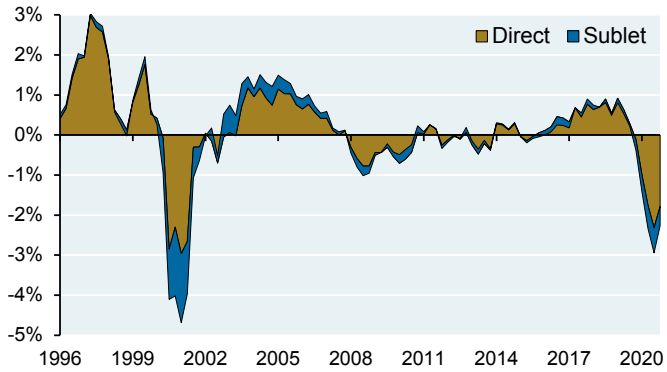
REAL ASSETS: COMMERCIAL OFFICE PROPERTY, INFRASTRUCTURE and TIMBER

[4] US office market fundamentals: already improving despite COVID

We have written a lot about low office utilization rates in US office markets: ~45% in Dallas, Houston and Austin, and 20%-30% in NYC, SF, LA, etc (see page 26). There is clearly a wide bid-offer between employers and employees regarding work-from-home policies which has yet to be resolved. Even so, there are multiple signs in the US that office market fundamentals are improving.

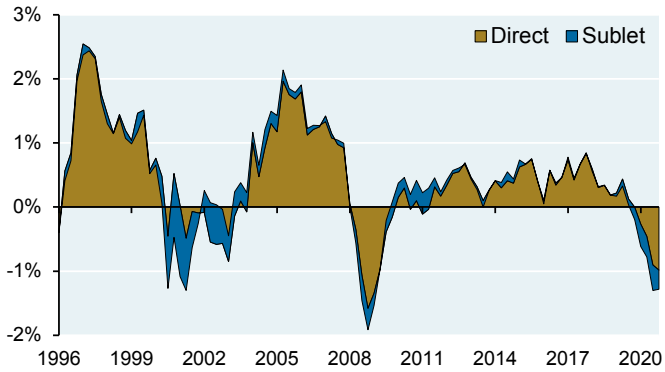
Vacancy rates can be an incomplete measure of available supply given the long term nature of most office leases. In other words, how much "shadow" vacancy of unwanted space still under lease will also weigh on the market? By adding net direct vacancies plus new net sublet vacancies and dividing by total office inventory, we can assess office market stress compared to prior business cycles. As illustrated below, the stress in New York City right now is pretty intense: more than twice as high as during the Global Financial Crisis, although not nearly as bad as the aftermath of the tech crash in 2001. In Chicago, the current stress numbers are lower than NYC in absolute terms, and also more similar to both prior cycles.

New York direct and sublet quarterly absorption
% of inventory, trailing 4-quarter sum



Source: Costar, JPMAM. Q3 2021.

Chicago direct and sublet quarterly absorption
% of inventory, trailing 4-quarter sum



Source: Costar, JPMAM. Q3 2021.

US office markets are very heterogeneous, so it's important to look at details. NYC, DC, Seattle, Minneapolis and Denver stand out as having higher stress than during the GFC, and for DC and Denver, the stress is worse than during the tech bust as well. One generalization does emerge: in almost all large US office markets, vacancy trends were already improving in Q3 2021 vs Q2 2021 despite the ongoing debate about the future of office work. In other words, Q3 2021 absorption data were almost all less negative than they were in Q2.

US office market stress

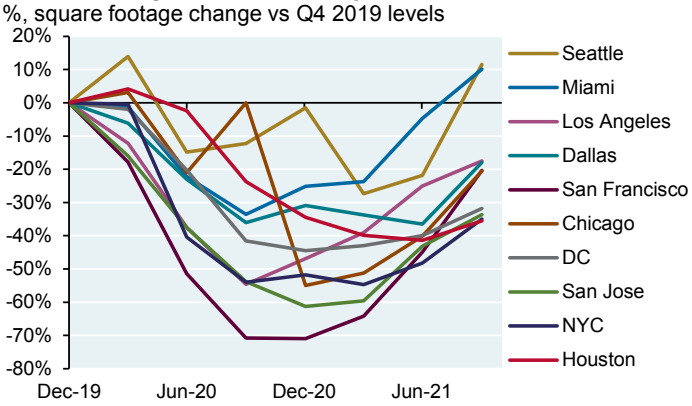
	Inventory (mm sq ft)	Direct plus sublet absorption as % of inventory: COVID (Q3 2021)	COVID (Q2 2021)	GFC	Tech bust	Q3 COVID multiple of GFC weakness	Q3 COVID multiple of tech bust weakness
New York - NY	979	-2.3%	-2.9%	-1.0%	-4.7%	2.2x	0.5x
Washington - DC	527	-1.6%	-2.0%	-0.3%	-0.6%	5.1x	2.6x
Chicago - IL	511	-1.3%	-1.3%	-1.9%	-1.3%	0.7x	1.0x
Los Angeles - CA	435	-1.5%	-2.2%	-2.1%	-1.4%	0.7x	1.1x
Dallas-Fort Worth - TX	423	-1.1%	-1.3%	0.3%	-0.3%	na	3.4x
Boston - MA	377	-1.4%	-1.8%	-0.9%	-2.9%	1.5x	0.5x
Houston - TX	356	0.0%	-0.8%	0.9%	-0.5%	na	0.0x
Atlanta - GA	344	-0.8%	-1.5%	-1.1%	0.6%	0.7x	na
Philadelphia - PA	326	-1.2%	-1.8%	-1.0%	-1.6%	1.1x	0.7x
Seattle - WA	236	-1.5%	-2.0%	-0.7%	-2.0%	2.1x	0.8x
Detroit - MI	204	-0.5%	-1.0%	-1.3%	-1.5%	0.4x	0.3x
Minneapolis - MN	203	-1.8%	-1.6%	-0.4%	0.0%	4.5x	na
Phoenix - AZ	201	-1.1%	-1.0%	-1.7%	1.1%	0.6x	na
San Francisco - CA	188	-2.7%	-3.9%	-2.7%	-6.3%	1.0x	0.4x
Denver - CO	184	-1.8%	-2.6%	-0.6%	-1.2%	2.9x	1.5x

