Real Trends

The Future of Real Estate in the United States

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Sponsored by:

Capital One Commercial Banking

Contents

Methodology and Acknowledgments

This report results from a combination of research methods. Chapters 1 and 2 draw heavily from the research of one of the authors as well as from substantial academic literature regarding issues such as housing affordability, the evolution and fluctuations of home values, and the demographics of real estate markets. Relevant citations appear in the text, and the references can be found at the end of the report.

Chapter 4—and parts of other sections—mostly draws from one of the authors' experience as a startup entrepreneur in the Internet of Things as applied to real estate and urban planning. In other sections, we have drawn from a few written sources—as documented in the report—and hundreds of talks and conversations with real estate professionals, including targeted interviewees, visitors at the MIT Center for Real Estate, innumerable students and alumni in our Master of Science in Real Estate Development (MSRED) program, students in our professional education program, and a large number of speakers at the MIT World Real Estate Forum (WREF) and at Real Disruption conferences and seminars. h We also have learned a lot from MIT staff and professors including: Schery Bokhari, Andrea Chegut, Ryan Chin, Dennis Frenchman, David Geltner, Ken Larson, Joseph Paradiso, Skylar Tibbits, Carlo Ratti, Bill Wheaton, Sarah Williams, and Chris Zegras.

Special thanks are due to Steve Weikal, whose conversations have illuminated our understanding of the real estate startup world. His wisdom features prominently in Chapter 5. We also are grateful for Steve's leadership pioneering the Real Disruption conferences and WREF Edge Sessions at the MIT Center for Real Estate. These events have helped position MIT as one of the foremost thought leaders in technology and the future of real estate.

All of the opinions, forecasts, and guesses—and there are many of them in this document—remain the sole responsibility of the authors. We want to thank Capital One Banking for its sponsorship, and for allowing us to work on this project. They have indeed played the part of the perfect research benefactor, providing us with general guidelines to make the report relevant and appealing to a broad audience as well as with the necessary funds to write it, all without interfering with our research. To remove all doubt, we want to emphasize that *all of the opinions in the paper are solely those of the authors and do not represent the view of Capital One Banking, its staff, or any of its affiliates*.

Introduction: The Shape of Urban Trends to Come

In this report, we venture into the future of real estate markets and products. Our definition of "real estate" for this purpose is not limited to buildings —such as homes, apartments, hotels, retail malls, offices, factories, and warehouses. Our definition also includes the social relationships that are formed and take place therein: How will we live, work, and socialize during the next decades?

Our work further considers relevant trends in economic and financial markets, and how real estate markets mediate local and regional mobility or population growth. We also devote some time to the evolution of businesses that provide services to the real estate industry: leasing, transactions, energy, and the like.

Hundreds of innovations and ideas hit the marketplace during any given month. We could not possibly include them all. Conversely, some of the technologies and trends that we do identify will turn out to be irrelevant or peter out in popularity. We have made a conscious effort to carefully triage our findings, retaining what we see as possible trends and discarding products and ideas that are obviously hyped by their promoters. We apologize for any remaining unintended boosterism, and for the inevitable omissions and oversights.

We have structured the report in six chapters. In the first chapter, we tackle the impact of demographic change. This is the lowest-hanging fruit because the changes that will shape America's population are taking place right now. Our nation will be larger and older, and regional growth disparities will continue. Family structures will favor small households, although they will not be much smaller than today's.

Chapter 2 is devoted to the urgent issue of affordable housing. In some metropolitan areas of our country housing is getting extravagantly expensive. In all areas, real estate prices are rising much faster than other manufactured goods. Here we examine some of the most promising ideas that could help alleviate the housing affordability problem in the future. The outlook for a comprehensive solution to the affordable housing crisis is bleak, given the lack of national consensus about redistribution of income policies. Nonetheless, a toolbox of technological and institutional solutions exists. We expound on some of the tools we regard as promising in the hope that some combination of them proves to be effective.

In Chapter 3 we conjecture about new and forthcoming innovations that have to do with physical space, building shapes, real estate products, and innovations in the usage of existing edifices. What new structures

will be erected and lived in? How will we work in offices? What is the future of retail spaces? We start by highlighting some of the new types of buildings that are emerging. We talk briefly about the need for green real estate paradigms, and at length about how the 21st-century transportation revolutions will impact real estate. New modes of human interaction with space are additionally explored.

We then move in Chapter 4 to the technological building add-ons: sensors, cameras, computing devices, networks. Automatized feedback loops will make building operations more efficient and seamless. Data analysts will strategically use the engineering, behavioral, and financial data generated by these devices to improve our quality of life—and corporate bottom lines too. Combining the Internet of Things with data clouds and machine learning will make our buildings smarter; with some becoming akin to giant robotic structures.

Chapter 5 discusses computer and online technologies that are transforming the property market without changing its physical structures. New business models are emerging to facilitate transactions and leasing. Business leaders increasingly are making decisions based on analyses of big data. And internet crowdfunding has become a viable alternative for raising capital. 3D models and augmented reality are literally changing the way in which we see the built environment, and they ultimately will effect its design, development, and construction management processes. Dozens of internet startups are being born to support the real estate services industry. And more are on the way. How many of them will survive and prosper?

Chapter 6 summarizes the highlights of the report: trends that we feel most comfortable betting on. We hope readers enjoy this voyage through our imagined future of real estate as much as we enjoyed writing about it.

1 Demographic Change and the Future of Real Estate in the United States

In many European countries and Japan, demographic forces that formerly had fueled the growth of real estate markets are on the wane. Population growth is declining or negative, and household sizes are stabilizing, suggesting that real estate growth in these countries will remain lackluster. Most new development will take place in the more prospering cities, drawing residents from declining areas and rendering the housing in those areas obsolete. Additionally, the real estate construction sector will benefit from the renovation and upgrading of the existing stock, which includes redevelopment (teardowns leading to new construction), additions, renovations, and retrofits.

In the United States the construction sector will profit from the same trends. However, the real estate development engine in the U.S. has some additional fuel to burn due to the expected positive growth in the number of households. Forecasting exact numbers of real estate developments is fraught with uncertainty (Belsky et al., 2007). The most recent projections from the census have the population of the United States growing from 319 million in 2014 to 417 million by 2060, which will require 38 million additional housing units. Demographic growth is expected to be relatively faster in the short run, increasing by 2.68 million people a year between 2014 and 2020, when the US population is projected to reach 334 million (Colby and Ortman, 2015). Therefore about a million households will be formed annually in the next few years, and all those people will require shelter.

Census estimates for 2010-2016 show an average of just 665,000 new housing units were added each year. Indeed, some commentators have raised fears about a housing shortage in the country (Williams, 2016). Recent census counts of housing unit completions (Hardin and Wolverton, 1999) are more optimistic, showing that 1,164,000 new homes were built in 2016, up from around 600,000 in 2012. The net growth in the number of housing units is less because that figure also considers housing that has been removed from the available stock. The data capture the cyclical pattern of the economy, with new home construction decelerating after the 2008 recession and then picking up steam progressively.

From 2010-2016 aggregate numbers, we hazard to extrapolate an average net housing shortage of 345,000 units per year from mid-2008 through mid-2016. This shortage indicates a potential for catching up to the net addition of 2,760,000 units. Using the ratio of removals from the stock (0.25

percent) reported in Belsky et al. (2007) , every year sees the destruction of 350,000 units. Therefore, we may need to build 1.35 million units per year to accommodate projected household natural growth. Adding the above catch-up requirements—spread over a period of 10 years—it would not be unreasonable to expect new housing completions to surpass 1.65 million per annum soon (2018-2026).

Of course, these rough estimates do not take into account the extent of potential over-construction during the 2003-2007 boom, and they disregard the possibility of permanent adjustments to housing vacancy rates. For instance, reduced mobility may imply that homes stay vacant less often. If vacancy rates are lower, we can house more people with the same amount of real estate.

Forecasts are also contingent on the accuracy of past census counts, the actual rate of obsolescence of existing real estate, assumptions about the evolution of household sizes, and the extent to which population growth estimates turn out to be correct. It is therefore highly speculative to quantify the development of the housing stock over the longer run. Its is even harder to forecast the evolution of construction in commercial real estate. However, some trends and innovations in the demographic underpinnings of real estate markets are already apparent and deserve attention.

Immigration

According to census projections (U.S. Census Bureau, 2017), native-born mothers will give birth to 156.8 million new babies through 2040. These newly minted citizens will not quite replace the 162 million people who will die during the same period. Hence, immigration and its echo boom—children born of foreign parentage—will be the main forces keeping America demographically vigorous.

In all, 64 million immigrant arrivals are forecast by the census though 2040. Foreign mothers are expected to have an additional 40 million babies born in the homeland. These two figures total the expected growth of the United States. The evolution of new real estate development is thus reliant—to a great extent—on the growth of the foreign-born population.[1]

Of course, there is substantial uncertainty about the numbers of new immigrant arrivals and their subsequent offspring. Immigration reform is a subject of considerable debate. Recent political trends would suggest that

[1]This does not technically mean that all *net* growth will be fully accounted for by the foreign born population since many of the deceased will be foreign-born, implying lower *net* foreign population growth.

immigrant arrivals may be reduced in the future. If more restrictive immigration policies come to pass, we should expect less real estate development. It nevertheless is perilous, and probably unwise, to forecast what the future holds, particularly in the political realm.

