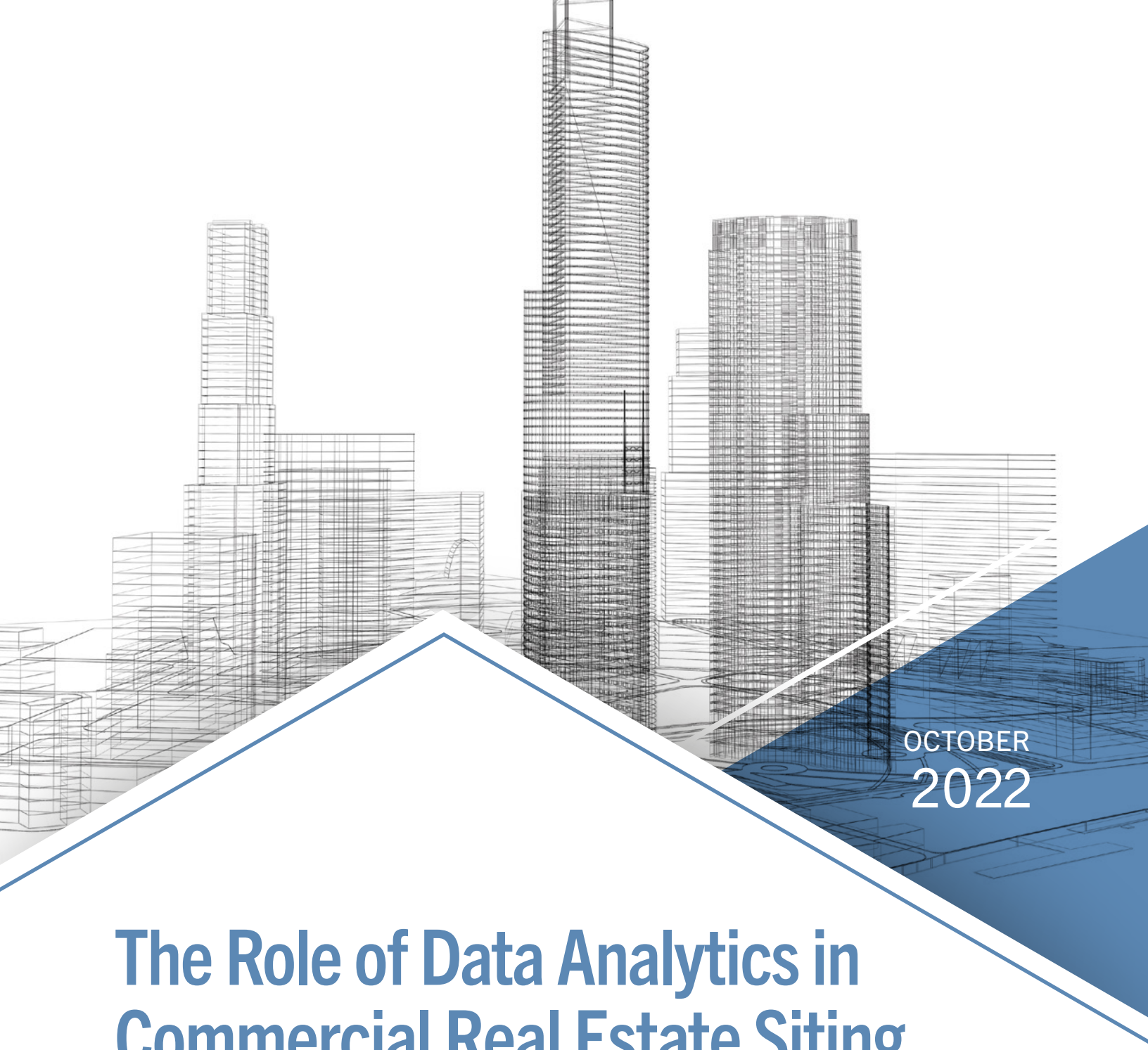

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The Role of Data Analytics in Commercial Real Estate Siting, Design and Valuation Decisions

By Clifford A. Lipscomb, PhD, MRICS

NAIOP RESEARCH FOUNDATION

About NAIOP

NAIOP, the Commercial Real Estate Development Association, is the leading organization for developers, owners and related professionals in office, industrial, retail and mixed-use real estate. NAIOP comprises some 20,000 members in North America. NAIOP advances responsible commercial real estate development and advocates for effective public policy. For more information, visit naiop.org.

The NAIOP Research Foundation was established in 2000 as a 501(c)(3) organization to support the work of individuals and organizations engaged in real estate development, investment and operations. The Foundation's core purpose is to provide information about how real properties, especially office, industrial and mixed-use properties, impact and benefit communities throughout North America. The initial funding for the Research Foundation was underwritten by NAIOP and its Founding Governors with an endowment established to support future research. For more information, visit naiop.org/foundation.

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Disclaimer

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Executive Summary

Industries are rapidly evolving as business processes grow more interconnected and automated. Data and analytics play an important role in information technologies and their interaction with the physical world, including emerging fields such as artificial intelligence, the Internet of Things (IoT), and virtual and augmented reality. Although commercial real estate (CRE) has been slower than other industries to adopt data analytics, some firms have identified several ways that data analytics can support land and building development and contribute to better project outcomes.

To gain a sense of how CRE firms are using advanced data analytics, the NAIOP Research Foundation commissioned this report to examine applications in site selection, design and valuation for commercial buildings. The author conducted secondary research and interviewed brokers, data providers, investors, developers and professionals at CRE technology firms.

Firms continue to rely primarily on traditional forms of market research when making investment and development decisions. Nonetheless, several commercial real estate technology companies have developed specialized software that draws from data analytics to support applications ranging from highest and best use analysis to real-time building rendering. These emerging applications suggest that data analytics has the potential to add substantial value to new development projects through improved siting decisions and building design. This report makes several findings of interest to the development community:

- Emerging applications for data analytics in commercial real estate development include examining parcels within a jurisdiction to identify land packaging or building development opportunities, advanced construction planning and project management, evaluating the rent premiums associated with different building amenities, and evaluating a building's suitability for conversion to a new use, among others.
- However, respondents indicate that data analytics are not yet being widely used to identify building locations or influence design characteristics for new or renovated buildings.
- Adoption of data analytics in commercial real estate has been slow due to the high costs associated with developing in-house capabilities and the currently limited range of applications for data analytics in the industry.
- Most commercial real estate firms currently outsource data-analytics tasks as the need arises. More companies will develop their own analytics capabilities as applications for data analytics expand.
- Advancements in artificial intelligence and further investments in structuring CRE data will expand the utility and potential applications for data analytics in siting and design.