Source: Costar, JPMAM. Q3 2021.

More evidence of a recovery in office markets despite COVID: leasing and lease terms

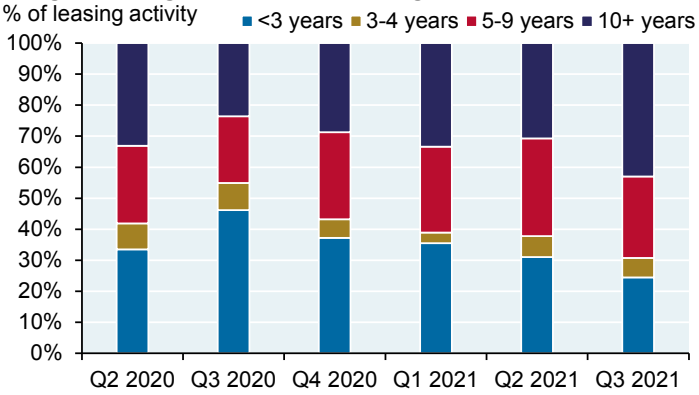
Leasing activity is arguably an even better leading indicator of what's going on than vacancy, since leasing can be tracked before the official start date of the lease itself. As shown on the left, office leasing trends are already improving for many of the large office markets, although Houston, NYC and DC are lagging. The other notable improvement: a lengthening of lease terms since Q3 2020, a sign that renters are becoming more confident in their long-term space needs assessments. **To reiterate: commercial real estate markets are already firming despite the fact that labor-vs-management disagreements over office utilization are still ongoing.**

Office leasing trends (quarterly)
%, square footage change vs Q4 2019 levels



Source: CoStar. Q3 2021.

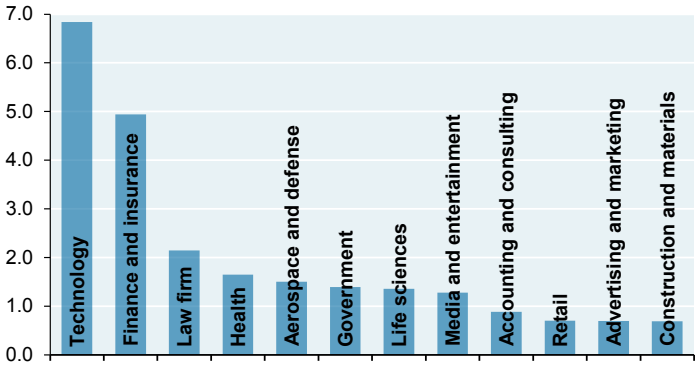
Longer leasing terms are increasing
% of leasing activity



Source: JLL. Q3 2021.

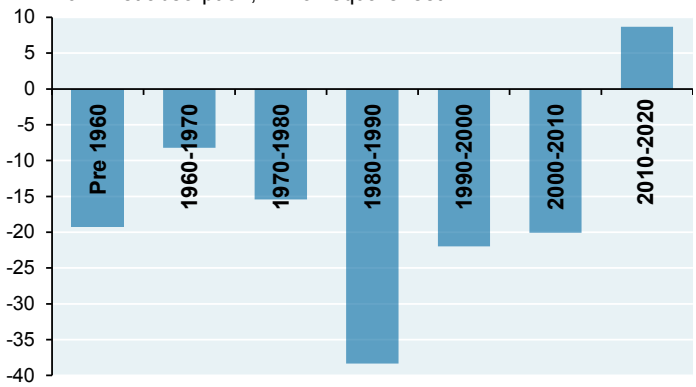
While this might seem like a return to pre-COVID conditions, there are important changes to highlight. There are clear trends showing a rise in space demand by technology firms in newer buildings in growth node areas. As a result, our commercial real estate investment teams believe that owning generic central business district office is no longer as reliable a route to appreciation. Even as vacancies come down, a large swath of the office market may likely remain weak as long-term returns for those buildings are dragged down by higher capex designed to fight these secular trends. Accordingly, generic office should ideally make up a smaller share of portfolios, and real estate portfolio investors should focus on buying or building modern office in growth nodes.