The impact of immigrants on local U.S. housing markets has been widely documented. Across metropolitan areas, the population pressure exerted by immigration tends to push up average home values and rents in destination cities (Saiz, 2003, 2007; Ottaviano and Peri, 2011; Vigdor et al., 2013). A general rule of thumb is that for each immigrant inflow amounting to 1 percent of the original metro population, we can expect average housing rents to increase by an additional 1 percent. Housing prices may increase by a bit more, depending on the market.

Nevertheless, immigration settlement patterns have heterogeneous impacts *within* metropolitan areas. Compared with the metro average, housing price growth is relatively lower in middle-to-high-income neighborhoods that receive immigrants who have little education (Saiz and Wachter, 2011). Unfortunately, there seems to be a phenomenon of "native flight" out of middle-class neighborhoods where immigrants with low earning capacity settle (Cascio and Lewis, 2012). This effect is absent, however, in low-income neighborhoods. Because housing prices and rents are growing on average in immigrant gateway cities, very-low-income areas with migrant arrivals may be experiencing a revitalization effect. Paradoxically, however, most of the growth in real estate values in immigrant gateway areas is expected to happen in predominantly native neighborhoods that are distant from enclaves where immigrants tend to cluster.

The distribution of immigrant skills in the country is bimodal, meaning that we receive inflows of both immigrants whose education and credentials are below average and very highly educated ones. According to the National Foundation for American Policy, 42 percent of the top cancer researchers in the nation were born overseas. Borjas (2005) reports that 50 percent of engineering doctorates in the U.S. are awarded to young, foreign, bright individuals, about half of whom stay in the country. The phenomenon of native flight is absent in the data concerning highly skilled immigrants because their housing tends to decentralized: They do not cluster in neighborhoods close to one another.

In sum, all the net gains in the number of housing units in the near future will be determined by the number of foreign citizen arrivals and their offspring. Metropolitan areas that have stronger foreign population inflows will unequivocally experience higher average housing prices and rents. However, the heterogeneity of home values and ethnic segregation

by neighborhood will increase in cities that receive substantial arrivals of relatively less-educated immigrants. As a result, "fortress" native white developments will become disproportionately more expensive.

Aging

Although the future resident alien population is difficult to predict, we are certain that the U.S. population will be getting older. According to the latest census forecasts, “Between 2012 and 2050, the United States will experience considerable growth in its older population. In 2050, the population aged 65 and over is projected to be 83.7 million, almost double its estimated population of 43.1 million in 2011” (Ortman et al., 2014). In percentage terms, the share of the population aged 65 and above will shift from 13.7 percent to 21 percent. The growing cohorts of "golden boys and girls" will require adequate housing and are bound to demand a higher quality of life than their forebears.

At the regional level, the implication is that states that cater to retired—but still active—individuals, such as Florida, Arizona, and New Mexico, can expect to retain this important driver of economic growth and real estate demand. Other implications for the future of real estate revolve around which products and locations seniors will prefer and be able to afford. While in a few dozen cities active seniors may now be moving back to denser urban downtowns, the general trend in the United States is still toward increased suburbanization of the elderly population (Kolko, 2016). Although we believe that a great opportunity for active senior housing awaits in denser urban cores, we will have to confront a key real estate question posed by a growing suburban elderly population for years to come: will those who remain in their current geographic areas downsize to smaller living quarters or stay in their homes?

Many older homeowners tend to have high- or full-equity stake in their house. This is due to their enjoying lower outstanding mortgage amounts as a percentage of home values. Thus, their cash costs of staying in place are relatively small. This could make it easier for active seniors to remain in their existing units, even if they do not fully utilize the space. Also, research shows that older homeowners tend to "downscale" on housing by reinvesting less in renovations and maintenance (Davidoff, 2006).

Some elderly persons become limited in their ability to carry out daily activities independently. As we become more of a country for old men and women, life expectancies also will grow. Those who reach 65 are expected to live an additional two years as of 2050 (Feliz, 2012). Absent extraordinary

medical breakthroughs, more of us may end up with limited mobility and cognition. A potential path to jointly provide shelter and services (health, food preparation, daily activities) to such a growing segment of the population is through the development of assisted-living facilities.

We no doubt will see a flourishing of innovation in the design of assisted living facilities and the technologies therein. The ratio between dependents (senior and children) to workers will increase. Thus, perhaps sadly, some of the services in retirement homes will be automated, including sensors to monitor the evolution of residents, automated pill and IV dispensers, robotization, and other technologies that we cannot even envision today. Larger and more complex buildings used as assisted living facilities likely will emerge to take advantage of economies of scale in the provisioning of care. Larger complexes will allow for the social interactions between residents to partially substitute for paid services.

While land may be cheaper in exurban locations, we forecast a move away from isolated, stand-alone assisted living facilities and senior residences. Some of these facilities—only accessible by car and distanced from social, cultural, and retail opportunities—may still play a necessary role for many, due to their proximity and convenience. Nonetheless, we believe society will want to honor our seniors with richer social environments where they can promenade or receive help moving around. Ideally the elderly would have access to more varied entertainment opportunities and a diverse group of friends. Hence some new facilities will be sited in more urban environments.

We also look forward to the proliferation of "civic centers" in suburban and exurban environments: public buildings, schools, retail, multifamily units, mixed-use buildings—encompassing residential, office, and shopping space—and senior residences, all clustered in proximity. In addition to serving our elderly, such future civic centers have the promise of facilitating social interactions across age groups, anchoring smaller local retail and entrepreneurial activities, providing a sense of identity, and facilitating leisure opportunities and active lifestyles.

Due to financial constraints on private individuals and Medicare, some of the attention required by seniors with reduced mental or physical capabilities may also need to be provided by family members. Extended families will still look for comfort and privacy in their living arrangements. Therefore, in suburban environments, we could see growing interest in "intergenerational compounds," consisting of a conventional unit with either adjacent in-law buildings; attached additions; finished basement with bathroom and kitchenette; or a garage retrofitted to house the elder members of

the family.

Architects and interior designers will no doubt come up with numerous incremental design improvements to make homes more comfortable for their older customers. So will city planners and architects working on commercial real estate and hotel projects. As Stefano Recalcati, the leader of a recent report about urban planning for the elderly by the architectural firm Arup, succinctly declares, "Small innovations can make a difference" (Grahame, 2016).

Other arenas where we will see robust real estate development and new design are hospitals, outpatient care buildings, and end-of-life care facilities. An additional interesting trend to watch will be the evolution of retail environments to accommodate the tastes and spending patterns of seniors. Current shopping malls still seem relatively focused on young families and teenagers. Providing accessible spaces with more entertainment options and services for the elderly and monetizing senior pedestrian traffic flows will progressively necessitate more time and attention from retail strategists.

Household Composition

The way in which we live is summarily captured by residential density. The following formula describes the number of housing units in a country: $Housing\ Units = \frac{Population}{Persons-per-Unit}$. For instance, if we have 100 people and, on average, four people live in each house, there must be 25 housing units ($\frac{100}{4}$).

The secular decline in the number of persons living in each home has been one of the historical drivers of real estate demand. In 1960, the average household size was 3.29 persons per unit, but in 2010 it was only 2.58. While the difference may seem trivial, it implies a housing stock that is 30 percent larger than it would have been otherwise.

However, the long-winding decline in residential density seems to be reaching its zenith. During the recent decade, residential density experienced a much smaller reduction. In 2000, the average household density was very close to today's: 2.59 persons per unit.

For comparison, in Norway—a Scandinavian country that has a low fertility rate and a low average propensity for marriage—the average number of persons per home is 2.2. The U.S. is unlikely to reach that number anytime soon, for many reasons. Most saliently, housing units are smaller in Norway, as people tend to cluster in very densely urbanized areas. Therefore, it would not be unreasonable to expect that over the next decades the average household size in the U.S. will stabilize somewhere between 2.45 and 2.55.

Indeed, best-in-class studies, such as Zeng et al. (2013), corroborate this expectation by providing detailed state-level forecasts. We thus expect smaller average household sizes to account only for 1 to 5 percent of extra units over the current stock. We are running out of fuel to keep building homes by the way of shrinking family sizes.

The flip side of the aging phenomenon is an increase in dependency ratios—that is, a higher percentage of the population will rely on a proportionally shrinking base of working-age adults. The dependency ratio can be defined as the population that is under 18 or older than age 64 divided by the number of those aged 18 to 64. According to census projections (U.S. Census, 2012), this ratio will climb from 59 percent in 2010 to 74 percent in 2050. In such an economic context, it is hard to imagine scenarios where the total number of hours worked by working-age couples and singles declines. Female labor force participation will probably keep on growing, making nonwork time for dual earners even more of a scarce commodity. The need for housing with convenient access to jobs for both women and men, transportation, schools, day care, grocery shopping, assisted living facilities, and family-oriented amenities will likely become even stronger. American families will look for housing environments where they can work, live, play, *and take care of others*.

A social trend that—in our view—has not yet been fully addressed by housing market typologies or policies is the proliferation of single-mother-headed families. According to a study by the Pew Research Center (2015), 26 percent of American children are now living in single-parent homes, mostly headed by a female. Another 15 percent of children live with one parent and their second-marriage spouse. And 7 percent live with one of their parents and a cohabiting—but not married—partner. These cohabiting relationships tend to be less stable and more prone to dissolution.

