PGIM REAL ESTATE

GLOBAL DATA CENTERS

Getting Connected With a Niche Sector

February 2021 | Investment Research

Executive Summary

- The COVID-19 pandemic has led to mass adoption of technologies, and the resulting increase in global internet traffic and data creation is without precedent, driving growth in demand for data centers.
- Data centers are best described as buildings designed specifically to house computer systems and network equipment. They differ from standard industrial buildings because of the more-complex technical specifications for the physical building and the fit-out, which comprises large amounts of electrical and mechanical hardware. Tenants usually sign long leases because of the high initial costs incurred. This provides resilient income streams.
- To date, supply growth has been focused in major cities, where economic and demographic drivers underpin strong demand. Key technical factors for the sector include the availability of cloud operations, power and fiber network cable connectivity, and land cost and government policies.
- Data centers are still viewed as a niche real estate asset class, but transparency and liquidity are improving as the sector grows. Including corporate acquisitions, total transaction activity averaged US$25 billion per annum from 2017 to 2019, showing notable growth in capital flows.
- Investors can invest via three main structures: a powered shell and core structure; with or without fit-out; or as fully owned operators. These are distinguished by several key investment options, and leasing profiles vary.
- Globally, unlevered returns for powered shell and core data centers are estimated at 11% per annum on average. The sector is expected to continue offering attractive returns in the coming years, with potential for further yield compression. Major investment risks include technological obsolescence and depreciation, a limited pool of operator-tenants and government policies.
- The United States is the largest data center market in the world. Total capacity has grown 10% per annum over the past five years as the market continues to scale up, though the gradual vacancy uptrend has weighed on rents.
- In Europe, data center demand has reached record levels, led by strong absorption from cloud providers. Over the past five years, total returns have been estimated at 16% per annum, outperforming the global average largely because of a rental recovery.
- In Asia Pacific, capital flow toward data center development remains strong. Despite an expected significant increase in supply, occupancy rates are likely to remain high, supported by robust demand from hyperscale cloud providers.

INTRODUCTION

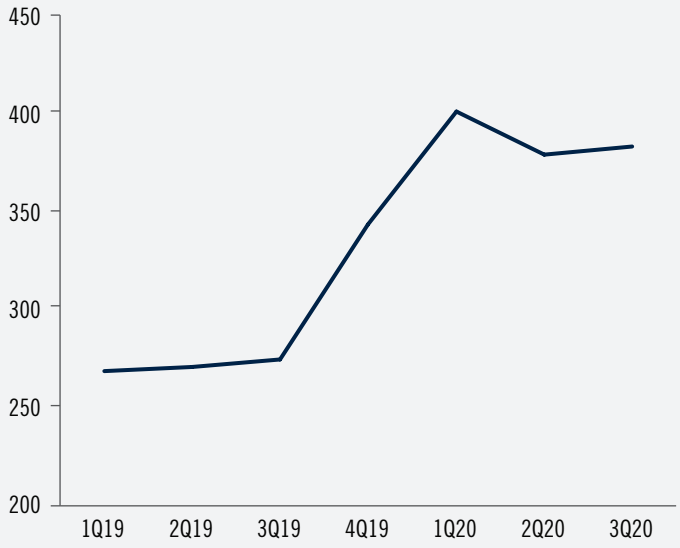
The COVID-19 pandemic has caused the largest economic shock in generations. Significant disruption across all segments of the economy has resulted in severe recessions globally. Government-imposed restrictions to contain the virus — such as those on travel and social distancing — have led to a significant increase in the mass adoption of advanced technologies. Technologies that enable remote working, distance learning and online shopping and entertainment, for example, have helped societies cope with and even overcome these new barriers to our ways of life.

The resulting increase in global internet traffic and data volume is without precedent. Examples include a ninefold increase in unique-user count on communication tools Microsoft Teams and Zoom,[1] a 40% annual increase in average monthly household broadband usage and a 35% increase in the average number of hours spent on mobile phone usage (exhibit 1). Although impressive, those numbers hide the reality that both the application of and advances in technology have been on a strong upward trend for several years.

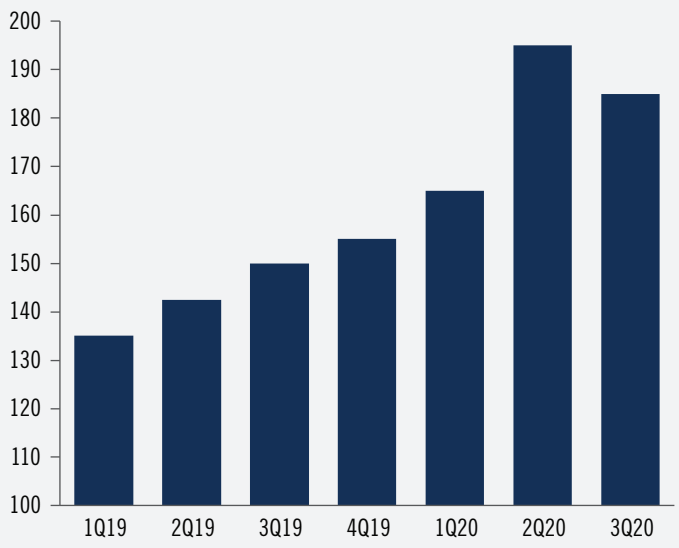
The sheer growth in the size of the information, communication and technology (ICT) sector provides a useful backdrop to how important technology has become to societies and with that, how significant the associated ICT infrastructure growth has been.[2] When it comes to real estate, the ICT sector is the underlying driver for demand for data centers — buildings built specifically to house computer systems and network equipment to support digital information processing — and based on current trends, this sector is set to grow significantly in the coming years.

Exhibit 1: Impact of COVID-19 on Technology and Internet Usage

Monthly Average Household Broadband Usage (Gigabytes)



Monthly Average Hours Spent on Mobile Applications (Billion hours)



Sources: Openvault, App Annie, PGIM Real Estate. As of January 2021.

[1] Comscore, May 2020.

[2] According to Economist Intelligence Unit data, from 1999 to 2019 the average annual real growth rate of the global ICT sector was almost twice that of real GDP (4.59% versus 2.72%).

What Is a Data Center?

Data centers are best described as buildings designed specifically to house computer systems and network equipment.[3] They are designed to support the process of collecting, storing, computing and distributing data and digital information. Often classified as a subset of the industrial property sector, data centers differ from standard industrial or logistics buildings because of their technical specifications such as stronger weight-bearing floors and higher on-site power capacity.

These technical specifications also give rise to a distinction between a data center's physical building itself — the so-called shell and core, and the fit-out — the large amount of electrical and mechanical hardware, which includes high-specification cooling and power equipment. Given the technical aspects, all data centers require an operator to handle day-to-day management. Appendix II provides more detail about the components of a fitted data center.

Users of data centers broadly fall into two types: owner-occupiers and third parties.

> **Owner-occupiers:** Typically, these are businesses that run data servers for internal purposes — often housing them on-site — or businesses in the technology or telecommunication sector running data servers for external purposes such as to provide customers with mobile, network and content services.
>
> **Third parties:** Typically, these are professional data center operators that lease out space and power capacity in a data center. For single tenancies, this is simply a tenant arrangement, but if multitenanted, the operator would run a colocation arrangement[4] wherein tenants are allocated power capacity by the operator. Third-party operators cater to retail tenants and wholesale tenants — a distinction based on the amount of power capacity each needs — with very large wholesale tenants also known as hyperscale tenants.[5]

Data centers are still commonly viewed as a niche real estate asset class with too little understood about it to allow a clean pricing of the risks and returns, but transparency and liquidity are improving as the sector grows.

Data Center Market Fundamentals

As the capabilities, power and role of technology have grown in importance in everyday life, so have data centers become a critical part of society's infrastructure; and based on current technological trends, they will continue to grow in importance. Over the past 30 years, the transformation of and the reliance on technology by businesses and households have seen what were once nascent or small server rooms located in the workplace become, through the scaling and sophistication of computing power and systems, self-styled off-site, professionally managed data centers. And as the level of expertise required to manage such ICT infrastructure continues to increase, so will the number of third-party data centers.

It is unsurprising that the potential growth in the scale and importance of data centers is attracting real estate investors. But the opportunity set, although growing, is small. Global investment into data centers averaged US$7.5 billion per annum over 2017–19 compared with global annual commercial real estate transactions of US$1 trillion.[6] So, how big will the opportunity set become? The history of investable real estate illustrates how the ever-growing need for expertise in managing real estate helps drive the transformation of real estate from an owner-occupier model to a third-party model. This is happening in data centers today, so for investors, it may be more pertinent to establish how big a sector data centers could become. And that involves the size, strength and sustainability of demand.

[3] This is a simplification given the evolutionary history of workplace data rooms in which, for instance, workplace IT infrastructure in the forms of servers and data processing systems would be housed within offices, government buildings and the like. See later.

[4] For more details, see the glossary at the end of the paper.

[5] Retail tenants take up much smaller power commitments, such as, for instance, several racks within a data center. Wholesale means a single tenant committed to large amounts of capacity (more than 300 kW). Hyperscale tenants constitute a subset of wholesale tenants, taking up much larger amounts of capacity (more than 2 or 3 MW). For more details, see the glossary at the end of the paper.

[6] Real Capital Analytics, transaction volume of completed-assets, assets excluding development sites.

Demand Drivers

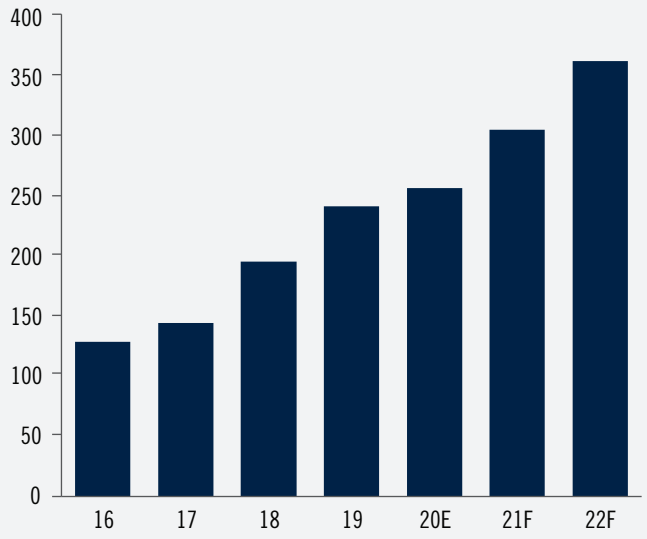
1. Scale

What fundamentally drives demand for data centers is the computing power offered. Data center capacity is commonly measured in megawatts — the more megawatts, the more valuable the data center. Based on both the conversion of owner-occupier centers to third-party management models and accelerating growth in the mass adoption of new technologies, more data centers are needed.[7] Drivers of demand growth include:

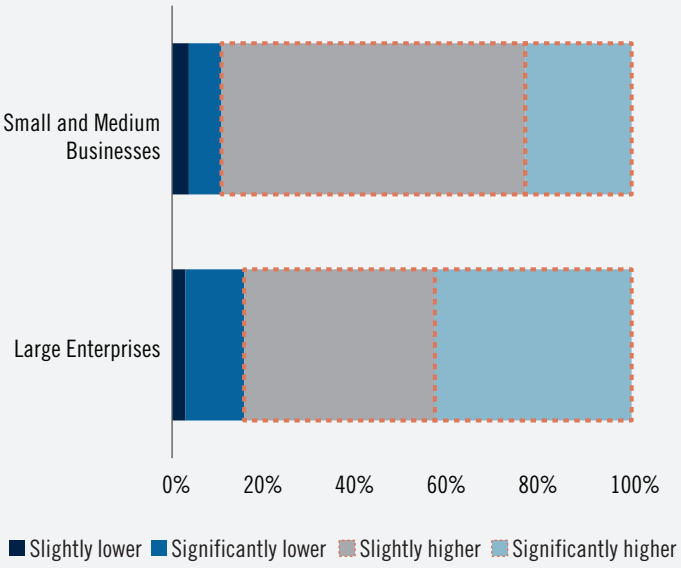
a. **Cloud services:** These are services that provide virtual storage and data processing resources without the need for local computer servers.[8] Most significant is the demand for virtual data warehouses managed by professional cloud operators such as Amazon and Google. Business surveys point out the significant increases expected in cloud usage.[9] According to Gartner,[10] the global public cloud services market is forecast to reach US$364 billion by 2022, translating to a growth rate of approximately 20% per annum in the next two years (exhibit 2).

