators; Equinix.com; Arthur Sullivan, "Europe is seeing a data center boom. But can the environment sustain it?" Deutsche Welle, September 10, 2021, https://www.dw.com/en/europe-is-seeing-a-data-center-boom-but-can-the-environment-sustain-it/a-59139118#:~:text=The%20traditional%20hot%20spots%20for,services%20is%20changing%20the%20dynamic; Synergy Research Group, "Pipeline of Over 300 New Hyperscale Data Centers Drives Healthy Growth Forecasts," March 23, 2022, https://www.srgresearch.com/articles/pipeline-of-over-300-new-hyperscale-data-centers-drives-healthy-growth-forecasts.
83 Synergy Research Group, "Pipeline."
84 Synergy Research Group, "Virginia Still Has More Hyperscale Data Center Capacity Than Either Europe or China," September 6, 2022, https://www.srgresearch.com/articles/virginia-still-has-more-hyperscale-data-center-capacity-than-either-europe-or-china. https://blog.telegeography.com/does-70-of-the-worlds-internet-traffic-flow-through-virginia
85 Synergy Research Group, "Virginia." Tim Stronge, "Does 70% of the World's Internet Traffic Flow Through Virginia?" Telegeography, May 30, 2019, https://blog.telegeography.com/does-70-of-the-worlds-internet-traffic-flow-through-virginia.
86 Synergy Research Group, "Pipeline"; Sullivan.
87 F. Montevecchi, T. Stickler, R. Hintemann, S. Hinterholzer, S., *Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market*. Final Study Report for the European Commission, Vienna, 2020, https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market; Synergy, "Pipeline"; Pieter Haeck and Antonia Zimmermann, "Europe's hidden energy crisis: data centers," Politico, October 3, 2022, https://www.politico.eu/article/data-center-energy-water-intensive-tech/; Ivy Main, "Virginia has a data center problem," *Virginia Mercury*, December 9, 2022, https://www.virginiamercury.com/2022/12/09/virginia-has-a-data-center-problem/.
88 Linda Hardesty, "European cloud providers take hit from AWS, Google, Azure, says Synergy," Fierce Telecom, September 23, 2021, https://www.fiercetelecom.com/platforms/european-cloud-providers-take-hit-from-aws-google-azure-says-synergy; European Commission, "Cloud computing," https://digital-strategy.ec.europa.eu/en/policies/cloud-computing.
89 Synergy Research Group, "European Cloud Providers Continue to Grow but Still Lose Market Share," September 27, 2022, https://www.srgresearch.com/articles/european-cloud-providers-continue-to-grow-but-still-lose-market-share.
90 Equinix, "Global Interconnection Index 2023," 2022, https://www.equinix.com/gxi-report; European Commission, "5G for Europe's Digital and Green Recovery," January 14, 2021, https://digital-strategy.ec.europa.eu/en/library/5g-europes-digital-and-green-recovery; Accenture.
91 Dan Swinhoe, "Thales details French sovereign cloud joint venture with Google: S3NS to operate three data centers in France," Data Center Dynamics, July 4, 2022, https://www.datacenterdynamics.com/en/news/thales-details-french-sovereign-cloud-joint-venture-with-google/; Thales, "Thales Introduces S3NS in Partnership with Google Cloud and Unveils Its Offering in a First Step Towards the French Trusted Cloud Label," June 30, 2022, https://www.thalesgroup.com/en/group/press_release/thales-introduces-s3ns-partnership-google-cloud-and-unveils-its-offering-first; Caroline Donnelly, "Vodafone and Google Cloud collaboration gives rise to AI Booster platform," Computer Weekly, July 6, 2022, https://www.computerweekly.com/news/252522379/Vodafone-and-Google-Cloud-collaboration-gives-rise-to-AI-Booster-platform; Amazon, "AWS and Atos Strengthen Collaboration with New Strategic Partnership to Transform the Infrastructure Outsourcing Industry," November 30, 2022, https://press.aboutamazon.com/2022/11/aws-and-atos-strengthen-collaboration-with-new-strategic-partnership-to-transform-the-infrastructure-outsourcing-industry; Richard Waters, "Every company may soon be a cloud company," *Financial Times*, December 2, 2021; Oliver Noyan, "Europe's Cloud Dreams Come Crashing Down to Earth," Center for European Policy Analysis, https://cepa.org/europes-cloud-dreams-come-crashing-down-to-earth/; Alice Pannier, "The Changing Landscape of European Cloud Computing: Gaia-X, the French National Strategy, and EU Plans," Briefings de l'Ifri, July 22, 2021, https://www.ifri.org/sites/default/files/atoms/files/pannier_european_cloud_computing_2021.pdf.