We will likely see future housing typologies address the needs of this growing segment of the population. Struggling single mothers hardly have enough time to juggle one or more jobs with child care, healthy meal preparation, and tending to housing needs. Potential innovations in this area include single-mother-oriented interior design and home technologies, co-living arrangements, cross-generational housing, apartment complexes with integrated services (day care, babysitting, healthy dining, homework assistance, parental coaching, child behavioral counseling), and other sorely needed but as yet unforeseen innovations.

Red Versus Blue

As we have seen, national demographic trends drive overall real estate development. Yet even in the absence of strong aggregate demographic change, cities in modern, mobile societies are effectively competing with one another to attract residents. New homes in a thriving city will be built to house residents from a declining metro area, whose housing stock consequently becomes obsolete. With regard to real estate development exclusively, intermetropolitan competition has the nature of a zero-sum game, wherein the gains of one party come at the expense of another's loss.

Table 1, adapted from U.S. Census Bureau (2016), shows the 50 fastest growing counties in the U.S. from 2010 through 2016. The data consider counties that have at least 5,000 housing units, and we use a red font to single out those that have more than 50,000 housing units. The columns alternatively show the number of housing units in both 2010 and 2016, its net change, and its percentage growth during this period. In the list, we find a number of mostly suburban counties in booming metro areas. These include Atlanta, Georgia; Denver, Colorado; Indianapolis, Indiana; Fargo, North Dakota; Jacksonville, Florida; Jacksonville, North Carolina; Nashville, Tennessee; Raleigh-Durham-Chapel Hill, North Carolina; and virtually all Texas metros.

Table 2 shows the same data by state. The columns display the number of housing units standing in 2010 and 2016, the total net change, and the percentage growth, together with the share of each state's net housing gain as a percentage of new homes in the United States. Texas, Florida, and the Carolinas alone amounted to more than one third of the net residential real estate development in the nation. The pattern of recent growth in housing seems to confirm the oft-cited 'blue state versus red state' dynamic, with Northeastern and Midwestern states, and to a lesser extent California, seeing growth rates below the U.S. average. Southern and Western states, in contrast, are growing very fast (together with the DC metro area).

A number of explanations lie behind this trend, but a particularly important one examines the role of housing supply in urban growth processes (Glaeser, Gyourko, and Saks, 2006). Although metropolitan areas are multifaceted and complex, a simplified model of their growth relies on classical supply-and-demand schedules from basic economics.

In this graphic model, we focus on the median price of housing, which we display on the vertical axis of the graphs in Figures 1 and 2, and on the number of housing units in the metro area (the horizontal axis). The latter figure corresponds to the quantity of goods produced and consumed, in a

Table 1: Fastest Growing U.S. Counties, 2010-2016

RANK	County, State	Housing Units: April 2010	Housing Units: July 2016	Net Gain	Percentage Gain
1	McKenzie County, North Dakota	3,090	6,592	3,502	113.3
2	Williams County, North Dakota	10,464	19,357	8,893	85
3	Stark County, North Dakota	10,736	14,534	3,798	35.4
4	Sumter County, Florida	53,026	68,199	15,173	28.6
5	Hays County, Texas	59,407	75,482	16,075	27.1
6	Dallas County, Iowa	27,261	34,535	7,274	26.7
7	Fort Bend County, Texas	196,748	242,441	45,693	23.2
8	Ward County, North Dakota	26,744	32,808	6,064	22.7
9	Morton County, North Dakota	12,079	14,660	2,581	21.4
10	Forsyth County, Georgia	64,052	77,444	13,392	20.9
11	Madison County, Idaho	11,287	13,561	2,274	20.1
12	Broomfield County, Colorado	22,638	27,087	4,449	19.7
13	Loudoun County, Virginia	109,448	129,914	20,466	18.7
14	Wasatch County, Utah	10,573	12,550	1,977	18.7
15	Cass County, North Dakota	67,939	80,248	12,309	18.1
16	Montgomery County, Texas	177,652	209,415	31,763	17.9
17	Burleigh County, North Dakota	35,755	41,962	6,207	17.4
18	Rockwall County, Texas	27,933	32,693	4,760	17
19	Douglas County, Colorado	106,859	124,755	17,896	16.7
20	Collin County, Texas	301,009	351,306	50,297	16.7
21	Comal County, Texas	47,106	54,803	7,697	16.3
22	Denton County, Texas	256,061	297,896	41,835	16.3
23	Hamilton County, Indiana	106,772	123,950	17,178	16.1
24	Bryan County, Georgia	11,835	13,640	1,805	15.3
25	Columbia County, Georgia	48,628	55,897	7,269	14.9
26	Williamson County, Texas	162,738	186,964	24,226	14.9
27	Williamson County, Tennessee	68,523	78,585	10,062	14.7
28	Boone County, Indiana	22,753	26,079	3,326	14.6
29	Onslow County, North Carolina	68,232	77,785	9,553	14
30	St. Johns County, Florida	89,829	102,280	12,451	13.9
31	Chambers County, Texas	13,293	15,106	1,813	13.6
32	Washington County, Utah	57,734	65,472	7,738	13.4
33	Richland County, Montana	4,550	5,157	607	13.3
34	Montgomery County, Tennessee	70,110	79,455	9,345	13.3
35	Bossier Parish, Louisiana	49,351	55,899	6,548	13.3
36	Travis County, Texas	441,313	499,062	57,749	13.1
37	Wake County, North Carolina	371,844	420,410	48,566	13.1
38	West Baton Rouge Parish, Louisiana	9,324	10,540	1,216	13
39	Guadalupe County, Texas	50,016	56,505	6,489	13
40	Wilson County, Tennessee	45,585	51,488	5,903	12.9
41	Uintah County, Utah	11,970	13,514	1,544	12.9
42	New Kent County, Virginia	7,296	8,217	921	12.6
43	Ascension Parish, Louisiana	40,774	45,878	5,104	12.5
44	Hancock County, Mississippi	21,868	24,605	2,737	12.5
45	Utah County, Utah	148,386	166,794	18,408	12.4
46	Rutherford County, Tennessee	102,962	115,467	12,505	12.1
47	Brazoria County, Texas	118,324	132,653	14,329	12.1
48	Osceola County, Florida	128,170	143,514	15,344	12
49	Gallatin County, Montana	42,289	47,345	5,056	12
50	Hoke County, North Carolina	18,191	20,355	2,164	11.9

Source: Housing Unit Estimates for the 100 Fastest Growing Counties With 5,000 or More Housing Units: April 1, 2010 to July 1, 2016. U.S. Census Bureau, Population Division

Table 2: U.S. States by Housing Growth, 2010-2016

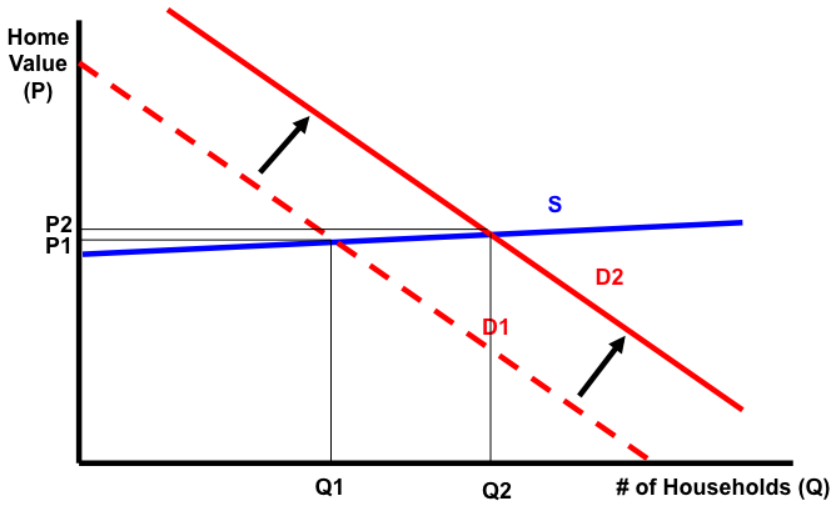
State	Housing Units: April 2010	Housing Units: July 2016	Net Gain	Percentage Gain	As % of US Gain
North Dakota	317,498	368,624	51,125	16.10%	1.28%
Texas	9,977,436	10,753,629	776,190	7.78%	19.44%
Utah	979,709	1,054,164	74,454	7.60%	1.86%
District of Columbia	296,719	313,718	16,980	5.72%	0.43%
Colorado	2,212,898	2,339,118	126,220	5.70%	3.16%
South Dakota	363,438	383,838	20,395	5.61%	0.51%
Delaware	405,885	426,149	20,259	4.99%	0.51%
Idaho	667,796	700,825	33,033	4.95%	0.83%
North Carolina	4,327,528	4,540,498	212,977	4.92%	5.33%
Washington	2,885,677	3,025,685	140,006	4.85%	3.51%
South Carolina	2,137,683	2,236,153	98,466	4.61%	2.47%
Arizona	2,844,526	2,961,003	116,484	4.10%	2.92%
Nevada	1,173,814	1,221,698	47,885	4.08%	1.20%
Tennessee	2,812,133	2,919,671	107,520	3.82%	2.69%
Nebraska	796,793	827,156	30,366	3.81%	0.76%
Virginia	3,364,939	3,491,054	126,115	3.75%	3.16%
Louisiana	1,964,981	2,036,975	71,995	3.66%	1.80%
Florida	8,989,580	9,301,642	312,059	3.47%	7.82%
Oregon	1,675,562	1,732,786	57,225	3.42%	1.43%
Oklahoma	1,664,378	1,721,045	56,668	3.40%	1.42%
Hawaii	519,508	537,114	17,606	3.39%	0.44%
Wyoming	261,868	270,600	8,732	3.33%	0.22%
Iowa	1,336,417	1,380,162	43,746	3.27%	1.10%
Georgia	4,088,801	4,218,776	129,894	3.18%	3.25%
Montana	482,825	497,756	14,931	3.09%	0.37%
United States	**131,704,730**	**135,697,926**	**3,992,791**	**3.03%**	**100.00%**
Arkansas	1,316,299	1,354,762	38,434	2.92%	0.96%
Maryland	2,378,814	2,447,127	68,267	2.87%	1.71%
California	13,680,081	14,060,525	380,439	2.78%	9.53%
Alabama	2,171,853	2,230,185	58,320	2.69%	1.46%
Minnesota	2,347,201	2,409,935	62,735	2.67%	1.57%
Mississippi	1,274,719	1,307,441	32,720	2.57%	0.82%
Vermont	322,539	329,525	6,987	2.17%	0.17%
Kansas	1,233,215	1,259,864	26,651	2.16%	0.67%
Indiana	2,795,541	2,854,546	59,049	2.11%	1.48%
Kentucky	1,927,164	1,965,556	38,398	1.99%	0.96%
New Mexico	901,388	917,568	16,169	1.79%	0.40%
Massachusetts	2,808,254	2,858,026	49,783	1.77%	1.25%
Missouri	2,712,729	2,760,084	47,358	1.75%	1.19%
New Hampshire	614,754	625,307	10,545	1.72%	0.26%
Wisconsin	2,624,358	2,668,444	44,089	1.68%	1.10%
New York	8,108,103	8,231,687	123,574	1.52%	3.09%
New Jersey	3,553,562	3,604,409	50,833	1.43%	1.27%
Maine	721,830	730,705	8,880	1.23%	0.22%
Alaska	306,967	310,658	3,688	1.20%	0.09%
Pennsylvania	5,567,315	5,612,002	44,702	0.80%	1.12%
Connecticut	1,487,891	1,499,116	11,218	0.75%	0.28%
Ohio	5,127,508	5,164,361	36,849	0.72%	0.92%
Michigan	4,532,233	4,560,055	27,788	0.61%	0.70%
Illinois	5,296,715	5,326,970	30,063	0.57%	0.75%
West Virginia	881,917	886,640	4,724	0.54%	0.12%
Rhode Island	463,388	462,589	-803	-0.17%	-0.02%