Introduction

Previous NAIOP Research Foundation reports have examined how data and analytics are used across various asset classes. In **The Office Property and Big Data Puzzle: Putting the Pieces Together**, Kimberly Winson-Geideman looked at the operational efficiencies of building systems and privacy issues related to the use of big-data techniques in office properties. Steve Weikal and Robert Scott observed that increased adoption of data analytics is an emerging trend in e-commerce and logistics, and their connection to industrial building design, in **The Evolution of the Warehouse: Trends in Technology, Design, Development and Delivery**. Building off previous work, the focus of this report is the use of analytics in siting and design decisions made by commercial real estate firms.

Data analytics is being used by a variety of firms, including CRE services firms, brokers, investors, developers, architects, CRE technology firms, information technology (IT) firms and consultants. Uses include site selection, construction cost estimation, building lease-up and associated services, brokerage and more. The data include internally generated information from surveys (e.g., Cushman & Wakefield vacancy-rate surveys conducted across various CRE markets). These data are consumed primarily by investors, brokers and consultants for purposes such as investment underwriting, building lease-up, portfolio optimization, correlation of vacancy rates to other economic indicators and CRE space demand forecasting.

Data analytics tools include regression analysis, artificial intelligence, machine learning and other big data workflow techniques. These frequently include data gathering, management, preparation, exploration and cleaning, which ultimately produces data analysis.[1] These can be applied to non-traditional data elements such as foot traffic, cellular phone movements, walkability scores, online reviews and school ratings.

Data analytics can be defined as the processes that turn raw data into actionable intelligence. Often these processes analyze large volumes of data from various sources, with different levels of velocity and different geographic scales. Software such as R, SAS, Python, and PowerBI can leverage repeatable workflows to automate the process as the underlying data become more complex. Traditional real estate data are limited in scope. Because of that, they have less sophisticated IT architecture and software needs for conducting a proper analysis compared to big data, which have greater volume, velocity and variety compared to traditional real estate data.[2]

It is helpful to note that the respondents in this report agreed about the distinction between "data analytics" (more quantitative data analysis with well-known data lags) and "market intelligence" (more qualitative data focused on the present). Often newer quantitative methods are combined with practitioners' experience and knowledge, in-person observations and real-time reports.

The ways that developers and other commercial real estate firms approach data analytics should be shaped by whether they are focused on short-term exits or long-term value creation. The a priori expectation is that valuation could be the "end" for some companies and a "means to an end" (e.g., one analytical output that influences the siting and design decisions) for other industry participants. The expectation is that data analytics will have a positive impact on siting, valuation and design decisions. Secondarily, siting and design will ideally have a positive impact on valuation.

Glossary of Terms

Data lake: centralized repository that permits storage of structured and unstructured data at any scale.

API (application programming interface): a type of software connection between computers or between computer programs.

Hashes: fixed-size outputs of enciphered texts that are produced by algorithms.

Pointers: code that identifies the location of the stored data.

Methodology

This qualitative study explores how commercial real estate firms view the role of data analytics in siting (i.e., identifying building locations) and design decisions, as well as the role of valuation in those siting and design decisions.

It combines primary research (interviews) and secondary research (literature review). A 10-question instrument, designed by the author with input from two industry executives, was used to guide each interview. Semi-structured interviews were conducted with industry-related practitioners from October 2021 to April 2022. Based on NAIOP's industry focus, most respondents work primarily with office and industrial asset classes.

In the next section, findings from the interviews are summarized and provide insight on the current state of data analytics usage in CRE. Next, emerging applications of data analytics in CRE are discussed. Finally, the report concludes with a discussion of what CRE professionals can expect to see with respect to data analytics in the future. Appendix A contains images of a zoning analytics interface, Appendix B contains a list of respondents and their respective firms, and Appendix C contains the interview instrument.

The State of Data Analytics in CRE: Findings from Interviews

Data Analytics in CRE Business Models

Data from semi-structured interviews with CRE practitioners suggest several ways that analytics can be used inside a business model. First, data analytics can be treated as a separate business line (or silo) that has its own financial (i.e., profit and loss) responsibilities. Second, data analytics can be used by other business units to enhance their bottom lines. Almost all respondents interviewed for this report collect and analyze data for different business purposes, but very few use it in a systematic way or create analytics from it to make business decisions or to resell to other customers.

Interview data also suggest that very few firms have specific teams dedicated to data analytics. Of the respondent firms that have internal data-analytics teams, only one said their firm has an innovation and insights team that builds internally facing analytics tools, specifically to inform the site-selection process (e.g., acquisitions and development deals). This firm, which is focused on industrial real estate, incorporates many data layers into its site-selection process. These layers include population and labor employment data from the U.S. Census Bureau and Bureau of Labor Statistics to gauge an area's growth potential. Different data are weighted differently in the creation of indices, which also vary across geographies.[3]

Another respondent said their firm has a very small, two-person data-analytics team that works across all business verticals, including property management, tenant representation, an arm that serves as a registered investment advisor (RIA) and an investment group.[4] This firm's data lake includes internal data captured from buildings and tenants (e.g., scraping unstructured data from tenant leases) as well as external data sources (e.g., mobility data, Moody's REIS data). Their evolving data-analytics efforts are not currently being used to algorithmically determine siting or design decisions, but the intent is to move in this direction.

One respondent working in the pre-design space focuses on analytical tools that are useful in their factory-based prefabrication processes as well as in their offerings to clients. Using off-the-shelf technology like TestFit (which uses algorithms that allow developers, architects and general contractors to produce multiple iterations instantly on building unit mix, road layout, parking configurations, etc.), this firm can provide clients with multiple design options in a single package based on zoning codes, the permitting process (and possible variances) and financial pro formas. Zoning codes dictate the process, followed by setback requirements and maximum allowable building height. While this limits developers' choices a bit, this firm said a lot of flexibility remains in space allocation after zoning is considered. Then, using TestFit, multiple iterations of renderings can be produced using different financial assumptions, resulting in an estimated cost of construction.