Commercial office leasing volume by sector
YTD 2021 leasing volume, million square feet



Source: JLL, CoStar, JPMAM. Q3 2021.

Office building absorption by construction year
YTD 2021 net absorption, million square feet

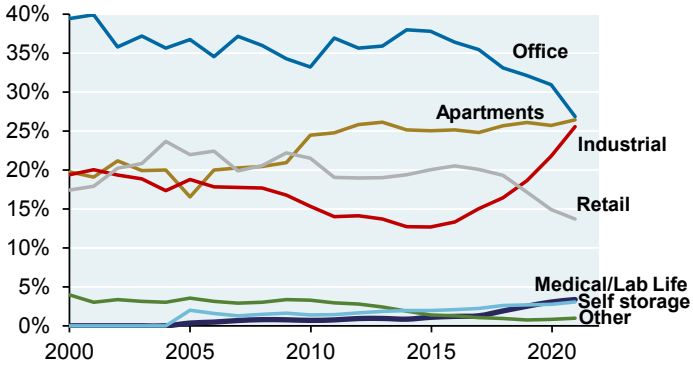


Source: JLL, CoStar, JPMAM. Q3 2021.

The declining share of office investing in institutional and REIT portfolios

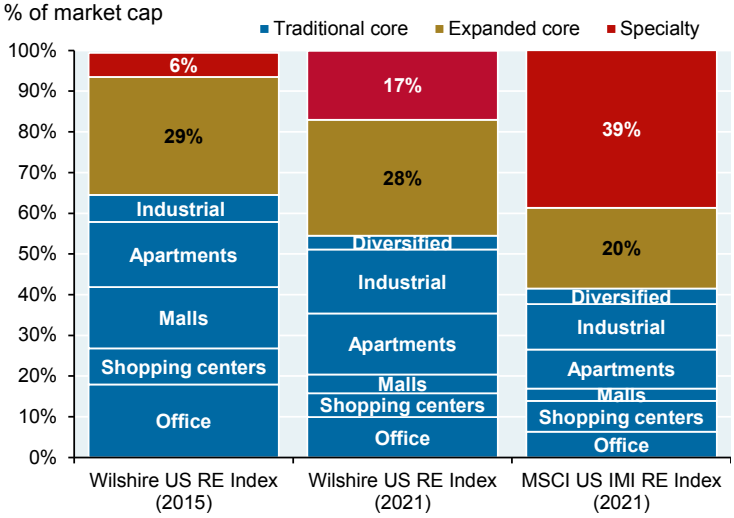
Any discussion on office fundamentals would be incomplete without mentioning its gradual decline in many institutional portfolios. As shown below, office allocations have declined in the bellwether MSCI Core Diversified Open-End Property Fund Index which captures allocations across $270 bn of real estate investment. The same lower exposure to office is true with regards to publicly traded REITs. Industrial, life sciences and specialty property types have been the major beneficiaries of this shift.

MSCI commercial real estate core index property type allocations



Source: MSCI, JPMAM. Q3 2021.

US REIT breakdown by sector
% of market cap

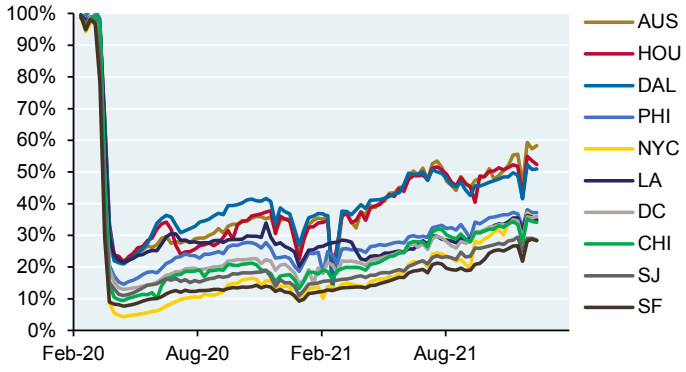


Source: Wilshire, Vanguard, JPMAM. Q3 2021.

Sector definitions:
Expanded core: self-storage, hotels, senior housing, medical offices, student housing and manufactured homes
Specialty: data centers, single family rentals, land and cell towers

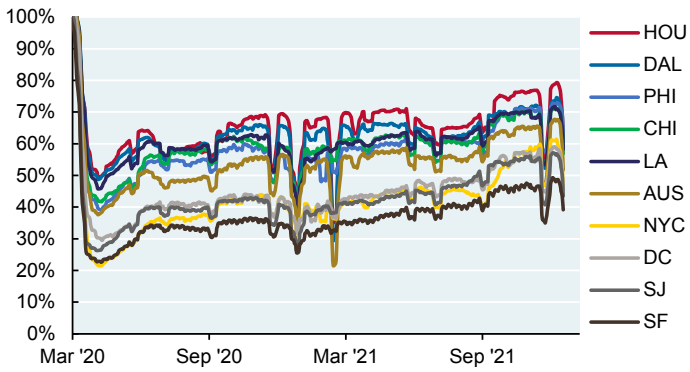
Measures of office utilization: Keycard/fob data and Google phone geolocation

Office utilization rates by metro area
Based on keycard/fob data



Source: Kastle. December 15, 2021.

