The Office Property and Big Data Puzzle: Putting the Pieces Together

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Executive Summary

Although the use of big data offers great potential, it also presents challenges. This white paper seeks to define big data and to identify some of the obstacles and opportunities associated with it in the context of managing office properties. It includes a general overview of the topic as well as examples of how property managers are collecting and analyzing data within their office properties.

Big data is defined as high-volume, high-variety and high-velocity information that is produced in either structured (e.g., predictable formats such as sensor data) or unstructured (e.g., pictures, text) formats. The sheer influx of big data can be overwhelming for many companies; they often choose to sit on the data they collect with no concrete plans to use it. Therefore, some firms, particularly those without the resources to sift through large amounts of data, risk missing valuable information that could improve their bottom line and position them favorably in an increasingly competitive market.

Although much of the big data now being collected by office landlords fails to trigger any privacy issues (e.g., building systems data), disclosure and permission are advised in some instances, such as cases where a landlord is monitoring tenant movements using Wi-Fi. Because of these complex issues surrounding personal data, landlords and tenants should approach data collection with a clear understanding of privacy laws and a great deal of transparency.

In regard to office properties, big data's usefulness can be categorized into two interrelated areas: 1) how big data improves a building's operational efficiencies; and 2) how landlords can use big data effectively to attract and retain tenants. To gain a deeper perspective on this topic, the author questioned seven office property management professionals – representing a real estate services company in Minneapolis and a development company in Dallas – to find out if and how they collect and analyze big data in their buildings. Specifically, were they using big data to improve operational efficiencies, attract tenants or both?

The author's conversations with property managers confirm literature and media accounts of how the large amounts of digital data generated within office buildings are used: primarily for analyzing building systems and improving operational efficiencies. The conversations indicate that there is interest in using Wi-Fi, beacons and sensors for: 1) tracking where people go and gather in buildings to improve the type and location of amenities in office buildings; 2) allowing tenants to more efficiently track and manage their own energy use; and 3) providing building navigation through smartphones. However, privacy issues and data management are obstacles that have hindered widespread collection of tenant data.

Several critical takeaways presented in this report deserve the attention of the real estate industry in general and the office sector in particular:

- Big data sets are more than just big. They are dynamic and multidimensional and can be challenging to work with, but they promise to give greater insight into some of the fundamental questions of real estate more than anything has before.
- The concept of big data is not solely about the data; it is also about the tools created to deal with the data. The collection, storage, analysis and visualization all present unique challenges that require innovative and ongoing solutions.
- Small data is still important. Real estate markets are local: to make big data meaningful, sometimes the data need to be selected and sorted to such an extent that they are anything but big.
- Office property managers are comfortable using nonpersonal big data to monitor and improve the performance of building systems but, in part because of privacy concerns, they have not yet embraced tracking tenant movements to improve the tenant experience.
- Landlords and tenants must approach data collection with a clear understanding of privacy laws and a great deal of transparency. Personal information should not be collected or, at the very least, records should be anonymized. Data should be released only in the aggregate, if possible, and systems should be put in place to ensure the security of the data.
- Big data is spurring new technologies and disciplines that affect the real estate industry. For example, blockchain technology will have an increasingly larger role in data management and property transactions. The need for job positions such as data scientists, data stewards and data visualizers will continue to grow as companies take stock of their data sets.

Introduction

Technology is changing real estate in remarkable ways as advances in computing power, coupled with the development of new data sources, have introduced a range of opportunities to the industry. Firms of all sizes are contending with the speed, depth and breadth of this change, and those with the resources to harness the new technologies are developing a distinct advantage over their competitors.

One of the more recent technological developments capturing industry attention is the concept of "big data." Media attention highlights this trend with Forbes defining big data as a "justifiable obsession" (Stuart, 2018) that will improve transparency and efficiency in real estate markets (Murphy, 2018). CIO asserts that "big data is disrupting the real estate industry" (Rands, 2017). The Financial Review states that there has been a "shift in mindset" as the "property sector is latching on to the power of big data" (Lenaghan, 2017). Furthermore, investors are using "science and big data to make more sustainable investments" (Scott, 2018).

Although the use of big data offers great potential, it also presents challenges. This white paper seeks to define big data and to identify some of the obstacles and opportunities associated with it within the context of office properties. For example, electronic data collection of tenants' movements through an office building may provide insights into how the building is used or could be improved, but it also triggers privacy concerns that may affect the tenant-landlord relationship.

To gain a broader perspective on this topic, the author questioned seven office property management professionals – representing a real estate services company in Minneapolis and a development company in Dallas – to find out if and how they collect and analyze big data in their buildings. Specifically, were they using big data to improve operational efficiencies, attract tenants or both? Their responses are included throughout this paper. See the appendix for the questions emailed to the property managers and selected responses.

It became clear from the author's conversations with the property managers that advanced data collection in office buildings is becoming a priority and is an area that will continue to grow in relevance, especially regarding improving buildings' operational efficiencies (e.g., energy use). A majority of the property managers stated that their industry is gradually using big data in new and inventive ways, either by building on current approaches or by using entirely new technologies. The property managers have been collecting building management data, but not widely using digital data analysis to attract and retain tenants. Collecting and synthesizing various forms of tenant data is an area of interest but is not yet commonplace.