92 Jill C. Gallagher, "Undersea Telecommunication Cables: Technology Overview and Issues for Congress," Congressiona Research Service, September 13, 2022, https://crsreports.congress.gov/product/pdf/R/R47237; The International Cable Protection Committee, "Submarine Cables and BBNJ (Biodiversity in areas Beyond National Jurisdiction)", 2016, p. 1, https://www.un.org/depts/los/biodiversity/prepcom_files/ICC_Submarine_Cables_& _BBNJ_August_2016.pdf; see also Maritime Awareness Project, "Factsheet: Submarine Cables," https://map.nbr.org/ 2018/07/submarine-cables/; Rona Rita David, "Submarine Cables: Risks and Security Threats," Energy Industry Review, March 25, 2022, https://energyindustryreview.com/analysis/submarine-cables-risks-and-security-threats/.
93 See Matt Burgess, "The Most Vulnerable Place on the Internet," *Wired*, November 2, 2022, https://www.wired.com/story/submarine-internet-cables-egypt/; Edward Stringer, "Putin knows that undersea cables are the west's Achilles heel," *Financial Times*, November 4, 2022; Jayne Miller, "Satellites and Submarine Cables: Myth vs. Reality," Telegeography, https://blog.telegeography.com/satellites-and-submarine-cables-myth-vs.-reality, January 5, 2022; Clifford Holliday, "Re-Imagining Telecom Subsea Cables," *SubTel Forum Magazine*, February 2020; David W. Brown, "10 Facts about the Internet's Undersea Cables," Mental Floss, Nov 12, 2015, http://mentalfloss.com/article/60150/10-facts-about-internets-undersea-cables; Geof Wheelwright, "Undersea cables span the globe to send more data than satellites," *Financial Times*, November 2, 2016; Nicole Starosielski, "In our Wi-Fi world, the internet still depends on undersea cables," The Conversation, November 3, 2015, https://theconversation.com/in-our-wi-fi-world-the-internet-still-depends-on-undersea-cables-49936. Telegeography, "Submarine Cables Frequently Asked Questions," https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions.
94 Alan Mauldin, "Economic Indicators and the Future Submarine Cable Industry," Telegeography, Presentation to Submarine Networks World – Singapore, September 7, 2022, https://www2.telegeography.com/hubfs/2022/Presentations/2022%20Submarine%20Networks%20World.pdf?utm_campaign=Prospects%3A%20Internet%202&utm_medium=email&_hsmi=2&_hsenc=p2ANqtz--UMfrCu9I8ID2URR6939WoVMlQVm5rwnzuNrkCgJ51jZj4darRnz1t5rO7zDbnPLGqVT6QqNfNSo6hYhotwSqG5WkdJw&utm_content=2&utm_source=hs_email.
95 Alan Mauldin, "Cutting off Europe? A Look at How the Continent Connects to the World," Telegeography, October 13, 2022, https://blog.telegeography.com/cutting-off-europe-a-look-at-how-the-continent-connects-to-the-world.