Google workplace mobility trends
% relative to January 2020 baseline



Source: Google. December 24, 2021. 7 day avgs.

[5] Infrastructure investing: devil is in the details (electricity distribution, solar power and bulk storage)

Infrastructure investing has become more broadly accepted over the last decade. In a 2019 survey[10], 96% of institutional investor respondents said they were either maintaining or increasing the pace of infrastructure investment. Investors are now comfortable with value-added approaches and co-investment in addition to core funds, with a focus on renewable energy, transportation, energy/power, waste management and telecom.

One difference between infrastructure and other alternative sectors is the presence of government projects structured as Public Private Partnerships ("PPPs"). A decade ago PPPs were a main pillar of core infrastructure investing, but politics, challenges to existing projects and complexity have been a problem in some jurisdictions, and they have fallen out of favor among many investors and managers.

Instead of walking through some bland facts and figures on infrastructure assets, I thought it would be more interesting to dive into the details of the risk and return catalysts affecting some of our actual infrastructure investments. Our infrastructure team and I review three of them below: one in regulated electricity distribution, one in contracted solar power and one in bulk liquid storage. The Q&A helps illustrate the micro and macro factors at work in infrastructure investing.

Regulated electricity distribution

What kind of utilities do you often look for?

Vertically integrated utilities can be attractive investments: they operate customer-facing distribution and interstate transmission lines and own generation capacity, which reduces power they need to purchase from third parties and allows them to sell power in wholesale markets. In addition to vertically integrated utilities, stand-alone transmission and distribution assets can be attractive as well. We pay attention to demographic and income characteristics of a region to ensure that utility bills represent a manageable percentage of earned income. Finally, we tend to avoid potentially distressed utilities with legacy operational and other problems since it can be difficult for new owners to distance themselves from mistakes of the past.

What kind of generation mix do you find in such integrated utilities?

There is obviously a wide variation across companies. One of our holdings generates around 40% of its electricity from natural gas, another 40% from nuclear power and the rest from purchased power and wholly owned renewables. The nuclear plant's license ends in 2044; furthermore, decommissioning costs are recoverable as long as the utility prefunds them on an annual basis.

What are the primary drivers of utility profitability? When we look at publicly traded utilities, the 75th and 25th percentile ROE is 11.3% and 6.4%, while the 75th and 25th percentile free cash flow margin is 24% and 17%. In other words, profits are more divergent than revenues.

Profitability is based on allowed ROE set by regulators, which management may try to exceed by controlling costs (i.e., actual ROE). Profit variability in public utilities is often driven by business mix as many are not pure-play regulated monopolies. While an unregulated business model might seem interesting, it has often led to underperforming assets and distress. One example: merchant power generation which was hurt by stagnant energy demand, the rise of renewables and the decline in natural gas prices. The key problem with the merchant business model: generator revenues generally do not cover all-in costs of energy supply, capital and variable costs[11]. Such costs can include existing and new regulations governing air emissions, coal ash disposal and cooling systems which renewable resources with zero variable cost do not contend with. Notable historical bankruptcies of merchant generators include Calpine, Dynegy, Mirant, NRG Energy and Texas Energy Future Holdings, and the competitive generation subsidiaries of AES, Edison International and PG&E Corp. These bankruptcies ended up destabilizing associated regulated utilities as well.

[10] "*Infrastructure institutional investor trends*", Probitas Partners, 2019

[11] "*The breakdown of the merchant generation business model*", Wilkinson, Barker and Knauer/PRG, 2017

Investments in pure-play monopolies where a majority of earnings are derived from remuneration structures and regulator-approved capital investment reduce uncertainty and result in more stable ROEs. In addition, investing into control positions in relatively high-margin utilities under investment grade capital structures provides relatively forecastable free cash flow for distributable yield.

When utility investments don't work out, what are the primary reasons?

We can think of three. First, unexpected and sudden regulatory/political changes could pressure the company to lower customer bills or prioritize other metrics (i.e. environmental goals), making allowable equity returns unsustainable. We generally prefer state and local jurisdictions with a long history of predictable policies regarding returns on capital invested. One example of a sudden regulatory change: after the Three Mile Island episode in 1979, regulators substantially changed rules and design requirements for previously approved nuclear power plants that ended up doubling, tripling and in some instances quadrupling costs.

Second, essential service utilities are responsible for providing critical services without interruption, keeping services affordable, maintaining safe operations, and operating in environmental compliance. A failure to deliver can result in loss of faith with customers, employees, the community, regulators and politicians. PG&E is probably the best example of a company that has through its merchant power and operations failures lost the support of many stakeholders, which complicates their ability to achieve a long term viable ROE.

Third, leverage can cause big problems for utilities. Most utilities are investment grade and businesses are managed to these levels carefully. Leverage can lead to business failures, particularly when allowable equity returns are reduced by the regulator. Allowable returns could decline due to the company benefitting from a decline in its own cost of capital, or when retrospective reassessments of prior contracts show the company's net cash flow outperformed initial expectations.