This white paper is intended for real estate professionals who are beginning to consider how they can identify big data and assess the relative value of the information they collect, regardless of whether those data are big or small. It includes a general overview of the topic as well as examples of how real estate practitioners are applying data collecting technologies in their office properties.

Because understanding the core characteristics of big data is essential to harnessing its value, this paper begins by defining big data and explores some common misconceptions. It then provides a framework for understanding the potential of big data in the context of the office market, including examples of how the integration of big data into conventional models affects profitability and strategic planning, specifically focusing on operational efficiencies and tenant retention. A portion of the paper is devoted to the limitations of big data, including the challenges associated with data use. It concludes with other ways big data affects the commercial real estate industry, such as the advent of new industries and types of jobs focusing on data collection, aggregation, management and analysis.

Big Data – A Working Definition

Doug Laney, a data analyst at Meta Group (now Gartner), developed the framework for understanding big data. After several years in the information technology (IT) industry, Laney observed that the amount, speed and breadth of data generated in the post-Y2K world challenged even the most well-prepared firms. Much of this growth came from e-commerce as the internet expanded, as websites developed into commercial enterprises and the dial-up modem became obsolete.

Laney lent his observations to a now-famous 2001 memo, in which he described the characteristics of this new type of data as the "3-dimensional data challenge of increasing data volume, velocity and variety," a concept now widely known as the 3-V's of big data. These are extremely large data sets (volume) that stream constantly (velocity) in many forms (variety). A fourth V (veracity) was added soon after refining the dependability of data, which are often subject to numerous abnormalities (Laney, 2001).

In later work Laney elaborated on the definition, recognizing that the observable characteristics of data were only part of the big data equation. His additional analysis explores the links between the proliferation of data and the tools and analytics used to evaluate them – the "cost-effective, innovative forms of information processing" – resulting in a fifth V, the value added through "enhanced insight and decision-making" (Sicular, 2013). Each V is more fully described below.

> *"'Big data' is high-volume, -velocity and -variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making." (Sicular, 2013).*

Volume

With the equivalent of 250,000 Libraries of Congress generated each day (2.5 exabytes), big data's most easily identifiable characteristic is volume. By 2020 the world will have an estimated 44 zettabytes[1] of total data, nearly 10 times what existed in 2013 (Khoso, 2016). Google is thought to be the largest single data producer, processing as many as 3.5 billion requests each day with total data stores approximating 10 exabytes about five years ago. Facebook is a close second because every post, photo and "like" contributes to the accumulation of data. Retailers like Amazon.com and eBay, as well as brick-and-mortar stores with an online presence such as Target Corporation and Walmart, also collect copious amounts of data.

Velocity

In many respects, Laney's insight was most valuable because it recognized that size (volume) was the least of the problems experienced by his clients. The speed and consistency of data generation are equally, if not more, important. Velocity focuses on the constant flow of data, such as the millions of transactions that take place on the stock exchanges each day. In the case of real estate, data include property transactions and sales, searches and "hits" on websites such as LoopNet and the dynamic information collected from building systems. In most instances, these data are generated around the clock and come from multiple sources in multiple formats.

Variety

Big data is produced in one of two varieties, either structured or unstructured. Structured data are generally easier to collect and analyze. They are defined, easily searchable with common algorithms and follow a predictable format. Bank statements, building sensor data, clickstream data (clicking on a website) and point-of-sale data are all examples of structured data. Structured data can typically be entered into columns and rows in a conventional spreadsheet application.

Unstructured data follow no predictable format. Photos, videos and GIFs are all examples of unstructured data. Language in the form of textual data is also considered unstructured. Intuitively we know that these data are important because we use them. Aerial photos, maps and descriptions are used to position properties for sale or rent on websites such as LoopNet and officespace.com. Satellites, surveillance cameras and traffic and weather sensors all generate unstructured data that are important, directly and indirectly, to the office property market.

What is less intuitive are the methods used to analyze the contribution of this type of data to improve business intelligence. Unstructured data analytics is a nascent industry and, unlike structured data analytics, is not a mature technology. It is not surprising that commercial real estate professionals (as well as academics) – working in an industry that has historically focused on interpreting numeric financial data – have been slow to explore the value of unstructured data systematically.

Veracity

The veracity of data refers to the dependability, accuracy or quality of the data. Big data is subject to numerous abnormalities regardless of whether the data are human or machine generated. Common problems involve an error of structure in which a value is of an incorrect data type, the inclusion of irrelevant data, an error of join matching when two data sets are joined incorrectly and the identifiers are matched improperly, duplications and missing data (Winson-Geideman et al., 2018).

In the real estate industry, the dependability of data is of primary importance whether the data are conventional, novel, big or small. Improper coding, inconsistencies in data collection and selection bias all affect accuracy. In short, the volume, velocity and variety of big data magnify the likelihood of veracity issues.

Value

Value is, of course, the ultimate goal, but the question is not whether the data have value but rather how to get to that value. Identifying those components that enhance decision-making with value-producing effects can be challenging. Furthermore, acting on that information can be risky, resulting in unforeseen or unintended consequences.