Source: Estimates of Housing Units for the United States, Regions, Divisions, States, and Counties: April 1, 2010 to July 1, 2016. Census Bureau, Population Division

conventional supply-and-demand graph.

The quantity of housing produced locally is both an economic variable and a demographic one. Given the number of people living in each unit and the number of housing units, one can easily obtain population estimates for each metropolitan area. The red, downward-sloping lines represent housing demand in the metro area: As the price of housing goes down, the city becomes more attractive (and current residents can afford to buy more housing). The blue, upward-sloping line represents the supply of housing: As home values go up, developers have more of an incentive to build more, which increases the total stock of housing in the city. The interaction of specific levels of supply and demand in the metro area determines housing prices and the stock of buildings: In the pictures these are denoted by the corresponding vertical prices and horizontal quantities at the exact intersection between the red and blue lines.

Figure 1: Slope of Supply Is Elastic

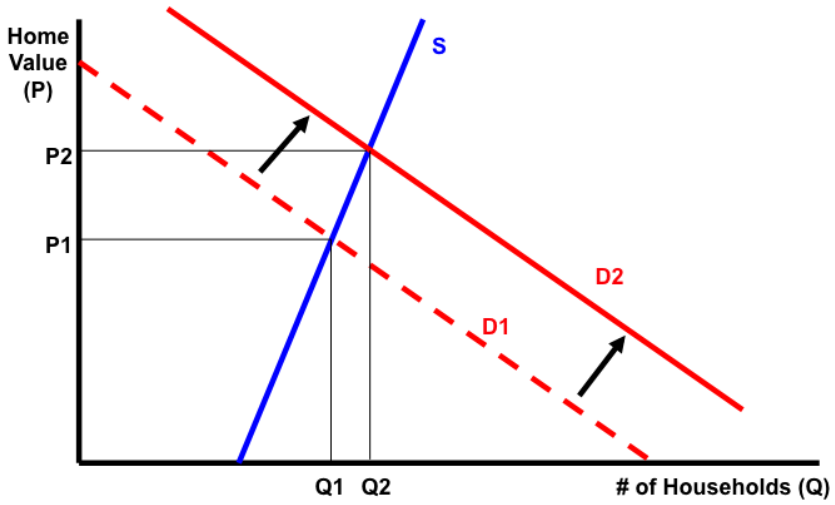


The slope of the blue line can be understood as a measure of how accommodating the supply side—the construction sector—in a city is with regards to changes in demand. The latter is represented by the shift of the demand function from the dashed red line (denoted by D1) to the solid line

of the same color (which we denote D2). The demand for living in the metro area, as shown in Figure 1, is growing, perhaps because the city specializes in thriving industries (such as IT or biotechnology) or because of better amenities.

In Figure 1 the market's housing supply easily accommodates the impetus from the increased demand for the city; this roughly corresponds to what economists call *elastic* supply.[2] The growing number of families vying to move into the metro area is accommodated via substantial additional construction (the number of housing units greatly increases from Q1 to Q2) at relatively smaller increments in home values (from P1 to P2). This situation corresponds to most of the booming metro areas in recent experience, such as Dallas, Jacksonville, Houston, and Raleigh-Durham.

Figure 2: Slope of Supply is Inelastic



In contrast, the housing supply schedule in the city represented in Figure

[2]Technically, the graphs should be in logarithmic scale in order to apply the concept of elasticity in comparing slopes. However, the intuition would be similar, and most readers can disregard this subtlety. Moreover, given that the initial prices and quantities (P1 and Q1) are the same in both graphs, the supply slopes are actually decreasing here with the price supply elasticities at the initial market equilibrium price.

2 is not very accommodating: It is *inelastic*. Here the increased appetite for living in the metro area results in very little construction (Q1 to Q2), and, consequently, in very modest population growth. Instead, the city's vigorous demand and scarce supply lead to much dearer real estate. High housing prices and rents in this successful but housing-inelastic city dissuade many prospective dwellers from moving into the city. They also may force existing citizens to move out. Figure 2 illustrates the situation in San Francisco, Boston, New York, San Diego, Portland, and Seattle.

The figures illustrate a very important principle that drives most of the regional differences in population growth across states: The demographic implications of urban success are strongly mediated by the housing market. In cities with many barriers to new construction, such as an inelastic housing supply, the economic success of the metro area will be translated into very expensive homes. Growing metro areas tend to be the ones that feature two characteristics: They are both successful economically and their local markets and institutions accommodate rapid real estate development.

Research on the determinants of housing supply elasticity (Saiz, 2010) points to two key factors. (1) Geography: Metro areas that are contiguous to large bodies of water and/or constrained by mountains—such as Honolulu in Hawaii—have more difficulty accommodating urban growth. (2) Policy: Municipalities in some metro areas seem to vigorously oppose real estate development. Citizens of all ideological persuasions in their relatively well-off suburbs tend to take 'not in my backyard' (NIMBY) political action against large development projects (Gyourko et al., 2007).

In our view, this issue is not an ideological dispute about laissez-faire versus government. Good urban planning is critically important to better growth. Municipal governments play a key role in ensuring fair taxation and the provisioning of local services, infrastructure, education, and social insurance to those who face less fortunate times. The problem is not with good, transparent, efficient, and swiftly implemented policies that ensure the *quality* of development. Rather, it lies with restrictions that focus on reducing the *quantity* of development. Anti-development pressures tend to be more acute in suburban areas; large cities can be more flexible. In some states, therefore, local government fragmentation might make the metropolitan housing supply more inelastic.

Changes to institutional and fundamental supply factors take time, and so we forecast that the basic development patterns that we have seen in the past will likely continue into the next decade or so. Successful metros in the Northeast and California will continue to get more expensive, while a large proportion of national real estate development and demographic

growth will continue to happen in the booming urban centers of the South and West.

We nevertheless look forward to policy changes in coastal supply-constrained areas. While their realization may require some patience, political capital for concerted action will gradually accumulate there due to 1) the lack of affordability; 2) the loss of the middle class; and 3) the lack of competitiveness due to exorbitant real estate prices. Re-emerging pro-development policy stances in expensive coastal metros will not seek to mimic patterns in the Sunbelt. Urbanization models based on speedy sprawl are unlikely to generate consensus in these regions.

We thus foresee within the next 30 years the revival of large-scale master-planned neighborhoods—similar to but not as large as "new city" real estate developments in China—or massive planned upzoning efforts (allowing for denser uses of land). Large master plans geared to facilitate real estate development may allow the public to shape—but not oppose—urban growth while they provide for mass-scale production of housing. Large-scale master planning can also allow developers to plan and phase the construction of projects with transparency and certainty.

In the future, we also will see ambitious transportation projects further open the hinterlands of our expensive coastal markets. These will require taxpayer buy-in and major fund dedications to transportation and infrastructure. Although it requires money, high-quality urban growth is likely to be cheaper than continuing to pay exorbitant housing costs in expensive coastal markets.