Contracted solar power

I have a number of questions on how independent solar power producers actually function within the grid. Let's start here. How are curtailment situations handled in countries they operate in? In other words, if they can produce solar power at a given moment but it's not drawn due to an excess of potential load over demand, do they suffer the opportunity cost loss of curtailment or are they paid for foregone generation?

Curtailment has not been a major issue for our solar company, although there are specific instances in countries like Chile and Japan when they experience intermittent curtailment. The big picture: a large portion of its generation is sold under tariff structures and/or take-or-pay power purchase agreements (PPAs), many of which have protection against curtailment. Spain's regulated return revenue structure is one example of this.

Similarly, as new solar assets are added to the grid, does the company end up having any priority or are all participants treated the same irrespective of when their plants were built?

Each market is different; our solar company typically invests in assets that have a large majority of cash flows contracted either through private PPAs, or benefiting from feed-in tariffs and other government-backed programs. Most independent power producers do not have explicit grid priority from a transmission dispatch standpoint, but the company's more seasoned assets usually benefit from higher feed-in tariffs. Having a global reach is critical, since from time to time, the latest PPA agreement and subsidy arrangements may no longer provide attractive returns to new investment. The ability to scan opportunities in North America, South America, Europe and Japan helps the company focus on the best investment opportunities available at the time.

Have your solar managers experienced declines in capacity factors over time? There are industry debates about the speed with which capacity factors decline as equipment ages.

Overall, the decline in capacity factors is minimal in solar when compared to wind. Active asset management is key to maintaining a high level of operational productivity across the portfolio. The company centralizes monitoring of performance across its global installed base in conjunction with on-the-ground operating teams that respond to issues as they arise. Additionally, the company engages in repowering and/or revamping efforts to benefit from declines in module pricing and any technological advances that occur.

Does the company build solar facilities from scratch or does it only buy existing completed ones?

The company predominantly operates existing "brownfield" projects, and also pursues completion of late-stage development projects where they already have an existing presence.

I know this can get complicated, but in a general sense, how much of its power is sold at a prefixed price per kWh vs spot market pricing reflective of demand conditions at that time?

The company generally enters into long-term contracts with investment grade counterparties, with the majority of operating assets remunerated under fixed-price government-backed revenue schemes (feed in tariffs). These contracts generally have minimal power price exposure. In some markets, remuneration can result in small merchant price exposure, but the company aims to minimize this exposure across its portfolio. Its weighted average contract life is around 22 years.

Bulk liquid storage facilities

I know you have also invested in Gulf Coast multi-modal bulk storage facilities for liquid fuels which are accessible by rail, truck, barge and deep water vessels. Like some of the solar power PPAs, I get the sense the storage facility cash flows are not highly sensitive to actual throughput volumes. Is that right?

That's right; around 70% of the company's revenues are derived from take-or-pay storage contracts, with contract rates indexed to inflation.

Do the company's storage tanks hold oil and other liquid fuels as well?

Part of the attraction here is the revenue mix by end product. The company actually does not store gasoline and also does not store a lot of oil derived products. Its facilities are mostly focused on storing industrial chemicals such as lubricants, caustic soda, acids used for chemical production, fertilizer and agriculture-related feedstocks, and some renewable fuels. As a result, we do not expect a material impact on the company from declining oil & gas demand resulting from electrification of transport or home heating.

Are the company's facilities primarily used for liquid fuels moving around the US from one place to another, or for import/export to other countries?

The primary customer profile is a large strategic player whose storage assets are fully integrated into their supply chain. In some cases, the company stores material as a last stop before shipment to domestic and international customers, and in other cases, it stores critical inputs for domestic manufacturing processes. Its facilities are a critical step in the supply chain for its customers, and the company tends to have high rates of contract renewal and customer integration (~85% renewal rate).

How long do these storage tanks last?

Physical useful lives are ~40 years, and existing ones can be refurbished and repositioned with minimal capital spending relative to replacement value. For certain product switches (i.e., mineral oils to agricultural oils), they would need full replacement.

[6] Timber: steady yields with potential upside in a world searching for real sequestration

Timber investing has been around for a long time; some of the first analyses of expected returns were derived by German forester Martin Faustmann in 1850. The tables below compare US timber returns to other US real assets, and show nominal and risk adjusted returns. US timber returns have been lower since the 2008 housing crisis caused a collapse in demand: the US has a surplus of Southern Pine that may take another decade to exhaust[12], even with today's tight housing markets. I'm not a fan of risk-adjusted returns applied to illiquid appraisal-based assets for the obvious reasons, and include them for those who put more stock in them than I do. US timber investing has been a pretty steady, modest-return addition to portfolios over the last 20 years[13].

The exhibits below show NCREIF index returns for real assets, which are not investable. These indexes track **unleveraged** property returns; in practice, most managed products investing in real assets hold some degree of leverage. One example: the NCREIF ODCE index tracks returns of commercial property funds which in aggregate use ~25% leverage, two thirds of which is at the property level.