Gradual Adoption of Data Analytics

Generally, with some exceptions, CRE firms are slowly adopting data-analytics techniques to mine their own data for insights, a practice common in other industries such as finance and electric utilities (e.g., Georgia Power Company). These data often are not captured, labeled or standardized across business units/silos. Interestingly, several interviews confirmed that some firms do not have standardized policies in place that foster cross-unit discussions. One respondent said the use of artificial intelligence (AI) in commercial real estate[5] is in its infancy, but they expect firms to continue to adopt analytics, especially as transportation logistics becomes increasingly digitized. A different respondent, who works for an industrial developer, estimated that 90% of competitors are "doing something" related to the use of data analytics, but only 30% of competitors are "working diligently" on their data-analytics efforts.

Firms are beginning to mine their own qualitative data for insights, but this is not being done uniformly across the industry.

Firms diligently incorporating data analytics into their business generally have three ways to achieve this—hire data scientists directly, outsource data analytics to a third-party firm, or grow them through a merger-and-acquisition (M&A) process. If hiring internally, firms often start with a few key hires. The cost of this kind of talent is a concern for respondents; one at a brokerage firm said data scientists "are expensive to hire." This can make a CRE developer's desire to outsource the data-analytics efforts (e.g., estimating correlations between traffic count and foot traffic, which have different implications for tenant-occupied real estate) to third-party consultants more financially palatable until more of a business case can be made to bring that function in-house. If these data-analytics efforts are brought in-house, respondents generally believe that full-time data-science positions in commercial real estate will increase over time. Third, a firm can grow its data-analytics capabilities through the M&A process. One respondent said their CRE services firm recently acquired a cloud-

based platform that leverages machine learning and granular local demographic and economic datasets to facilitate the building of client-facing predictive models and analytical tools used in modeling and forecasting. This concurs with general sentiment that while data science in CRE is currently both inward-focused and operational in nature (i.e., analyzing firm data via applications like Tableau and PowerBI to improve operational performance), respondents generally believe the focus will shift over time to be more outward-facing and predictive in nature, moving toward predictive-analytical tools that influence investment decisions and capital management.

Firms are beginning to mine their own qualitative data for insights, but this is not being done uniformly across the industry. Two examples from respondents are quite nuanced. First, when deciding between a warehouse with 36-foot or 40-foot clearance, one developer needs to know if tenants are willing to pay more for a 40-foot ceiling, all else being equal. This requires the collection of additional data and the performance of additional analyses, some of which utilize regression analysis, on market rents vs. the cost to build the extra height as well as the additional operational efficiencies that can be realized with the extra four feet of ceiling height. The goal is to maximize yield, not rent. Another respondent in the full-service brokerage space said that the construction costs and achievable rents for industrial properties specifically are determined by the ever-evolving amenity packages desired by tenants. Current amenities in high demand, in addition to higher ceilings, include open lighting, higher-grade common areas, locker rooms and nearby daytime retail. A range of options to apply data analytics exists, from simple paired sales analyses to sophisticated regression analyses, to isolate the marginal impact of adding a particular amenity to a building.

Current Uses and Constraints

As data grow in frequency and variety, relatively simple applications such as Microsoft Excel have limits on the amount of data that can be stored and analyzed. One respondent, who works for an industrial developer, estimated that the larger commercial developers and CRE services firms have at least one employee proficient in a programming language like R or Python who can analyze these more voluminous and complex data sets. Yet this kind of talent is expensive to hire and often difficult to find, as typically these workers transition from the finance industry and lack real estate experience. They said that while data-analytics efforts are expanding from operations to investment-related tasks, data analytics is the most mature in property management. They added that the current state of data analytics is focused on "summarization" and, as the correct data-analytics talent is hired internally, analyses will become more predictive in nature.

... while data-analytics efforts are expanding from operations to investment-related tasks, data analytics is the most mature in property management.

Data analytics are currently used more often in siting decisions than in design decisions. For example, Prologis uses an algorithm to site different types of buildings to maximize the efficiency of a distribution network. Prologis' supply-chain modeling starts with proximity to consumer households. The model uses drive times rather than distance, when available, to capture transportation infrastructure and congestion in the area. Business rules based on aggregate income reach within a certain drive-time radius in the metropolitan area, as well as indices that focus on relative positioning in a market, are used as filters to arrive at locations best suited for last touch, city, multimarket, and gateway facilities.[6]

In comparison, one respondent said their firm is more opportunistic in that it will purchase a portfolio of up to 20 buildings and pursue an equity recapture strategy instead of trying to make their current distribution network more efficient. Instead of a long-term hold position of a company like Prologis, this firm will create warehouse portfolios that will sell at a premium compared to selling each property individually. In fact, this firm follows a "portfolio by design" mentality, where the design of the portfolio is done with the

express purpose of assembling a group of properties that will appeal to a specific buyer, like Blackstone. As it relates to data analytics, this respondent uses more traditional metrics such as net operating income, internal rate of return (IRR) and profit/loss to decide whether to purchase a warehouse portfolio or not.

Gensler provided an instance where data were used to assist clients with design decisions.[7] In Spring 2020, the company created an algorithm using data on 3.2 million square feet of office space across more than 30 buildings in Calgary, Alberta, that utilized different features of existing office buildings. These included things such as site context (walkability, transit, natural light, viewshed and windows), building form (building shape and ease of planning out living units), floor plate (window-to-core distance, floor-to-floor height and number of existing elevators), building envelope (existing window-to-wall ratio and ease of window replacement) and servicing (e.g., loading and parking considerations). Then, Gensler weighted these features by how much each one influences the financial pro forma. Next, each office building was scored according to its potential to be converted into a multifamily building that would meet the local market needs. Weighted features were indexed to a maximum score of 100, where a score of 100 indicated 100% compatibility with that building becoming an office-to-multifamily conversion. Additional testing of floor plates against pro formas indicated that a score of 82 was the cutoff for a conversion project to be commercially and financially viable. So, while multifamily is not a focus of this study, this example shows how data analytics are being used to identify "adaptive reuse" opportunities where certain underperforming office assets are appropriate for redesign and eventual conversion to multifamily. Echoed by another respondent, adaptive reuse is popular because of the financial returns generated compared to existing uses.