Consumer Cities and Creative Class

In the 21st century, cities are becoming important as both centers of consumption and mega-machines for production. Highly educated workers—with college degrees or equivalent—spend more of their lives without children due to delayed marriage, lower fertility rates, late child-bearing, and longer life spans at old age. And highly educated couples with children probably have become more prone to enjoying new experiences as families. As their incomes grow, they tend to spend more of their discretionary income on leisure-oriented goods and services. Some of these goods—such as fashion, watches, TVs, video game consoles, and smartphones—are manufactured today at lower costs than ever before, thereby requiring smaller relative disbursements. Hence, a relatively larger share of expenditures in this demographic segment becomes more and more devoted to local, personal, or leisure-oriented services: health, restaurants, coffee bars, babysitters,

counseling, yoga classes, jogging, birthday parties, theaters, sports, and a long list of other activities.

In this context, cities that offer a compelling package of amenities and lifestyle- or leisure-oriented services tend to be favored by highly skilled workers. These have been called "consumer cities" by Glaeser, Kolko and Saiz (2001), and similar trends were predicted by Florida et al. (2001) and Florida (2012). Note that economists broadly interpret consumption—as in reference to 'consumer' cities—as the enjoyment of both goods and services. Under the economists lens, social activities or the enjoyment of public spaces and natural amenities also are seen as consumptive, regardless of their price. Indeed, many of the attributes that make cities attractive, such as sunny weather, panoramic views, aesthetically appealing architecture, or good urbanism, do not require payments per use. Housing prices, however, can be interpreted as the 'ticket price' to live in an area surrounded by amenities.

In the 21st century, we have seen the Consumer City trend at work worldwide with the emergence of global lifestyle hubs, such as Paris, Amsterdam, Dubai, Hong Kong, Barcelona, Berlin, London, New York, San Francisco, Boston, Sydney, Vancouver, and Shanghai. But this is a wide, fractal phenomenon, with examples of lifestyle-oriented neighborhoods popping up almost everywhere in most developed and many developing countries. Indeed, Carlino and Saiz (2008) find that American inner cities are still not gaining ground, but their beautiful, recreational cores are.

Around the globe, "live, work, play" has become a fashionable mantra for urbanism and real estate development. This trend has spurred the rescue and redevelopment of historical neighborhoods. It also has yielded new and denser mixed-use developments that have active and walkable public spaces, and it has reinvigorated aesthetic concern for buildings as an ensemble, arguably stimulating better urbanism. In the United States, the New Urbanism movement has inspired a generation of urban planners, real estate entrepreneurs, and architects to aim for developments that beautify and improve the quality of human experience.

The resurgent prominence of quality urbanism in the United States is here to stay and will keep on energizing a segment of the industry. Yet large-scale, fast suburban developments and sprawl will thrive simultaneously. We have to be careful not to make judgments about what the phrases "quality of life" and "lifestyle" entail. Regulated sports, religious functions, all-out barbecues, TV watching, fishing, and outdoor treks also constitute positive, fulfilling, and enjoyable social activities.

We do forecast, however, that the yearning for a sense of place and a partial return to frequent bipedal mobility will accelerate in suburban and

exurban environments. This does not presage the demise of sprawling edge cities. Rather, sprawling areas will remain much as they are, but with the addition of denser town centers, or cores. Suburban cores will include an array of housing alternatives mixed with commercial uses and jobs in tall buildings. They also will host entertainment venues and be anchored by well-urbanized civic centers, including town halls, schools, and senior housing or services. Elsewhere within the suburbs, single-home, low-density residential development will probably keep pace, facilitated by electric—and eventually self-driving—vehicles. Suburban residents may then let their clean cars drive them to the core—in the afternoons or on weekends—in order to promenade; attend a fitness class; buy a coffee, the newspaper, and artisan goods; or play bridge at the senior social center.

While making judgments about lifestyle is perilous, statistical trends are undeniable. Young people who are highly-educated in the innovative economy—computer science, information technologies, media, finance, design, health, biotech, etc.—tend to disproportionately locate in central cities that have cosmopolitan, urban amenities (Carlino and Saiz, 2008; Couture and Handbury, 2016). Richard Florida denominated them the "creative class" in his eponymous book (Florida, 2002). The consumer city and creative class paradigms turn upside-down the classical pattern of people following jobs. To a degree, creative industries are now locating in desirable metro areas in order to attract and keep talent. A virtuous circle springs up in these areas, with the concentration of highly skilled, creative workers accelerating the creation of new startups. Even an American icon such as General Electric is reinventing itself by moving from suburban Connecticut to its brand-new Boston headquarters: GE Innovation Point. GEs Vice President Ann Klee explains why, saying 'It was the obvious choice. Boston offered so much: a great innovation ecosystem, a huge talent pool, great leadership, wonderful quality of life, great airport. It was the perfect choice for GE.' (Gellerman, 2017).

This trend of an increased concentration of creative workers will keep on favoring attractive consumer cities that are heavily exposed to the medical, high-tech, IT, media, and design sectors. However, concerns are arising about these creative class cities because the arrival of highly paid professionals puts pressure on their housing markets, thereby displacing less-well-off residents. The risk of successful, high-tech, high-amenity cities becoming "playgrounds for the rich" has been emphasized, for instance, by urbanist Joel Kotkin. A recent book by Richard Florida also disparages the trend (Florida, 2017). Florida proposes holding tech companies financially accountable for the displacement of the working class by gentrifying geeks.

We agree that affordable housing issues in creative consumer cities need to be addressed. In the following chapter we envision a number of viable avenues in this arena. We also agree that some of the value generated with public funds and common resources should be partially captured for the public interest. Nevertheless, it is interesting to clearly define the nature and extent of the problem. The American cities with extensive gentrification—e.g., Boston, DC, New York, San Francisco, and Seattle—happen to be those with a quite inelastic housing supply. As in Figure 2 above, their economic success and vitality translate into people wanting in, thereby pushing up rents. In these cities, *any* alternative source of economic success would have resulted in more expensive housing. While anti-poverty policies will always remain a key concern, additional supply-side policies will unavoidably have to be considered too.

In such supply-constrained cities the problem can be exemplified by the following parable. Imagine that a school district commissions a school bus that has a capacity for 72 kids but that initially is used to transport 50. As school enrollments increase, our young passengers will feel more and more crammed in. When the number of kids in the bus reaches 85, there will not be enough seats for all passengers. Stronger older kids probably will push little ones out of their seats. The most vulnerable may suffer the most, having to stand on most trips or even be unable to board. In this situation, it is critical for the school district manager to protect the younger kids and ensure an equitable and fair allocation of seats. But it is also a good idea to consider ordering a second bus.

Problems in supply-constrained cities notwithstanding, there are many instances where improvements in the quality of urban life and the attraction of creative workers have been unambiguously positive. Cleveland, Oklahoma City, San Antonio, Indianapolis, Austin, Boise, Pittsburgh, and others have been positively impacted by urban beautification. These cities are now managing to attract, train, and retain a highly-educated worker base. And their creative class will act as an economic anchor. Since in these cities housing supply is very elastic—in some, real estate values are actually below replacement cost—housing issues are less pronounced. These cities, perhaps less glamorous to some, have counterparts all over the world, and they will continue to thrive in the future.

2 Affordable Housing

Access to affordable housing is fundamental to the health and well-being of Americans. In many cities, however, reasonably priced housing is hard to come by at market rates. In addition, subsidized housing cannot be made widely affordable to the truly underprivileged. The rule of thumb that households should not spend more than 30 percent of their income on housing has been a foundation of U.S. housing policy for more than three decades (Pelletiere, 2008). However, the financial capacity of every family varies depending on its income and size. Higher-income households can often spend more than 30 percent of their income on housing and still have adequate access to necessities, such as food and medical care. In contrast, large relative shares of housing expenditures do not leave much discretionary income to low-income families.

The reasons for current affordability problems are diverse, suggesting that future solutions also need to be heterogeneous. First, and perhaps most important, increased income inequality in the past two decades signifies that the income and wealth of low-income and middle-class populations has grown very slowly (Chetty et al., 2017). This problem is directly related to the labor market and not necessarily to inefficiencies in the housing market (Glaeser and Gyourko, 2017).

Fluctuations voters' appetites for national income redistribution policies make it difficult to ameliorate at the federal level the problems of growing income inequality and working-wage stagnation. Therefore, states and municipal governments are increasingly burdened with addressing social needs, of which the provision of shelter is fundamental. Paradoxically, many of the areas that have a higher degree of consensus for income redistribution policies happen to be those with higher construction costs and more expensive land. These metropolitan areas and states are suffering from the "double struggle" of lack of power over redistribution policies and a very high-cost housing base. Both factors limit the scope for feasible traditional, comprehensive, budget-centered policies and call for innovative approaches.

Second, the productivity of the housing construction sector tends to grow less rapidly than for other manufactured goods. While construction costs have not escalated much faster than inflation, they are climbing *relative* to other consumer goods. Combined with flat income growth in real terms, this implies rising housing expenditure shares for the poor and for wide sections of the middle class (Albouy et al., 2016). Also, a few particular and prominent cities in the affordability debate have experienced faster

inflation of construction costs than the U.S. average (Gyourko and Saiz, 2003). Innovations in design, products, construction techniques, and materials could play a major role in curtailing this trend in years to come.