Using the five V's framework, analysts can assess fairly readily if they are dealing with big data. If the data are large, constantly streaming, in different formats and subject to abnormalities, then the data are likely considered "big." However, what if they are not? What if your data are streaming in large volumes regularly but only in a structured format? Are they truly "big"? The answer to these questions is that it really does not matter. What does matter is that the data being used to advance decision-making are appropriate to the application and the needs of the firm. Real estate is a local industry, and small data sometimes tells us more about a market or a building than big data. Furthermore, as the volume of data decreases, relevance typically increases. In many cases, big data needs to be parsed, selected, sorted and reduced to a workable form before it is useful.

Issues With Big Data

The concept of big data is as much about technological adaptation as it is about the data; big data would lack relevance without corresponding advancements in the collection, storage, analysis and visualization (presentation) of the data. Data are collected each time a customer uses a loyalty card, uses a travel card on public transportation or logs on to a shopping mall or office building's Wi-Fi system. Every Google search, text message or satellite ping represents data collected by the agency or company that hosts the computing platform. This ability to collect information on the seemingly minute details of everyday life is being used to inform decision-making in business, government and society.

Although all of these data say something, depending on the needs of the firm and the issue being explored, not all of the data are valuable. Firms without data specialization experience the dual problems of, first, identifying and extracting the components pertinent to the firm's current objectives and, second, identifying the components that will be pertinent in the future. Rather than engaging an expert, they often choose to sit on the data they collect with no concrete plans to use it. Therefore, some firms, particularly those without the resources to sift through large amounts of data, risk missing valuable information that could improve their bottom line and position them favorably in an increasingly competitive market.

Developing a strategy to deal with the influx of data can be overwhelming. Each of the V's brings with it a host of interrelated problems that necessitate a proactive strategy to make the data useful. Storage and collection are primarily a chicken-and-egg issue, with the vast amount of data being collected matched only by the rapid development of storage options. Most companies collect as much data as they can store, although cloud-based storage options have alleviated some of these issues. As collection needs change, storage can be adapted fairly quickly (but at a cost) to meet new requirements.

Analyzing data is another issue altogether and is often exacerbated by staffing problems. Until recently, a clearly defined separation existed between IT- and computer-support personnel and real estate activities. Now firms look to hire professionals who possess the technical know-how as well as the industry expertise to work with, analyze, evaluate, interpret and extract the value inherent in big data. For smaller firms that lack the resources to hire a specialist in this area, many cloud-based services offer computational operations so that large data sets can be stored off-site and analyzed in the same location.

Reproducibility is a critical factor in generating usable information from data analytics. Processes and methods need to be meticulously documented (the data "provenance") to ensure that outcomes meet the objectives of the firm. Big data is often complex data, and a detailed data provenance helps analysts quickly identify issues to safeguard the seamless integration of building, operation and support systems.

Additional problems with big data relate to visualization and involve what data are selected, how they are visualized and in what context. The visualization of big data is subject to the same bias that affects any statistical representation of data. Data can be presented in many ways, manipulated to make a point or misinterpreted. Overreliance on visual representation can result in simplistic and even incorrect conclusions that are not supported by a detailed understanding of the data.

Furthermore, privacy and data protection cannot be overlooked. The recently enacted General Data Protection Regulation (GDPR) law dictates how firms must handle personally identifying data of European Union (EU) citizens. Companies anywhere in the world that have data on EU citizens must ensure the highest levels of privacy protection or face hefty fines. Under GDPR, companies must provide clearly written notice when collecting the personal data of EU customers. Customers must explicitly consent to have their data collected, and companies must state the exact purpose for which the data will be used.

Big Data in the Office Sector

Despite these issues, big data has the potential to be a major catalyst for evidence-based decision-making in the office sector. Big data's usefulness can be categorized into two interrelated areas: 1) how big data improves operational efficiencies; and 2) how to use big data effectively to attract and retain tenants.

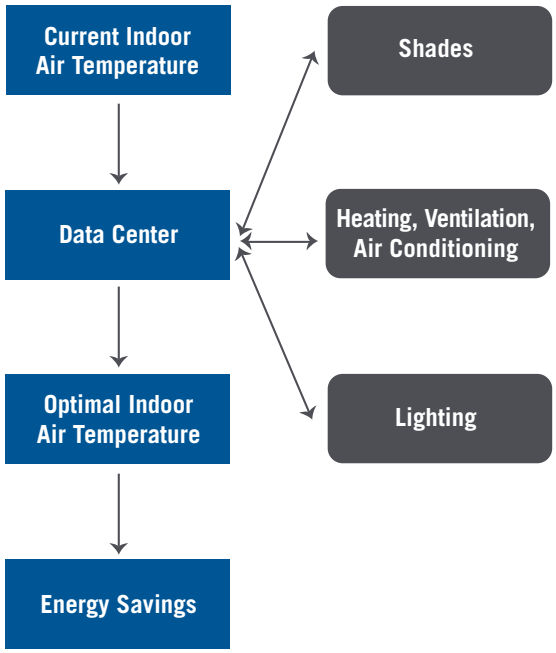
Operational Efficiencies

In many respects, the big data generated from the "internet of things" (IoT) provides the greatest potential (and disruption) to the office property sector. The IoT represents the merging of multiple technologies, all of which produce continuous streams of data that interact with each other over the internet. Wireless communications, GPS, smart buildings and machine learning are all part of the IoT. For example, sensors located throughout an office can assist in booking conference rooms, indicate which employees are using specific workspaces and for how long, and monitor energy consumption.

