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RESPONSIBLE INVESTING

Big data: seeing investments in an entirely new way

*How ESG data may help enhance long-term value
and manage downside risk*

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1Q19

Opening letter
from Amy O'Brien and
Mike Perry

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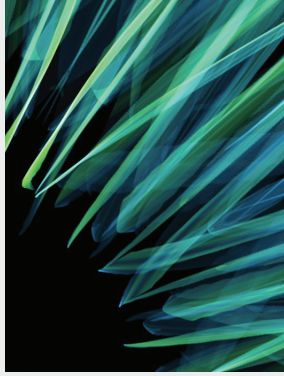
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Real estate:

Future value of assets may
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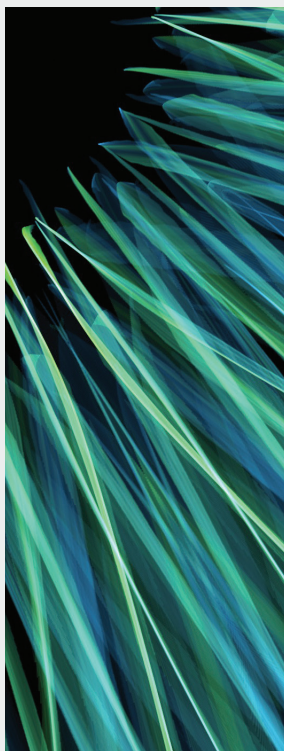
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Opening letter from **Amy O'Brien** and **Mike Perry**

By applying big data to big investments with an ESG lens, we can see potential advantages for both performance and risk management

For nearly five decades, we have been a leader in responsible investing, a discipline that incorporates the consideration of environmental, social and governance (“ESG”) factors into investment research, due diligence, portfolio construction and ongoing monitoring. We have believed that ESG information provides an additional lens to assess company and issuer performance, and we actively engage and influence companies and issuers in which we invest to make ESG issues a key consideration when running their businesses.

Now, as ESG data begins to mature and has a longer track record, we’re better able to see that our long-held premise is sound: ESG factors provide an additional lens to assess company and/or issuer performance that may enhance long-term value or help manage downside risk.

Big data is shining a brighter light on what has been previously viewed as ambiguous information. And data of every kind is allowing us to see and measure in all aspects of our lives — including how we make investment decisions. Our ability to curate vast amounts of ESG data is helping us see investment opportunities in an entirely new light.

In fact, we just launched Nuveen’s RI Data Platform — one of the first big data ESG technology platforms to enable better informed investment decisions that leverage our nearly 50 years of intellectual capital.

By leveraging the power of big data, our RI Data Platform processes a vast amount of structured and unstructured ESG data sources that can impact the performance of investment opportunities. In the following pages, our investment professionals share their views on big-data analysis and insights as they affect:

Public equities

As the old adage goes, “you cannot manage what you cannot measure.” Traditional valuation models like discounted cash flow can help assess financial risks, but they often fail to capture the complete picture. Intangible assets—which are impacted by financially material ESG risks and opportunities—now compose as much as 87% of the market value of the S&P 500.¹ Using alternative data sets such as material ESG factors allows us to detect otherwise underappreciated opportunities for increasing alpha, as well as underestimated risks.

Public fixed income

Big data is also revolutionizing how we assess opportunities in the municipal bond market by uncovering relevant ESG metrics that can help sharpen our view of risk. Two seemingly identical cities with the same credit quality may suddenly reveal stark differences when we apply our proprietary analysis using FBI crime data, EPA climate data, housing affordability data and more. Our sophisticated head-to-head comparisons draw on extensive data sources to identify ESG leaders who have the potential to deliver sustainable value relative to their competitor groups.

Real assets/private markets

When it comes to investing in real assets—farmland, timber, energy and infrastructure—sustainability is essential for assessing risk and preserving long-term value. Where does big data come in? As just one example, we engage technology and data analysis in our due diligence for land purchases. We combine data from satellite imagery to understand historical land use patterns, while matching it to government global positioning system data used to substantiate land claims. This is particularly important in regions where we must adhere to regulatory frameworks that promote zero deforestation and sustainable agriculture.

