



# Digital Infrastructure: Investment in U.S. Economic Exceptionalism

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## Key takeaways

- Over the past decade, the U.S. digital economy has experienced exponential growth—fueled by the rise of the cloud, AI, 5G connectivity, and other innovations that have the potential to enhance U.S. productivity and international competitiveness
- Digital infrastructure has provided the foundation for companies to incorporate these technologies and gain global market share
- We believe digital infrastructure offers investors an attractive mix of growth- and income-focused opportunities, and offer our clients access to these long-term secular trends via a number of vehicles, including our proprietary equity strategies, active manager platform, and private markets program

The emergence of new and disruptive digital technologies is transforming industries across the U.S. economy. Artificial intelligence (AI), internet of things (IoT) devices and apps, 5G mobile connectivity, and the cloud are considered core transformative technologies with the potential to enhance U.S. economic productivity and international competitiveness. Digital infrastructure—including data centers, cloud platforms, cybersecurity systems, and communications networks—has provided the foundation for U.S. companies to take advantage of these technologies to gain market share. Therefore, we view digital infrastructure as a critical component of America’s economic growth trajectory over the next decade.

In this paper, we discuss the importance of digital infrastructure in improving labor productivity. We then explore the elements of digital infrastructure most critical to future economic growth and how we are capitalizing on these themes in portfolios. Investing in digital infrastructure means finding opportunities across sectors, such as industrials, utilities, communications, real estate, and—of course—technology. As a key lever for digital transformation and U.S. economic exceptionalism, we believe digital infrastructure will continue to offer attractive long-term opportunities for investors within the public and private markets.

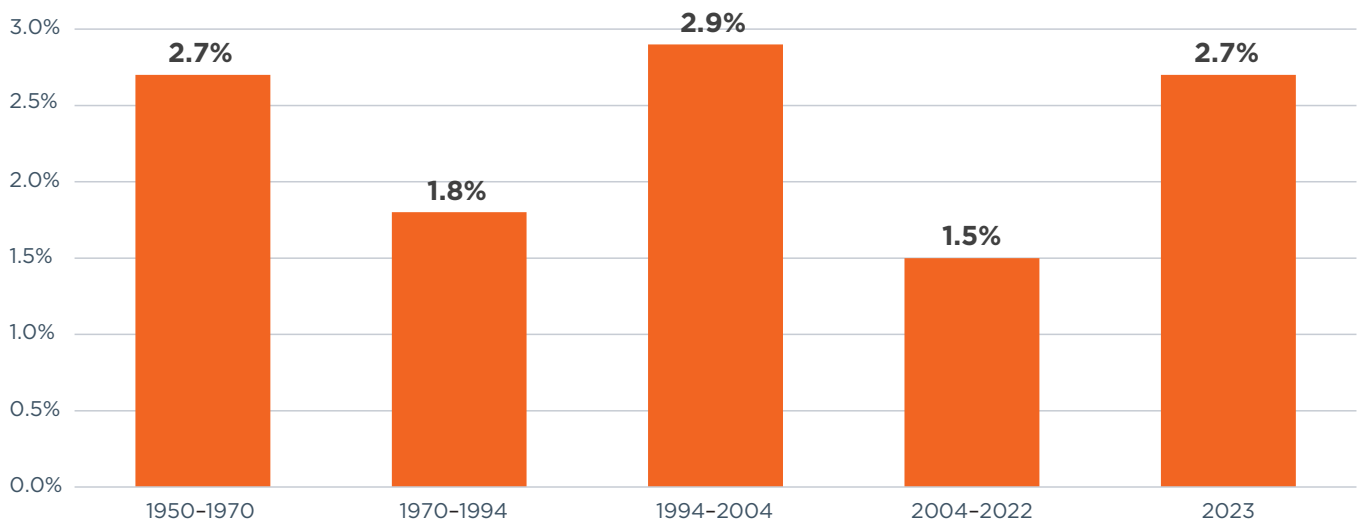
## On the cusp of another productivity boom