The growth in this area is extreme by any measure. By 2020, it is estimated that 30 billion IoT devices will exist worldwide. International Data Corporation[2] estimates that worldwide spending on IoT in 2016 was approximately $737 billion, a number expected to reach $1.29 trillion by 2020. Cross-industry IoT investments that are not industry specific (e.g., connected vehicles and smart buildings) will be among the top expenditures through 2020, and the industries with the fastest anticipated growth in IoT spending include insurance, consumer, health care and retail (IDC, 2017). Furthermore, the "use of IoT technologies to manage office spaces could have an economic impact of $70 billion to $150 billion per year in 2025" (McKinsey Global Institute, 2015).

All of this new information has produced a generation of smart buildings and smart systems that achieve functional efficiencies far greater than imagined possible a few years ago. New buildings like The Edge in Amsterdam use the data collected from computer technology embedded in lighting and ventilation to optimize total building performance and enhance the indoor working environment (Diehl, 2017). Existing buildings retrofitted with new technology realize similar benefits. The New York Times' offices, for example, implemented a system of sensors embedded in lighting and motorized window shades that operate under a single software structure used to monitor temperature and lighting needs. As a result, its 52-story, 1.5 million-square-foot headquarters in Manhattan achieved a 70 percent savings by reducing energy consumption from 1.28 watts of lighting power per square foot to 0.4 watts per square foot. AT&T achieved $8 million in energy consumption savings by installing similar systems in 240 buildings with an average size of 84,000 square feet (Barendrecht, 2017). Figure 1 illustrates the process of integrating multiple systems into a single software structure to optimize heating and cooling.

Figure 1: Flow of data to and from integrated systems



Source: Kimberly Winson-Geideman.

Furthermore, automated HVAC systems have the potential to reduce water consumption dramatically. Facility Executive cited a case in which a 220,000-square-foot office building saved 364,921 gallons of water per year by eliminating manual heating and cooling of individual offices, which is estimated to contribute 28-48 percent of a building's water consumption. A second study estimated a savings of 778,518 gallons of water per year for a 500,000-square-foot data center with 3,000 tons of cooling power (Dempster, 2017).

The data collected from these systems are analyzed in real time; because the data most often flow in a structured format (e.g., temperature, kilowatts), the analysis is relatively straightforward. This makes the predictability of building system data very reliable. Further, this technology has extended the smart building infrastructure to such a degree that buildings can now be part of a larger network that constitutes a smart campus or even a smart city.

Network-based security systems also offer some efficiencies to tenants. A building enabled with virtual credentialing technology via smartphones means employees no longer require keys or keycards to gain entrance, and visitors can be prescreened and granted admission with the use of an email barcode. The data shared between the smartphone, server and access reader are encrypted to improve security and access to each entry controlled remotely. If an employee resigns, his or her building access can be immediately terminated without having to collect keys and change locks.

Keycards and keys never need to be replaced, further reducing security costs (Dennis, 2018).

Although smart systems and network-based security are some of the most useful innovations in the office sector, they are only as good as a building's internet connectivity. Connectivity is, and will continue to be, one of the primary criteria of tech-savvy tenants, making it critical that owners and operators understand the demand for reliable and robust connections (Barendrecht, 2016). WiredScore,[3] a real estate tech startup in New York, addresses some of these issues. The company offers a commercial real estate rating system that certifies buildings' digital infrastructure, with the highest rating going to those with the greatest number of internet service providers, redundancy and resiliency of telecom infrastructure, ease of installation and capacity to readily support new telecom services.

Greater degrees of interconnectedness come at a cost, however, because buildings become more vulnerable to cyberattacks that disrupt or disable entire systems (O'Keefe, 2017). Hacking has evolved from the theft of personal data into cases where internal systems are held hostage for a ransom. Mecklenburg County in North Carolina recently fell victim to this type of scheme when a hacker did not steal, but rather froze access to, the county servers. The hacker shut down all email, printing and web applications; installed bitcoin mining software; and demanded a ransom of two bitcoins (approximately $23,000). Nearly all county services came to a complete halt, including the tax assessor's office (Stack, 2017).

Businesses and governments that fall prey to this type of activity often pay the ransom because it is cheaper and quicker than bringing in experts to resolve the problem internally. This choice of action makes risk management, particularly in regard to technology, a primary issue. The greater the reliance on the IoT to streamline operations and improve efficiencies, the greater the cybersecurity needs.

Attracting and Retaining Tenants

Attracting and retaining tenants is imperative to an investor's bottom line and, in the era of big data, involves a focus on *effectiveness* along with the efficiencies generated through the use of integrated HVAC and network-based security systems. Creating and maintaining spaces that enhance the tenant experience, improving productivity and developing a cohesive working environment are examples of the potential benefits big data can bring. Much of this potential is being sourced from our seemingly constant companion, the smartphone.

The proliferation of smartphones means that we now have more detailed

information on tenants, potential customers and clients than ever before. Big data tells us where people congregate, when they move through buildings, where they came from and in some cases why they were there. Retail is leading this charge as public Wi-Fi and other systems in shopping centers track shopper movements, capturing location information to target advertising and inform tenant placement.