Real estate

Improving the sustainability performance of real estate may improve the attractiveness of the asset, helps keep service charges lower and reduces operational costs for occupiers. Energy efficiency is a critical factor, which is why we seek to reduce the energy intensity of our real estate equity portfolio by 30% by 2030. Big-data analysis techniques are assisting us with this effort by helping us measure energy efficiency across a broad range of properties. We also are able to see relative performance of assets when it comes to water usage and other factors.

¹ Ocean Tomo LLC, 2018

As investors, we are champions of the long-term perspective — and that perspective must include analysis of an entity’s ESG practices. Nuveen believes that our responsible investing principles may provide enduring benefits for our investors, our communities and the planet.



Amy O'Brien

Global Head of Responsible Investing



Mike Perry

Head of Global Product

Public equities: ESG information may give you an investment edge

Market prices often reflect changes in many ESG characteristics before the information is captured, assessed and reported by ESG data providers. By the time the data is reported, much of the benefit is priced in.

Adam Cao
Head of Quantitative & Index
Portfolio Management,
Global Equities



As the old adage goes, “you cannot manage what you cannot measure.” Traditional valuation models like discounted cash flow can help assess financial risks, but they sometimes fail to capture the complete picture. Intangible assets – which are impacted by financially material ESG risks and opportunities – now compose as much as 87% of the market value of the S&P 500.¹ Using alternative data sets such as material ESG factors allows us to detect otherwise underappreciated opportunities for increasing alpha, as well as underestimated risks.

There has been a proliferation of ESG data thanks to investor interest, disclosure frameworks and industry-specific standards. For example,

corporate reporting on ESG metrics has soared over the past several years. In 2017, 85% of companies in the S&P 500 published a sustainability report compared to under 20% in 2011 – a fourfold growth.²

In addition to company-reported metrics, specialized ESG research organizations utilize company disclosures, as well as their own research and analysis, to produce scores and ratings that assess ESG performance. With all this data, investors now have various methods for quantitatively incorporating this information into their investment process. **But a key question remains: How can investors find an edge with all this information?**

Our analysis and research show that there are three key ways to potentially gain an edge:

- 1** Capturing ESG characteristics before it’s reported by ESG data providers
- 2** Marrying quantitative and fundamental analysis can add value
- 3** Engaging with companies to influence ESG best practices

¹ Ocean Tomo LLC, 2018
² Governance & Accountability Institute, 2018

S&P 500® companies sustainability reporting

Governance & Accounting Institute Research Results

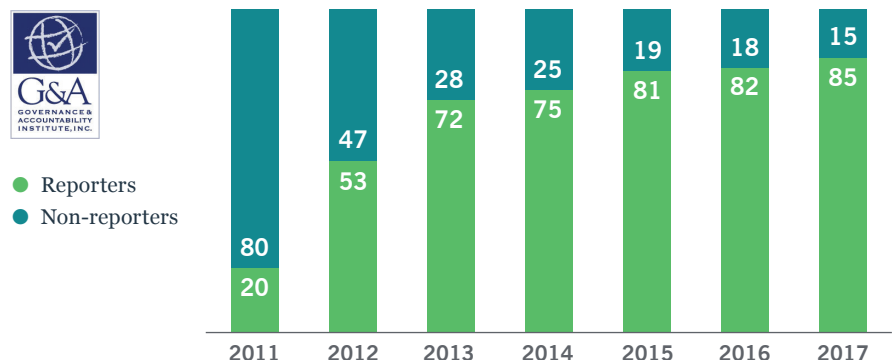


Chart does not represent the past performance of any Nuveen Fund. For fund performance visit nuveen.com.
Source: Governance & Accountability Institute, December 2017

Capturing ESG characteristics before it's reported by ESG data providers

Nuveen Quantitative Strategies, the quantitative investment affiliate of Nuveen, has done and continues to do research in ESG. Our research agrees with several external studies that highlight that changes in ESG characteristics, sometimes referred to as ESG “momentum,” is more promising from an investment perspective than the static ESG rating or score. Additionally, our research uncovered something interesting. We found that market prices were reflecting changes in many ESG characteristics before the information was captured, assessed and reported by the specialized ESG data providers. By the time the data was reported, much of the benefit was priced in.