Exhibit 2: Global Cloud Market Growth

Global Public Cloud Service Revenue (US$ Billion)



Post-COVID-19 Planned Cloud Usage Survey (%)



Sources: Gartner, Statista, Flexera, PGIM Real Estate. As of January 2021.

[7] See, for example, the World Bank Digital Adoption Index.
[8] For more details, see the glossary at the end of the paper.
[9] For instance, Flexera's 2020 State of the Cloud survey shows that nearly 80% of companies surveyed expect higher cloud usage.
[10] July 2020.

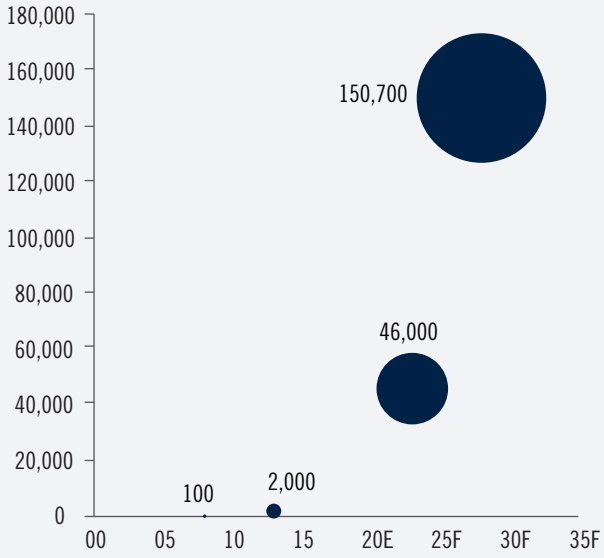
b. E-commerce: Online retail is forecast to grow 16% per annum globally[11] from 2020 to 2023. The rapid expansion of pure-play internet retailers, as well as that of traditional retailers establishing an omnichannel presence, underpins demand growth for robust online infrastructure that is capable of handling large bursts in user traffic. This will require improved data storage and computing facilities, as well as security and stability of the online platforms that are supported primarily by professionally managed data centers.

c. Technological advances: Breakthroughs in both existing and new technologies — including the rise of 5G technology, the Internet of Things and Big Data[12] — will drive significant data traffic growth and contribute to increasing demand for data center capacity.

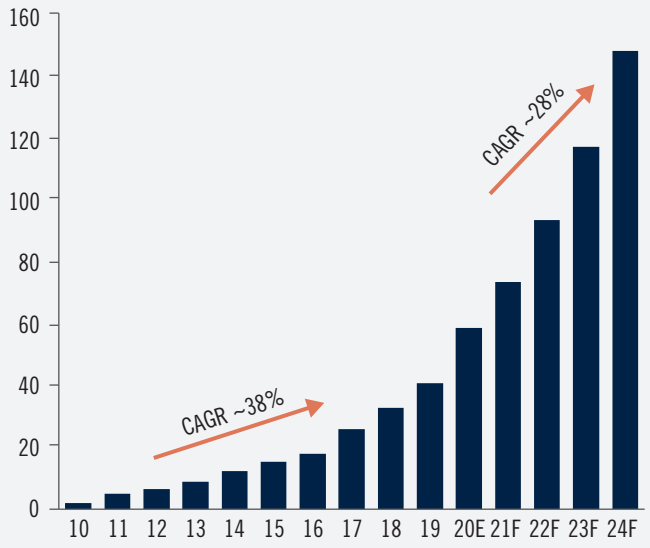
As shown in exhibit 3, whether it's global internet traffic or data creation, the recent and expected paces of growth are phenomenal.

Exhibit 3: Global Data and Traffic Growth

Global Internet Traffic (Gigabytes per second)



Volume of Digital Data Created Globally (Zettabytes)



Sources: United Nations, Statista, PGIM Real Estate. As of January 2021.

A zeggabyte is equal to 1 trillion gigabytes.

2. Location

Although a data center is about computing processes and operating power, effectiveness is also determined by its distance to users. Latency — the time required for data to be transmitted and processed — is affected by how far users are located from the data. Location, therefore, matters, and for any given power and processing ability, the closer a data center is to its customers, the lower its latency and therefore, the more attractive the data center is.

This also helps explain why data centers need to be within, or near, consumer and business hubs in order to maximize their effectiveness and provide low-latency services for large user bases. Furthermore, data protection regulations in many countries require certain types of personal user data to be stored locally.

[11] Source: Statista, August 2020.

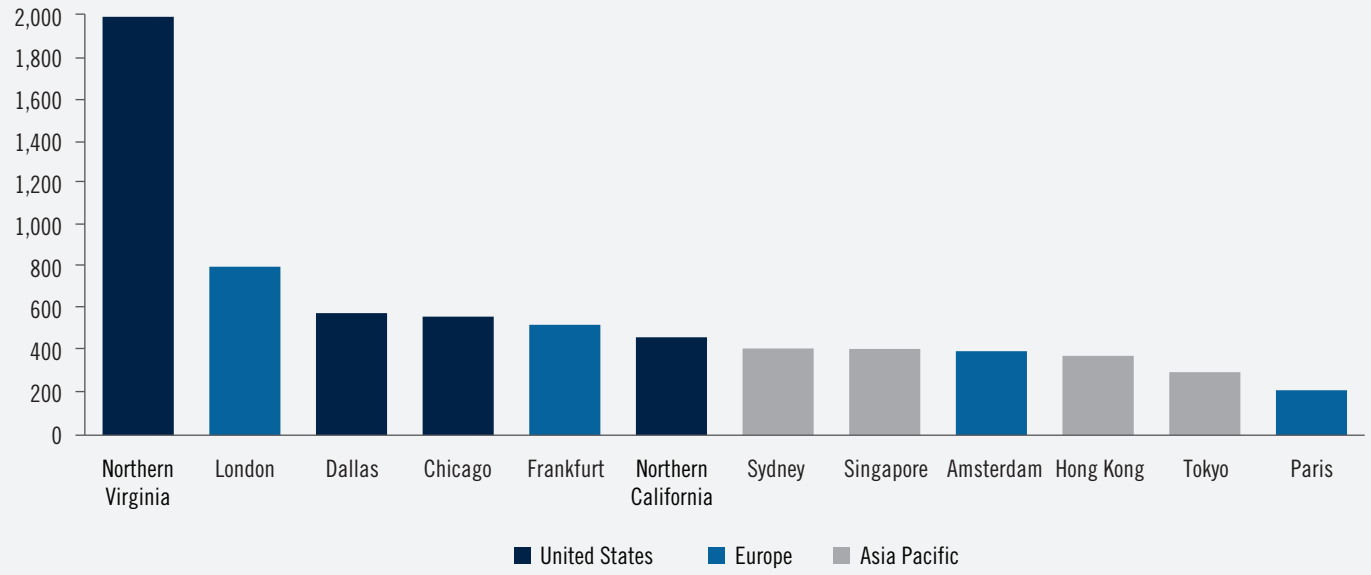
[12] Data sets that are too large and complex for traditional processing methods to deal with.

Supply

Best estimates are that there are currently 7,300[13] third-party data centers around the world providing more than 9,000 megawatts (MW) of power capacity.[14] Approximately half of this capacity is located in the United States, with Asia Pacific and Europe contributing another 40%, approximately. Growth of data centers has focused on major cities[15] where economic and demographic drivers underpin strong demand from households and businesses. Exhibit 4 shows some of the largest data center markets globally.

Exhibit 4: Global Data Center Markets

Data Center Capacity in Key Global Cities (Megawatts [MW])



Sources: CBRE, PGIM Real Estate. As of January 2021.

The United States has some of the most-established data center markets globally. Northern Virginia is a major telecommunications hub, with a high density of fiber-optic networks, and Northern California is the home of major global technology companies such as Apple and Google. Chicago is the third-largest U.S. city by population. In Europe and Asia Pacific, the key regional economic and financial hubs of Frankfurt, London, Tokyo and Singapore are headquarters to the largest regional corporations, providing data center operators with a critical mass of end-user demand.

Apart from economic and demographic drivers, there is a host of important criteria that determine the success of a data center market. As summarized in exhibit 5, the availability of cloud operations and power and fiber-optic-cable network connectivity are among the key technical requirements for a strong data center ecosystem. Other factors such as availability and cost of land, government policies and political and geographic stability also play critical roles in determining the attractiveness of a data center market.[16]

[13] Cloudscene.

[14] CBRE, 2020.

[15] Northern Virginia is an exception. Although the market has the advantage of being close to Washington, D.C., the major drivers of data center market growth in Northern Virginia are the density of high-speed fiber-optic networks, cheap electricity prices and tax incentives.

[16] Shanghai's cloud market is an exception because of restrictions on foreign providers; it is supplied predominantly by domestic players. We expect access to sustainable power as well as government policies to become increasingly important for further growth.

Exhibit 5: Key Global Data Center Markets and Attributes

	Real Estate and Physical Factors		Ecosystem Advantages			Political and Regulatory	
	Increasing Market Scale	Land Price Affordability	Cloud Availability	Fiber Connectivity	Economic Market Size	Sustainability	Government Incentives
Northern Virginia							
Northern California							
Chicago							
Dallas							
New Jersey							
Sydney							
Singapore							
Hong Kong							
Tokyo							
Shanghai							
London							
Frankfurt							
Amsterdam							
Paris							

Bars indicate the strength of the city in this factor, relative to their respective regions. Results are indicative.
Notes: Increasing market scale: Strong development pipeline that stems from demand; Land price affordability: Relative to other markets (the higher the rating, the more affordable the city); Cloud availability: Markets with accessibility to the largest cloud providers (Amazon Web Services, Microsoft Azure, Google Cloud); Fiber connectivity: Access to local, long-haul and international cable networks; Sustainability: Availability of renewable energy.
Source: PGIM Real Estate. As of January 2021.