96 Ibid; Tim Stronge, "Trans-Atlantic Submarine Corridor," Telegeography, June 2022, https://www2.telegeography.com/hubfs/2022/Presentations/Trans-Atlantic%20Submarine%20Corridor%20-%20June%202022%20Webinar.pdf; Wayne Nielsen, "North Atlantic Regional Roundup," Presentation to the 2017 Pacific Telecommunications Council, January 2017, https://www.ptc.org/assets/uploads/papers/ptc17/PTC17_Sun_Submarine%20WS_Nielsen.pdf; http://aquacomms.com/wp-content/uploads/P54-55-Aqua-Comms-advertorial.pdf; https://cacm.acm.org/magazines/2020/1/241709-how-the-internet-spans-the-globe/fulltext?mobile=false.
97 Submarine Telecoms Forum, "2022/23 Industry Report," October 2022, https://subtelforum.com/industry-report/.
98 Submarine Cable Networks, "Grace Hopper," https://www.submarinenetworks.com/en/systems/trans-atlantic/grace-hopper; Submarine Cable Networks, "Amitié/AEC-3," https://www.submarinenetworks.com/en/systems/trans-atlantic/amitie.
99 Telecom TV, "What's up with... Orange, Huawei in Europe, the Gateway to Europe," November 14, 2022, https://www.telecomtv.com/content/security/what-s-up-with-orange-huawei-in-europe-the-gateway-to-europe-45945/.
100 Tim Stronge, "Trans-Atlantic Submarine Corridor"; Submarine Telecoms Forum, "2022/23 Industry Report," October 2022, https://subtelforum.com/industry-report/.
101 Mauldin, "Cutting Off Europe".
102 Ibid.

103 Submarine Telecoms Forum, "Arctic Fibre-Optic Cable Secures First Investment," December 2, 2022, https://subtelforum.com/arctic-fibre-optic-cable-secures-first-investment/; Luca Bertuzzi, "EU eyes Arctic internet cable to connect Europe to Asia via Alaska," Euractiv, October 14, 2022, https://www.euractiv.com/section/digital/news/eu-eyes-arctic-internet-cable-to-connect-europe-to-asia-via-alaska/.
104 Ibid.
105 Peter O'Brien, "France tightens subsea cable security amid growing fear of sabotage," *Politico*, October 13, 2022, https://www.politico.eu/article/france-tighten-subsea-cable-security-fear-sabotage-pipeline-gas-leak; Mark Scott, "Will Russia attack undersea internet cables next?" *Politico*, September 29, 2022, https://www.politico.eu/article/everything-you-need-to-know-about-the-threat-to-undersea-internet-cables/.
106 Adam Entous, Julian E. Barnes and Adam Goldman, "Intelligence Suggests Pro-Ukrainian Group Sabotaged Pipelines, U.S. Officials Say," *New York Times*, March 7, 2023; Burgess; Christian Bueger, Tobias Liebetrau, Jonas Franken, "Security threats to undersea communications cables and infrastructure – consequences for the EU," European Parliament, April 2022, https://www.europarl.europa.eu/RegData/etudes/IDAN/2022/702557/EXPO_IDA(2022)702557_EN.pdf.
107 Burgess; Bueger et al.
108 TeleGeography expects their share to grow to 78% by 2027. Telegeography, "State of the Network 2021," January 2021, https://www2.telegeography.com/hubfs/assets/Ebooks/state-of-the-network-2021.pdf. Also Andrew Blum and Carey Baraka, "Sea change:
Google and Meta's new subsea cables mark a tectonic shift in how the internet works, and who controls it," Rest of world, May 10, 2022, https://restofworld.org/2022/google-meta-underwater-cables/.
109 Equinix, "Global Interconnection Index, 2023."
110 Equinix, "Global Interconnection Index, 2023"; Jim Poole, "Submarine cable boom fueled by new tech, soaring demand," Network World, March 6, 2018, https://www.networkworld.com/article/3260784/lan-wan/submarine-cable-boom-fueled-by-new-tech-soaring-demand.html.
111 See Pacific Telecommunications Council Secretariat, "Is this the end of the internet as we know it?" January 3, 2019, https://www.ptc.org/2019/01/is-this-the-end-of-the-internet-as-we-know-it/.