It is important to understand the difference between tracking the number of people moving through a building and tracking their identities. The level of detail retailers collect depends on the degree of access granted by an individual. In many cases, systems preserve nearly complete anonymity because they track only the number of people. Limited (but not strictly anonymous) tracking occurs in shopping centers when individuals access public Wi-Fi by providing an email address or agreeing to terms and conditions that permit tracking and the collection of other information. In other cases, individuals grant permission for more detailed tracking by sharing personal information, by granting access to social media accounts or through the use of apps. Social Wi-Fi, which allows users to log on to the internet using their social media accounts, gives the retailer or landlord access to a virtual treasure trove of information including demographics, "likes" such as movie and book preferences and contact information such as email addresses and mobile phone numbers. When shoppers "opt in," the system can match this information with shoppers' location data and funnel personalized advertisements directly to them.

Beacon technology supported by smartphone apps is another way retailers track customers' movements, specifically their microlocation activities. When a shopper is in range, beacons trigger location-specific messages that can be granulized to the aisle the shopper is standing in. Retailers use these data to maximize sales by delivering personalized promotions that create individualized shopping experiences for customers. This approach encourages customers to stay longer and spend more money (Fung, 2017). Users can regulate what personal data are collected, either remaining anonymous or distinguishable, for example, by linking their membership in a loyalty program to the app. The location-based technology underlying Wi-Fi and beacons is more precise and dependable than the traditional GPS, which can be subject to interference and accuracy problems. A phone's GPS does not have to be on for either Wi-Fi or beacons to work, although it can improve accuracy in some instances.

The office sector can realize benefits similar to those seen in retail. From the moment a tenant uses an access card to enter a building, the system can track his or her movements to help understand how tenants use the building. Radio-frequency Identification (RFID) uses electromagnetic fields and Bluetooth technology to monitor the location of labeled items and personnel. Wi-Fi can track past and real-time presence as well as dwell time, and sensors embedded in carpet can record foot traffic (Mobley, 2014).

This information, combined with predictive modeling, can answer questions regarding the type of space needed, where it should be positioned, and when it is most likely to be used. Collaborative space, quiet areas and enclosed offices can be located in the most efficient and effective areas of the building relative to the needs of the tenant. Some examples cited as now being used by property managers are as follows:

- Smart bathrooms that track peak use to save on custodial costs. Sensors collect data on restroom visits and use that data to predict when the restrooms will need to be serviced. This analysis has allowed the property manager to redirect the day cleaning staff to clean and restock the bathroom only when required.[4]
- Smart ceilings, containing movement and heat sensors, provide real-time data on occupancy. The data allow property managers to provide space use and analytics to existing tenants, as well as digital building navigation. The system operates on an internet-based platform and aims to improve the tenant experience while helping operators run the buildings and individual spaces more efficiently.[5]

Although big data can play an essential role in improving the tenant experience, overreliance has risks that can negatively affect the personal connections at the core of the tenant-landlord relationship. Big data needs to be reduced to a useable form to be valuable, but it should be narrowed in a way that does not compromise individual privacy. Narrowing the data can sometimes reveal sensitive information that subjects the tenant or individuals to unnecessary exposure with long-term and far-reaching consequences. Data breaches are relatively commonplace, and the bigger the data, the greater the potential problem. Furthermore, the way firms use data can introduce a host of public relations troubles, particularly when they do so in less than transparent ways. Target Corporation faced a public backlash when it used buying histories to determine if female customers were pregnant so that it could target advertising accordingly. When these incidents gain traction on social media, they can cause damage to reputations that takes years to rectify.

Privacy

Although much of the big data collected by landlords fails to trigger any privacy issues (e.g., energy use data), disclosure and permission are advised in some instances, such as cases where a landlord is monitoring tenant movements using Wi-Fi. In other cases, disclosure may be mandated by the local jurisdiction, for example, by requiring signs indicating camera surveillance in parking garages. Because of these issues, landlords and tenants should approach data collection with a clear understanding of privacy laws and a great deal of transparency. These types of data are most informative when everyone participates, but tenants should be able to opt out of data collection if they prefer. Personal information should not be

collected or, at the very least, records should be anonymized. Furthermore, data should be released only in the aggregate, if possible, and systems put in place to ensure the security of the data.

As previously discussed, technology has evolved to such an extent that sensors, RFID and Wi-Fi can produce extremely detailed information about individuals and how they use buildings; however, the fact that the technology exists and the data can be collected does not necessarily mean it should be used. To this end, building owners and operators often hesitate to collect and use tenant data because doing so can be viewed as an intrusion on the tenant's privacy, triggering disputes or even legal problems. This concern leaves landlords and building owners in the somewhat precarious position of deciding what data to use and for what purposes.