Advances in technology, in particular the growth of Natural Language Processing (NLP), have put better tools in the hands of investors to take advantage of information faster. The most up-to-date information on most companies tends to be the news — this is true for information regarding financial data as well as information about ESG issues. While the news may not cover all issues, it is the most expedient source. NLP, a branch of artificial intelligence, allows machines to interpret human language and in this context allows investors to gain insight from hundreds if not thousands of news releases. Other areas where NLP can be applied include social media and government/regulatory filings. For quants, this is a fruitful area to explore as it speeds up the availability of information. For fundamental investors, this would make a powerful, complementary tool. Some specialized ESG data organizations have already made headway into this area.

Marrying quantitative and fundamental analysis can add value

Our analysis suggests that the best time to look at ESG is from “three to six months ago.” While this may be a limitation of quantitative models relying on these scores or ratings, this analysis offers insight on how fundamental analysis can add value. The “real-time” knowledge gained from fundamental analysis through continuous dialogue with these companies may add an investment edge before the data is collected and disseminated by ESG data providers by allowing analysts to uncover details that may otherwise be difficult to discern based on public disclosures.

Engaging with companies to influence ESG best practices

Finally, the most important implication of this analysis is the proactive work that managers can do to influence and advance ESG best practices at the companies they own. Certainly, there is much to be gained by staying abreast of a company’s ESG characteristics. However, engaging and driving positive change at companies provides a far superior position than merely tracking progress or reading headlines. If and when their efforts are successful in improving a company’s ESG performance, the analysis suggests that the effort will be rewarded by the market. Proactive engagement with those companies that need the most improvement may yield the most benefit since they will offer the most opportunity for change.

By the time the data was reported, much of the benefit was priced in

Information ratio (the ratio of average annual active return to average annual active risk) using factor portfolio analysis for changes in MSCI’s governance score. MSCI governance scores from 2007 – 2014. Predicting the improvement of governance six months ahead of time (green bar) would yield an IR of nearly 1.5 while looking at governance changes after the data is available (blue bar) would yield a mixed outcome.

Information ratio by investment horizon

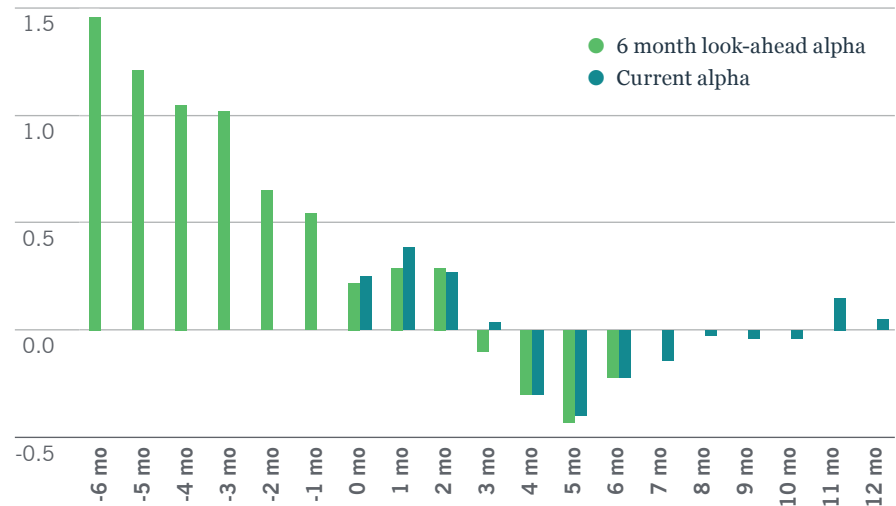


Chart does not represent the past performance of any Nuveen Fund. For fund performance visit nuveen.com. Source: MSCI, Nuveen, December 2018

Public fixed income: New-frontier in ESG analysis shines a new light on municipal bond valuations

Scrutinizing municipal bond issuers through an ESG lens may reveal relative value.

Tulsi Byrne

Fixed income, Responsible investing



Megan Fielding

Strategic partnerships, Responsible investing



Investors have long turned to municipal bonds as a strategy to help generate tax-exempt income and diversify their portfolios. While our industry-leading approach to fundamental credit research is central to our municipal investment process, at Nuveen we believe there is opportunity to introduce nontraditional data to help measure environmental and social outcomes of municipal issuers, which in turn can help reveal relative value that is perhaps unseen by traditional credit research.