Disruptive technologies have historically been a catalyst for U.S. economic growth and productivity. Between 1970 and 1994, for instance, the U.S. experienced a drop in labor productivity growth (output per hour worked), averaging just 1.8% a year. Productivity then accelerated to 2.9% between 1994 and 2004.<sup>1</sup>

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This temporary improvement is credited to advancements in information and communications technology (ICT) during America's Third Industrial Revolution—also known as the Digital or ICT Revolution. This period saw the wide-scale adoption of the personal computer (PC) and internet. As these technologies made their way through the economy, companies gradually figured out how to leverage their power to boost efficiency and automate tasks, paving the way for higher U.S. productivity.<sup>2</sup> As the incremental gains of these technologies slowed, productivity growth reverted to an average annual rate of 1.5% (Figure 1).<sup>3</sup>

Figure 1  
**U.S. labor productivity growth 1950–2023**  
Average labor productivity growth



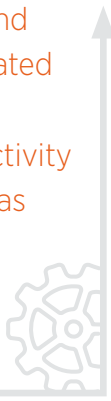
Source: The Aspen Institute. Data as of 2023. Productivity growth rates are averages of quarterly estimates within each period.

A surge in business fixed investment was also a key feature of the economic expansion and productivity boom of the late 1990s and early 2000s. From 1995 through 2000, business fixed investment accounted for about 32% of the total growth of real gross domestic product (GDP). Spending on ICT contributed a third of this number. Research has shown that technology alone is not sufficient to boost productivity. Rather, emerging innovations like computers must be combined with investment in intangible capital like new processes and skills. This explains why there is usually a lag between the adoption of a technology and subsequent productivity gains.<sup>4</sup>

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Some economists and analysts have estimated that AI alone could increase U.S. productivity growth by as much as

**1.5%**  
annually



It soon became clear to policymakers that ICT was now an important driver of economic growth and innovation. Successive U.S. administrations implemented a series of measures to boost competition and investment in telecommunications (telecoms) to support the growth of the ICT sector. This included deregulating broadband telecommunications, freeing up radio spectrum for wireless, limiting regulation of online privacy, protecting internet platforms from liability for content on their systems, and opening GPS satellite systems for commercial use.<sup>5</sup>

Two decades later, the adoption of new technologies and rebound in ICT investment is poised to yield similar gains. In 2023, the U.S. saw an acceleration in productivity growth for the first time in years. After averaging around 1.5% for nearly two decades, albeit with periods of volatility, it rose to 2.3% and 2.7% respectively in the third and fourth quarters of 2023.<sup>6</sup> While productivity data have been affected by pandemic-related factors, the diffusion of innovation across the economy, particularly AI—combined with robust spending on digital infrastructure in the public and private sector—has raised our expectations for a sustained period of higher productivity.

Some economists and analysts have estimated that AI alone could increase U.S. productivity growth by as much as 1.5% annually, assuming widespread adoption.<sup>7</sup> However, the effect of AI will depend on several factors, including how capable the technology actually becomes, the regulatory environment, and implementation. This makes us somewhat more cautious around its ultimate impact.

#### **The rise of the 5G mobile economy**

Since the 1990s, the telecoms sector has become closely intertwined with the daily functions of modern life. Increased internet usage, rising smartphone ownership, and the adoption of data-intensive applications have driven extraordinary demand for connectivity. Most Americans now have access to a fixed broadband network. The U.S. also leads the world in mobile communications. Advancements in cellular networks, such as 3G, 4G, and now 5G, have provided faster download speeds and more reliability, making it easier for Americans to access the internet on a smartphone.

Unlike Wi-Fi, where connectivity is limited to homes, offices, and localized hot spots, cellular networks like 4G and 5G provide seamless connectivity across geographic locations and vast public domains, enabling applications like self-driving cars. Today, nearly 100% of the U.S. has 4G coverage while 95% have 5G. As part of the 2021 Infrastructure Investment and Jobs Act, the federal government provided \$65 billion to ensure all Americans have access to the internet (42 million currently do not).<sup>8</sup>

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As technological advancements accelerate, America's investment in digital infrastructure has become a powerful force for U.S. economic exceptionalism.