Investment Market

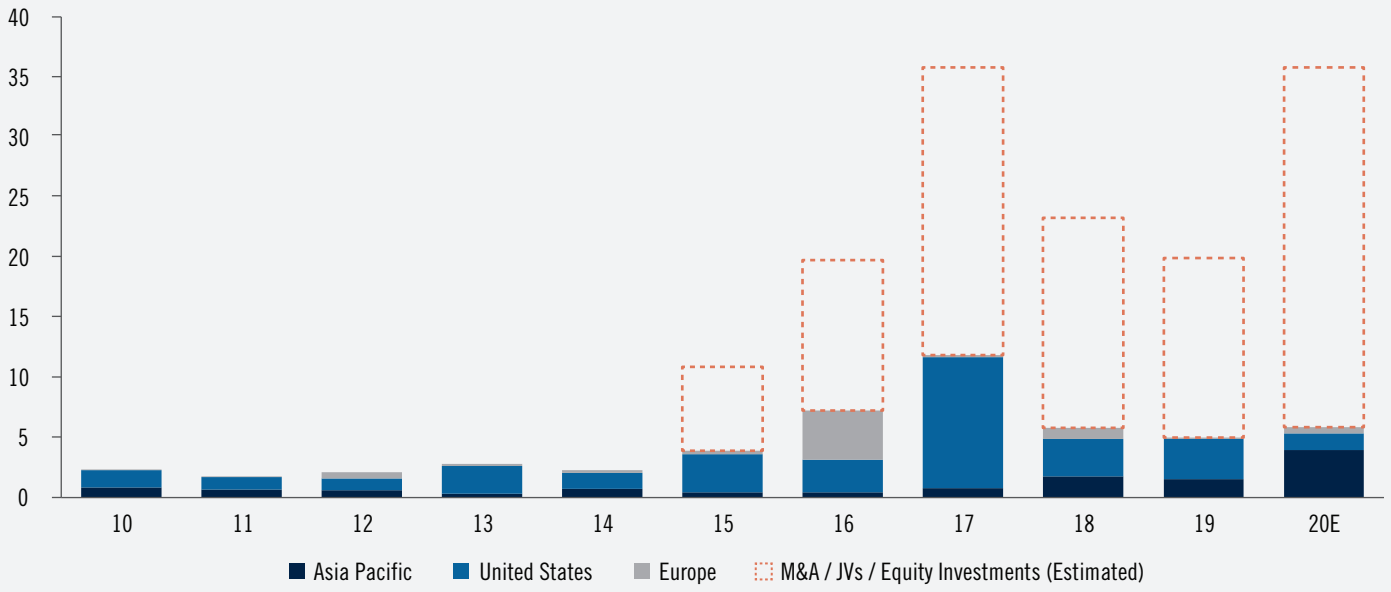
1. Investment Volume

Data centers are still commonly viewed as a niche real estate asset class because the sector is still too small, with too little understood about it to allow a clean pricing of the risks and returns. Access to independent market intelligence on sector data as well as the sourcing of transactions remains challenging. As the sector grows, transparency and liquidity are improving, but it also means that investors have focused on development and partnerships with operators to build out new centers, giving rise to short-term supply risks.

The market size of the sector is currently estimated at US$300 billion.[17] This is small compared with the global commercial real estate invested universe of US$10.3 trillion.[18] For 2019, global transaction volume of completed data center assets remained relatively low, at US$5.4 billion, compared with US$1.01 trillion for the more-established sectors. Data center transaction volume in 2020 is likely to exceed US$6 billion, based on preliminary estimates.[19] There are, however, sizable corporate acquisitions involving purchases of entire platforms or operating companies that include underlying data centers, which are not typically reported as completed asset transactions. Including those investment activities, total global transaction activity is estimated at an average of US$25 billion per annum from 2017 to 2019 and clearly shows notable growth in capital flows in recent years (exhibit 6).

[17] Hoya Capital Real Estate, June 2020.
[18] PGIM Real Estate *Bird's Eye View*.
[19] Real Capital Analytics, January 2021.

Exhibit 6: Global Data Center Transaction Volume (US$ Billion)



Europe refers to key European cities London, Frankfurt, Amsterdam and Paris.
Sources: Real Capital Analytics, Synergy Research, PGIM Real Estate. As of January 2021.

2. Investment Options and Structures

There are three key structures through which real estate investors can invest in data centers.

a. **Powered shell and core:** Investors own and provide the land, building and access paths to redundant power and fiber connectivity, leaving the data center fit-out, such as the mechanical and electrical hardware, to operator-tenants. Often, the data center is leased to major operators or telecom companies with very long leases. Rents and lease terms are broadly similar to those of industrial assets (exhibit 7).

b. **Powered shell and core and fit-out:** Investors set up the data center as a turnkey for tenants. The data center can then be leased to a single hyperscale tenant that will operate the data center on its own or to an operator that would then sublease to a single large tenant or several large tenants. Rents are set according to the committed power capacity, for instance, per kilowatt (kW), with electricity consumption cost passed through to tenants. Investors taking on this structure will expect higher returns than a shell and core investment, given the provision of fit-out and the related capital expenditure.

c. **Fully operational:** In addition to providing the land, shell and core as well as fitting out the data center, investors take full responsibility for managing the data center facility for tenants, including operational expenditures and obligations typically set out in a service-level agreement. This investment requires specialist operational capability, and investors will need an operating partner to pursue this investment structure.

These structures are illustrated in exhibit 7, which distinguishes them by using a combination of six key investment options. Depending on the type of investment, leasing risk profiles can vary, also summarized in exhibit 7.

Exhibit 7: Investment Options and Standard Leasing Profiles

Investment Options	Powered Shell and Core	Powered Shell and Core + Fit-out	Fully Operational
Building shell	√	√	√
Secure power/fiber connection	√	√	√
Fit-out (Mechanical/Electrical)	X	√	√
Capital expenditure	X	√	√
Operational expenditure	X	X	√
Operations/facility management	X	X	√
Standard Leasing Profiles			
Standard rents[20]	Per square foot	Per kilowatt; Powered shell and core + fit-out	Per kilowatt; Powered shell and core + fit-out + operational service fees
Typical leases	Operator lease: 15+ years	Hyperscale: 10+ years Wholesale colocation: 5+ years	Hyperscale: 10+ years Wholesale colocation: 5+ years Retail colocation: 3+ years
Typical tenants	Data center operators	Data center operators, hyperscale cloud service providers and large enterprises	Hyperscale cloud service providers, small to large enterprises

Source: PGIM Real Estate. As of January 2021.

What stands out about the leasing profiles is the typical length of leases: 15 to 20 years for operator leases in powered shell and core[21] ownership structures, five to 10 years in the case of wholesale colocation leases and more than 10 years for hyperscale tenants[22] (exhibit 7). Tenants prefer long leases because of the high costs they incur when they initially occupy a data center: operators incurring fit-out costs or end-tenants investing heavily in IT equipment such as computer servers and racks. These long leases provide resilient, stable and secure income streams that are very attractive to investors. Even with the shorter terms of retail colocation leases, tenants often renew rather than relocate at the end of their lease terms because of the high costs of moving and concerns about downtime during relocation.

3. Global Data Center Returns

The powered shell and core is the most transparent investment structure due to its straightforward lease and rental profile relative to the other structures discussed in exhibit 7. Data transparency is also higher. Globally, unlevered returns for powered shell and core data centers were estimated at 11% per annum on average from 2014 to 2020 (exhibit 8). These returns have been driven largely by yield compression across global markets due to strong investor interest and capital inflows, rewarding early investors in the sector.

[20] Rents often exclude power cost, services and cross-connection fees.

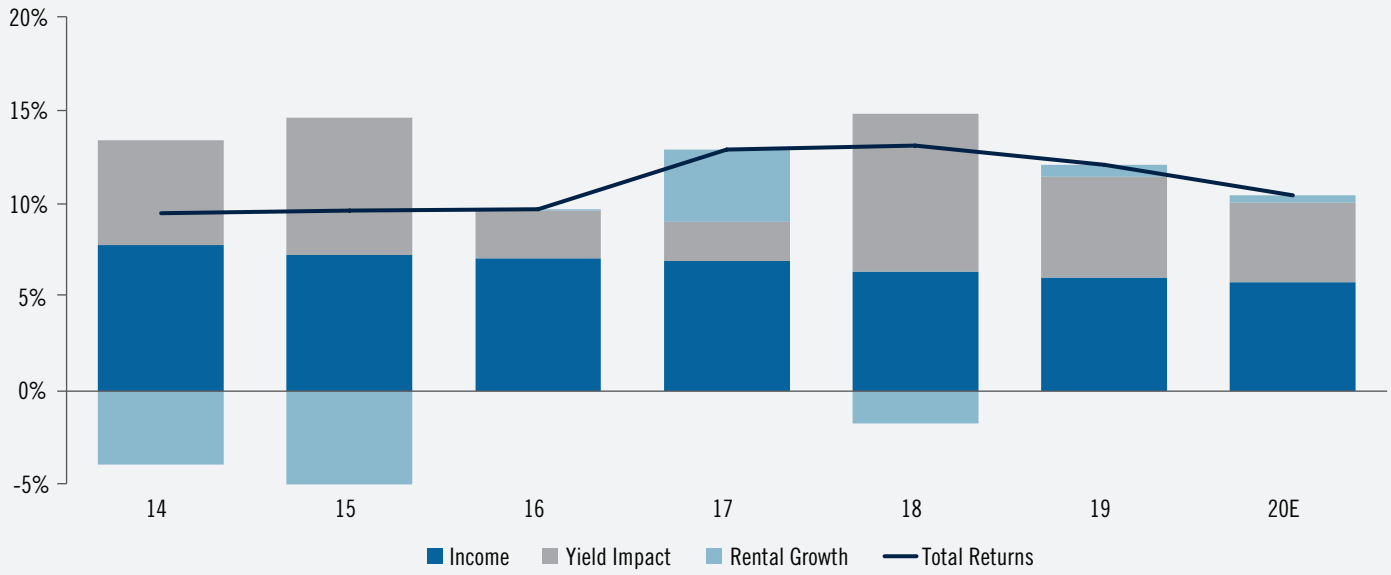
[21] Shell and core ownership includes only the building shell and excludes fit-out within the data center. Commonly known as powered shell and core if power supply is provided. For more details, see the glossary at the end of the paper.

[22] Wholesale tenants typically take up large power commitments of more than 300 kW; hyperscale tenants typically take up more than 2 or 3 MW. For more details, see the glossary at the end of the paper.

Benefiting from the structural growth of demand, the data center sector is expected to continue offering attractive returns in the coming years. Yields are currently at circa 6%, and there could be further compression as the sector continues to mature, driven by lower risk premiums between data centers and other traditional commercial real estate sectors. In addition, rents are stabilizing and are expected to grow in the medium term as supply becomes more constrained, given increasing restrictions on power availability.

Exhibit 8: Global Data Center Returns

Estimated Total Returns (Unlevered, Powered Shell and Core Assets)



Sources: Green Street Advisors, CBRE, Structured Research, PGIM Real Estate. As of January 2021.

4. Investment Risks and Mitigants

There is a strong investment case for data centers, but there are also risks associated with the sector. The risks fall broadly under three groups, as follows.

a. **Obsolescence and depreciation:** Due to rapid technological progression, the evolution of data center designs and cooling technologies could potentially make new data centers more energy- and cost-efficient. This could exert leasing and rental pressure on existing, older facilities that may lack the appropriate infrastructure to accommodate new technology and hence require substantial capital expenditure or face obsolescence. To mitigate that depreciation risk, investors could consider sharing the responsibility for modifying or upgrading mechanical and electrical fit-out with operators or tenants through joint-venture investments.

b. **Smaller operator-tenant pool and lack of leasing-market depth:** This risk arises due to the specialized nature of the data center industry. For example, the four largest cloud providers — Amazon, Google, Microsoft and Alibaba — account for nearly 60% of the public cloud market,[23] and major data center operators such as Digital Realty and Equinix have been at the forefront of a consolidating operator landscape. This will likely continue and will weaken landlords' negotiating and pricing power in leasing discussions. Investors can mitigate this risk by partnering with top-tier operators and maintaining an alignment of interest.

[23] Canalys, February 2020.

c. **Government policy:** Government incentives and restrictions can play important roles in the sector — especially with regard to environmental and sustainability issues. Such policies can significantly change data center supply fundamentals. Consuming vast amounts of electricity to run their servers, networking equipment and cooling systems, data centers are estimated to account for 3 to 4% of global power consumption and at the current pace of expansion, could increase to 20% by 2030,[24] which may lead to policy responses from governments and cause uncertainty in development approvals. The potential removal of existing tax-related and other incentives also poses risks to investors' return expectations. Higher hurdles for new supply could hamper the overall growth of the sector over the longer term, but they do give existing owners a more favorable negotiation position. Market selection and a good understanding of policy guidance on the environmental impact and incentives for the data center and technology sector will be critical for long-term investors.

