Urban Big Data and Real Estate Markets
A period of extraordinarily rapid technological change is transforming our cities and the ways we work, live, and travel. As important as the physical changes, are the vastly improved collection and use of data.

The aggregation of digital information collected by sensors, internet-enabled devices and the computerization of administrative and business data is improving the standard of urban life in many ways:

• More efficient transportation systems
• Lower energy usage
• Reduced criminal activity
• Better urban public services: lighting, waste collection and disposal
• Less government waste
• Creation of urban environments that adapt and respond to human needs in real time

This CBRE ViewPoint reviews the implementation and impact of several big-data initiatives in the context of urban real estate markets, and draws out some insights and lessons on their wider potential. It is based on a fuller paper, prepared by MIT and CBRE.
KEY TAKEAWAYS

• Urban big data collection, analysis and usage are advancing rapidly, but some cities and locations are leading.

• Successful use of urban big data techniques will boost real estate values. Long-term investors should add big data initiatives to their asset-selection criteria.

• Urban big data initiatives will reinforce major global gateway cities’ dominance, at least in the short term. This would expand opportunities for “core” investors in what is a very competitive segment of the market. It also supports current pricing levels.

• Initiatives pursued in smaller or cheaper markets could raise these cities’ status and investor appeal, while generating micro-level shifts in the appeal of certain districts. Investors should seek these out for value gains, but occupiers will also benefit from identifying locations that would improve their amenity offers.

• Developers looking for new angles and enhanced returns should identify sites with the potential for value uplift from big data initiatives. Partnership with knowledgeable advisors and, in some cases, city authorities, is also advisable.

• Urban big data projects have the potential to influence many of the factors that drive occupiers’ location decisions, such as accessibility, quality of place and workforce appeal. Occupiers should seek early engagement in such schemes, and strive to assess their impacts and benefits.
WHAT IS BIG DATA?
The three V's\(^1\) are a useful way of defining big data:

1. **Volume**: Big data is large—often measured in petabytes or more. “Simply put, big data is too big to sit on your hard drive”, says Eric Scharnhorst, a data scientist at Redfin.\(^2\) Examples include user-data from Facebook, transport systems’ passenger-flow data, transactions data, etc.

2. **Velocity**: Big data is often generated continuously, in or near real time. Twitter posts, cell phone location data, and information from weather and air quality sensors are examples.

3. **Variety**: Big data can comprise any or all types of data—numbers, text, images, video, audio and other kinds of data. Its analysis needs to be flexible enough to deal with any type or mix of types.

We would add that big data requires *collection and analytical efforts*, and must be *socially or commercially useful*.

THE ECONOMICS OF CITY DATA AND URBAN EFFICIENCY
Urban big data is in its infancy, but already has a label: the term ‘smart city’ describes places and initiatives that use digital information and analytics to enhance urban areas and buildings. Because smart city initiatives affect urban areas’ quality of life, land-use patterns and real estate markets, the real estate industry needs to anticipate their effects to identify new opportunities and take necessary steps to avoid harmful disruption of established practices.

Economists sometimes view cities in terms of ‘spatial equilibrium.’ Theoretically, a city is in spatial equilibrium when no citizen is motivated to move from one location to another in search of higher wages or greater amenity. Everyone is as happy as they can be, where they are. Real cities are never like this—not because spatial equilibrium does not exist, but because it changes over time in response to changing prices, such as a decrease in the cost of travel, and it takes time for people to move to their new best location. Cities are always moving towards a new spatial equilibrium.

---

2. Conversation with author, October 17, 2016.
There is much evidence showing that people move to high-wage cities and, increasingly, toward their greater availability of amenities. This is the live, work, play phenomenon. However, as cities grow, they also get more expensive to live and work in. In equilibrium, living costs—a high proportion of which are housing costs—would exactly balance out the city’s wage and amenity offer. The city would be neither too “expensive” nor too “cheap” in terms of its overall package.