The author's conversations with several property managers indicated that they have a strong desire to use data to know more about how tenants occupy buildings (e.g., the locations and times of day that tenants gather in buildings). They also want to use evidence-based information to help make decisions about improving and investing in common spaces, determining peak occupancy hours, analyzing parking use and determining the amount of foot traffic in and around a building. Although landlords are generally comfortable with collecting and using nonpersonalized data to improve operational efficiencies, privacy concerns, along with uncertainty about how to analyze data, have most likely delayed widespread application of tenant-tracking technology. A property manager commented, "The technology to enable data collection has advanced faster than the ethical, legal and moral requirements discussions."[6]

The general consensus among the property managers the author spoke with was that they are in the early stages of advanced data collection. Although they are aware of privacy issues, they agree it is an area that will grow as landlords begin to realize their competitive advantages in attracting and retaining tenants.

Other Considerations Related to Big Data

Although the most notable effects of big data now relate to operational efficiencies rather than tenant retention, big data and related technologies affect the commercial real estate industry in some other ways, with significant implications for the office sector. Despite being conceptually distinct, all of the following have evolved from the big data framework.

Creation of New Disciplines

Using big data means leaving the confines of the traditional Excel spreadsheet, where an analyst or appraiser could single-handedly process cash flows, and moving to the era of the data scientist, a specialist who can manage volumes of continually streaming data and evaluate their importance to an organization. Working with big data is not impossible, but it is different from working with the data conventionally used in commercial real estate. Firms lacking the specialization of a data scientist may find themselves losing ground in a highly competitive industry. Consulting groups with a real estate focus may fill the need for smaller real estate firms, whereas others may find it strategically advantageous to pay the $100,000-plus salary the specialization demands (Columbus, 2017). Other new types of positions that have grown around big data include data engineer (liaison between a company and the data scientist), data architect (database designer), data steward (manages and protects data) and data visualizer (explains outcomes to decision-makers in plain language).

Location and Acquisition Decisions Are Subject to More Detailed Analysis

Locating and acquiring sites for purchase or lease that meet long-term tenant needs can be aided by the incorporation of big data into advanced analytic programs that predict macroeconomic trends, demographic shifts, real estate prices and workforce accessibility. This information can be added to a risk-return model to guide corporate strategies and decision-making.

Health care is one example of an industry using this technology to predict demographic shifts that inform site selection and leasing decisions earlier and more cost-effectively. The industry follows cohorts to understand where their best patients are through an examination of health care use, health expenditures, insurance coverage and source of payment. Proprietary information and data from the Medical Expenditure Panel Survey[7] are integrated into Geographic Information System (GIS) software to identify trends for improved location decisions (Davidson, 2014). Although the availability of this type of data will likely increase, privacy concerns and government regulation will temper how much and what type can be used.

Data Collection and Aggregation Are Now an Industry

The collection and aggregation of real estate data have become an industry unto itself, with companies such as LoopNet, Real Capital Analytics and CoStar among the first to see the value in collecting, standardizing and automating commercial property data such as transaction prices, cap rates, concessions and operating expenses. These companies have progressed from simply collecting, aggregating and disseminating data to creating their own set of proprietary metrics that can be incorporated into strategic decision-making.

Real Capital Analytics (RCA), for example, launched its latest metric in 2017: the capital liquidity score, which is designed to estimate the depth and breadth of capital and liquidity in a given market. The score incorporates market volume, unique market activity, global cross-border capital, institutional and real estate investment trust (REIT) capital and the presence of top-ranked investors by zone and globally; it can be used in any market where those data are available. Of note is the vetting process used to ensure the relevancy and reproducibility of the metric. According to Leahy (2017), it compared favorably "with the ask-sale price spread in Central London – one market where there is sufficient data on the spread," thus validating the RCA approach to market liquidity. Data aggregators are now, arguably, an indispensable part of the commercial real estate industry.

Although most aggregators focus primarily on traditional sources of data, some smaller firms have developed specialized products using a combination of proprietary and public information with real estate implications. For example, Walk Score™[8] produces a series of metrics that measure walkability, public transit and bike access within neighborhoods. In a similar vein, Streetlight Data[9] provides transportation analytics including travel times, travel distributions and commercial and personal travel comparisons. Other data aggregators combine different data sources to create unique products targeting a specific segment of the industry. CrediFi,[10] for example, combines property, mapping and loan information with commercial mortgage-backed securities (CMBS) and financial data to provide detailed loan and asset information for commercial real estate lenders. These new aggregators exemplify the first wave of data marriages and nuanced analytics of the big data era.

Blockchain Will Change Recordkeeping

As big data and the associated technology proliferate, blockchain technology is expected to play an increasingly larger role in data management and storage for property transactions. A blockchain is a digitized, distributed ledger that permanently records and shares data in a hypersecure, unchangeable format. The information a blockchain contains is public and can be searched easily but requires multiple levels of permissions to access. Every computer on the specialized network continuously verifies the sanctity of the blockchain.

In real estate, blockchain has the potential to streamline transactions, eliminate the need for third parties such as escrow agents, increase the reliability of public records and reduce fraud. Specifically, it plays an increasing role in managing smart contracts, computer programs that take the place of traditional contracts and can be executed automatically without the need for intermediaries. For example, an office lease agreement can be entered into a ledger, with the parties agreeing that the contract will be executed at an exact time and date for a certain amount of money. The tenant then places his or her rental fees into a digital cryptocurrency wallet. If the office space is available and occupied by the renter at the agreed-upon time, the money is released automatically from the tenant's wallet to the owner's (Spielman, 2018).