Exhibit 9: Key Risks

	Key Risks
Obsolescence and Depreciation	▪ Technological progression in computer and IT infrastructure ▪ Evolution of data center designs and cooling technologies ▪ Rental pressure and end-of-life capex requirements for older assets
Leasing-Market Depth	▪ Reputation and capability of data center operator are critical ▪ Cloud services drive data center demand growth, but dominated by a few very large players ▪ Pricing power is increasingly shifting away from landlords with the increasing scale of cloud providers
Government Policy	▪ Sustainability and environmental issues are important given high energy consumption of data centers ▪ Government incentives (including taxes and grants) ▪ Government restrictions (including power approvals, requirements for data onshoring, etc.)

Source: PGIM Real Estate. As of January 2021.

[24] All data centers, including third-party data centers. Anders S. G. Andrae and Tomas Edler. "On Global Electricity Usage of Communication Technology: Trends to 2030."

REGIONAL VIEWS

UNITED STATES

Data Center Fundamentals

As highlighted in the global section, the COVID-19 pandemic has accelerated many of the demand trends among data centers — most noticeably in the areas of remote working, social and entertainment streaming and e-commerce. In the United States, Green Street Advisors estimates[25] that e-commerce penetration will have risen from 11% in 2019 to 15% by the end of 2020, driven by stay-at-home orders that have converted many consumers to e-commerce.

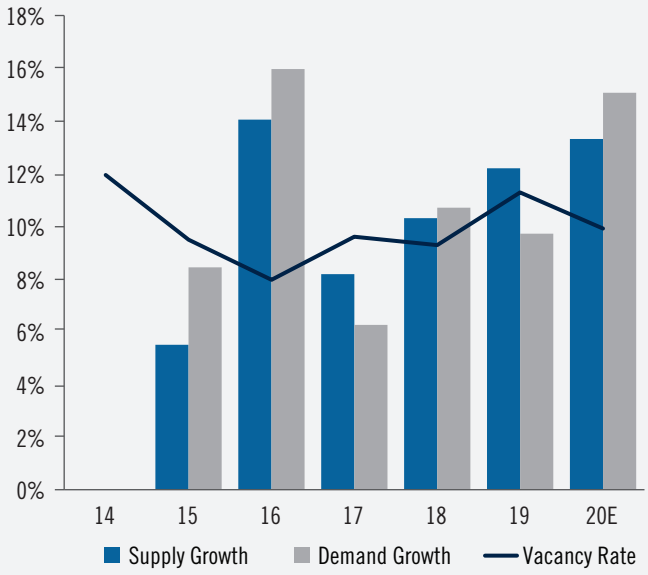
Three of the four largest cloud providers internationally, as well as several of the largest third-party data center operators, are headquartered in the United States. The companies have been at the forefront of driving data center demand globally and domestically and have played a key role in shaping the development of the U.S. data center market.

Overall data center demand growth has been solid in recent years, keeping average vacancy rates in the United States at 8 to 12% since 2014. Driven by expectations of continued leasing demand from cloud service providers, supply completions have been increasing faster than demand, and vacancy has been on a gradual uptrend since 2017. This has weighed on rental rates, which have moderated in recent years to an average of US$126 per kW per month (exhibit AM1).

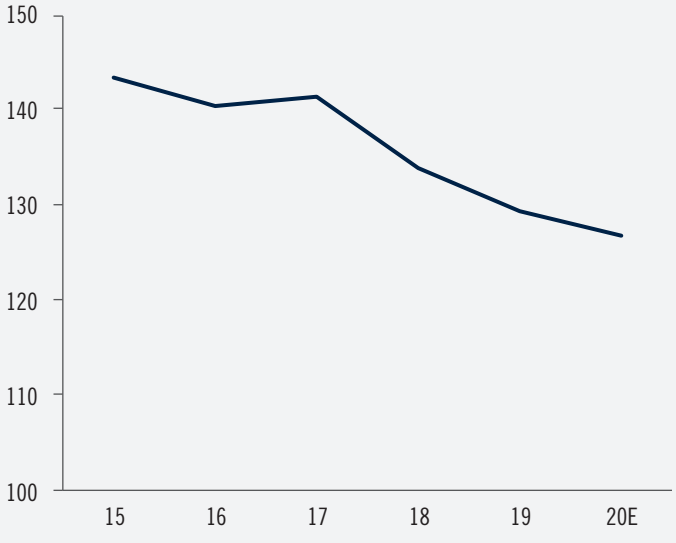
We expect fundamentals to improve and help rental rates stabilize, with data center demand being pushed upward by the COVID-19 pandemic. Furthermore, the supply pipeline remains moderate in most markets, with the only exception being Northern Virginia, where construction has picked up significantly.

Exhibit AM1: U.S. Data Center Market Fundamentals

Data Center Market Supply Growth, Demand Growth and Vacancy Rate



Data Center Rents (US$ per kW per month, >250kW)



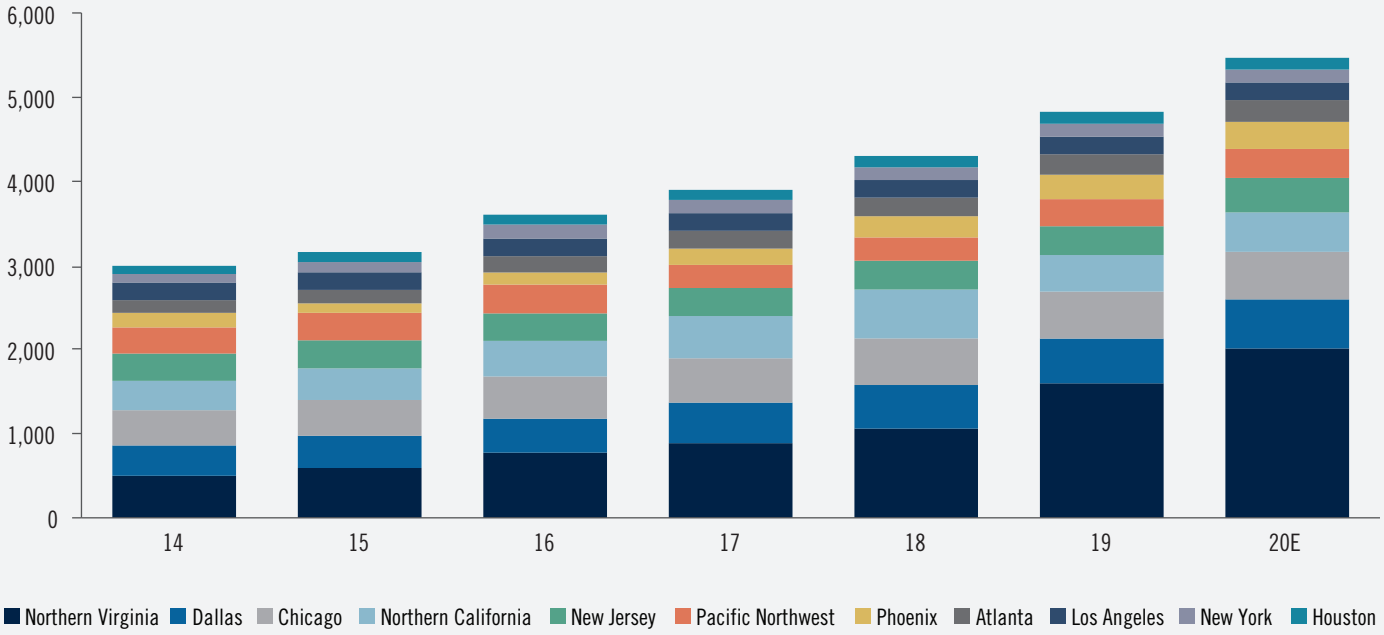
Sources: JLL, CBRE, PGIM Real Estate. As of January 2021.

[25] Green Street Advisors, Industrial Sector Update August 2020.

Data Center Market Scale

The United States is the largest regional data center market in the world, offering total third-party data center capacity of over 5,000 MW — more than half of global capacity (exhibit AM2) — and is also home to some of the largest data center markets by city, as shown in the global supply section earlier. With total inventory growing 10% per annum over the past five years, the U.S. market continues to scale up rapidly. Looking across national markets, there is a disproportionate share of data centers in Northern Virginia, where capacity is more than double the size of that in Northern California, the second-largest market. Other large markets are Dallas and Chicago. Outside those megamarkets, data center activity will continue to be concentrated in major metros that are home to technology and/or Fortune 500 companies because of their more-established infrastructure and security measures. Furthermore, major metros have higher population densities, and data centers located in these metros will be able to provide low-latency services for large consumer markets.

Exhibit AM2: U.S. Data Center Market Scale (Megawatts [MW])

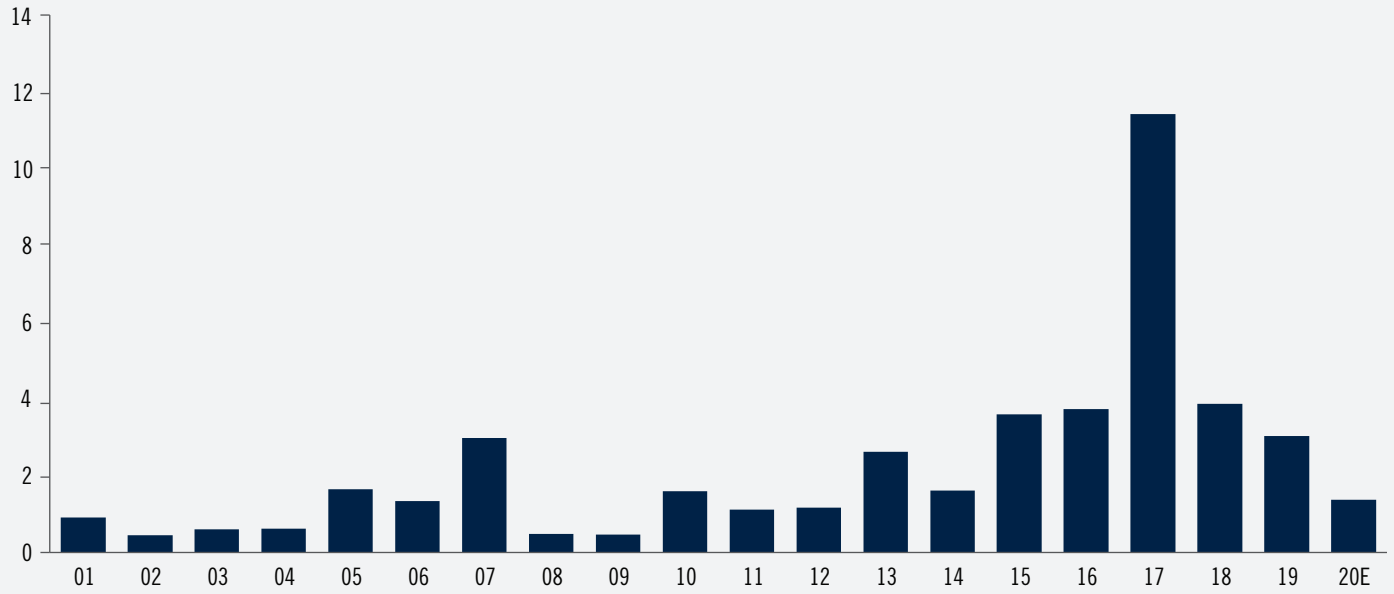


Sources: JLL, PGIM Real Estate. As of January 2021.

Capital Market Trends

In the investment market, the United States typically accounts for 50% of completed-asset transactions globally. Prior to 2020, transaction activity had been broadly stable — at around US$4 billion per annum (exhibit AM3), with 2017 being exceptionally high due to a few portfolio transactions, including a US$3.6-billion portfolio acquisition. However, transaction activity of completed assets slowed in 2020. Nevertheless, the U.S. market continues to attract strong interest from international investors — especially in Asia — with cross-border and private investors making up nearly 80% of net buyers.