Glaeser, Kolko and Saiz³ express this idea in an equation. In a city in equilibrium, the availability of high-wage, high-status jobs (known as the ‘productivity premium’) plus the local effect of quality of life (the ‘amenity premium’) will be equal to local real estate values or rents (‘rent premium’).

The productivity premium arises from two sources:

- Efficiency gains from firms being located close to one another (clustering)
- Higher productivity from better access to the latest ideas, technology and skilled workers (innovation)

The amenity premium can arise in four areas:

- A rich variety of services and consumer goods (choice)
- Physical and visual attributes of the urban environment that make life more pleasant (stimulation)
- High-quality public services—such as schools, public utilities and cultural opportunities (provision)
- The ease or speed of moving around a city (accessibility)

This is where big data initiatives impact real estate: Where big data can generate productivity or amenity gains in cities, there will be a proportionate rise in real estate values. There are many possibilities for the innovative application of big data in urban areas:

- Improvement of public urban amenities, or maintenance of existing municipal service levels at lower cost. This is particularly relevant, given the constraints on public sector budgets in many countries.
- The reduction of negative features, such as crime, and the encouragement of greater civic engagement and community projects.
- Raising productivity and/or creating new business opportunities for private firms in the city by enabling gains in operational efficiency or locational appeal.

---

4. Ibid.
5. Ibid.
BIG DATA AND CITY MANAGEMENT: THE PRESENT

Urban big data is comparatively new, so the scope of initiatives pursued in different parts of the world varies widely. Here are some specific big data projects that are underway around the world right now:

<table>
<thead>
<tr>
<th>City Examples</th>
<th>Impact on City &amp; Real Estate Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SANTA CLARA, CA, USA:</strong> The drought in California prompted Santa Clara to retrofit its municipal irrigation system with sensors to more efficiently manage limited water supplies. The system is expected to save 180 million gallons of water. 6</td>
<td></td>
</tr>
<tr>
<td><strong>LONDON, UK:</strong> Transport for London (TFL) uses ticketing data to build travel patterns across its rail and bus networks. This information helps in improving the network and assessing the impact of closures and diversions.</td>
<td></td>
</tr>
<tr>
<td><strong>YINCHUAN, CHINA:</strong> Yinchuan is a smart city pilot project in China, with features such as facial recognition on buses, grocery delivery via apps and an online portal connecting doctors with patients. 7</td>
<td></td>
</tr>
<tr>
<td><strong>RIO DE JANEIRO, BRAZIL:</strong> IBM has designed for the city an operations center that integrates data from 30 different agencies. These provide a foundation for valuable public safety services, including an early warning and evacuation system for Rio’s favelas.</td>
<td></td>
</tr>
<tr>
<td><strong>SPAIN:</strong> Spain’s tax agency analyzed data from unmanned drones surveying 4000 municipalities. It discovered 1.69m properties paying insufficient taxes on new construction, expansion and pools. The initiative brought in 1.2bn euros in additional taxes.</td>
<td></td>
</tr>
</tbody>
</table>

6. CityOS (Nov 2016), Case Study: Santa Clarita Reduces Water Usage by 20% with Smart Irrigation.
7. See also.
**SOURCES OF URBAN BIG DATA**

All the projects described above had to identify and select ways of generating and using the necessary data. There are many ways of doing this, some of which are still at a very experimental stage.