Recognizing this potential, but identifying the gaps in the market for environmental, social and governance (ESG) data and disclosure in municipals, we leveraged diverse

data from sources such as the Environmental Protection Agency and Federal Bureau of Investigation to understand underlying ESG characteristics of muni issuers. Using unstructured data sets that are typically used in a nonfinancial context, we applied a proprietary methodology to pinpoint municipal issuers leading on ESG outcomes. The analysis uses sector-specific ESG factors that align with the objectives of the U.N. Sustainable Development Goals (SDGs), a global agenda that seeks to drive a more sustainable, equitable future. The chart below offers a glimpse of some of the material factors used to assess ESG-related outcomes for cities, hospitals, electric utilities and water/sewer issuers.

In the public power sector, for example, we score issuers on their overall management, reliability, affordability, energy conservation efforts and inclusion of renewable energy in their generation portfolio. For cities, we weigh data related to air quality, housing costs, access to transit and safety. For hospitals, quality of care, patient satisfaction and affordability of care are key ESG metrics used in our assessment. An illustrative example of how we weight ESG factors to develop an issuer score can be found below.

ESG performance factors are selected for each sector in support of the U.N. Sustainable Development Goals.

U.N. Sustainable Development Goal	3 GOOD HEALTH AND WELL-BEING	7 AFFORDABLE AND CLEAN ENERGY	6 CLEAN WATER AND SANITATION	8 DECENT WORK AND ECONOMIC GROWTH
Municipal sector	Hospitals	Electric utilities	Water/sewer	Cities
ESG performance factor	<ul style="list-style-type: none"> Quality of care Patient satisfaction Affordability of care 	<ul style="list-style-type: none"> Renewable energy capability & targets Affordability of rates Reliability of service 	<ul style="list-style-type: none"> Drinking water quality Water availability Age of infrastructure 	<ul style="list-style-type: none"> Air quality Housing costs Access to transit safety

Other municipal sectors that are researched and scored include higher education, school districts, counties and states.

	California City 1	California City 2
Credit rating <i>(Moody's/S&P/Fitch)</i>	Aa1/AA+/AA+	Aa2/AA/AA-
Population	1 MM	3.9 MM
Full market value	\$166.5 B	\$532.9 B
Per capita income <i>(as a % of the nation)</i>	126.9%	100.2%
Direct debt <i>(as a % of full market value)</i>	0.6%	0.5%
Overall debt <i>(as a % of full market value)</i>	2.4%	2.9%
General fund reserves <i>(as a % of revenue)</i>	34.7%	17.7%
Days cash on hand	122	86
ESG eligibility	Eligible Scored in the top 14% of cities	Ineligible Scored in the bottom 26% of cities
Considerations include:		
Air pollution	Better performance than 58% of cities of a similar size	Better performance than 1% of cities of a similar size
Housing costs	Better performance than 48% of all cities	Better performance than 6% of all cities
Violent crime rate	Better performance than 100% of cities of a similar size	Better performance than 45% of cities of a similar size

Source: Merritt Research Services, U.S. Census Bureau and Nuveen, as of 30 Jun 2018. Certain information was obtained from third-party sources we believe to be reliable, but is not guaranteed as to its accuracy or completeness. **Past performance is no guarantee of future results.**

Muni ESG methodology in action

We weigh and score sector-specific ESG factors for each municipal issuer to determine its overall ESG municipal score. This is how our proprietary methodology would be applied to hospital issuers.



Example sector: hospitals

ESG factor		ESG factor weighting		ESG municipal score
Quality of care		50%		Scores of 3 or higher are eligible for portfolio
Patient satisfaction	X	30%	=	
Affordability of care		20%		
				1 2 3 4 5

A tale of two (surprisingly different) cities

Integrating nontraditional data sources into the investment decision-making process helps us assess the ESG performance of municipal securities and allows us to apply an innovative lens with which to address relative value and to manage risk. Even though a selection of municipal issuers might have similar credit ratings, their ESG profiles could diverge significantly. Strong ESG performance and management practices can help with head-to-head comparisons and can be an indicator of future credit quality.

For example, two cities in California appear similar when assessed using standard valuations of credit metrics and ratings. And, due to exceptionally strong in-state demand for California municipal bonds, both munis are priced very aggressively compared to those from elsewhere in the United States. However, by harnessing a range of data in an ESG analysis, we may detect value that cannot be observed through standard analysis alone. This is demonstrated in the example to the left, in which the cities have similar credit ratings, debt and per capita income. However, higher ESG performance in air quality, housing affordability and crime rates make the security California City 1 stand apart.