Another respondent in the industrial space provided an example of a San Jose, California, firm that can literally move interior walls as needed to adjust space needs for meetings as well as to optimize HVAC system usage. Algorithms similar to those in the Gensler example can be used to adjust rooms in real time to accommodate different meeting space needs.

One respondent noted that data related to environmental, social and governance (ESG) initiatives are a current priority at their firm. The focus is currently more on the "E" in ESG. Whereas so-called "green premiums" were the focus for a while (e.g., which environmentally related building amenities commanded a rent or sales price premium, like LEED status), the focus today is environmental data related to flooding, wildfire risk, weather variability and other factors to assess climate risk. Another interesting change mentioned by this respondent is that the walkability of the neighborhood around a building was important for a while. Now, parking spaces are more important due to ride-sharing cars needing a place to park when they are not in use. Similarly, in the future, personal autonomous vehicles will need places to rest when not in use.

Data Analytics vs. "Market Intelligence"

One comment that cropped up in all but one interview is that market participants draw a clear distinction between "data analytics" (more quantitative data analysis with well-known data lags) and "market intelligence" (more qualitative data focused on the present).

Generally, respondents said that data-analytics efforts have focused on the traditional real estate variables (e.g., lease terms, capitalization rates, demographic trends, building performance data, waste management systems and walkability). Using these variables, relatively simple analyses are common in commercial real estate, such as the use of algorithms to determine rents (dynamic or variable pricing of self-storage units or other rents requires a more sophisticated algorithm and constantly refreshed pricing data). A few respondents noted that the type of data collected and used to determine correlations with other variables, as well as the sophistication of modeling efforts, has changed.

One respondent shared a story of how they use data analytics to gain informational advantages over their competitors. This firm uses data analytics to identify the broad market (e.g., Greater Houston) in which to invest. However, "boots-on-the-ground" market intelligence provided by local real estate brokers

was used to identify the specific site to target for acquisition. Interestingly, this same respondent said that brokerage firms will often provide this type of research (if it's not already being done in-house) at no charge, knowing they will likely get the leasing assignment work from the industrial developers and investors that use the data. According to this respondent, market intelligence involves intuition. They added that the proptech industry had slow adoption because algorithms failed to capture the intuition of developers and brokers, which in this respondent's mind can never be replaced.

One respondent from a full-service brokerage firm said that the use of data analytics allows their firm to maintain some level of separation from complete reliance on traditional market fundamentals. This brokerage firm couples the more "clinical" data-analytics approach with the more "qualitative" market-intelligence approach (e.g., logistical issues, competitive environment) to solve client problems. The key is that each approach provides unique data points beyond traditional market fundamentals. Another respondent echoed this sentiment, saying that "the role of the gut is hard to include in a model" related to the example of how a computer model likely could not justify the conversion of an old office building into a mixed-use property. While some companies are using data analytics in highest and best-use determinations (e.g., CityBldr) and to shorten the site due-diligence process (e.g., Deepblocks), the interview results were mixed overall. Some respondents use data analytics and then market intelligence (e.g., determining where to build a new warehouse facility) to make an investment decision, while others use market intelligence before data analytics (e.g., buying a CRE portfolio off-market). Respondents, particularly those who use market intelligence before data analytics, seem to do so because market intelligence is provided by in-house employees, while data analytics are outsourced functions.

The Role of Valuation

Interviews suggest that company strategy determines whether valuation is the "end" or the "means to the end," or whether a feedback loop exists between valuation and other aspects of siting and design decisions. One respondent, a CRE developer, said their firm uses valuation only when deciding whether

... analytics related to possible amenity premiums can help identify a price floor in the event of a liquidation and can provide insight on the amenities to add to an existing property prior to a sale.

to purchase a property or not. That purchase decision, however, has multiple layers of complexity, including how the valuation today relates to value expectations at some future sale date (reversion), the targeted IRR and evaluating exit strategies (preserving so-called "strategic optionality"). In this example, however, the application of data analytics is limited to sensitivity analysis. Another respondent at a CRE brokerage firm said valuation analytics are useful in the site due-diligence process to the extent that potential sites can be compared inside an off-the-shelf tool like Argus to project cash flows.[8] A third respondent at a different CRE brokerage firm said that they focus on valuation in terms of how it relates to the rent premium that tenants are willing to pay for "evolving" industrial amenity packages, which include open lighting, higher-grade common areas, locker rooms and available daytime retail. These items are included in their data-analytics workflow through a sequence of business rules or data filters in a manner similar to Prologis' approach. Other firm strategies that influence how valuation is used include "own and hold" or "fix and flip," as well as a targeted yield from a particular real estate asset.

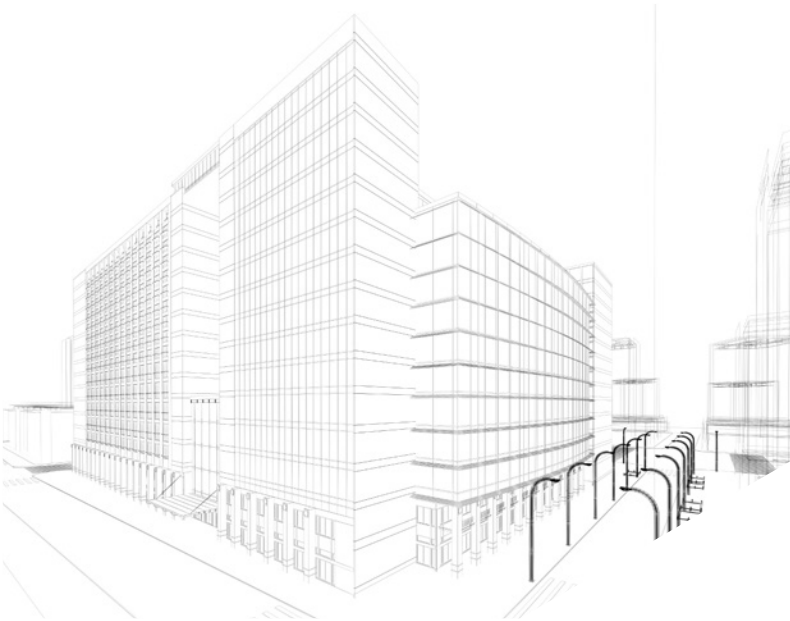
A CRE service provider said that valuation can shed light on the premiums paid for amenities, which can provide downside protection on the value of an asset in case there is a need for disposition. Buildings with more amenities, as long as those amenities are valued by tenants, are likely to have higher selling prices. Put another way, analytics related to possible amenity premiums can help identify a price floor in the event of a liquidation and can provide insight on the amenities to add to an existing property prior to a sale. This is where the related metrics of targeted IRR and contractual year-over-year rent increases (sometimes called escalation clauses) become relevant for deal sponsors and investors. Future asset values are important for asset managers looking for a certain financial return to meet or exceed what investors were told in "pitch decks."