Third, some of the most increasingly popular cities in the United States, which have better amenities, access to education, and valuable better-paying jobs, happen to be severely constrained in the land available for real estate development. A number of them are in coastal or mountainous regions, which limits their potential for geographic expansion. In most of them, NIMBY and anti-growth municipal policies and regulations make it very difficult to build new housing at high densities (Saiz, 2010). In coastal high-amenity areas, land values have been escalating since the 1990s, and modest-quality suburban homes are almost impossible to build. These factors account for a good deal of their increasing unaffordability. Future solutions to mitigate these problems will necessarily involve changes in the use of urban land.

To complicate matters further, affordable housing developers and policymakers sometimes have multiple objectives that are not always easy to reconcile. These conflicting interests—which we summarize in Appendix 1—will require societal consensus above and beyond technological innovation. In addition, there seems to be a growing realization that traditional tools—including housing vouchers, rent control, and developer requirements—have not been able to resolve the nation's housing affordability woes. It is thus crucial to explore new models that challenge the existing paradigms. To this end, the rest of this chapter summarizes some of the alternative strategies that city planners, real estate developers, economists, and other urban experts have proposed to make housing more affordable, and that we forecast will grow in importance. Some of these involve primarily the public sector, but many others engage a much wider cast of actors, including enlightened real estate developers, nongovernmental organizations (NGO), and the users themselves.

Adaptive Reuse

Adaptive reuse is one of the promising alternatives that could provide affordable housing. It entails taking an older, vacant, and sometimes dilapidated property and repurposing it into affordable housing. In theory, preserving historic properties can act as a catalyst to reinvigorate areas suffering from urban blight and help strengthen their social fabric.

Retrofitting industrial buildings has become a leading trend. An excellent example is in Lawrence, Massachusetts, on a site located on 2.6 acres

along the city's main commercial strip. The firm WinnDevelopment used state and federal tax credits to retrofit two historic mill buildings into a mixed-income housing project. Ninety-five percent percent of the units have been set aside for local workforce housing. Extensive on-site amenities include an indoor play area complete with climbing structure; an indoor track; a fitness center; a lounge room with catering kitchen; a media room; and outdoor patio areas.

In Denver, developers are increasingly pursuing adaptive reuse opportunities to build communities that combine affordable and market-rate units. The restoration and adaptive reuse of the Kuhlman Building provides 49 rental units affordable to households earning 60 percent of the area's median income or below, and 27 market-rate row houses. Other proposals in Denver's downtown area involve turning parking lots into apartments, offices, hotels, or other structures to reconnect the urban fabric.

A team from Savannah College of Art and Design is conceptualizing studio apartments that fit inside a single parking space. Each unit is fully equipped with a kitchen, a bathroom, and a flexible living space that can be used for sleeping, eating, working, or leisure. The prototypes also were designed with private outdoor spaces that take advantage of the parking deck's view of the city skyline. The installation includes a community garden lit with a daylight-harvesting system installed on the roof and a maker space where the apartments' occupants can 3D print specific accessories for their new home.

In another project, designed by NA NO WO architekci in Poland, three former farm buildings have been converted into a single health care and residential building complex for seniors. The entire complex—on a total area of 8,928 square meters—includes a rehabilitation center and is supported by a hotel, catering facilities, and cultural events.

Adaptive reuse projects leverage numerous underused urban structures to respond to current needs, frequently at a lower environmental cost than building new ones. Retrofitted projects are usually close to city centers, allowing incoming users to benefit from improved access to transportation and services. Adaptive reuse projects often provide promising opportunities for developers because frequently there is less competition than in standard affordable housing construction.

In practice, many of these ideas take time and money to implement—and often require changing building codes, zoning, and regulations. Hence, it is important for cities to adopt a creative mindset.

Adaptive Reuse for Immigrants

In 2016 more than 1 million refugees and migrants arrived in Europe. Innovative solutions have emerged as cities struggle to provide housing for everyone. The German government has allowed for zoning exceptions in new adaptive-use projects that offer housing solutions to refugees. In Berlin, for example, the Mezzahome project uses modular structures to transform abandoned buildings into new apartments. This self-supporting system is easily adaptable to different apartment sizes and family needs.

These types of projects provide property owners with an alternative that allows the transformation and occupation of space that otherwise would be vacant. Using advanced building techniques, developers can produce large numbers of relatively low-cost housing units and, with fewer adaptations, provide medium-term affordable housing for refugees.

The creativity unleashed by the new flexibility in municipal zoning for these projects in Germany has been remarkable. For example, a student-led project transforms vacant parcels using modules made of timber that can be constructed within one week and provide housing for up to 40 refugees. Architecture students at Leibniz University have designed a concept called Fill the Gap to build housing on underutilized spaces, such as above parking lots, on roofs, and in abandoned train stations. Other complementary solutions make the existing housing stock more flexible by designing temporary shelters that can later be transformed into schools.

Industrial Second-Tier Cities

Around many of our most expensive and successful metropolises, old industrial small cities or suburbs abound. Oftentimes these places are experiencing decline due to deindustrialization and blue-collar job loss. To some degree they resemble fractal, smaller-scale, mirror images of the rustbelt.

Newark, Elisabeth and Trenton, New Jersey; Worcester, Lowell, and Lynn, Massachusetts; Norristown, Pennsylvania; Yonkers, New York; Pawtucket, Rhode Island; provide some examples, but there are scores of smaller such places. These cities possess the basic infrastructure and urban qualities—a sense of place, walkability, architectural charm, civic buildings—to play an important role again in their metropolitan economies. The redevelopment or retrofitting of existing real estate provides opportunities for affordable housing. Of course, for such "rust cities" to be reintegrated into their metropolitan economy, comprehensive transportation or economic development strategies are required if jobs are to be made available to their

residents.

Inclusionary Upzoning

Income inequality is widening in cities around the globe. As a result, housing programs are promoting economic integration by offering an optional floor area bonus in exchange for the creation or preservation of affordable housing. "Inclusionary upzoning" policies increase the floor-to-area ratio (FAR) limits of a given property (i.e., they upzone the land) to capture part of the added value by setting aside some affordability requirements.[3] In other words, they require developers to sell or rent a portion (typically 10-20 percent) of the units they build at below-market prices. In effect, higher-income households cross-subsidize their lower-income neighbors in exchange for an increased availability of units for all.

This re-emerging trend is noteworthy for at least two reasons. First, tying affordability to upzoning is an efficient mechanism for cities and denser suburbs to harness the demand for urban living while addressing affordability challenges. Such initiatives can be designed as a win-win inasmuch as gains in density would not have happened without partial public capture of the value released by upzoning. In other words, they display the potential to increase the supply of both market-rate and subsidized, means-tested units. Second, these practices can facilitate inclusionary outcomes in places where legal, market, or political barriers have historically impeded the adoption of affordable housing.

Admittedly, such a strategy can be successful only in areas where new housing demand is robust. Otherwise, developers will prefer to build fewer units at existing or even lower densities, which can result in less total affordable housing supply. After all, it is cheaper to produce low-rise garden apartments than high-rise towers.

Inclusionary upzoning policies can take several forms. They can be mandatory or voluntary. Their implementation can vary by neighborhood. But they tend to fall into one of three categories:

- Voluntary inclusionary housing policies tied to specific areas (examples: New York City; Arlington County, Virginia; Santa Monica, California)
- Voluntary inclusionary housing policies that apply whenever a developer seeks a zoning change (example: Boston).

[3] Broadly defined, FAR ratios result from dividing the total built area of a building—encompassing units in all floors—by the land area of the building lot at the surface.

- Mandatory inclusionary housing confined to areas that have been upzoned (example: Redmond, Washington).

The city of Boston, for example, fine-tunes affordability requirements on a neighborhood-by-neighborhood basis via comprehensive rezonings. In 2015, the city produced 1,718 affordable units and generated an additional $32.3 million in fees that support affordable housing citywide (National Housing Conference, 2015). Developers have the triple option of building affordable units within the development, erecting them off-site, or paying a "buyout fee." Collectively, New York City, Boston, and Redmond have generated over 4,000 affordable homes through inclusionary upzoning.

As stated, the effectiveness of inclusionary upzoning varies depending on the neighborhood context. Research suggests that inclusionary upzoning is especially well-suited to communities that have hot housing markets, low base zoning restrictions, and districts where residents are supportive of greater development intensity (Hickey et al., 2014).

Densification, Infill, and Reduction of NIMBY Pressures

The term "infill" describes the development of new buildings on vacant properties within existing urban neighborhoods that are otherwise largely developed. This strategy typically involves policy reforms that allow 1) land reconfiguration by way of parcel subdivisions or consolidation; 2) higher densities and building heights; 3) conversion of industrial or office space to residential use; iv) relaxation of minimum parking requirements; and 4) the streamlining of the construction approval process. The goal is to shift cities into greater sustainability by enabling increased home production, reorienting neighborhoods to the transportation infrastructure, and revitalizing aging property stocks.

Infill is gaining in popularity among developers as central city locations become more attractive to prospective home buyers and to office and retail tenants. The infill development strategy minimizes infrastructure and future transport costs, including residents' vehicle expenses as well as indirect costs such as road and parking infrastructure requirements, congestion, accidents, and pollution (Litman, 2016). Municipalities encourage the practice of infill because it is more efficient to use existing infrastructure close to town centers than it is to extend it farther away.

Infill development can also help neighborhoods sustain thresholds of population density necessary for amenities such as park space, community services, retail establishments, and affordable housing. In communities

where undeveloped or vacant properties are safety hazards, infill development removes blight. In Portland, for example, a comprehensive plan highlights strategies to attain higher-density infill development while preserving cherished aspects of neighborhood character.