Exhibit AM3: U.S. Data Center Transaction Volume (US$ Billion)

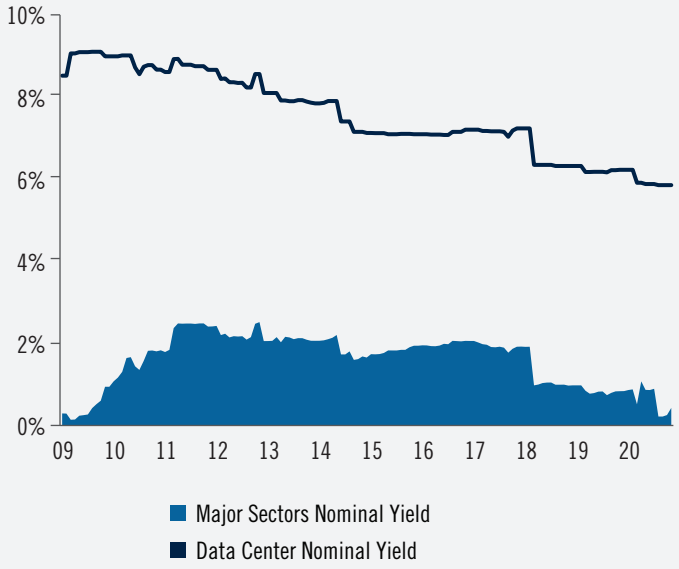


Sources: Real Capital Analytics, PGIM Real Estate. As of January 2021.

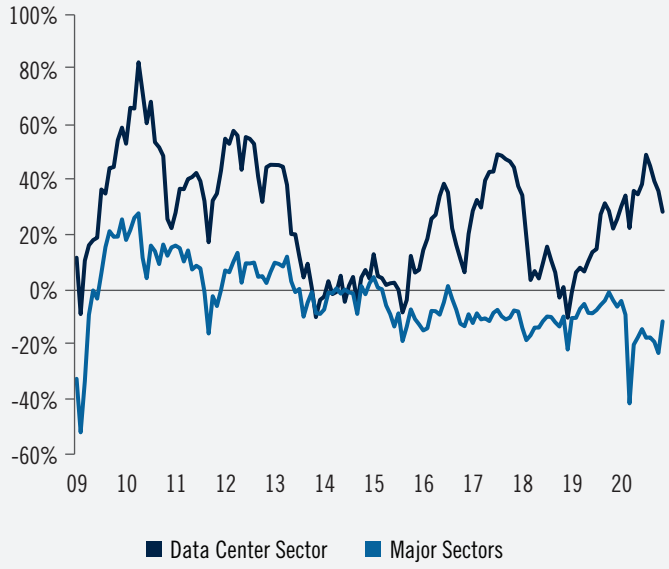
The U.S. data center market is the most transparent compared with Europe and Asia Pacific, given the relative maturity of the market and availability of data on leasing fundamentals and pricing. Data center yields, currently at 5.8% according to Green Street Advisors, have been compressing over the past two years while maintaining an attractive spread over major commercial real estate sectors except retail (exhibit AM4). Listed data center REITs have performed well relative to other real estate sectors throughout the COVID-19 pandemic market volatility, suggesting market confidence in longer-term structural drivers that the data center sector offers. With data center REITs' net asset value premiums averaging 40% in the second half of 2020 compared with a 17% discount for other major real estate sectors over the same period, the public market seems to believe that there could be an upside for data center asset valuations (exhibit AM4).

Exhibit AM4: Data Center Yields and Listed Data Center REIT NAV Premiums

Data Center Yields



Average Data Center REIT NAV Premiums

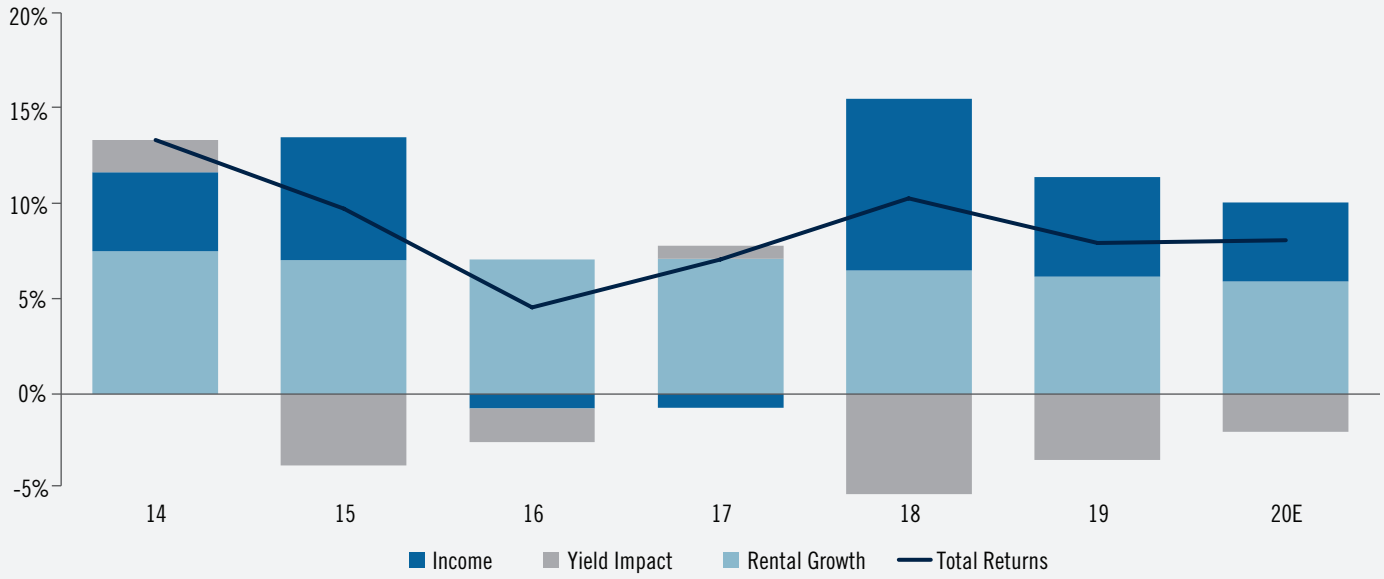


Sources: Green Street Advisors, PGIM Real Estate. As of January 2021.

Since 2014, unlevered total returns for powered shell and core data centers have averaged 9% per annum (exhibit AM5). Yield compression has been a key driver of returns, though partially offset by modest rental growth. However, we expect rents to stabilize in the medium term due to strong demand and moderating supply. Keen interest from global investors in U.S. data centers could potentially compress yields further, keeping prospects positive for the overall market.

Exhibit AM5: U.S. Data Center Total Returns

Estimated Total Returns (Unlevered, Powered Shell and Core Assets)



Sources: Green Street Advisors, PGIM Real Estate. As of January 2021.

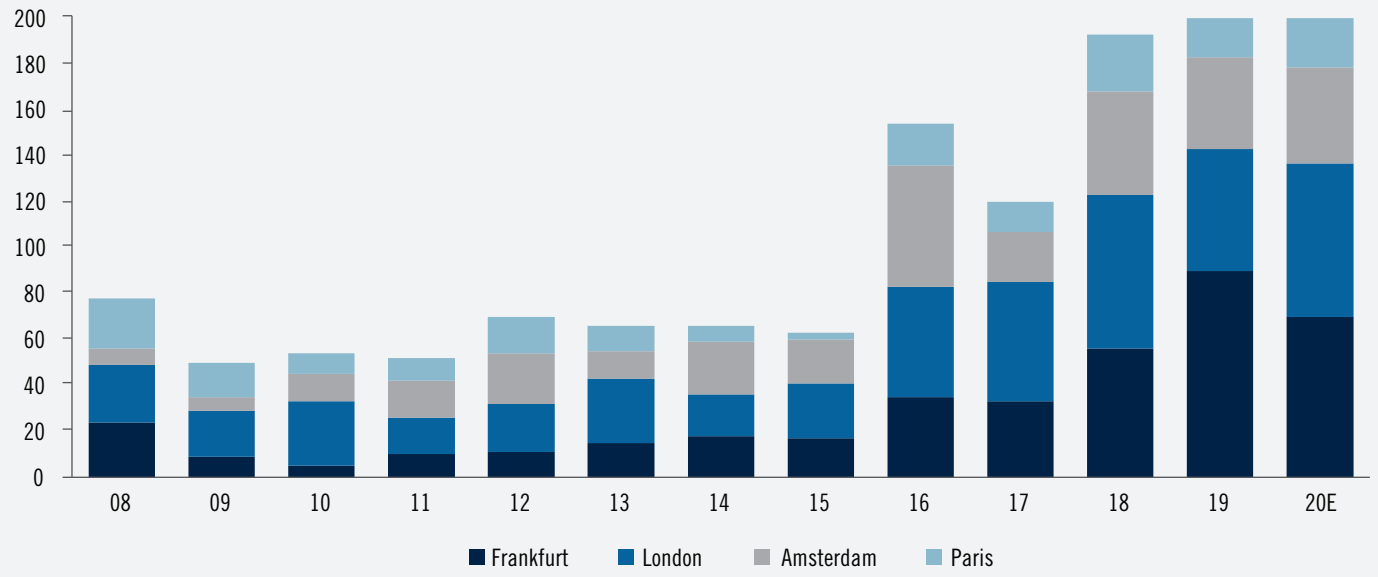
EUROPE

Data Center Fundamentals

Similar to other regions, the European data center market has been a beneficiary of global demand drivers such as structural changes, growth in cloud services, e-commerce and remote working and learning, as described in the global section earlier. Established economic centers in developed countries like the UK, France, the Netherlands and Germany have continued to scale up their data center markets as both demand and supply grow.

The surge in data creation and traffic has translated into data center demand in Europe,[26] which reached record levels of 200 MW per annum during the past three years, led by strong absorption from cloud providers (exhibit EU1). Since 2016, all four major data center markets in the region have seen significant growth in demand.

Exhibit EU1: Estimated European Data Center Demand (Megawatts [MW])



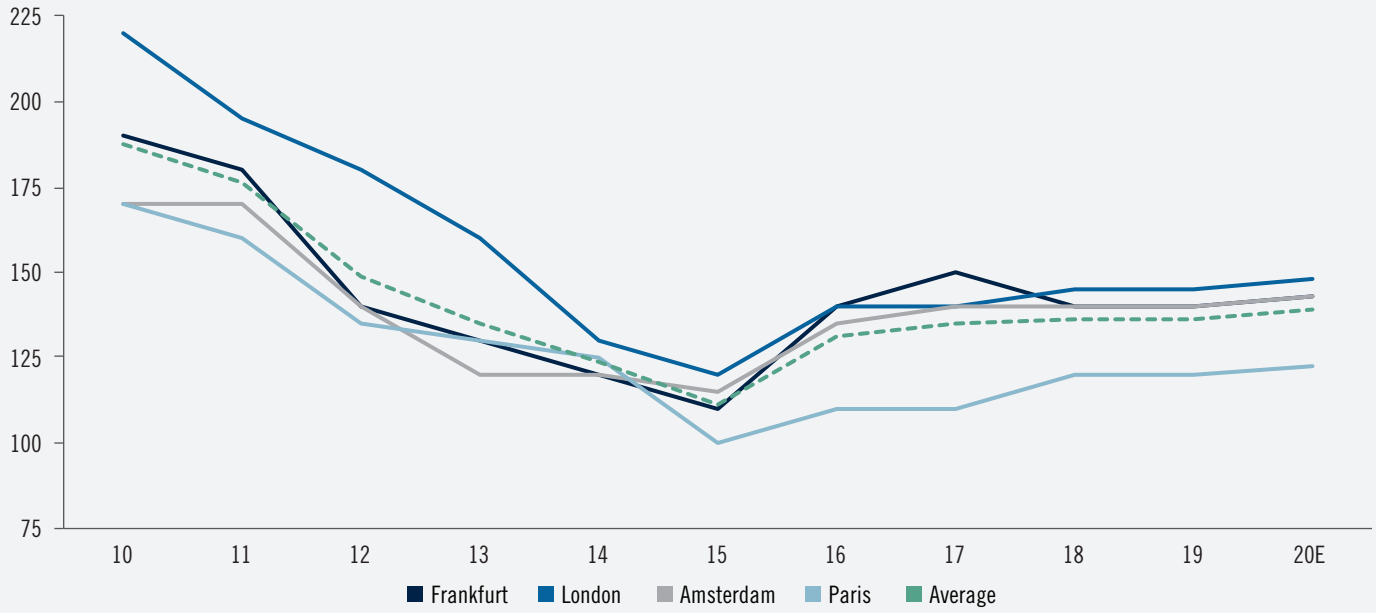
Sources: CBRE, PGIM Real Estate. As of January 2021.