The launch of the first large-scale 4G network in 2010 was largely responsible for accelerating the transition to mobile growth of digital businesses like Netflix and Uber. The rollout of 5G across the public and private sectors is expected to generate even greater value throughout the U.S. economy. The initial boost to GDP will come from building out the necessary network infrastructure, including investments in cell towers, small cells, data centers, and fiber optic cables. For example, while 4G uses large, generic towers, 5G requires small cells towers. Reduced government regulation has spurred more cell site construction in the past two years than in the previous seven years combined.<sup>9</sup>

The next phase of growth will come from the advanced applications 5G makes possible through the real-time transfer of data. 5G provides faster download speeds than 4G, as well as better bandwidth and lower latency (the amount of time it takes data to move from one point to another). Improvements in latency are essential for real-time applications like factory robots, smart grids, remote surgery, autonomous trucks, and drones. As these applications are integrated into the U.S. economy, they are expected to make businesses more productive and cost-efficient. Some of 5G's greatest benefits may come from its potential to reduce medical costs as America's health care burden grows. For example, 5G has improved the delivery of remote health care services, such as monitoring, care, and surgery, reducing the need for more expensive hospital visits.<sup>10</sup>

#### **Europe risks falling behind in digital infrastructure**

As technological advancements accelerate, America's investment in digital infrastructure has become a powerful force for U.S. economic exceptionalism. The deployment of the internet and communications infrastructure has been supported by a favorable regulatory environment for telecoms and robust private and public sector investment. Numerous studies have shown a positive correlation among advanced communications networks, productivity, and growth. Economies with faster internet speeds have fostered companies that are more digitally enabled, adaptable, and resilient.

Over the past decade, for instance, the European Union (EU) has been falling behind the U.S. on several measures of competitiveness, including capital spending, research and development (R&D), and labor productivity. Many economists have attributed this discrepancy to Europe's failure to capitalize on early advancements in digital technology and infrastructure. When labor is scarce, the U.S. has traditionally been faster to automate and invest in innovation to remain competitive and fuel growth. The EU faces larger demographic headwinds than the U.S. due to a rapidly aging population. This means the region must do more to lift labor productivity to maintain its share of global GDP.<sup>11</sup>

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Europe has a history of prioritizing regulation over innovation, which has exacerbated a highly fragmented telecoms market.

Europe has a history of prioritizing regulation over innovation, as well as a highly fragmented telecoms market. This has made it difficult for the industry to scale, find efficiencies, and create a single unified market. While Europe has over 30 mobile networks, the U.S. has just three.<sup>12</sup> Although telecoms have been governed by broad EU rules for many years now, individual member-state laws still apply. Today, just 81% of Europeans have 5G access (compared to 95% in the U.S., referenced earlier) and rural areas still lack reliable connectivity.

The region also trails the U.S. in other investments, such as data centers and cloud computing infrastructure.<sup>13</sup> Along with government funding, private capital plays a large role in infrastructure development. More regulation has meant lower expected returns for investors in European digital infrastructure. As a result, the U.S. has tended to attract the most private capital, generating 51.6% of commitments over the past decade versus 30.2% for Europe. America's share has been particularly strong in recent years, totaling 70% in 2022 and 2023.<sup>14</sup>

Digital infrastructure is critical to Europe's industrial ambitions and goal of being a global leader in green tech. Smart grids, for example, rely on advanced computing power and data centers. Insufficient spending on infrastructure has limited the competitiveness of European firms, prompting many start-ups and investors to seek better opportunities in America. In 2020, EU companies attracted just 4% of venture capital funding for AI versus 57% for America.<sup>15</sup> Europe has also seen its share of the global ICT market weaken, dropping from 22% in 2013 to 11% as of 2023.<sup>16</sup> In the near to midterm, we expect this trend to persist.