Conclusion

We are only beginning to test how nontraditional datasets will transform our ability to see and measure the underlying factors that contribute to municipal bond issuers and other sub-asset classes in which Nuveen invests. We will continue to refine our methodology as new data sources emerge and existing data becomes more granular. This capability strengthens our ability to apply an additional lens to public fixed income — bringing new opportunities to light.

Real assets/private markets: Data-fueled insights may help drive farmland performance, address risk factors

With technology and data insights, farm managers may improve yields while ensuring long-term asset sustainability.

Justin (Biff) Ourso
Head of Real Assets



Nuveen is the largest manager of farmland assets globally, with nearly 2 million gross acres of farmland across the United States and Australia, and in parts of South America and Europe.¹ In managing these assets, we employ rigorous sustainability practices, both because it aligns with our corporate values and because long-term investment success in this sector demands sound and diligent stewardship.

Technology plays a major role in informing our farmland investment and management approach. From a global investment perspective, we conduct data analysis to understand how macro trends will impact and support financial performance. Our models take into consideration the rising world population, changing dietary patterns of expanding middle income classes in developing markets, as well as the reduction in arable land in the coming decades and how such factors will drive supply-demand balance for food and fiber. We also analyze data that relates to climate change, because its manifestations — from droughts and floods, to wildfires and deforestation — represent a threat to sustainable agricultural production and enduring investor value.

¹ Pensions & Investments, 16 Oct 2017. Rankings based on institutional tax-exempt assets under management as of 30 Jun 2017 reported by each responding asset manager.

Thanks to technological development and data analysis we can clearly see . . .



Critical details — Satellite imaging, combined with land history databases and expert analysis, give us a bird’s-eye as well as bottom-up view of a farmland asset.



Effects of time — Imagery and data analysis identify historical changes in land use, terrain and climate effects.



Compliance performance — Rigorous analysis ensures that we acquire and manage farmland in accordance with relevant regulatory frameworks that promote zero deforestation and sustainable agriculture.

Beyond this global view, data also plays a vital role in driving strategies to reduce risk and increase productivity within each of our farmland assets. Although a rigorous and consistent overarching due diligence framework exists, each farm is distinguished by its local attributes, which defies one-size-fits-all evaluation:

- **Crops differ by type and region:** Wine grapes require cultural care and harvesting techniques that are far different from that of tree nuts or apples. What’s more, there may be very different methods for cultivating and sustaining potato yields in the U.S. as compared to Poland.

- **Climate risks vary greatly:** California regions must address drought conditions, while regions with complex biomes such as natural forests or savannahs must forestall deforestation.
- **Land record availability varies:** Land purchases in developed markets often can rely on very long and detailed records of land usage and rights, while documentation in emerging markets can be much harder to find and authenticate.

This thoughtful analysis lays the groundwork for our diversification strategy across the regions and crops. This allows us to mitigate risk. The combination of rich datasets and deep local experience — provided by our Westchester subsidiary and local farmers — allows us to tailor our sustainability activities to each individual farm to address threats to productivity in the short term while helping to ensure long-term performance and value. Let’s look at two examples of this tailored approach in action.

California: Aerial image data drives greater water efficiency

In California’s Central Valley, nearly all of our tree nut operators have begun using aerial spectral imagery to optimize water and nitrogen use. High-resolution, multispectral images provide farmers with accurate, real-time information about the water and nutrient status of plants, and flag irrigation leaks and blockages for repair. Images captured throughout the growing season let farmers gauge their progress in addressing issues. When combined with soil moisture monitoring programs already in place, this data-intense imaging technology helps to derive optimal value from every drop of water in this drought-challenged part of the U.S.