<table>
<thead>
<tr>
<th>Source</th>
<th>Example</th>
<th>Impact on Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative:</td>
<td>A new online voting platform lets residents of a Massachusetts city to democratically allocate $700,000 to community improvement projects. The city benefits through more efficient operations, better communication, more competitive contracting, and lower risk of fraud or abuse.</td>
<td>Administrative data can reduce long-term operating costs and increase productivity across a city. This has a long-run positive effect on values.</td>
</tr>
<tr>
<td>Sensors:</td>
<td>In New York City, fiber-optic sensors monitor cracks in the Brooklyn Bridge, as well as indicators like temperature fluctuation. This information helps structural engineers in determining when the vaults need to be replaced.</td>
<td>The continuous data collected by sensors can be real-time information monitoring safety measures, charting user behavior patterns and creating automated response systems. This raises productivity overall, and improves the quality of local services.</td>
</tr>
<tr>
<td>Apps:</td>
<td>A Boston group created a crowd-sourcing mobile app called Street Bump, which helps residents improve their neighborhood streets by inputting road condition data while they drive.</td>
<td>Apps save time for city residents as well as workers. Better mobility can be a competitive advantage for city.</td>
</tr>
<tr>
<td>Crowdsourcing:</td>
<td>Journalists attending the Beijing Olympics were given handheld aerosol-monitoring and GPS devices for the Beijing Air Tracks project. Their results provided independent confirmation of the poor local air quality, pressuring municipal governments to act on improving the quality of life of residents.</td>
<td>Crowdsourced data mobilizes citizens to generate information that may creatively address problems or beautify the city. These can prevent long-term declines in values and/or generate local growth.</td>
</tr>
<tr>
<td>Remote Image, GIS and User Behavior:</td>
<td>The city of Louisville, KY distributed to asthmatic residents 500 smart inhalers that recorded the time and place of use. IBM analyzed the data to create heat maps of asthma emergency attacks and suggested interventions such as SMART inhalers that let residents track where and when they are having breathing difficulties. The maps also facilitate avoidance behavior. It is estimated that asthma symptoms declined by 43%.</td>
<td>Studied via remote imagery and GIS, user-behavior data obtained via social media and Urban Patterns potentially provide solutions to difficult urban problems and improve the quality of life. This could lead to local positive impact on residential values.</td>
</tr>
</tbody>
</table>


IMPACTS ON CITIES AND REAL ESTATE VALUES

Big data can raise adopting cities’ productive capacity and quality of life, and increase real estate values quite quickly. These value impacts will reflect the pattern of social and economic gains, which may be citywide or localized.

Our analysis suggests four categories of city impact:

1. **Improved or more efficient municipal services.** This is potentially a citywide effect, though there may be specific local impacts if city government is fragmented, as in, for instance, London. As people move to locations with better or cheaper municipal services, values will rise—particularly in the residential sector. The benefits will be magnified as funds are freed up for other projects.

2. **Improved information or operating environment** for local firms. This would drive efficiency and innovation in the private sector and the potential value gains would, through higher rents, be transmitted to commercial real estate. This is also a potentially citywide effect, although more local impacts may accrue around the main commercial clusters.

3. **A more efficient urban transport system,** which is a focus of many big data initiatives, has several positive effects, including higher residential values in the city periphery and suburbs, and around specific transport nodes.

4. **Smaller-scale placemaking initiatives** to improve pedestrian flow, security and safety, or usage would have positive localized value effects (although increased usage of public facilities might sometimes generate negative effects for local residents). (Related placemaking research can be accessed here.)
WILL IT WORK EVERYWHERE?
Many early adopters are cities with forward-looking and commercial leadership, a multicultural open-minded citizenry, an already active cultural and amenity base and a high-tech worker base. Those ‘super-star cities’,¹⁰ in which there are high barriers to new real estate development, are likely to become yet-more-expensive, 24/7 public-service locales.

In smaller creative cities with a more elastic housing supply, implementing smart city concepts will be feasible without producing excessive residential price growth. While real estate values would grow, they would remain competitive due to increased supply and substantial real estate development.

We also note a strong relationship between density and cost-benefit in the application of big data technologies. ‘Smart city’ interventions are likely to be more successful in densely-urbanized, data-rich central areas. Sensors, lighting, traffic and pedestrian flows, accurate statistics, crowdsourcing opinions, etc., may all be too dispersed in the suburbs to justify the cost. These would seem to be a force towards densification and higher residential and retail rents in denser locations.

In smaller creative cities with a more elastic housing supply, implementing smart city concepts will be feasible without producing excessive residential price growth.

However, improvements in transportation systems could have the opposite effect. By lowering transportation costs, they would help to decentralize employment and hence flatten the real estate value curve, making suburban locations relatively more attractive.