#### Opportunities in digital infrastructure expansion

We believe GenAI could be the next inflection point for digital transformation ("The Future of AI Is Here: Investment Risks & Opportunities.") Digital infrastructure—including cloud platforms, semiconductors, data centers, and edge computing—will be critical to the adoption and monetization of the technology, putting the U.S. at a competitive advantage. We view these industries as attractive long-term investment opportunities.



**Cloud.** One of the biggest opportunities for the U.S. tech sector is expected to come from increased enterprise spending on the cloud. Companies will typically purchase cloud computing services from the likes of Google Cloud, Microsoft Azure, and Amazon Web Services (AWS)—the world's biggest cloud companies—which provide access to the vast computing power, data storage, hardware, software, and other resources needed to adopt new technologies.

This eliminates the need for companies to build and operate their own data centers, which require significant investments in electricity, cooling, data security, and connectivity. There are several types of cloud services, including infrastructure, platforms, and software applications. ChatGPT, for instance, runs on Microsoft Azure's supercomputing platform. Software as a service (SaaS) often comes as ready-to-use applications managed by cloud providers.<sup>17</sup>

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**Chips.** AI systems also require specialized hardware, such as graphics processing units (GPUs), which are designed to accelerate the training and inference of AI models. The most advanced and widely used are produced by Nvidia, a U.S. company that has 80% share of the global market. Notably, the company saw 262% revenue growth over the past year.<sup>18</sup> Nvidia has built a commanding lead in AI hardware that is expected to persist as competitors race to catch up. Strong demand and a limited number of suppliers is a potential headwind to industry growth. Smaller start-ups are already finding it difficult to source the advanced chips they need to develop models. It's estimated that at least 10,000 GPUs were used in the 2022 version of ChatGPT. Long term, though, we expect more competitors to come online, creating a more balanced market.<sup>19</sup>



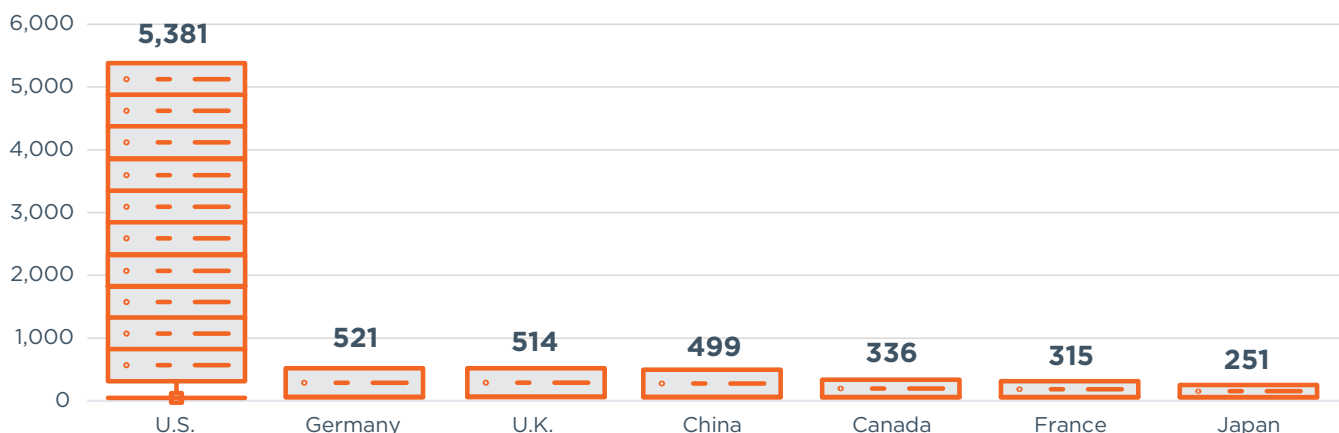
**Data centers.** The need for computer servers equipped with more powerful AI hardware has also sparked demand for new data centers. In 2023, the U.S. market expanded by 26%.<sup>20</sup> Over the past decade, the industry has experienced rapid growth, fueled by the adoption of cloud computing, e-commerce, AI, and smartphone and smart device usage. Hyperscale data centers—which provide data processing and storage services to large corporations—have driven the bulk of growth. Thus far in 2024, annualized capital expenditures by the biggest cloud providers, including AWS, Alphabet, Meta, Oracle, and Microsoft, totaled \$166 billion. This spending included physical “warehouses,” servers, networking equipment, GPUs, and fiber optic cables.<sup>21</sup>