Unleveraged real asset returns, 1991-2021

Asset class	Annualized return	Standard deviation	Sharpe ratio
Farmland	10.6%	5.8%	1.36
Industrial properties	9.9%	4.9%	1.49
Timberland	8.9%	6.8%	0.91
Apartment properties	8.7%	4.3%	1.43
Retail properties	7.5%	4.2%	1.16
Office properties	6.9%	5.3%	0.81

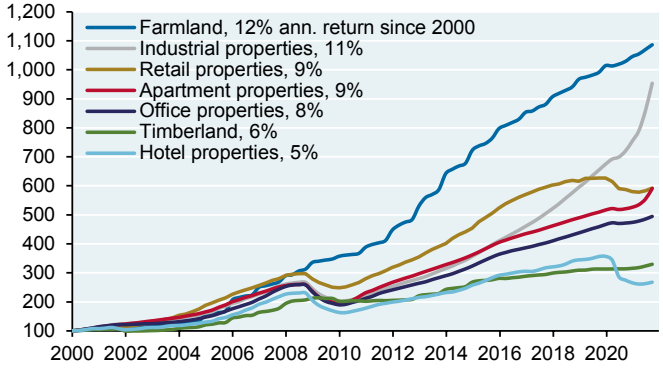
Source: Bloomberg, NCREIF, JPMAM. Q3 2021.

Unleveraged real asset returns, 2000-2021

Asset class	Annualized return	Standard deviation	Sharpe ratio
Farmland	11.6%	6.7%	1.55
Industrial properties	10.9%	5.1%	1.92
Retail properties	8.5%	4.6%	1.60
Apartment properties	8.5%	4.7%	1.55
Office properties	7.6%	4.9%	1.33
Timberland	5.6%	4.7%	0.95
Hotel properties	4.6%	7.0%	0.49

Source: Bloomberg, NCREIF, JPMAM. Q3 2021.

Unleveraged real asset returns since 2000
Total return index (100 = Q4 1999)



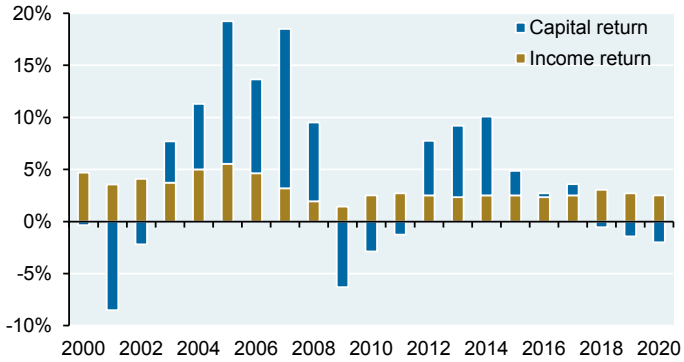
Source: Bloomberg, NCREIF, JPMAM. Q3 2021.

[12] **On Southern Pine**. Our timber managers believe that in the US Southeast, while sawlog prices could start rising in 2-4 years, it could take another 8-10 years for structural demand to fully restore the Southern Pine supply/demand balance and price trajectory that existed before 2008.

[13] An October 2018 article in the WSJ highlighted the losses incurred by a large US institutional investor selling its timber portfolio. The details are important to understand: its timber portfolio was purchased at peak valuations in 2008 right before the housing collapse impacted timber prices; the project was highly leveraged and some of the best timber was harvested early to pay down debt; the timber portfolio was undiversified (just Texas and Mississippi); and according to our forestry contacts, was subject to a lease with below-market price, quantity and escalation clauses.

Timber total returns can be variable from year to year. As shown in the chart, income from harvesting is steady. Capital return refers to changes in valuation and can vary, a reflection of monetary policy, changes in long term interest rates, housing policy and the value of potential land use changes. Over the last three decades, timber returns have exhibited higher positive correlations with inflation than other real assets. On tax treatment: in the US, income from timberland harvesting is treated as capital gains rather than as ordinary income.

Timberland performance: income vs capital return
%, year-end total return, NCREIF U.S. Timberland Property Index



Source: Hancock Natural Resource Group. December 2020.

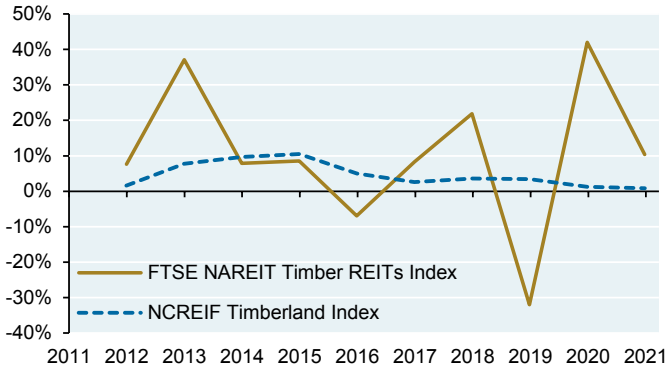
Returns vs inflation (1991 - Q3 2021, 5 yr ann)

Asset class	Correlation	R squared
Timberland	54%	30%
Apartment properties	31%	9%
Office properties	27%	7%
Retail properties	19%	4%
Farmland	13%	2%
Industrial properties	3%	0%

Source: Bloomberg, NCREIF, JPMAM. Q3 2021.