Brazil: Integrated data analysis reduces risk

Before we purchase farmland in emerging markets such as Brazil, we carefully assess data from a range of sources to crystallize our understanding of each asset’s history and to reduce risk. At times, it’s hard to find documents that confirm land ownership in the past, so title searches and farmland licenses may not be sufficient. So, we use satellite images, some dating as far back as the 1950s, to understand the historical use of land, cultivation patterns, any transformation or development, the presence of indigenous populations, and environmental issues. We also review government GPS data — such as the Brazilian National Institute of Agrarian Reform electronic system — to substantiate ownership claims, indigenous territories and conservation

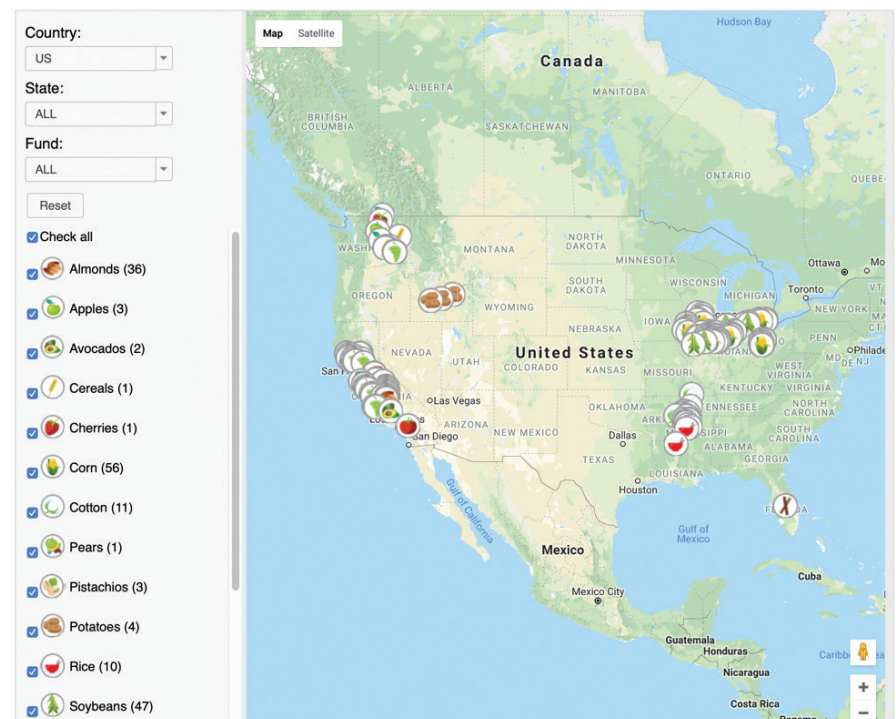
areas. Such rigor is essential to reduce deforestation risk, respect the rights of indigenous peoples, and preserve positive relationships with communities. Finally, not only do we conduct our own extensive analysis, but we also hire third-party experts to verify and confirm information from companies, farmers, tenants and lenders.

Data and technology can potentially increase alpha and manage risk for investors by strengthening our sustainability practices across our global farmland assets. Whether we are scrutinizing past uses of land we’re seeking to acquire, or comparing image data to optimize our resource use, we’ll continue to harness data and technology to help ensure productive and sustainable farms across our portfolio.

Transparency: Powered by technology

Each year, Nuveen publishes a farmland sustainability report that details our integrated approach to meet the U.N.-backed Principles for Responsible Investment (PRI) Farmland Guidelines as we manage our agricultural holdings.

nuveen.com/institutional/farmland-map



Real estate: Big data is the future of investment and asset management

Big data analysis is already a key tool in managing real estate assets — and things are only getting started.

Jack Sibley

Head of Innovation and Technology Strategies, Nuveen Real Estate



Abigail Dean

Head of Sustainability, Nuveen Real Estate



Real estate investors are well aware of the crucial role big-data analysis can play in measuring the operational performance of their holdings. A building manager's ability to monitor energy and water use relates directly to the asset's efficiency, attractiveness to tenants and, ultimately, market value. The potential ongoing cost savings are compelling: An owner could potentially reduce energy consumption by 10% to 20% with little or no capital expenditure, saving hundreds of thousands of dollars annually for large commercial or retail complexes.

The next phase of big data's application to real estate will be much more profound. We are at a point where technology and big data will move from monitoring to automated decision-making and active management.

HERE ARE JUST SOME OF THE RELEVANT TRENDS:

• **Smart buildings**

The digital and physical worlds will continue to converge as the Internet of Things (smart, inexpensive sensors) and the rollout of 5G (the next mobile data standard) allow people to interact with and manage the built environment more effectively.