The U.S. is home to around 5,400 physical data centers, the most of any nation by a significant margin (Figure 2).<sup>22</sup> Many states have implemented tax breaks to spur data center investment. Northern Virginia has attracted the most activity due to its central location on the East Coast, low utility rates, land availability, and favorable tax policies.<sup>23</sup> Constrained supply has also provided attractive leasing opportunities for data center REITs as their pricing power rises. Vacancy rates in the overall market fell to 3.7% in 2023.<sup>24</sup> A surge in private equity deals is another sign of growing confidence in long-term demand. In 2024, Digital Realty entered a \$7 billion joint venture with Blackstone—the world’s largest alternative asset manager—to build data centers.<sup>25</sup>

Figure 2

**U.S. leads the world in data centers**

Leading countries by number of data centers



Source: Statista as of 2024.

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Gartner estimates that by 2025,

75%

of data processing will take place at the edge rather than the cloud.



**Edge computing.** The need for real-time data processing to support AI and IoT has also led to the development of edge computing. The edge processes data closer to the source rather than relying on centralized cloud infrastructure and traditional data centers. This has made data processing more efficient by minimizing bandwidth requirements, reducing operating costs, and enabling applications to be used in remote areas that have limited connectivity. Gartner estimates that by 2025, 75% of data processing will take place at the edge rather than the cloud.<sup>26</sup>

#### Digital infrastructure headwinds bring growth opportunities

As investment in GenAI gains momentum, it is expected to fuel new investment opportunities across the digital infrastructure landscape. To fully take advantage of the technology, companies will need to address several potential headwinds to adoption, including cybersecurity risks, power needs, resource scarcity, and escalating tensions with China. These challenges will also create new growth opportunities for industries helping to address them.



**Cybersecurity.** The emergence of technologies like AI and shift to the cloud has resulted in cybersecurity concerns that pose risks to enterprise security and data privacy. As companies move critical operations and sensitive information to the cloud, they have become more vulnerable to online attacks. For example, if hackers gain control of the prompts guiding an AI application, they could potentially manipulate business processes at a systemic level.<sup>27</sup>

Amid escalating geopolitical tensions, the U.S. has also become a target of cyber attacks from foreign adversaries like China and Russia. These countries have typically been focused on shutting down critical supply chains and infrastructure, such as the U.S. grid. In 2024, America's biggest tech firms agreed to build stronger security into their software, a big step for the government's cybersecurity initiative.<sup>28</sup>



**Utilities.** Companies will also need to consider the ability of energy grids to manage much higher AI-related workloads. In recent years, U.S. electric utilities have experienced sharp ramp-up in demand growth—driven by the rise of electric vehicles, data centers, AI, and other technologies. According to the International Energy Agency, U.S. electricity consumption for data centers is expected to grow around 30% between 2022 and 2026.<sup>29</sup>