Emerging Applications for Data Analytics

Real-Time Zoning Simulation

On the design side, a few firms are doing some innovative work related to zoning. Building off the Gestalt school of thought in the 1900s, which was adopted from Aristotle ("the whole is greater than the sum of its parts"), CityBldr identifies a parcel's highest and best use and then determines if an assemblage with other parcels creates a market value that is greater than the combined market values of the individual parcels. In contrast, Deepblocks accelerates the site-selection process by using data on zoning, demographics, property prices, construction costs and opportunity zones inside a GIS-like interface to allow customers to canvass an entire city for specific development opportunities. The novelty of Deepblocks is the combination of seemingly disparate data sets into a single searchable data lake to facilitate financial analysis, due diligence and 3-D modeling (see **Appendix A** for images of the Deepblocks interface). One interesting application of their technology is to assist a city in the Southeast U.S. to understand the financial implications of upzoning.[9]

Sidewalk Labs' Delve product uses AI and generative design, along with financial data, energy data and site constraints, to create 3-D models of buildings for use in site-feasibility studies. This allows developers to prioritize development options by overall index score or quality of life metrics (e.g., walkability, access to amenities), structural features (e.g., maximizing leasable area, preferred unit mix), design features (e.g., zoning, open-space strategies) or financial outcomes (e.g., construction cost minimization, profit on cost).[10]



Real-Time Building Renderings

Once a location has been determined, building rendering often occurs with new construction and value-add projects. Rendering is the creation of an image to describe a scene or visual model. Real-time rendering facilitates the design process by allowing a continuous feedback loop between the designer/architect and the client. One respondent pointed to a different kind of feedback loop that exists between the site selection and renderings processes. Renderings also are important in that they influence the cost estimation and profit projections of multiple sites. Here are some examples of companies doing innovative work with respect to rendering.

- CyberCity 3D (cybercity3d.com) produces digital building models for mapping and planning purposes primarily, including uses as diverse as optimal security camera placements and ground temperature forecasting. As an example, the firm's Chicago 3-D city model contains more than 14,000 structures modeled as individual vector files. These files can be combined

with Nextspace.ai or ESRI software to view and manage multiple renderings for the purposes of urban climate analysis, flood modeling and solar energy generation on commercial roofs.

- TestFit (**TestFit.io**) is a commercial software used by architects, general contractors and developers to generate building site plans for hotels, parking lots and multifamily developments. Its algorithms use inputs such as unit mix, road layout, parking configurations, etc., to produce a single rendering that the client can edit or manipulate. Additional analytics include real-time updates to the financial pro forma (e.g., land costs, setbacks, hard and soft costs, income and expenses, and projected yield-on-cost) based on the site and current design iteration. Users can also simulate the use of different construction materials and map that change through the projected financial performance of the building.
- OpenSpace (**openspace.ai**), used by JLL among others, offers software to automate image capture and produce Google Streetviews of the jobsite. OpenSpace Capture is a hands-free, automated jobsite-capture tool that uses proprietary AI algorithms to produce images in less than 15 minutes. These images can be mashed against a BIM to track actual progress vs. the BIM model.[11] OpenSpace's ClearSight tool uses AI (similar to the perception and navigation systems used in autonomous vehicles) to quantify jobsite progress automatically using metrics such as percent complete, quantities installed, rates of work and estimated completion dates for critical parts of the project. Thus far, client data suggest overall savings of 2.5% on construction costs, 50% savings in travel costs, and a one-month acceleration for a project that would otherwise take 24 months to complete.
- Pix (**pix-virtual.com**) uses virtual reality to enhance the marketing of a property, as users can create an unlimited number of renderings. The enhanced benefits of using virtual reality in real estate occur at the pre-development (e.g., design, financial proposal, entitlement process and permit approvals), development (e.g., construction management and pre-sales/pre-leasing), and completion stages (e.g., leasing/sales, reimagining the property). As a client builds out a rendering, Pix automatically estimates the materials budget. One client, IPA, built a digital twin of a new student housing facility. Using Pix's time-of-day light displays and other tools, IPA was able to pre-lease 93% of the units.
- CubiCasa (**cubi.casa**) has an application that scans and brands real estate floor plans. Essentially, the application takes indoor space data (up to 10,000 square feet regardless of whether the property is residential or commercial) and converts it into a form that can be indexed, searched, sorted and interpreted by the end user. Its "Video to BIM" technology captures property interior data and applies AI algorithms to create floor plans for its users (e.g., photographers, studios and real estate agents) and can shorten the appraisal process.

The Increased Use of Digital Twins

There are various definitions of digital twins.[12] The definition used here is a software solution that manages data throughout the life cycle of an asset.[13] Real estate practitioners generally use building information modeling (BIM) and computer-aided design (CAD) software to complete renderings and to model the systems inside a building.[14] This technology has evolved as digital twins provide a more complete replica of the places, people, processes, devices and physical assets in a building.[15] Digital twins effectively manage the voluminous data produced by a building and use big data analytics techniques to measure different performance features.