The net effect of smart city technologies on the respective growth of suburban and central values depends on the relative impact on urban amenities and transportation. In isolation, improvements in public service and amenities will tend to have a centralizing effect, whereas reductions in transportation costs should work in the opposite direction. Displacement impacts—households or businesses changing location to take advantage of (or to avoid) micro-location value impacts—are also common and can distort assessments of any aggregate urban-level impacts.

There are other issues to consider in the emerging markets. The resource and policy challenges involved in mounting big data projects are significant. Also, given lower absolute levels of development and prosperity, the potential for leapfrogging (of the status of one city over others) is high. Where the necessary educational, financial, and political assets can be assembled, we may well see big data projects causing a re-ordering of emerging market cities’ economic pecking order. At the moment, it would seem that Asian cities are pushing for market leadership in smart technologies.

**WHO BENEFITS?**

Understanding the scale, distribution and duration of such impacts is critical, in at least two ways:

- **For public sponsors in making assessments of the benefits of potential competing projects, and seeking funding from the urban community to support them**
- **For developers, investors, funders and occupiers whose decisions and rewards may be affected, either positively or negatively.**

Big data initiatives can expand the choice of attractive opportunities for investors, and enhance occupiers’ ability to attract labor.

For this second group, it will be critical to understand how big data initiatives interact with existing strategic challenges. Many global investors are facing constraints on stock capacity and very low yields in core markets; could big data initiatives expand their choice by more quickly repositioning certain districts to “prime”? For corporate occupiers, particularly those in areas or industries where specialist skills are scarce, incorporating big data initiatives (for example, in car parking, way-signing or general accessibility) into locational decision-making could become a major differentiator in attracting labour.
OPPORTUNITIES AND CHALLENGES

We have barely seen the beginning of the big data wave. Estimates suggest that the amount of data that IoT (“Internet of Things”) devices generate each day is doubling every 40 weeks. The raw material for urban big data projects is growing exponentially, and in the next decade we expect to see hundreds of similar or better ideas emerging.

OPPORTUNITY AREAS OF PARTICULAR RELEVANCE TO REAL ESTATE

**Leases**

Over recent decades, large databases have evolved that track sales transactions of properties, both residential and commercial, facilitated by title laws and the need for ownership registration.

The same has not been true for lease transactions, making leasing far less transparent and understood than ownership. With greater lease transparency, both tenants and landlords could spend less time on rental negotiations, speeding up the process of re-location and letting. New and innovative lease features could also be assessed more quickly and adopted to the benefit of all parties.

**Urban travel patterns**

Transportation costs—both money and time—contribute to urbanization, as travel costs influence firms’ and households’ location decisions. Real estate rents and prices in core areas include a premium that reflects an avoidance of the high commuting and transportation costs further out. Providing and improving transportation infrastructure not only helps cities function better, but also enhances overall productivity levels.

**Tracking urban land use—combining local property tax parcel data**

In much of the developed world, official and often very efficient systems exist for appraising real property and collecting annual taxes from it. This system is always operated at the local (city, town, municipal) level. There are hundreds and often thousands of jurisdictions within a country, or even within a city, collecting this data.

What has yet to be accomplished is the efficient combination of these data to provide a picture of land use at the metropolitan area level. By studying the timing and geography of recent land use changes, real estate planners and developers could better understand process of urban change and identify opportunity areas for future development and investment.
CHALLENGES AND ISSUES
Of course, in addition to the enormous opportunities, there are some challenges that will need to be addressed.

Open data: use and usability
The open data movement is based on the three principles: transparency, participation, and collaboration. Generally, observing these principles helps maximize data's value to society, but ideas for the rapid opening of government data remain fiercely argued.

Privacy
In much of the developed world, privacy is considered a basic human right and is often protected by law. The concept is in flux, however. Data on individual behavior is already gathered in many ways: through social media, the Internet of Things, GPS, transaction records, credit cards and more. We are some way from reaching consensus on access to, and usage of, this information. The General Data Protection Regulation (GDPR) will be introduced in the EU in May 2018, expanding and strengthening the territorial scope, penalties, consent conditions and rights of citizens with respect to data privacy and data breaches. Companies holding data on individuals will need to take steps to ensure that their protocols are compliant.