By releasing more land into the market, urban and suburban infill strategies can reduce the price of housing. Hickey et al. (2007) show substantial differences in pressures against new housing developments across metropolitan areas in the U.S. Anti-development policies occur because citizens prefer no construction to the perceived alternative: NIMBY, as defined by Frieden (1979). As we have seen in the previous chapter, very restrictive land-use policies can lead metropolitan housing markets to respond to employment growth with faster housing price inflation.

Because citizens always need to be listened to, NIMBY pressure cannot simply be legislated away. The future probably will bring both new housing development models with amenities that are attractive to existing residents and more aggressive political marketing that favors affordable housing development. The focus will move away from public engagement strategies that question *whether* development should happen, and toward those that empower residents to shape *how* it will happen. We may also see the emergence of bipartisan political platforms that build the necessary consensus to re-densify our most expensive and desirable cities.

Suburb Beautiful: Comprehensive Suburban Master Planning and Place Making

Reducing NIMBY pressures in the suburbs requires building coalitions and garnering support from local communities. This can be done by offering a positive holistic vision for development. In some cases this underscores the need for large master-planned neighborhoods that offer plenty of amenities to be enjoyed by all in town. A prototypical NIMBY situation pits developers of a multifamily project against its immediate neighbors. But to be fair, many scattered, isolated multifamily buildings do not add much to their surrounding communities.

The execution of suburban development master plans can add value to existing residents' lives by delivering mixed-use, walkable town centers that provide amenities such as parks, promenades, playgrounds, and restaurants. These large-scale, multi-period developments can also anchor civic activities—festivals, farmers' markets—or integrate and centralize public buildings—senior centers, libraries—in a convenient and enjoyable location. Existing residents may be even more likely to support such plans if

they bring permanent local jobs, have well-designed positive impacts on local education systems, and replace previously developed sites that were eyesores.

At the turn of the 19th century, the City Beautiful movement was an urbanistic and civic movement that emphasized aesthetic virtues and the ubiquity of public spaces in urban development. We would hope for a Suburb Beautiful movement to emerge in the 21st century in our most expensive metro areas, focusing on affordable suburban development at higher densities, but with strong aesthetic qualities and the provision of services and civic venues to existing residents. The role of civic associations and local colleges may be important here because most suburban cities and towns do not have the technical or financial capacity to invest in large-site design and planning.

An example of a large-scale multifamily suburban development in a very expensive market is Union Point in Boston's southern suburbs. The master plan encompasses 1,450 acres on what previously was the site of a naval base. Two-thirds of the land will be kept as open space. The neighborhood is expected to eventually include 4,000 housing units and more than 9 million square feet of commercial space. There are plenty of amenities to make the development attractive to existing residents, such as 50 miles of trails, a walkable downtown with cafes and restaurants, and retail. The developers also are building a sports complex with "three multi-use turf fields with domes, a regulation turf rugby field, outdoor basketball and pickleball courts, a Wiffle ball field, a park with a playground, a dog park and a full-service restaurant. The existing gym will be completely redone as well" (Trufant, 2017).

While this and similar developments target middle-class dwellers, affordable set-aside requirements provide some help. More important, by increasing supply, *such projects avoid gentrification and displacement in other areas of the city that otherwise would have accommodated the growth of the middle-class segment*.

Micro-Units

Small spaces have become widely talked about wherever housing prices increase and people want to live closer to work. A micro-unit is a small studio apartment, typically less than 350 square feet, with a fully functioning kitchen and bathroom. Micro-units were initially conceived to take pressure off of the middle- and low-income rental markets. However, until now they have mostly been a solution for transitional housing or younger, upwardly

mobile population segments. Arguably, they are unlikely to solve the housing affordability problems for working families.[4] In cities like Los Angeles, for example, micro-units are still mostly being used as transitional housing for formerly homeless individuals (Walker, 2015). Despite having a positive effect on housing affordability, they have not yet proved to be a permanent solution.

Some micro-unit examples have repurposed old commercial areas. In fact, America's very first indoor shopping mall, in Providence, Rhode Island, was transformed into a micro-apartment project (Berger, 2014). In San Francisco, Panoramic Interests has come up with a new mode to provide high-quality housing for homeless populations (MicroPAD). Their solution can be assembled quickly and is economically viable. Each dwelling comes fully furnished with a private bathroom, kitchenette, desk, and bed. Made from steel, with 9-foot ceilings, all in 160 square feet, a micro-unit tower could be built in nine months for 40 less than conventional project costs.

Urban compactness is ideal for efficiency, but how do we provide practical solutions to rising rents while making micro apartments livable and pleasant? To address this issue, the Changing Places group at the MIT Media Lab is creating a new generation of hyper-efficient and responsive furniture. The team deploys robotic tools that allow traditional furniture elements to transform and intelligently connect to the world around them. Since domestic activities do not all happen simultaneously, controlling furniture through robotics will allow spaces to flexibly adapt to our needs, rather than the other way around. The idea is to ensure optimal functionality by transforming interior environments at the touch of a button so that the same space has the flexibility to become a bedroom, a living room, or even a meeting room.

Despite the growing demand for micro-unit apartments, a germane question is whether these units are adequate to provide a stable housing solution for large sections of the working population. The worry is that structures abundant with tiny homes at large occupant densities will become new slums, as in turn-of-the-20th-century tenement housing. In many neighborhoods, larger housing units command a premium: The average price per square foot of larger apartments is higher than that of smaller apartments (Disbrow, 2013). Wherever large homes are preferred by the average consumer, developers will tend to oblige and produce more spacious units. In these areas, cheaper and smaller spaces (given countermarket pressure) may

[4]Transitional housing is an intermediate step between emergency crisis shelter and permanent housing.

mostly be occupied by subsidized, lower-income residents—potentially further stratifying inequality. Moreover, such occupants might prefer different accommodation choices at the same subsidy level.

Despite these concerns, micro-units are bound to feasibly occupy some niches as 1) *transient* alternatives for low-income and working families; 2) transitional spaces for young millennials who will accept small units to avoid long commutes—but who also demand top-notch common spaces and expensive services and amenities; 3) permanent or transient alternatives for very-low-income single occupants with limited options; or iv) transitional or second homes for middle-income baby boomers who can still live independently but are looking to downsize from a bigger apartment or suburban home.

Tiny Homes

Tiny houses are small single-family homes with an area of approximately 200 square feet. They are geared to resolving affordability issues—reducing expenses in electricity and heating—and addressing the need to mute the environmental impact of housing and its carbon footprint. Tiny homes can help with affordability by offering an option for people interested in an alternative lifestyle. However, tiny-home developments take up more land than multifamily housing, leading to reduced densities, greater land use, and increased transportation needs. Given that tiny homes lessen the cost of the house but not its land footprint, massive adoption by working families is unlikely.

Nevertheless, tiny houses can create opportunities for transitional housing and in underutilized space. For example, homeowners considering downsizing their yard space can benefit from the A Place for You initiative in Portland, Oregon. Given Portland's affordable rental shortage of 24,000 units (Flaccus, 2017), homeowners willing to share underutilized space in their backyard get an outbuilding for free, in exchange for an agreement to serve as a landlord for an otherwise homeless family. This solution provides more affordable housing units while making use of available and currently underutilized backyard space.

Co-living

In the United States and abroad, residential institutions, such as college dorms and assisted living facilities, have traditionally provided housing at high densities, combining relatively smaller rooms with shared common

spaces.

The IT revolution is opening new opportunities for shared living space. For example, the budding startup Nesterly, coming out of the DesignX accelerator program of the School of Architecture and Planning at MIT, proposes to turn two separate intragenerational living arrangements into one inter-generational share-space solution. The company is dedicated to solving the challenges of housing affordability for student guests and aging-in-place for older hosts. More than 54 million bedrooms sit empty across the U.S. every night. Nesterly's internet application facilitates a matching process that meets both parties' needs through task-housing arrangements. Young students can provide services and company to their elder hosts, in exchange for discounted or fully subsidized room and board. Elderly hosts can offer their guests plenty of underutilized space in their homes—space that is larger than what the host actually needs. The mismatch between social needs and housing space surplus is especially significant for the widowed.

Co-living arrangements offer yet another escape route to move us away from the one-size-fits-all ownership-with-a-mortgage model as the only way to provide affordable housing. Potential future models could incorporate co-living arrangements for divorced parents, single mothers, young professionals, at-risk youth coupled with host families, and others.

Sweat Equity

Sweat equity is an alternative to the traditional rental and ownership housing models that have been around for a long time. The NGO Habitat for Humanity uses the term "sweat equity" to define the hours of labor that homeowners dedicate to building or improving their homes (Habitat for Humanity, n.d.). This strategy reduces the amount of paid labor needed to build a house, which in turn helps reduce its cost. Additionally, the occupiers finish the construction themselves as they inhabit the unit, thereby instilling a sense of pride and ownership. Habitat for Humanity regularly uses sweat equity, garnering the efforts of the final users together with that of friends, family, and volunteers to provide affordable housing in the United States and throughout the world. The success of their model hinges on cooperation with public entities, community contributions, and the provision of education and on-site training to users who provide sweat equity.

The design firm Elemental provides another example of a practical solution that addresses the housing shortage in Chile. This solution, which

centers on a building typology that has "middle-class DNA," allows residents to add extensions and to partially auto-construct their units. The sweat equity approach allows flexibility in the housing production process, so that it can be progressively phased according to the family needs over time.