Adopting blockchain technology on an industrywide basis will be a challenge, but some are already speculating on its potential. Two of the early market entrants include Ubiquity,[11] a "blockchain-secured platform for real estate recordkeeping," and Flip,[12] a peer-to-peer residential leasing marketplace that stores records in blockchain format (Ungerleider, 2016).

Conclusion

Conversations with property management professionals confirm literature and media accounts that property managers are using the digital data generated within office buildings primarily to analyze building systems and improve operational efficiencies. However, there is growing interest in using Wi-Fi, beacons and sensors to: 1) track where people go and gather in buildings in order to improve the type and location of amenities in the office building; 2) allow tenants to more efficiently track and manage their own energy use; and 3) provide building navigation through smartphones.

Data collection and analysis have increased operational efficiencies by saving money as well as environmental resources, but privacy issues and effective and efficient data management are obstacles that have hindered its widespread use. Although solutions exist for challenges that may surface relating to collection, storage, analysis and presentation of data, privacy and disclosure concerns may be more difficult to overcome since they are subject to changing laws and social pressures. Firms are rightly cautious when considering how they incorporate big data into decision-making, especially if it involves the use of personal information versus simply numbers of people flowing through spaces.

It remains to be seen how the innovations brought about by big data will change commercial real estate. However, for now, several critical takeaways presented in this paper deserve the attention of the real estate industry in general and the office sector in particular and lend themselves to further research:

- Big data sets are more than just big. They are dynamic and multidimensional and can be challenging to work with, but they promise to give greater insight into some of the fundamental questions of real estate more than anything has before.
- The concept of big data is not solely about the data; it is also about the tools created to deal with the data. The collection, storage, analysis and visualization all present unique challenges that require innovative and ongoing solutions.
- Small data is still important. Real estate markets are local: to make big data meaningful, sometimes the data need to be selected and sorted to such an extent that they are anything but big.
- Office property managers are comfortable with using nonpersonalized big data to monitor and improve the performance of building systems, but, due in part to privacy concerns, have not yet embraced tracking tenant movements to improve the tenant experience.
- Landlords and tenants must approach data collection with a clear understanding of privacy laws and a great deal of transparency. Personal information should not be collected or, at the very least, records should be anonymized. Data should be released only in the aggregate, if possible, and systems put in place to ensure the security of the data.

- Big data is spurring new technologies and disciplines that are affecting the real estate industry. For example, blockchain technology will have an increasingly larger role in data management and property transactions. The need for job positions such as data scientists, data stewards and data visualizers will continue to grow as companies take stock of their data sets.

Office buildings will most likely become equipped with more sophisticated technologies that will not only monitor energy use but also have broader applications that give landlords greater knowledge of how their building is (or is not) being used by tenants. Furthermore, the aggregation of complex data sets, driven by machine learning and predictive analytics, will affect real estate investment research. For example, how can complex and diverse data sets merge to evaluate investment decisions and improve the investment performance of an office building? Can big data help determine the ideal location of an office building, either now or several decades into the future?

As early adopting sectors, such as retail and social media, lead the charge on big data collection and privacy issues, property managers are learning the value, as well as the pitfalls, of collecting and analyzing diverse sets of data from their properties. Commercial real estate firms of all sizes can no longer expect to remain at the leading edge of their industry unless they begin to harness the potential of big data and its associated technologies. Integrating big data into an industry based on local information and personal relationships will be gradual, but companies that embrace the possibilities of big data will reap powerful advantages.

Appendix

In April 2018, the author contacted two groups of professionals responsible for property management. One team worked with a real estate development company and the other with a real estate services firm. The following questions were sent to determine if and how the companies were collecting and analyzing big data in their office properties. The author generated the questions after conducting a literature review and conversing with several real estate professionals. Included are some of the responses provided by members of the office property management teams. Comments have been edited for clarity.

1. In your opinion, how prevalent is advanced data collection and analysis within the commercial office sector?
    - » *Advanced data collection and analysis is becoming increasingly prevalent in today's commercial office sector. In an effort to cut costs and attract top talent, large and small companies are taking a more calculated approach when addressing their real estate needs. Conversely, more sophisticated landlords are placing a greater emphasis on harvesting large data sets. Landlords on the cutting edge of the industry are able to draw meaning from this data and better position their building to appeal to the needs of current and future tenants in the market.*
    - » *At this time, I believe advanced data collection is just beginning in the commercial office sector. However, it is coming very fast and will only continue to grow.*
    - » *I don't think advanced data collection is very prevalent outside of energy monitoring/tracking and operating expense information.*
2. As an office building operator, are you collecting data on people's movements through your buildings? If so, how, and how is the data used? If your company does not collect data from tenants, do you think it should? What type of tenant-tracking data would be useful to office building owners?
    - » *From a security perspective, movement data would include camera surveillance. We record such movements going back months in some cases, but do not save or analyze it. We would review this information only when needed to investigate various incidents. Card access can also be used for both incident investigation and movement during these times.*

» *We are currently tracking movement via access controls (security) on a very rudimentary basis. We have, however, implemented "smart" bathrooms that collect data on restroom visits and utilize that data to predict when the restrooms will need to be serviced. This has also allowed [us] to redirect the day cleaning staff from simply restocking to actually cleaning restrooms and only stocking consumables when required. In this one small instance of data collection, we have been able to reduce our restroom consumables waste (toilet paper, paper towels and soap) to zero, saving in the first year over $50,000 for the property.*

3. Concerning building operations, what systems (elevators, lighting, HVAC, etc.) are you tracking? How (e.g., remotely, platforms, etc.) and what has been the result?