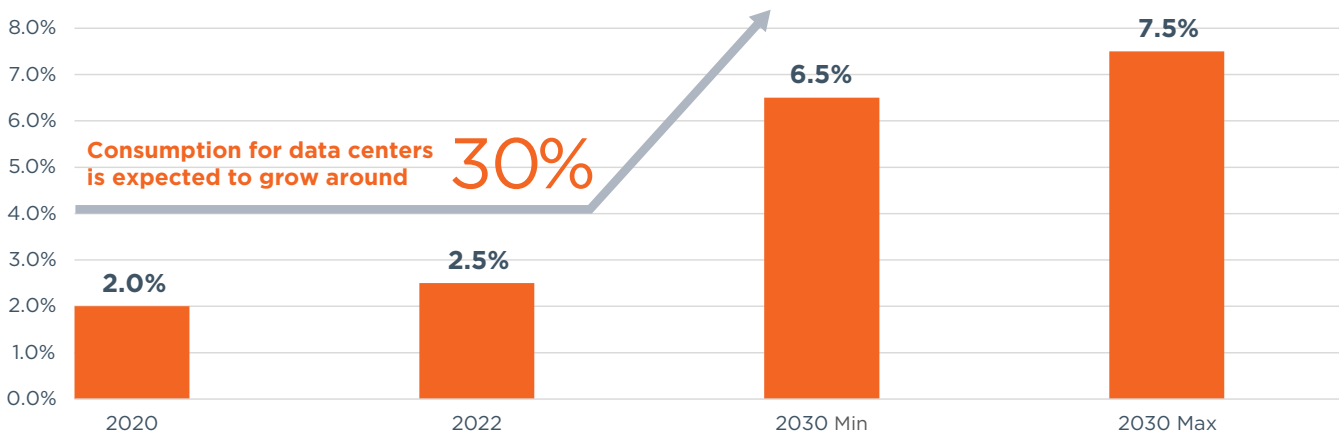
Analysts have also predicted that data centers as a percentage of U.S. electricity consumption could total as much as 7.5% by 2030 (Figure 3). In the near term, access to grid and generation capacity are potential headwinds to data center expansion in the U.S. and worldwide. Utilities are also dealing with aging infrastructure and a clean energy transition that will require massive upgrades and capital investment.<sup>30</sup>

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Figure 3

### Data centers share of U.S. electricity consumption could triple by 2030

Percentage of U.S. electricity use



Source: Boston Consulting Group 2024.



**Clean energy.** While surging demand for electricity has been a tailwind for the overall utilities sector, a few companies stand out. For instance, independent providers of nuclear energy have outperformed as cloud hyperscalers look for other sources of carbon-free power to fuel their data centers. Wind and solar, along with nuclear, will be essential to meeting ambitious climate goals. Vistra, the biggest U.S. competitive power company, has seen its share price more than double this year, while Constellation Energy, which operates 14 nuclear power plants, is up 70%.<sup>31</sup>



**Copper.** While utilities will be integral to powering data centers, copper is equally important. Copper is one of the best conductors of electricity and is used in wires that connect electrical grids and data centers globally. It also plays a significant role in energy technology, defense, consumer electronics, and other applications. Annual demand for copper is forecast to grow as much as 50% by 2040, raising concerns about future supply amid a lack of new mining. The prospect of deepening shortages has caused the price of copper to climb 50% from pre-pandemic levels.<sup>32</sup>



**Industrials.** Another potential headwind is America's reliance on foreign chip suppliers. While the U.S. is currently home to the top chip designers in the world, they rely heavily on countries like Taiwan for production. For example, many Nvidia's chips are manufactured by Taiwan Semiconductor Manufacturing Company. In 2023, Nvidia accounted for 11% of their revenue.<sup>33</sup> In June of 2024, demand for AI fueled \$3.5 billion of chips exports and equipment from Taiwan, a 422% increase from a year ago.<sup>34</sup>

Amid heightened tensions with China, the U.S. has been focused on increasing production at home. In 2022, the CHIPS Act was passed, which provides \$39 billion in funding for chip manufacturing, tax credits to encourage investments in factories and equipment, and \$13.2 billion for R&D and workforce development.<sup>35</sup> As the U.S. builds out its manufacturing sector, it will benefit industries like construction and engineering, building products, and robotics/automation.