Technology and human capital constraints
To develop effective urban big data projects, cities need to be aware of their own resources and technical capabilities and find ways to generate the necessary funding. Building the necessary data infrastructure, such as a high-capacity, machine-readable data portal, is a substantial technical challenge that will not be within the scope of all cities.

Solutions in search of a problem
Without downplaying any of the previous three points, this may be the most important for real estate. It is tempting to think that the vast amount of data being generated every day will, in itself, provide solutions to urban problems, and to building-design and -management issues as well. At the very least, it is possible to be blinded by the sheer amount of city- and building-related information that can be produced.

Practitioners should be cautious about over-hyping and over-promoting 'solutions' that do not solve problems in a cost-effective way. Talmai Oliveria, Senior Researcher at Phillips, says, “We understand that just putting in a sensor will not solve any problem.”
In other words, start by articulating the problem that needs solving; not with the data that happens to be available.
CONCLUSIONS AND IMPLICATIONS FOR REAL ESTATE
The big data revolution is already affecting our daily lives. Some of the most significant opportunities lie at the municipal level. Urban information technologies can make our cities ‘smart.’ Siemens’ MindSphere, for instance, is a cloud-based open IoT platform that supports combination and analysis of data from a wide variety of sources. Alphabet’s Sidewalk Labs is investing in the development of a waterfront community in Toronto, Canada on smart city principles, with a strong emphasis on environmental sustainability and quality of life.

The next phase—creative destruction and the disappearance of non-viable approaches—should leave us with many feasible smart city technologies. We expect innovations that substantially reduce businesses’ operating and capital costs to be the first to be widely adopted. Technologies with clear immediate benefits to quality of life—however measured—will follow. Finally, technologies that improve quality of life and the productivity of cities over the long run will progressively expand as the benefits of earlier projects become apparent.

Many of the most impressive examples of the application of big data techniques are in Asia—China in particular, but also Korea.

In real estate consultancy and services, CBRE has developed a number of data-driven tools. The Calibrate platform uses proprietary technology to analyse the digital footprints of millions of mobile phone users—this gives occupiers and landlords access to consumer profiling and spending data to inform location-selection and investment decisions. Portfolio Optimizer combines occupier portfolio data with market benchmark data and forecasts to identify operational efficiencies and support occupiers’ decision-making around leases and occupancy. Sequentra is an industry-leading lease administration software system designed to identify savings and risk-mitigation actions across occupier portfolios.

11. See White House Directive
Initially at least, it may be that smart city technologies reinforce the dominance of the most successful global metropolises. These cities have the IT know-how, human capital base, and experimental attitude required, and often more progressive leaderships as well. As technologies develop, improving quality of life and local productivity, these cities will be better positioned to reap the benefits. This means that real estate values in these areas will continue to grow—especially in metropolitan areas with inelastic supply caused by barriers to new development.

However, the more advanced technology-oriented emerging countries may also leverage these technologies to leapfrog others in the provision of local public services. Many of the most impressive examples of the application of big data techniques are in Asia—China in particular, but also Korea. In these countries, concerns about privacy are often secondary to the push for broader social and economic progress.

In the longer term, all cities across the urban system will end up adopting successful and cost-effective smart city initiatives, eventually diluting the leaders' first-mover advantage. And smaller-scale interventions are likely to crop up everywhere, even in the short term. These programs are more likely to improve conditions in blighted or relatively deprived neighborhoods, which would produce gentrification and higher values there. Those who can best understand and anticipate these micro-location impacts will profit.

Nevertheless, there are already numerous examples of big data products, existing or in development, that can be adapted or applied at the urban level.

In addition to a wide range of urban-level initiatives that affect real estate values, there are also potential big data applications that could more directly transform how real estate is appraised, traded and taxed.

**ACKNOWLEDGEMENTS**

We would like to thank Professor William Wheaton for his helpful comments on this research.