With elevated demand helping to absorb the new supply coming to market, headline rents have been largely stable in the past three years, averaging around €140 per kW per month (exhibit EU2). Looking further back, data center rents had been declining for several years after 2010, reflecting the imbalanced fundamentals during the time when significant supply was being brought to market.

Looking forward, with structural demand growth expected to remain robust and construction activities being delayed due to COVID-19, competition for quality space is expected to continue and rents are likely to stay at least stable with further potential to grow, especially in London and Frankfurt, where demand from hyperscale cloud service providers has been particularly strong.

[26] Due to their market size and strategic locations, the four major data center markets in Europe (Frankfurt, London, Amsterdam, Paris) are used as a proxy for the regional market.

Exhibit EU2: European Data Center Colocation Rents (€ per kW per month, 500kW)

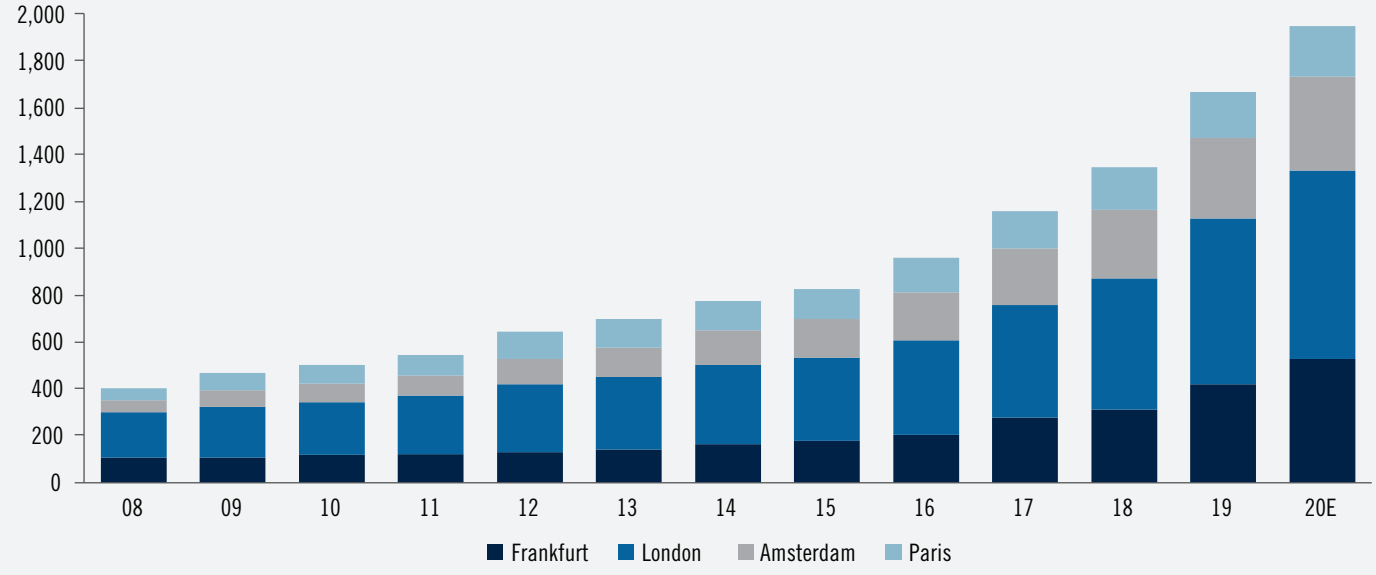


Sources: JLL, PGIM Real Estate. As of January 2021.

Data Center Market Scale

The largest data center markets in Europe are Frankfurt, London, Amsterdam and Paris. As discussed in the global section, those four markets are strategically located in gateway cities with proximity to a large base of end users and current readiness of fiber accessibility to global networks. The current estimated third-party data center capacity of the four markets is 1,950 MW, or approximately 20% of the global market size (exhibit EU3).

Exhibit EU3: European Data Center Market Scale (Megawatts [MW])



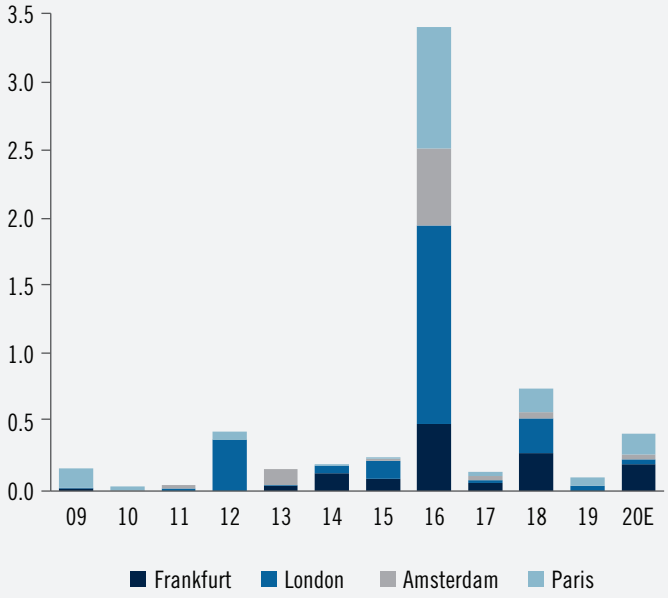
Sources: CBRE, PGIM Real Estate. As of January 2021.

Capital Market Trends

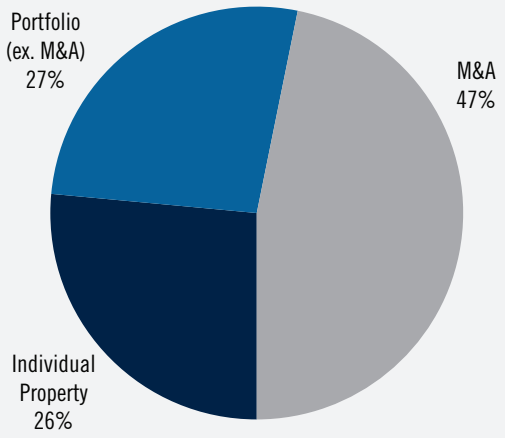
As pointed out in the global section, investment activity in data centers captured in completed-asset transactions does not reflect overall capital flow in the sector because of the high volume of corporate mergers and acquisitions (M&A). The fact is particularly evident in Europe, where M&A activities have accounted for around 50% of total activities in the past decade (exhibit EU4). Among major European markets, London has seen the highest transaction volume in the past few years.

Exhibit EU4: European Data Center Transaction Activity

European Data Center Transaction Volume (€ Billion)



Types of Data Center Transactions in the Past 10 Years

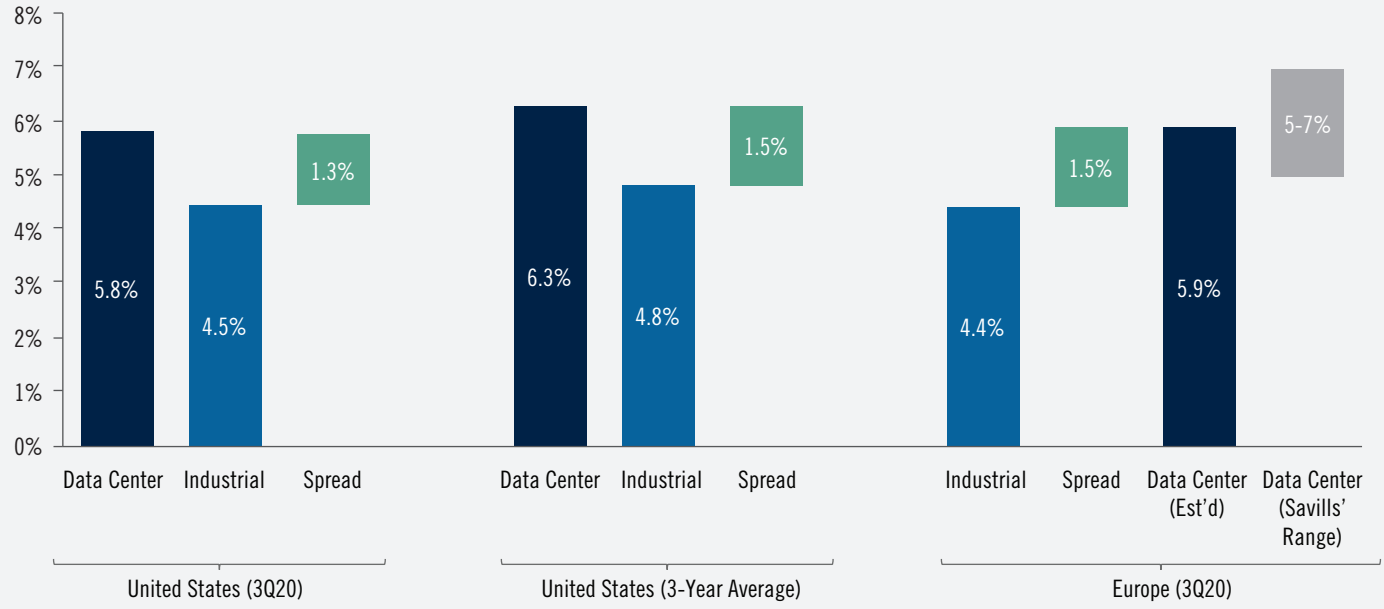


Sources: Real Capital Analytics, PGIM Real Estate. As of January 2021.

With regard to pricing, there is limited data on transaction yields, though data from the United States provides useful guidance (see U.S. section above). Using a 1.5% average spread above industrial yields in the past three years in the U.S. market, we estimate data center yields in Europe at around 5.9%, which is broadly consistent with the range of 5 to 7% data center yields estimated by Savills[27] (exhibit EU5).

[27] Savills Spotlight: European Datacentres Nordics, the Rising Star out of the Cloud

Exhibit EU5: European Data Center Yields

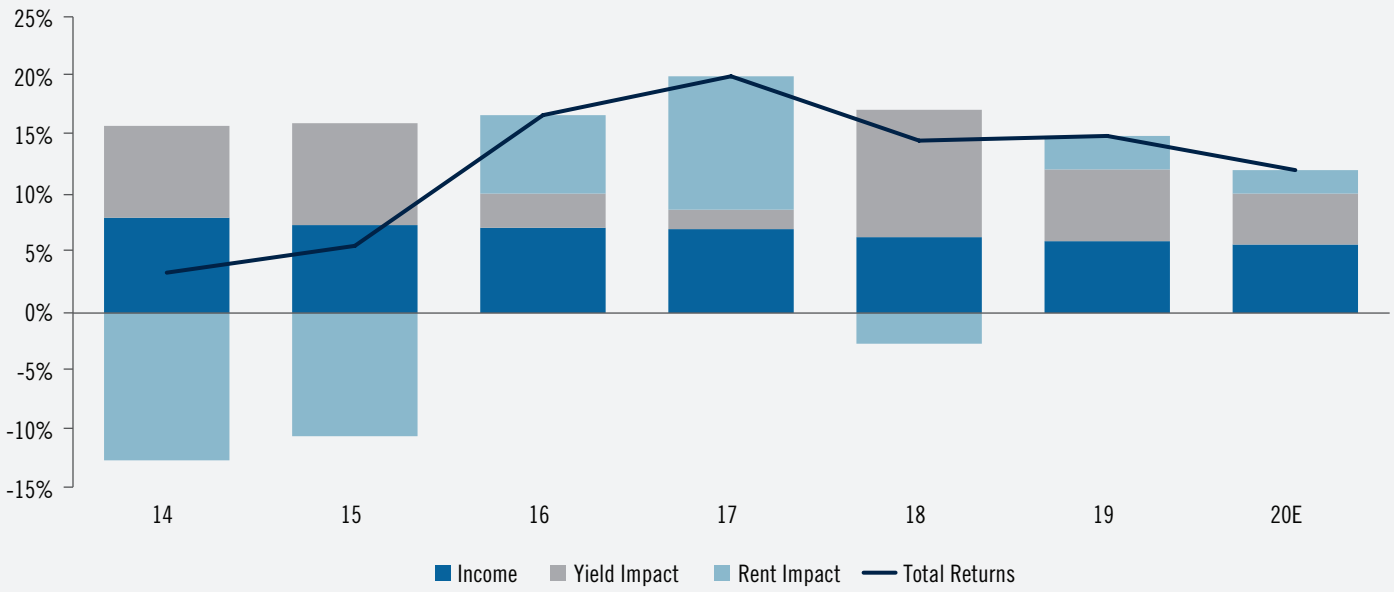


Sources: Cushman & Wakefield, Green Street Advisors, Savills, PGIM Real Estate. As of January 2021.