What about timber REITs? Investors in publicly traded REITs typically expect annual distributions irrespective of the economic or timber cycle. As a result, timber REITs tend to harvest timber every year whether lumber prices are high or low. In private timber vehicles, managers have the option to time harvesting more closely to the variations in log prices. For many institutional investors, private vehicles may make more sense since while REIT structures avoid double taxation, they still incur some level of corporate tax.

NCREIF Timberland vs Timber REITs
%, annual total return



Source: Bloomberg, NCREIF, JPMAM. 2021.

Timber REITS have different return profiles than the NCREIF timberland index:

- Timber REITs use leverage, NCREIF is unleveraged
- Timber REITs can own saw mills to convert saw logs into lumber & manufactured wood products; Weyerhauser usually earns almost as much from wood products as it does from timber harvesting, in some years 3x more
- Timber REITS like Rayonier own forests outside the US where returns can be higher; its New Zealand forest holdings and some non-forest interests represent 50% of net income; NCREIF Timber index is US forests only
- Timber REITs reflect recessions immediately, while NCREIF valuations rely on intermittent appraisals

Some timber investment risks[14]:

- Insects and diseases are unlikely to attack managed forests; mortality likelihood less than 0.2% per year
- Historically, fire losses have been < 1% per year on all US forestland, including public lands in California and other areas in the Western US. One example: in Oregon, the US Forest Service owns 60% of all forestland which has sustained 86% of all burned acreage over the last decade. However, very high winds created anomalous conditions in 2020 and resulted in high loss rates on private lands as well: of the 1 million acres that burned in Oregon, 40% were on industrial or private lands. Possible benefits of greater logging and clearing on private lands to reduce fire risks are inconclusive. After a fire, soil rehabilitation, clearing and planting seedlings can cost as much as $1,500 per acre on more mature forests
- Hurricanes and storms affect less than 0.2%-0.5% of US timberland per year

[14] "*Global timberland investment returns and prospects: 2020*", Fred Cubbage, North Carolina State University

Timber: non-US investments

The return data shown above reflects US timber investments only. Many timber portfolios have substantial international holdings as well, where returns can be higher. There's a lot of heterogeneity to global timber, and risks outside the US can be higher as well. A 2020 paper in "*Forest Policy and Economics*" included the table below on timber returns in 2020 by country and species. This analysis excludes land costs and reflects the IRR earned assuming pre-existing land ownership. The IRR differences primarily reflect variations in timber planting costs, forest management costs, timber prices for stumpage and timber growth rates. Including land costs can reduce the IRRs shown by 3%-8%; the main point of the table is to highlight the higher returns often obtainable outside the US.

Timber investment rates of return excluding land costs

Country	Species	IRR
Argentina	*Pinus taeda* - Misiones	7%
Argentina	*Eucalyptus grandis* - Corrientes 1	21%
Brazil	*Pinus taeda* sawtimber	12%
Brazil	*Eucalyptus urophylla* pulpwod, S.P.	9%
Chile	*Pinus radiata s* awtimber - good site	14%
Chile	*Pinus radiata* pulpwood - poor site	12%
Chile	*Eucalyptus globulus* pulpwood	15%
Chile	*Eucalyptus nitens* pulpwood	12%
China	*Eucalyptus*	29%
China	*Pinus massoniana*	8%
Colombia	*Eucalyptus grandis*	2%
Colombia	*Pinus patula* sawtimber	11%
Colombia	*Pinus patula* pulpwood	0%
Colombia	*Pinus tecunumanii*	14%
Ecuador	*Tectona grandis*	11%
Ecuador	*Eucalyptus globulus* (4 cutting cycles)	12%
Ecuador	*P. radiata / P. patula* - 80%/20%	7%
Finland	*Picea abies*	4%
Finland	*Pinus sylvestris*	4%
Laos	*Eucalyptus spp.* Industry	21%
Laos	*Eucalyptus spp.* Outgrower	32%
Laos	*Tectona grandis*	21%
Laos	*Tectona grandis*	16%
Mexico	*Pinus gregii*	12%
Mexico	*Eucalyptus grandis*	21%

Country	Species	IRR
New Zealand	*Pinus radiata,* no pruning	11%
Paraguay	*Eucalyptus sp.* clones	22%
Poland	*Quercus Sp.* State Forest	3%
Poland	*Quercus Sp.* Private	4%
Poland	*Pinus sylvestris* State Forest	1%
Poland	*Pinus sylvestris* Private	3%
Spain	*Populus*	10%
Spain	*Eucalyptus globulus*	11%
Spain	*Eucalyptus nitens*	10%
Spain	*Pinus radiata*	6%
Uruguay	*Eucalyptus smitthii*	15%
Uruguay	*Eucalyptus dunnii*	12%
Uruguay	*Eucalyptus grandis* pulp	14%
Uruguay	*Eucalyptus grandis* sawtimber - faster	12%
Uruguay	*Eucalyptus grandis* sawtimber - slower	4%
USA	*Pinus taeda* / Medium Yield & Intns NC	5%
USA	*Pinus taeda* / High Yield & Intensity NC	7%
USA	*Mixed Hardwoods,* Even Age, Planted, Clearcut	3%
USA	*Psuedotsuga menziesii* Site I	7%
USA	*Psuedotsuga menziesii* Site III	6%
Vietnam	*Acacia* Smallholder	26%
Vietnam	*Eucalyptus urophylla* High growth	22%