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### Actionable investment opportunities

At Wilmington Trust, we believe digital transformation and the increasing adoption of data-intensive technologies has created attractive investment opportunities across the technology, industrials, communication services, and real estate sectors (Figure 4). We have the most conviction in areas like data centers, cloud infrastructure, industrial robotics/automation, advanced AI hardware and software, and cybersecurity. Digital transformation is also fueling unprecedented demand for electricity, including carbon-free power and critical minerals, boosting the outlook for companies active in the materials and utilities sector.

Figure 4

#### Our view on sector opportunities

Sector	Overview
<b>Technology</b>	The tech sector trades at a premium to the market due to the outperformance of a few select stocks, including MSFT (Microsoft Corp.), AAPL (Apple Inc.), and NVDA (NVIDIA Corp.). The sector is expected to have double-digit revenue growth in 2024, justifying its premium, in our view. While the semiconductor industry is trading above its three-year average PE ratio of 35.1x, earnings are on track to grow 24.4% this year. Semis and hardware look most expensive. Software is relatively cheaper, but margins have been weaker. Overall, a solid fundamental foundation makes us positive on tech despite elevated valuations. Secular tailwinds include growing demand for cloud services, AI, chips, and cybersecurity.
<b>Industrials</b>	The adoption of new digital technologies, such as industrial robotics, AI, and IoT devices and apps, is transforming manufacturing processes and supply-chain management. Valuations are above historical averages. Both nearshoring and reshoring initiatives should continue to be a tailwind for the sector.
<b>Utilities</b>	Utilities have become an AI play due to expectations that data centers will boost electricity demand. Utilities with exposure to both traditional and renewable energy are seeing higher customer growth. After a period of strong performance this year, valuations look less attractive. Defensive properties often outweigh rate sensitivity at this point in the cycle.
<b>Communications</b>	Cap-weighted communications have surpassed 2021 highs, supported by a few names like Meta and Google. Communications is estimated to have the strongest earnings per share (EPS) growth in 2024 among sectors in light of digital transformation.
<b>REITs</b>	Sentiment has been negative due to office weakness and higher rates. We like REITs for their earnings stability, dividend income, and inflation protection through long-term lease agreements. A fall in rates this year could make the income more attractive. Secular growth trends like rising data center demand could also improve sentiment.

Metrics (as of 2Q 2024)	S&P 500 total return	Technology	Industrials	Utilities	Communications	REITs
Forward P/E	21.2x	30.9x	20.4x	16.3x	19.6x	16.8x
20-year average	15.7x	18.5x	16.3x	15.7x	18.7x	17.1x
NTM earnings growth	12.8%	19.4%	10.9%	9.5%	17.8%	2.8%
20-year average	10.9%	12.1%	13.8%	4.7%	11.3%	6.9%
12-month total return	24.6%	41.8%	15.5%	7.8%	44.9%	6.6%
YTD return	15%	28%	8%	9%	27%	-2%

Source: JP Morgan Guide to the Markets. U.S. Data as of June 30, 2024.

Past performance cannot guarantee future results. Indices are not available for direct investment. Investment in a security or strategy designed to replicate the performance of an index will incur expenses such as management fees and transaction costs which will reduce returns.

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For clients seeking greater visibility into how these themes are making their way into portfolios, please reach out to your investment advisor.

Clients can access these long-term secular trends through a number of investment vehicles, including Wilmington Trust's proprietary equity strategies. The Fourth Industrial Revolution Equity (FIRE) portfolio, for instance, invests in high-growth industries like cybersecurity, industrial automation, and chips. Clients can also invest in the T. Rowe Price Large-Cap Growth Fund, where top holdings include communications services, semiconductors, and cloud services companies. Our Disciplined Core Equity strategy provides diversified exposure to multiple industries, such as tower REITs, hardware, chips, data centers, and cloud infrastructure. Internationally, the Ballie Gifford Emerging Markets Equities Fund has large weightings in chips and communication services. Our real assets "fund of funds" has exposure to physical infrastructure like towers and data centers.