Even though actual market returns data are limited in Europe because of a lack of reporting transparency, we can estimate indicative total returns for powered shell and core data centers based on proprietary estimates of market yields and rents, as described earlier. Mirroring the substantial pickup in underlying data center demand since 2016 (exhibit EU1), indicative total returns have since risen (exhibit EU6). Over the past five years, average indicative total returns were 16% per annum on an unlevered basis, with capital value growth consistently driven by yield compression. This is higher than estimated global average returns of 11% — as shown in the global section — due largely to rental recovery in Europe.

Exhibit EU6: Europe Data Center Total Returns

Estimated Total Returns (Unlevered, Powered Shell and Core Assets)



Sources: CBRE, Cushman & Wakefield, Green Street Advisors, JLL, PGIM Real Estate. As of January 2021.

ASIA PACIFIC

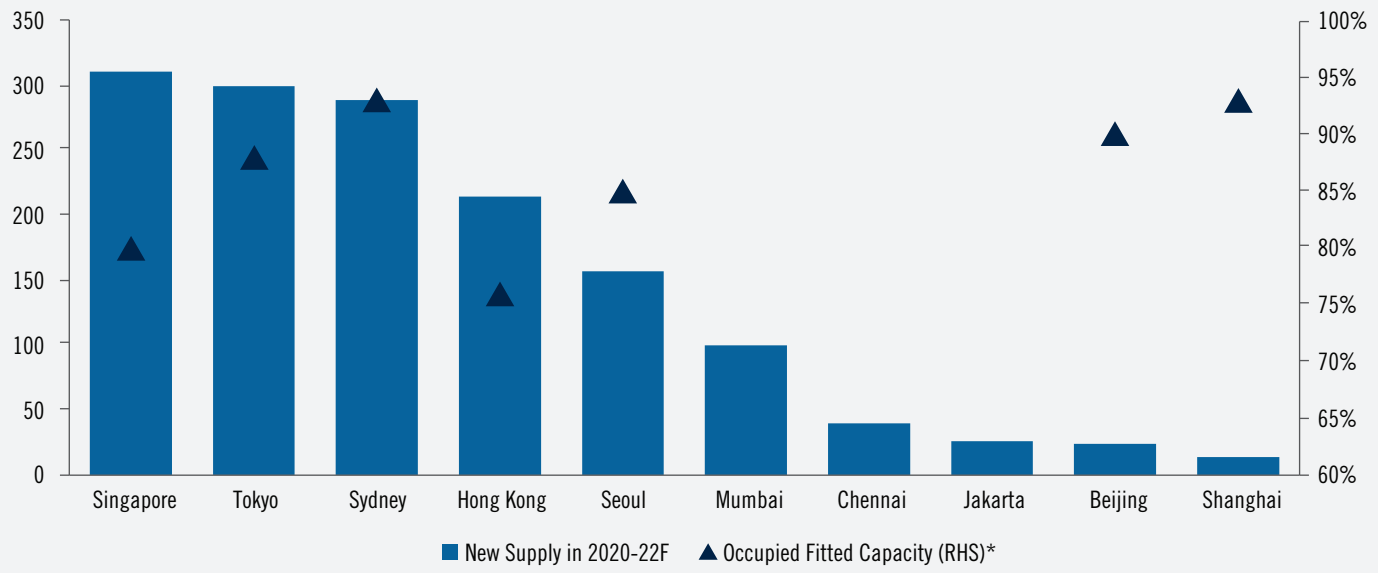
Data Center Fundamentals

Like the U.S. and European markets, the data center sector in Asia Pacific has been benefiting from the growth of internet traffic and data volume as the numbers of and usage by both individual and corporate users rose. In line with global trends, the cloud services industry is currently leading the next wave of data center demand in the region. In addition, the COVID-19 pandemic has accelerated consumer trends such as e-commerce penetration and led to changes in infrastructure for home working and distance learning.

With those strong demand drivers in place, occupancy rates are high, ranging from 75 to 95%. A number of markets are expected to significantly increase supply, as capital continues to flow toward development (exhibit AP1). The top four markets of Singapore, Tokyo, Sydney and Hong Kong have attracted the most development interest, and capacity is expected to double by 2022. However, occupancy rates are likely to remain high because of robust demand from hyperscale cloud service providers.

Exhibit AP1: Asia Pacific Data Center Market Fundamentals

Data Center Supply Pipeline and Occupancy (Megawatts [MW])

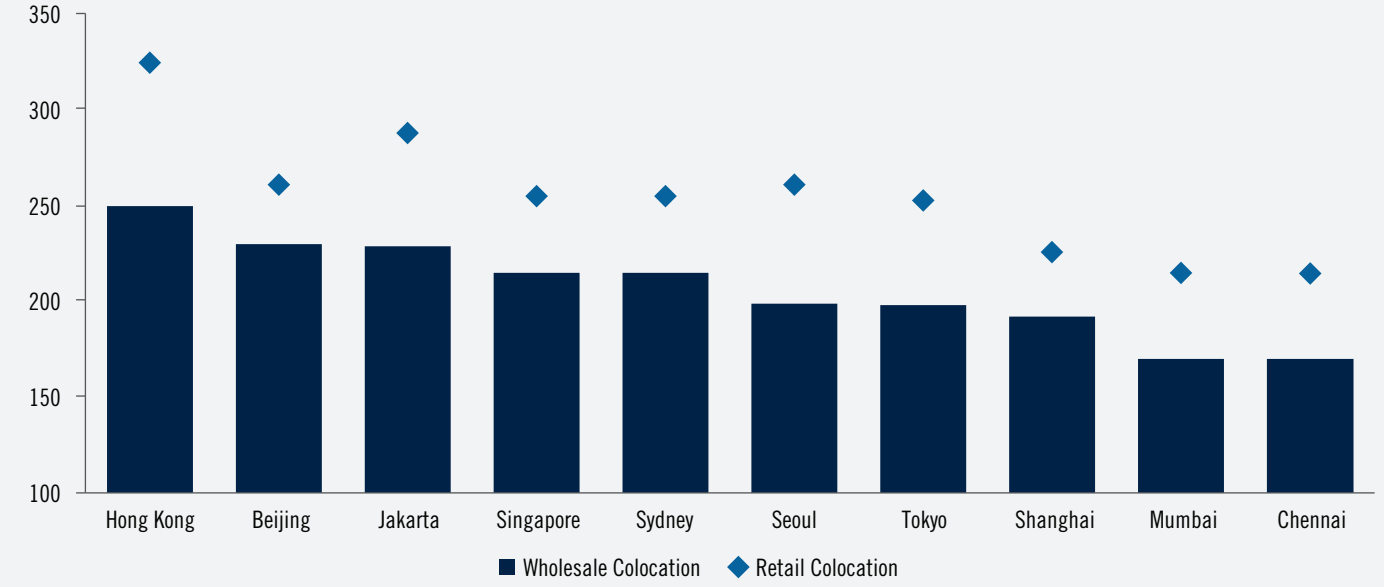


*Occupancy rate of fitted capacity, excluding shell capacity
Sources: CBRE, PGIM Real Estate. As of January 2021.

Rents are fairly diverse across the region — especially for retail colocation rents that range from US$200 to US$320 per kW per month (exhibit AP2). Wholesale colocation occupiers see rents fall within a narrower range: US$170 to US$250 per kW per month. Hyperscale occupiers could enjoy a substantial, 30 to 40% discount from wholesale rental rates.

Looking ahead, the rental market is expected to remain largely stable, or to moderate slightly in the near term, as the sizable supply coming to the market offsets the strong demand drivers. However, the Singaporean government moratorium on new data center site approvals and the challenges involved in securing power supply in Tokyo could cause supply constraint in those markets, which would support a stronger rental growth outlook in the medium term.

Exhibit AP2: Asia Pacific Data Center Rents (US$ per kW per month)

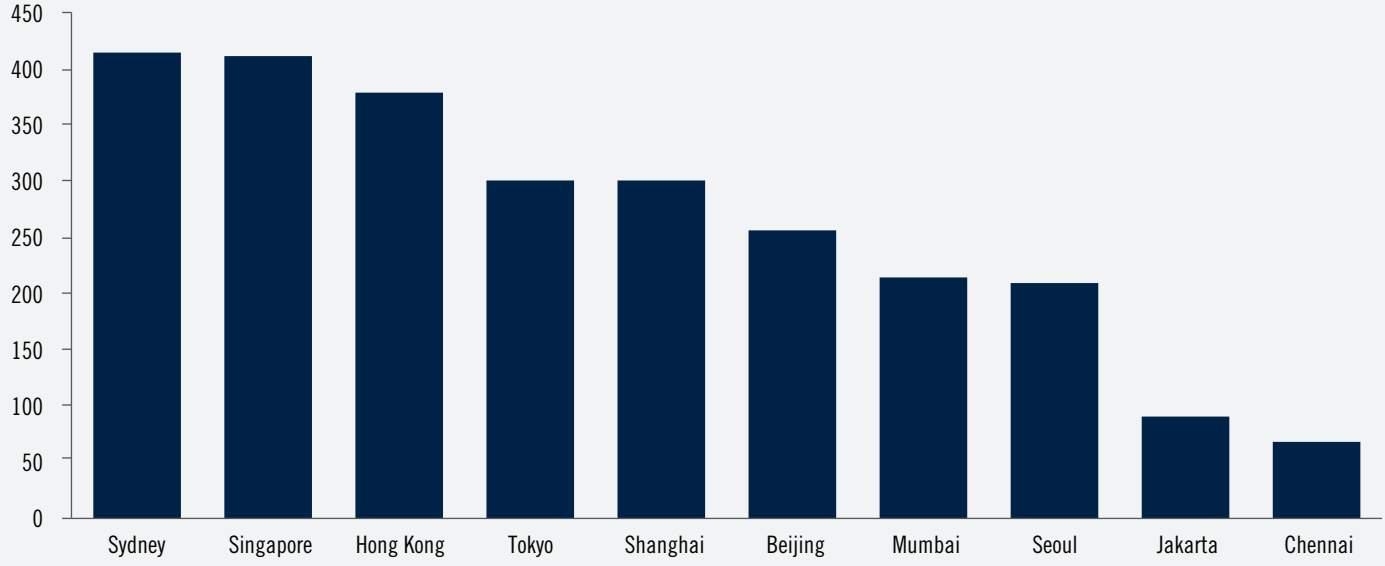


Sources: CBRE, PGIM Real Estate. As of January 2021.