Source: *"Global Timber Investments Benchmarking Triennial Report, 2020"*, Cubbage et al. (NC State University)

A few comments on the table:

- Timber growth rates vary considerably, but in general Northern Hemisphere native temperate forests grow more slowly than exotic plantations in subtropical and equatorial Southern Hemisphere forests. Temperate exotic plantation growth rates and prices in Oceania, Chile, and South Africa fall between Northern Hemisphere and subtropical regions
- South American forests are generally comprised of pine from North America and eucalypt from Australia. These species are now in the second or third generation of genetic improvement and intensively managed on relatively good sites where they can grow almost all year long. As of 2017, average growth rates in Brazil were the highest in the world, at up to 40 cubic meters per hectare per year for pine and 50 cubic meters per year for eucalypt. These high growth rates and good forest management practices often require medium to above average forest establishment costs as well
- Timber investing in Asia can be difficult: land is scarce, rural infrastructure is poor, government institutions are weak, biological and political risks are higher and achieving good forest management can be challenging

What about cross laminated timber demand ("CLT")? Builders are examining the potential to use CLT mass timber as an alternative to steel and concrete. If this became commonplace, it could provide additional demand for Southern Pine and Douglas Fir and for Canadian softwoods as well. In 2019, the International Code Council approved proposals to allow tall wood buildings as part of the 2021 International Building Code. The code includes provisions for up to 18 stories of heavy timber construction for businesses and residences. Here are some pros and cons; to be clear, mass timber is still a negligible component of current demand.

CLT Pros: performs well in fire vs steel and concrete according to the US Forest Service, the International Code Council and the Fire Protection Research Foundation; reduces carbon emissions compared to traditional building methods; allows buildings to be constructed faster with lower labor costs and less waste; performs well in earthquakes; and can support better forest management on public lands.

CLT Cons: durability and structural concerns given the cracking and collapse of CLT subflooring panels used in a college of forestry building in Oregon. Subsequent investigation found that the root cause was a factory error related to binding agents used to glue individual boards together, and not a pervasive risk related to use of CLT itself. Water can also lead to warping, rotting and mold if not properly addressed.

Timber optionality, corporate carbon emissions commitments and carbon sequestration by trees. More than two thirds of companies and 80% of S&P 500 market cap have announced commitments to reduce or eliminate their carbon footprints, some committing to reverse emissions from prior years. If they're planning to accomplish this via direct air capture or carbon mineralization, they're facing a rude awakening: as explained in our 2021 energy piece, direct air capture energy requirements appear to be 6x-10x higher than traditional geologic carbon sequestration, a process which itself now only sequesters 0.1% of global emissions due to its high costs and complexity. If that's the case, many companies may find themselves eventually needing to invest in timber in order to deliver on their sequestration commitments.

Might it make sense at some point to own timberland in order to monetize carbon sequestered by the trees rather than to harvest them? This is a very forward-looking idea, particularly since nationwide markets for selling tree-sourced carbon sequestration do not exist yet in the US. The Western Climate Initiative market only includes California, Quebec and Nova Scotia, and the Regional Greenhouse Gas Initiative is limited to 11 Northeastern states; both combined only represented 12% of the global carbon market by value in 2020. But it is notable that in a variety of studies, the breakeven price per ton of carbon for timber owners (i.e., the indifference point between either selling carbon credits or harvesting the trees) was consistently less than $50 per ton. **In other words, should carbon markets emerge with prices per ton that are similar to levels now seen in Europe, timber owners might eventually have another route to monetizing their investment.**

Estimates of breakeven carbon price needed to offset revenues lost from foregone forest harvesting

Study location/authors	Year	Description	Breakeven price (per ton of CO_2)
British Columbia, Canada (Man et al.)	**2014**	At 30% of baseline harvest level, study analyzed three forest regions in British Columbia over a range of top heights at age 50 and timber net revenues.	$3.9-$40.8
Gabon, Africa (Ndjondo et al.)	**2014**	Assumes a median timber contribution margin (selling price less construction price) is $25 per m^3 for all commercial species.	$11-16
Nepal (Pandit et al.)	**2017**	Examines the feasibility of financial incentives for forest carbon sequestration in community forests within Nepalese watershed regions.	$2.4-$41.8
Washington, USA (Fischer et al.)	**2017**	Using regional average land-holding costs and assuming a no-harvest scenario, study uses probabilistic simulation to estimate carbon credit break point price.	$14
Legal Amazon region, Brazil (Silva et al.)	**2018**	Assumes average forest carbon density of 132 tons per hectare to estimate the price of reducing deforestation in terms of agricultural income foregone.	$16

Source: University of Nebraska, University of British Columbia, University of Washington, University of Western Australia, Research Institute for Tropical Ecology (Gabon), JPMAM. 2018.

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