Digital twins also improve the design of physical products by helping reduce gaps between as-designed building models and as-constructed buildings. This is often achieved through "what-if" simulations that do not overwhelm or interrupt the actual physical systems. A digital twin can include historic and contemporary data about a property and its improvements, including floor plans; real-time sensor data; heating, ventilation, and air conditioning (HVAC) data; security systems; environmental sensors (e.g., lighting and fire); and data on assets and people that use buildings (e.g., tenants, visitors and custodial staff).[16]

Existing buildings are slow to adopt digital twins because it is cost-prohibitive to retrofit them with smart sensors and IoT devices.[17] Newly constructed buildings can have sensors and IoT devices added from the beginning, which means that the benefits of digital twins can be realized more quickly. Overall, digital twin usage is increasing. Yet, while digital twin usage was identified in the literature review, only one respondent mentioned it in their interview. This is likely because digital twins currently are discussed more in facilities-management and engineering than real estate development.

Willow, a global technology company working within the real estate and infrastructure industries, has been engaged on One Manhattan West "to implement the WillowTwin™ platform and provide digital engineering services to create and secure the digital foundation of their assets and transform the way the building is constructed, managed and experienced." WillowTwin will provide a digital strategy for the collection of asset data from the design and construction supply chain and input into the digital twin. This provides Brookfield, the property owner, with an intuitive digital twin, which enables a single "source of truth" for the visualization and management of its building systems.[18]

CityZenith is a digital twin platform for efficient, low-carbon cities, buildings and infrastructure. Built by the architects of Google Earth, CityZenith creates urban digital twins focused on identifying ways to decarbonize cities. Its technology, which utilizes AI, allows building owners and infrastructure managers to redesign buildings in the middle of construction to simulate different outcomes and minimize carbon production. One current project is the development of an urban twin for Phoenix, Arizona, to measure the impact of heat on house prices and then identify the greatest decarbonization opportunities. This is similar to what one respondent in the software development space said—that the combination of digital twins and BIM will allow a firm to measure different building configurations and choose which layout minimizes the carbon footprint.

The Promise of Distributed Ledger Technology

Distributed ledger technology (DLT), also known as blockchain, offers the opportunity for firms to establish better workflows, improve data transparency, provide permissioned data access to stakeholders and implement better data-provenance standards. In this way, DLT can enhance the data infrastructure supporting various data-analytics applications. Several CRE service providers, including Inveniam.io, said that commercial real estate firms are only scratching the surface of how to incorporate blockchain to enhance efficiency in real-time data processing and documentation.

One application of DLT could apply to one of the firms interviewed for this study. TranswesternHub.com, powered by Cohesion, is Transwestern's platform focused on the tenant/occupant experience. This platform can be used to request an elevator, to enter a building, to control access through permissioned floor and room clearances, and to report incidents/issues. Other services include visitor management, indoor air quality, connecting with building occupants, searching local amenities and automating cleaning schedules for different workspaces. The experiential, financial and environmental performance data coming from an asset, like Transwestern's 77 West Wacker Drive property in Chicago, Illinois, could be connected to blockchain via a non-fungible token (NFT), linked to a QR code and then displayed so that building entrants could scan the QR code for up-to-date building performance data (e.g., current indoor air quality, temperature and elevator servicing records).

Also, the same data could be loaded into the payload of a block monthly, made available to valuation agents for monthly marks, and then made available to potential purchasers to shorten the due-diligence process upon liquidation of the asset. In this instance, DLT facilitates data analytics on a permissioned basis. The asset owner can provide access to only the data elements needed for a given professional to complete their work—accountants have access to profit/loss statements and balance sheets for the preparation of tax returns, whereas engineers have access only to blueprints and other documents related to the operational performance of the asset.

Conclusion

Commercial real estate firms are gradually adopting data-analytics techniques to mine their own data for insights. These data often are not credentialed or standardized across business units/silos. However, this is not being done uniformly across the CRE industry. Several respondents confirmed that their firms do not have standardized policies in place that foster discussions across business units. For those who actively use data analytics in their firms, often firm strategy dictates whether the data-analytics function is in-house or utilizes a third-party external firm.

Data analytics are currently used more often in siting decisions than in design decisions. This is due to the legacy "location, location, location" mentality of what drives real estate value. A sea change is imminent, as commercial real estate seems to be transitioning somewhat to a new "location, data, design" mantra. "Location" will remain an inherent characteristic of real estate. On "data," market participants draw a clear distinction between "data analytics" (more quantitative data analysis) and "market intelligence" (more qualitative data). In some cases, these are given equal weight in decision making; in others one approach precedes the other. On "design," the literature and professional firms working in this area support the idea that design influences value—and that certain design features command a price premium, like energy efficiency certifications.