• **Optimization and automation**

As more data is created at each building, owners can optimize how systems support the health, comfort and productivity of tenants while also enhancing efficiency. This also opens the door to buildings that self-manage, modifying environmental factors without the need for human intervention. Buildings will be able to self-manage and to provide optimal conditions for specific occupants (e.g., automatically adjusting temperatures in spaces when sensors detect that the space is occupied).

• **Virtual power plants**

As the world moves toward greater electrification of heating and transportation, rising demand may strain the electrical grid and drive peak prices higher. In response, asset owners are likely to leverage on-site renewable energy and battery storage — in essence, virtual power plants — to manage their supply dynamically and potentially generate significant revenue by selling energy back to the grid.

• **Smart cities**

Cities, local authorities and land registries are fast adopting open data initiatives, which allow third parties to access digitized public data. Datasets such as transit data, air quality, demographic information and more, as well as property-specific information about ownership and leases — are increasing available.

Impact on real estate investment

In addition to assisting in managing assets, big data will also transform the real estate investment process, as new large datasets can be leveraged to potentially generate alpha and better underwrite risk in real estate portfolios.

We envision that investors will place greater emphasis on understanding energy efficiency and climate change risks associated with real estate — harnessing insights to inform their due diligence process. This will be more important as the world transitions to the low-carbon economy and climate change begins to have a more significant direct impact on property value.

In addition to the data generated from Smart Buildings and Smart Cities, the development of FinTech and blockchain will ultimately create more transparency in real estate as an asset class in the longer term. Traditionally, real estate has had the characteristics of a typical private market: higher transaction costs, opaque data, illiquid and inaccessible to noninstitutional

investors. Through the digitization of asset ownership and lowering of transaction costs, FinTech and blockchain may give real estate more public market attributes, potentially creating publicly accessible and verified records of asset-level financials. If this evolution occurs, real estate will ultimately become better suited to advanced data analysis — including Artificial Intelligence — which will seek to fill the gap between insights and investment recommendations. Real estate quant trading strategies currently used in public markets may soon be a possibility. This would be truly disruptive to the investment characteristics of real estate as an asset class.

The data disruption

Underpinning all of these trends is the dramatic increase in the volume, variety, speed and accuracy of data at the fingertips of all real estate stakeholders, including investors. Those who are able to develop the right expertise to collect, analyze and extract insights from these datasets will be well positioned to create substantial real estate value in tomorrow’s world.

Big data is just one part of the wider technological transformation that real estate is facing. Many other industries have faced disruption and have successfully transitioned to become more dynamic, flexible and responsive. Now is the start of this transition for real estate.

**Goal:
30% by 2030**

Nuveen Real Estate seeks to reduce the energy intensity of its real estate equity portfolio by 30% by 2030, as measured against its 2015 baseline.

Energy is a critical factor in improving the sustainability performance of real estate, which keeps service charges lower, reduces operational costs and improves the overall attractiveness of the asset.

Our Tomorrow’s World approach

The real estate industry is well accustomed to cyclical change. But today there is also a more fundamental and structural threat of disruption. There are three main categories of disruptors that are most relevant in shaping the future of real estate: demographics, technology and sustainability. Our view is that this disruption also presents opportunities to create value, and that the key to harnessing such opportunities is to have a deep understanding of the character and scope of these disruptors. At Nuveen Real Estate, this approach is part of our Tomorrow’s World approach, a philosophy that sits at the core of our investment process and business operations, informing our long-term view of real estate investments for the enduring benefit of both clients and society.



With nearly **five decades** of responsible investing leadership, Nuveen has a history of investing by example — beginning when our clients asked us to engage on product and social issues in 1970. *Nuveen knows* is a regularly recurring thought-leadership series designed to connect investors with our best insights and ideas across the firm's core investment capabilities — **income investing, alternatives** and **responsible investing**.

nuveen.com/NuveenKnowsRI



Risks and other important considerations

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Investing involves risk; principal loss is possible. There is no guarantee an investment's objectives will be achieved. An investment which includes only holdings deemed consistent with applicable Environmental Social Governance (ESG) guidelines may result in available investments that are more limited than those that do not apply such guidelines. ESG criteria risk is the risk that because the criteria excludes securities of certain issuers for nonfinancial reasons, an investment may forgo some market opportunities available to those that don't use these criteria.

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