» *We monitor the lighting in both interior (common areas) and exterior spaces through the building automation system (BAS-Niagara), along with the HVAC systems. We have the ability to monitor our energy usage also through the BAS (Electricity and Natural Gas), and we can also provide trend logs on everything on the BAS and have the ability to access the system remotely. Currently we have no way to monitor the elevators. The BAS is a useful tool when we need to retrieve data and for scheduling equipment run times, lighting, HVAC, etc. Our company is also utilizing on-demand HVAC. This allows a tenant to schedule when they need/don't need to have their space conditioned and enables tenants to save on their utility bills, while providing savings to the landlord from reduced wear on equipment. We are going to be using a third-party energy management platform to track our energy consumption. This platform will track against our historical usage as well as against similar size buildings. Using these platforms will help us reduce operating costs along with reducing our environmental impact.*

» *We are looking to begin tracking movement via [occupancy sensors] in ceilings. This will allow us to heat map our spaces and provide real time data to our building occupants about their space needs, enabling them to use their space more effectively. We are in the process of updating our elevators to destination dispatch, [i.e., grouping passengers going to the same destinations] which will track building occupants' location, (although we will not be collecting that data at this time). I have been working with Honeywell Building Solutions specifically on a Connected Building platform. One of the pieces we are very excited about is using data from lights [sensors inside light fixtures]. The data will allow us to provide space utilization information and analytics to our existing tenants, as well as wayfinding, workspace/conference hoteling/use information, HVAC and lighting efficiency gains, temperature data, etc. The system operates on an internet-based platform. We are also utilizing our Honeywell partners for "black box" data collection on all of our major HVAC and automation components to provide us with predictive maintenance rather than preventative and reactive maintenance.*

- » *The first [operational] area that has attracted attention relates to monitoring and improving energy performance. We began analyzing real-time energy data back in 2010. This effort allowed us to reduce energy consumption by over 10 percent each year. Of the 125 office properties we manage, energy data analysis is completed on about 25 percent of them. Over the years, the software that we are using is getting more sophisticated. We have begun to not only analyze the utility meter data, but also to connect to the building control systems, and analyze the HVAC equipment operation. This newer software identifies faults and diagnoses what is causing them. This drives additional energy savings.*

4. Collecting and using data (big or otherwise) can sometimes reveal sensitive information that subjects the tenant or individuals to unnecessary exposure with long and far-reaching consequences. Can you provide an example of how landlords are (or are not) dealing with disclosure and privacy issues? Are you purposely placing limits on the type of data you collect and how it is used? If so, for what reason(s)?
    - » *At this point, we are purely using the data for operational efficiency; we are not (yet) looking to the data for individual occupant information. More than anything else [our efforts are focused on] efficiency and energy savings.*
    - » *Currently we have not dealt with this issue. In the future, we probably will have to deal with it. For example, there are camera systems available that provide a count when people enter a particular space. We have not purchased any of these yet. Once we do, we will need to disclose the information to occupants.*
    - » *I think most people expect a certain amount of data collection via security cameras and access card readers in public places. I think they are comfortable with it if it's used for security purposes. It's when these systems are used in private areas (i.e., restrooms) or within tenant spaces that it would be considered far-reaching for a landlord. If the landlord was to sell the information collected via these systems that would be considered too far as well. I don't think the landlords are purposefully limiting the data collected but do not currently have a need for any further information.*
5. How do you envision data generated in office buildings will be used in the future? What are the long-term ramifications, in your opinion?
    - » *I think there will be further integration of all systems onto one platform. This will allow the individual building systems to talk to each other. By doing this, the building will run more efficiently.*

» *There is a lot of opportunity to get more real-time data on tenants and occupants. Technology can use cellphone Wi-Fi access to pinpoint locations and employee identification. Newer furniture has embedded sensors that can note when it is occupied and by whom. Generally this technology is expensive, and most companies have not figured out how to monetize the investment. Companies will need to balance the data collection with the privacy concerns of the populace. The technology to enable data collection has advanced faster than the ethical, legal and moral requirements and discussions. For example, Facebook is currently getting a lot of blowback for abusing its customers' privacy considerations. Long term, this will impact how people share data on the platform.*

» *I think tenants will continue to expect that a certain amount of data will be collected in common areas but they will absolutely have privacy expectations and anticipate limits on the type and amount of data collected. I think long-term ramifications include potential legal action unless the data collection is well disclosed by landlords upfront.*

Endnotes

1 One zettabyte is the equivalent of 44 trillion gigabytes.

2 A subsidiary of International Data Group, a global tech media company.

3 https://wiredscore.com/en, accessed on March 7, 2018.

4 Author's email conversation with a property manager, April 11, 2018.

5 Ibid.

6 Ibid.

7 U.S. Department of Health and Human Services.

8 https://www.walkscore.com, accessed on March 7, 2018.

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