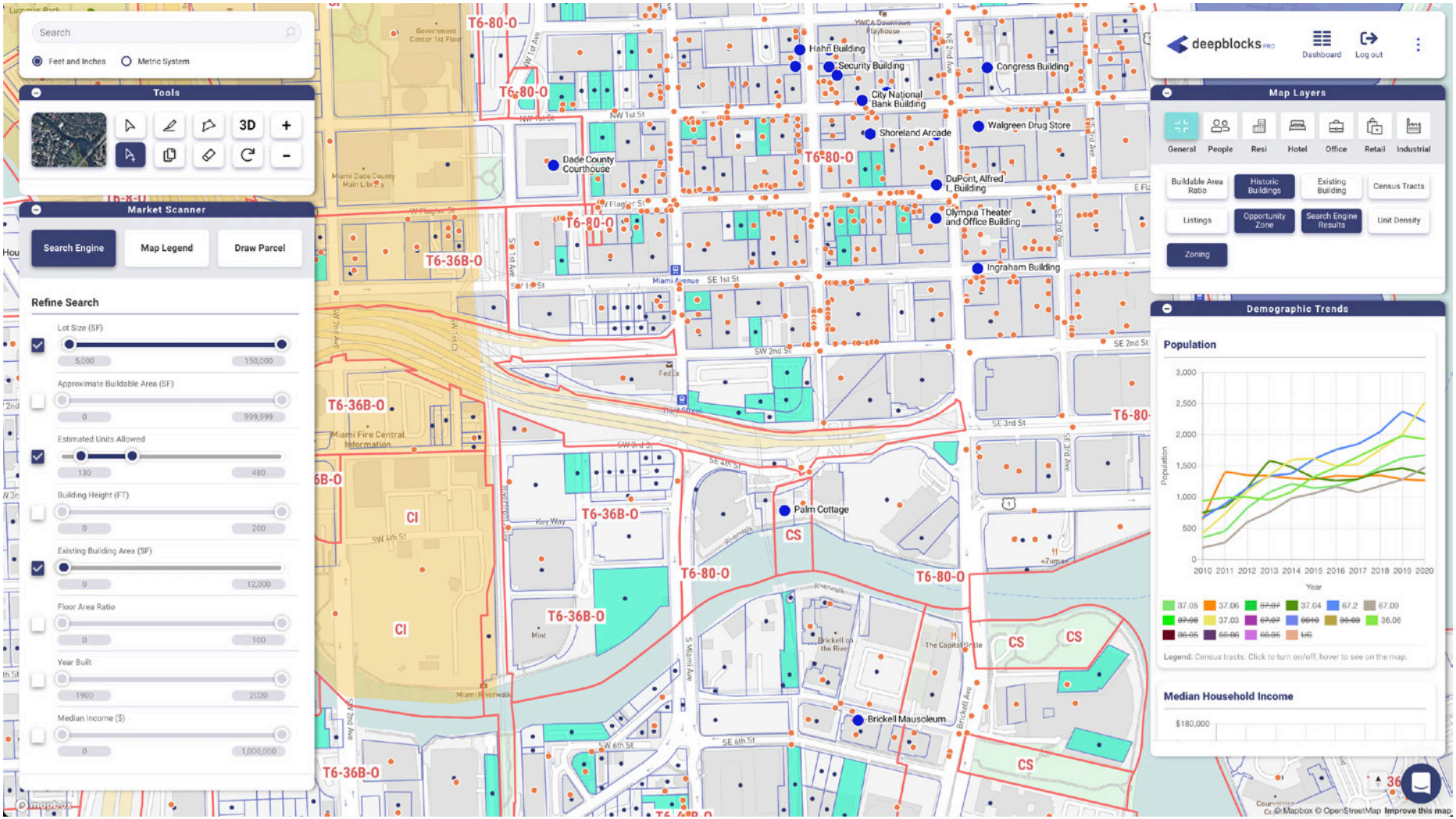
Evidence also supports the idea that valuation plays a complicated role as an intervening variable between data analytics and the siting and design decisions being made by commercial real estate firms. Valuation is the "end" in some scenarios and the "means to the end" in other scenarios. However, evidence presented here suggests that one cannot ignore the feedback loop that exists between valuation and siting/design.

Finally, the future of data analytics in CRE holds much promise. Digital twin usage is on the rise, especially on the operational side of CRE. DLT offers the opportunity for firms to establish better workflows, improve data transparency, provide permissioned data access to stakeholders and implement better data provenance standards. Real-time zoning offers clients the ability to streamline the site-selection process. Real-time rendering, which often occurs after site selection and is closely tied to building design, can have a feedback loop with site selection as new technology converts rendering data into construction cost data to facilitate site comparisons, especially when different sites cannot accommodate the same building structure.

Looking ahead, developers, investors and other commercial real estate professionals can expect data analytics to become a more frequent topic of conversation. Data-driven approaches to CRE development are already in use, but with only a few firms leading the way. As interviews suggest, data-analytics adoption is still in the early stages but is gaining traction inside CRE firms that wish to differentiate themselves from their competitors.

Appendices

Appendix A. Deepblocks Images



The Deepblocks site selection interface allows a development team to generate a short list of properties that meet specific criteria. The user can view approximately 10,000 properties in a single screen and then filter these properties according to criteria such as zoning development capacity, existing building area, lot size, population median income and opportunity zones. The interface can reduce the time needed to canvas properties by several months when compared with traditional methods.

Courtesy Deepblocks. ■

The Deepblocks modeler combines a financial return-on-cost calculation, a 3D model and assumption sliders, and can produce a PDF report. The development team can look at the parcel-specific zoning rules and adjust the project program, conduct sensitivity analysis on any assumptions and use this information to identify a purchase price. The modeler feature includes functionality for condominiums, multifamily, single-family, hotel, office, retail and industrial uses. The modeler can reduce feasibility study timelines by two to three weeks per project.

Courtesy Deepblocks. ■

Appendix B. List of Respondents

Aaron Ahlburn, Avison Young

Jeff Adler, Yardi Matrix

Miki Byers, Enscape/Chaos

Bryan Copley, CityBldr

Michael Jansen, CityZenith

Chris Martin, Sealy Industrial Partners

Alex Morrise, Silk Spaceships

Patrick O'Meara, Inveniam Capital Partners

Doug Prickett, Transwestern

Olivia Ramos, Deepblocks

Doug Ressler, Yardi Matrix

Dean Violagis, CoStar

Raymond Wong, Altus Group

Appendix C. Interview Instrument

1. What are the different segments of your business?
2. Does your business primarily focus on individual buildings as stand-alone projects or a broader network of buildings, either owned by the developer or a prospective tenant?
3. How are data analytics being used by industry practitioners to a) identify building locations and b) identify design characteristics for newly constructed buildings?
4. If a developer is considering a mixed-use building, how can analytics inform what the optimal ratio of space allocation to different uses would be (e.g., to maximize value)?
5. If a developer is planning an office building, can analytics help them decide whether to include ground-floor retail?
6. What is the role of valuation (internal or third-party) in identifying building locations for new construction?
7. What is the role of valuation in identifying design characteristics for new construction?
8. What are the analytical outputs/metrics that influence the siting and design decisions being made by your firms? Do you use any approaches that might be considered "cutting edge"?
9. Do you know if your competitors use data analytics? If so, how do they use it and do they use analytics differently than you do? Are there other companies that you would like to emulate?
10. How will the use of data analytics change in your industry in the next five years?

Endnotes

[1] Kimberly Winson-Geideman et al., *Real Estate Analysis in the Information Age: Techniques for Big Data and Statistical Modeling* (New York: Routledge, 2017).