Lastly, clients have exposure to these themes via our private markets (PM) program. For qualified investors, the portfolio includes a number of businesses that benefit from the boom in data centers, such as electrical contractors that specialize in customized/complex electrical servicing. On the software/cloud/AI side, we have exposure to early-stage growth companies. Pure-play digital infrastructure strategies, as well as venture capital/growth managers, continue to be an area of research focus in the digital infrastructure space. For clients seeking greater visibility into how these themes are making their way into portfolios, please reach out to your investment advisor.

#### **Core narrative**

In today's complex global landscape—characterized by slowing GDP growth, extraordinary technological change, and escalating geopolitical tensions—digital infrastructure has become the foundation enabling economies to adapt, innovate, and remain competitive. Over the next several years, we expect capital spending on physical and virtual infrastructure to accelerate as the potential of digital technologies to boost growth and productivity becomes clearer. While AI has dominated the conversation around long-term tailwinds, other secular shifts, such as the adoption of IoT applications and devices, autonomous cars, and hybrid work, is also driving investment. Spanning multiple sectors and industries, including data centers, towers, and the cloud, this theme offers an attractive mix of both growth and income-focused opportunities. As a provider of essential services like the internet, certain investments may also be more resilient to economic downturns, potentially making digital infrastructure an effective way to enhance diversification in a portfolio.

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## APPENDIX

### ENDNOTES

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## DISCLOSURES

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Investing involves risks, and you may incur a profit or a loss. Past performance cannot guarantee future results. Indices are not available for direct investment. Investment in a security or strategy designed to replicate the performance of an index will incur expenses such as management fees and transaction costs which will reduce returns. There is no assurance that any investment strategy will be successful.

Diversification does not ensure a profit or guarantee against a loss. There is no assurance that any investment strategy will succeed.

Private funds are available only to certain investors who meet the specific income, experience, and investable assets thresholds set forth by the U.S. Securities and Exchange Commission's definition of accredited investors and/or qualified purchasers as necessary. In addition, any offer of such products will be made only in connection with the delivery of the appropriate offering documents, which are available to prequalified persons upon request. Investments such as private funds and mutual funds that focus on alternative strategies are subject to increased risk and loss of principal and are not suitable for all investors. These types of investments may use aggressive investment strategies, which are riskier than those used by typical mutual funds, and you may lose more money than if you had invested in another fund that did not invest as aggressively. You are encouraged to seek professional investment advice prior to making any investment decision. In addition, nothing relating to the material provided should be construed as a solicitation, offer, or recommendation to engage in any investment strategy or other transaction.

The main risks of private equity funds that may reduce returns are described below and are in addition to the individual risks associated with the asset classes private funds may hold.

**Information:** The investment manager relies on information provided by third-party resources, underlying funds, and their managers. If tools/data used in managing a strategy prove incorrect, decisions made in reliance on them may not produce desired results and the strategy may realize losses.

**Limited control:** Investors in private equity funds generally have no authority to make or influence decisions made by the investment manager. Their investments in a fund represent their willingness to entrust all aspects of the investing activities to the investment manager.

**Liquidity:** Investors may be unable to convert (sell) their holdings into cash in a timely manner without affecting the market price or contributing to other unfavorable economic conditions.

**Market:** The value of securities in the fund's portfolio will fluctuate; therefore, their share prices may decline suddenly or over a sustained timeframe.

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## GLOSSARY

**Cambridge Associates U.S. Private Equity Index** is a horizon calculation based on data compiled from 2,354 private equity funds, including fully liquidated partnerships, formed between 1986 and 2019. All returns are net of fees, expenses, and carried interest.

**Russell 3000 PME** (CA Modified Public Market Equivalent, or mPME) replicates private investment performance under public market conditions. Shares of the Russell 3000 (which represents the broad U.S. market's small-, mid-, and large-cap companies) are purchased and sold according to the private fund cash flow schedule, with distributions calculated in the same proportion as the private fund.