Data Center Market Scale

The Asia Pacific data center market is estimated to offer 2,600 MW of third-party data center capacity, accounting for approximately 28% of the global data center market. The four largest city-markets in Asia Pacific are Sydney, Singapore, Hong Kong and Tokyo. In addition to being key regional economic and financial hubs, these gateway cities are major landing points for submarine fiber cables, making them the most suitable for the development of local and regional data centers — as discussed in the global section. The four markets currently have a combined third-party capacity of 1,100 MW (exhibit AP3).

Exhibit AP3: Asia Pacific Data Center Market Scale (Megawatts [MW])



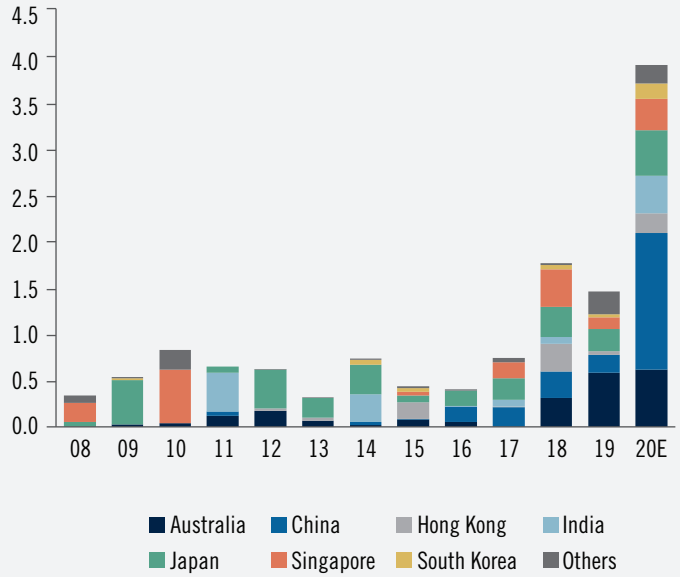
Sources: CBRE, PGIM Real Estate. As of January 2021.

Capital Market Trends

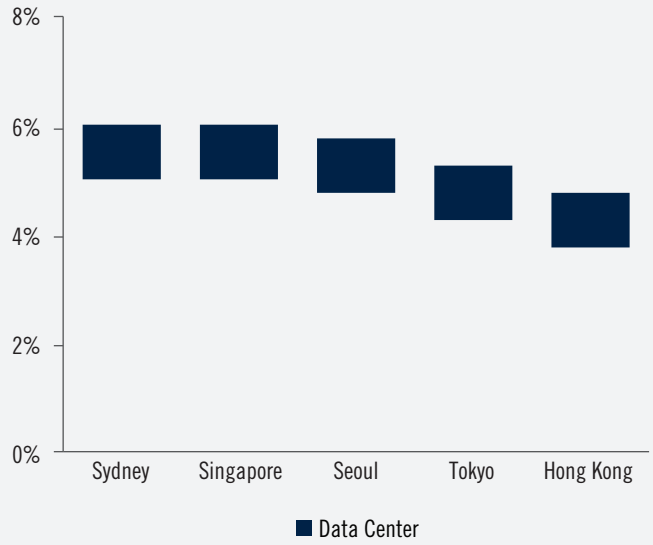
Investment activity has increased significantly in recent years, with overall transactions of completed-assets averaging US$1.5 billion in 2018-19 — almost doubling the previous five-year average. Capital market activity accelerated sharply in 2020 (exhibit AP4). That volume, however, excludes M&A activities, which could be significant, as demonstrated in exhibit 6 in the global section. There is no aggregated regional M&A data on data center operators or platforms in Asia Pacific, but examples of development joint-ventures and acquisitions by Australian operators in recent years — each of them worth US$1 billion to US$2 billion — reflect the scale and capital flows of platform transactions.

Exhibit AP4: Asia Pacific Data Center Capital Markets

Asia Pacific Data Center Transaction Volume (US$ Billion)



Asia Pacific Data Center Yields



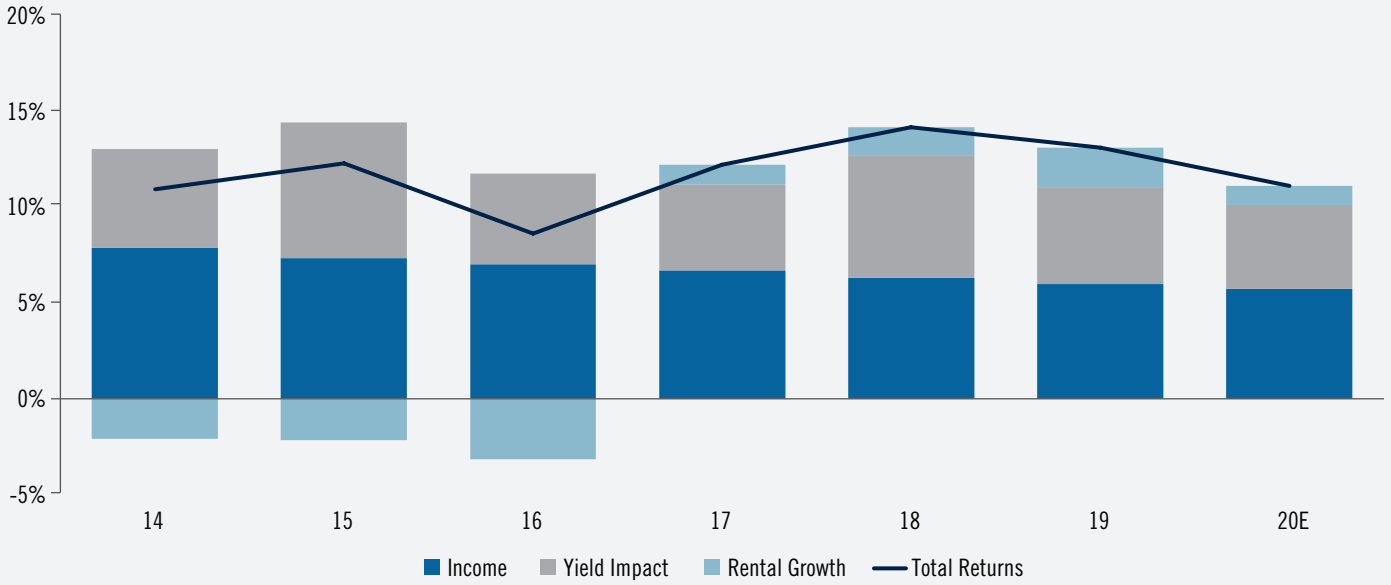
Sources: Real Capital Analytics, CBRE, PGIM Real Estate. As of January 2021.

With regard to pricing, yields for powered shell and core data centers range from 4 to 6% in major markets (exhibit AP4), which implies an average yield spread of 50 to 150 basis points over prime logistics yields, excluding Singapore — broadly in line with the relative pricing observed in the United States and Europe.

Based on asset-level evidence and relative pricing references, estimated total returns in the four major Asia Pacific markets have averaged 12% per annum since 2014 (exhibit AP5). That return has been driven largely by stable income returns and yield compression. Looking forward, supply is expected to moderate, and the rental growth outlook is likely to stabilize. Prospective returns are expected to remain attractive, and data centers in Asia Pacific will continue to draw strong interest from institutional investors on the back of strong structural growth and the resilience and lengthy duration of income returns.

Exhibit AP5: Asia Pacific Data Center Total Returns

Estimated Total Returns (Unlevered, Powered Shell and Core Assets)



Sources: CBRE, Structured Research, PGIM Real Estate. As of January 2021.

CONCLUSION

Data centers are buildings designed to house computer systems and network equipment that support the collection, storage, computing and distribution of data. And although the growth in data center demand has been on an upward trend due to innovations and the adoption of new technology, the COVID-19 pandemic has accelerated demand due to growth in both internet traffic and data creation.

Based on current trends, the global data center market is set to grow significantly in the coming years, potentially leading to a further decrease in risk premium and providing investors with relatively attractive returns. However, deal sourcing is difficult as this is still only a small sector. Moreover, an associated lack of liquidity and transparency — especially around pricing for different ownership and leasing structures, as well as the potential for technological obsolescence — raises the risk profile relative to more-traditional commercial real estate sectors. The sector is set to grow significantly, however, leading to a further decrease in the risk premium and providing investors with relatively attractive returns across the world.

The three major regional markets studied here — the United States, Europe and Asia Pacific — are each benefiting from the same global demand drivers, alongside the ICT industry — especially cloud service providers that are expanding their requirements for data center capacity — although those regional markets face different near-term demand–supply challenges. In the United States, total capacity has grown sharply in recent years as the market continues to scale up, although rising vacancy has weighed on rents. In Europe, data center absorption was elevated in 2018 and 2019, and a rental recovery led to returns outperforming the global average. In Asia Pacific, despite expected significant supply increases, robust demand is expected to help keep occupancy rates high.

APPENDIX I:

GLOSSARY OF TERMS

Big Data:	Structured and unstructured data sets that are too large and too complex for traditional processing methods to deal with. Challenges include the capture, storage, analysis, sharing and protection of such data.	
Cloud Computing:	The delivery of software, storage and other computing services via the internet (the cloud) rather than deployment on local hardware.	
	Private Cloud:	A private cloud that is set up for use by a single organization and that resides on an organization's intranet or hosted data center where all hardware, management, maintenance, security and updates are the responsibilities of the organization.
	Public Cloud:	A public cloud that resides in a service provider's data center and wherein the provider is responsible for all management and maintenance. Examples are Google Cloud, Apple's iCloud, and Microsoft's OneDrive.
Colocation:	A multitenanted arrangement whose prices are based on power commitment. Under such an arrangement, a customer pays a third-party data center provider for use of floor space or rack unit space at a data center for the customer's IT equipment, an allocation of power for its IT equipment and interconnection services. The customer owns and operates everything that resides within its floor or rack space, and the third-party provider is responsible for redundant power and cooling provisioning.	
	Wholesale Colocation:	A type of colocation, with larger power commitments from individual customers that typically range upwards of 300 kW and that often involve commitments of entire floors or data halls.
	Retail Colocation:	A type of colocation wherein commitments from individual customers can be much smaller than 300 kW.
Fitted Data Center:	An ownership structure that includes the building shell as well as the fit-out within the data center (i.e., electrical, mechanical and building fit-out).	
Hyperscale:	A scale that can be used to describe large data center leases that typically involve initial power commitments of 2 or 3 MW, with further demand growth reaching upwards of 50 MW in a single location. They can be wholesale colocation tenants or single tenants within a data center. Hence, hyperscale cloud providers refer to large technology companies providing cloud-computing capability as a service and taking up large power commitments, such as Amazon, Google, Microsoft and Alibaba.	
Internet of Things (IoT):	The global network of smart devices, vehicles, buildings and other objects embedded with intelligent software and sensors that enable the things to communicate and collect data.	
Rack/Cabinet:	A metal framed chassis that holds, secures and organizes a vertical stack of network and server hardware, including routers, switches, access points, storage devices and modems.	
Shell and Core Data Center:	An ownership structure that consists of only a building shell and core and that excludes fit-out within the data center. Commonly known as *powered shell and core* if power supply is provided.	
Turnkey Data Center:	A data center that is designed, supplied, built or installed fully complete and ready to operate. The end user has only to move in its IT equipment (i.e., racks and computer servers) to use it.	

APPENDIX II: WHAT IS IN A DATA CENTER

Physical Components of a Fully Fitted Data Center

IT Equipment
- Server Racks
- Computer Servers

Fit-out: Building
- Security Systems
- Fire Depression and Suppression

Fit-out: Electrical
- Generators
- Uninterruptible Power Supply (UPS)
- Power Distribution Units (PDUs)

Building Shell and Power
- Building Shell and Access to Power
- Fiber Connection
- Raised Floor

Fit-out: Mechanical
- Cooling Systems

Source: PGIM Real Estate. As of January 2021.

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PGIM REAL ESTATE

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