[2] Ibid.

[3] For example, investment firm Archer in California hired a data scientist with a hedge fund background to build a proprietary technology platform to identify acquisition opportunities. See Jenn Elliot, "Seeking an Edge, CRE Investors Embrace Non-Traditional Data," *Wealth Management Real Estate*, 18 May 2021, https://www.wealthmanagement.com/investment-strategies/seeking-competitive-edge-cre-investors-embrace-non-traditional-data-sources.

[4] In a similar vein, Nuveen launched an in-house data analytics group (Nuveen Labs) in 2019 to enhance returns and give Nuveen a competitive edge by leveraging AI, ML, and big data techniques. As one example, Nuveen uses foot traffic data from Placer.ai to study retail trends. It also uses causaLens and StratoDem Analytics for its AI based solutions using government economic and demographic data, including migration patterns. See Elliot, "Seeking an Edge."

[5] AI is one tool in the data analyst's toolbox. AI can be used to extract insight and patterns, for predictive purposes, from large data sets. AI includes machine learning, neural networks, natural language processing (NLP), and natural language generation.

[6] Prologis, "The Modern Supply Chain: A New Model for Defining Logistics Real Estate," September 17, 2019, https://www.prologis.com/news-research/global-insights/modern-supply-chain-new-model-defining-logistics-real-estate; Ryan Thompson, "Cloud and Data Science Success with Agile Data Management," Slideshow prepared for Fast Data Strategy Virtual Summit, May 10, 2019, https://www.slideshare.net/Denodo/prologis-how-data-virtualization-enables-data-scientists.

[7] "Key Considerations for Office to Life Science, Medical or Multifamily Conversions," NAIOP webinar, May 24, 2022, https://learn.naiop.org/products/key-considerations-for-office-to-life-science-medical-or-multifamily-conversions-webinar.

[8] Other software tools like WebLOCI, IMPLAN, and REMI are used in the site selection process to estimate the economic impact of a project. These programs estimate the number of jobs created and total economic impact (expressed in dollars).

[9] Upzoning refers to situations where a municipality changes the zoning to allow for higher-value (e.g., from industrial to residential) or more dense uses (e.g., increasing the number of stories that can be built or increasing the floor-to-area ratio). See The World Bank, "Up-zoning," https://urban-regeneration.worldbank.org/node/21.

[10] Sidewalk Labs, "Delve," https://www.sidewalklabs.com/products/delve.

[11] OpenSpace, "Futuristic Technology, Years in the Making," https://www.openspace.ai/the-tech/. According to OpenSpace, images are turned into metrics through a process called semantic segmentation, which is "the process of grouping pixels together into logical chunks. These chunks can be purely feature based—for example, all the pixels of a yellow shirt would form one chunk, while the pixels of a red scarf would form another. Or the chunks can be associated with predefined classes and given a label. OpenSpace is using semantic segmentation to develop a series of construction-specific classes and classifiers to transform raw images into logical segments that can be tracked and counted."

[12] Mordor Intelligence says digital twins are an "integration of all modern intelligence technologies including big data, artificial intelligence, machine learning, and Internet of Things (IoT) used for predictive analysis of any system or equipment." See Mordor Intelligence, "Digital Twin Market—Growth, Trends, COVID-19 Impact, and Forecasts (2022-2027)," 2021, (https://www.mordorintelligence.com/industry-reports/digital-twin-market). Rebecca Engvall and Anna Larsson define digital twins as a "digital ecosystem where data flows from existing facility systems to a data cloud that enables applications to access the data." See Rebecca Engvall and Anna Larsson, "Digital Transformation in Commercial Real Estate: A Case Study on Creating Digital Twins of Existing Buildings," (Master's Thesis, Chalmers University of Technology, 2021).

[13] A digital twin is "[a]n integrated software solution to manage static and dynamic information of a built asset across its lifecycle phases. It usually provides a realistic digital representation of the physical asset, generated by enriching the geometric or graphical data with support from building automation systems (BAS), sensors, internet of things (IoT) components, and other feedback systems informing about the asset, its occupants, or its environment." José Carlos Camposano, Kari Smolander and Tuomas Ruippo, "Seven Metaphors to Understand Digital Twins of Built Assets." *IEEE Access* 9 (2021): 27170, https://doi.org/10.1109/ACCESS.2021.3058009.

[14] Data analytics can leverage the data inherent in BIM software and apply predictive models, which may include an AI component.

[15] Camposano, Smolander and Ruippo, "Seven Metaphors."

[16] A related issue is how to manage digital twin data. Digital twin data can be stored on building premises; but this requires an excessive and impractical amount of IT support. [Essentially, each building would have to operate and maintain digital twin software covering all devices found in the building.] Alternatively, digital twin data can be stored in centralized cloud locations (e.g., Microsoft Azure or Amazon Web Services IoT TwinMaker). The solution with the most promise seems to be blockchain-based solutions where digital twin data remain on cloud servers (accessible by property owners) and are accessed via cryptographic hashes and pointers. This allows digital twin data to remain at their place of rest (e.g., cloud servers); and data owners can give permissioned-access to others on an as-needed basis. This is an important cybersecurity risk mitigation tool. For example, if a building manager tries to locate the correct document to address an issue in a particular area of a building, then building occupants must wait until the issue is resolved. A digital twin, coupled with immutable data linked to the blockchain, provides a real-time opportunity to reconfigure space or find the most cost-effective way to resolve the issue. The benefits to real estate owners include quicker decision making, reduced maintenance costs, an ecosystem-level of understanding about the building, improved user satisfaction, a more efficient development process (continuous comparison between design and the work in progress), and improved performance with respect to sustainability metrics (e.g., carbon emissions, noise pollution, waste collection).

[17] "Smart Building Digital Twins," Pix webinar, October 2021, https://www.pix-virtual.com/webinars.

[18] Willow, "Brookfield Properties Case Study – 1 Manhattan West," https://www.willowinc.com/stories/brookfield-properties-case-study/; "Brookfield Launches Willow Digital Twins at One Manhattan West," Citybizlist, December 2, 2020, https://newyork.citybizlist.com/article/641561/brookfield-launches-willow-digital-twins-at-one-manhattan-west.

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