Building Cooperatives

In many European countries, and especially in Scandinavia, building cooperatives play a major role in the provision of affordable housing. Social developers and NGOs—the promoters—are at the center of the building co-op movement. The work of promoters often starts with generating a list of interested co-op homeowner prospects. Subsequently, they identify good sites for the development and do preliminary planning for the project. The promoters finally enroll co-op members who, after making a downpayment, become active shareholders. Upon construction, co-op members acquire individual ownership rights to their units and collective rights to common spaces in exchange for periodic fees. The management of the building is conducted by a private property management organization or by the promoters themselves. Promoters finance their operations through a development fee assessed to the construction cost of the building and, in some cases, via management fees.

For homeowners, the co-op development model can provide cheaper housing because all development profits flow back to members. Also, the financial costs of construction are lower due to the member installment payments made prior to and during the development process. These payments are substantial. The fact that all units are pre-sold makes the construction loan very safe for banks. Often co-op developments obtain better regulatory conditions from municipalities because of their social mission: higher densities, less onerous public-space or infrastructure set-asides, and so on. Finally, by timing their developments counter-cyclically and taking advantage of social policy mandates, cooperatives can obtain land at prices lower than those available to for-profit developers; for instance, from community land trusts or public land banks.

A way to make new co-op development even more affordable is for the construction loan to be assumed by all cooperative members as a collective liability. Mortgage payments are then made from regular co-op fees, which are higher in this model because they combine loan installments and management fees. Co-op members are responsible for covering any collection shortfalls in the case of default by any one member. Covering

shortfalls requires the existence of sufficient provisions (rainy-day funds) and a mechanism to repossess units from defaulting co-op members. In exchange, mortgage rates can be lower due to the reduced risk to the lender.

Building cooperatives are not to be confused with simple co-op structures of ownership geared toward providing services in common areas of condo buildings—typically in upscale neighborhoods. If structured as financially sustainable businesses and managed professionally, the former provide a vehicle for the market-driven provision of affordable housing. Moreover, they are likely to garner support from policymakers from all sides of the political spectrum. For some, building cooperatives represent community-driven initiatives in social policy and exercises in economic democracy. For others, they can be seen as entrepreneurial collections of people associating freely to pursue their mutual interests, working in fair competition with other economic agents. This model could gain traction in the United States at some point in the future.

Mixed For-Profit/Nonprofit Development

Hundreds of enlightened real estate developers and entrepreneurs are working every day in America to provide affordable housing to the middle class and those in need. A significant and necessary segment of the affordable-housing industry is formed by private and public organizations that work with government subsidies or tax credits.

Other entrepreneurs are finding ways to provide housing at a lower cost without large explicit government subsidies. These entrepreneurs tend to leverage some combination of five neighborhood-centered strategies: 1) improve neighborhoods by investing in an ensemble of complementary properties and at a large enough scale to have a positive impact on livability; 2) assist in the creation of social and cultural capital, thereby improving personal outcomes, and reducing the incidence of local tensions; 3) capture the financial value unleashed by better economic conditions and amenities—increments in value come from commercial and retail rents and (partially) through the sale of housing at improved market rates; 4) simultaneously cross-subsidize a substantial portion of local low-income tenants; and 5) assist long-term neighbors with job-training and business development skills.

For example, the Turner Multifamily Impact Fund focuses on for-profit inner-city redevelopment that has a positive social impact. According to an LA Times profile, its main sponsor, Bobby Turner, "believes his fund can be profitable by buying the same kind of mid-level apartments in gentrifying

neighborhoods that other developers also are eying However, instead of improving them with granite countertops, upscale appliances, and other amenities to raise rents, the plan idea is to improve security and offer social services that will make the buildings attractive to blue-collar and middle-income workers. Renters can make no more than 80 percent of a neighborhood's annual median income."

In Central America, the real estate company Conservatorio specializes in the redevelopment of historical, dilapidated neighborhoods in Panama City (Panama) and Tegucigalpa (Honduras). Its strategy combines the five points above with careful restoration of architecturally sensitive real estate assets, thereby increasing housing supply for both working-class locals and incoming professionals.

A new and growing generation of knowledgeable real estate professionals and impact investors hopefully will continue to use the tools of for-profit development to provide a mix of housing products, including cross-subsidies to affordable housing, hence stabilizing neighborhoods characterized by mixed incomes.

Dual Construction Markets

Some key construction markets in the country display high levels of unionization in the building trades. Trade unions display features that many people find positive. They reduce income inequality, can increase the training and qualifications of workers, productively mediate disputes between management and employees, facilitate the fair capture of part of the increases in productivity by labor, and have a fundamental role in ensuring the preservation of a working middle class, thereby shoring up local civic values.

However, observers have claimed that in some environments, building-trade union preponderance can also evolve in ways that impede innovation, create an adversarial culture, fail to promote minorities (Berman, 2015), and slow productivity growth.

In the United States, Gyourko and Saiz (2006) show that most heavily unionized construction markets tend to display higher construction costs, above and beyond what would be accounted for by the positive effects of unions on wages. This is not a clear causal relation but a correlation, and it is certainly possible that other factors impact the building industry in heavily unionized environments.

Nonetheless, because most believe that higher wages for workers are a positive outcome, future efforts are likely to be oriented toward *partnering*

with unions to make housing more economical for working families. The idea of dual markets hinges on working with building-trade unions to allow more flexible working practices in affordable housing projects.

In some localized areas of large metropolises—or in declining cities—it is not economically feasible to build new structures or retrofit old ones under the current cost structure. In these areas, development is not expected to occur. Therefore, it is a win-win for organized labor to allow for flexible practices in these projects, which do not compete with others and which generate a net positive increase in labor utilization. From the perspective of unions, these strategies should resemble those used by firms to segment markets into different quality-price structures in order to maximize profits. In this case, however, the objectives are worker earnings and employment as well as affordability for low-income populations.

For example, the Philadelphia Housing Authority and the building-trade unions in that city agreed in 2014 to reduce wage bills applied to affordable housing programs, which reduced the cost of the construction of each unit by $50,000. We believe that future efforts will focus less on the wages of union workers and more on other aspects of work organization. The first step is to identify the submarkets where development is not economically feasible under current cost structures. In these areas, cost reductions can be structured as win-wins for labor and developers.

The geographic extent of such affordable partnership areas (APA) can change annually in response to market conditions. Within APAs only the following types of agreements could be negotiated: 1) relaxing rules that require excessive time; 2) hiring local subcontractors in union apprenticeship programs; 3) using new technologies more intensively; 4) allowing the deployment of modular and prefabricated components; and 5) consensually making more flexible practices that otherwise increase costs at no risk to workers. We nevertheless believe that *rules geared to protect the comfort and safety of employees should be excluded from such negotiations and should never be relaxed*.

Cost-effective Construction Practices and Materials

Low-cost housing mass production is typically a critical component of economic development in rapidly growing countries. In the United States, pre-assembled materials, Taylorist management principles, and standardized home plans made possible the construction of massive post-war developments, such as Levittown (New York). Massive low-cost suburban construction allowed millions of families to own their homes.

In the 1960s Soviet Union, prefabricated concrete panels facilitated the rapid and cheap construction of large numbers of "Khrushchevkas," or small condos (400-650 square feet), that featured shared facilities in five-story buildings lacking elevators. Large portions of contemporaneous housing construction in China are taking place through the development of isolated towers that have moderate structural qualities and unfinished interiors. While it has to be acknowledged that mass-scale developments have provided affordable housing for the middle classes around the globe, many observers are critical of their aesthetic, urbanistic, and environmental attributes.

Aided by new technologies in materials science, building information model (BIM) software, 3D printing, and the rapid diffusion of ideas and plans over the Internet, a new revolution in low-cost housing is underway. This revolution will allow for ubiquitous cheaper construction, this time unleashing more creativity, flexibility, better aesthetics, and bottom-up thinking in execution.

For example, the Spanish startup ARCHITEChTURES has created BIM software that allows developers to quickly and flexibly design a vast number of alternative housing building specifications. Simple computer models, which combine standard units that exactly fit the site and provide sound structural engineering, can be put together in a few hours. Construction cost calculators in the software provide real-time estimates of infinitely possible building configurations. These models can be exported into computer-assisted design (CAD) software to add the desired architectural finishes. Although the models provide a standardized solution, the customization abilities of software can make the final products utterly innovative.

While 3D printing probably will not be feasible for the construction of high-rise buildings in the foreseeable future, it has the potential to quickly deliver smaller structures on the spot. Russian startup Apis Cor claims to be able to cut the construction cost of a modest single home by 40 percent using a large rotating arm that delivers ready-mixed cement and prints in 3D according to specifications. Its first prototype, a small 400 square feet home, was built in the Stupino town of the Moscow region at a reported cost of $10,000 (Marks, 2017). Chinese company Winsun has already successfully printed the materials to build some homes and assembled them on-site. There is no doubt that technology will allow us to print on larger horizontal footprints and at lower costs in the not-too-distant future.

Mark Goulthorpe, professor of architecture at MIT, is leading a multi-disciplinary team that is pursuing the design and production of low-cost, high-quality housing construction methods that use modular components

made of composite materials. Such petrochemical derivatives may become abundant if and when cheap mass-energy alternatives to hydrocarbons are found. These materials are durable, flexible, and recyclable, and using them to build structures prevents these compounds from being burned, thereby avoiding the release of greenhouse emissions into the atmosphere.

Improvements in prefabricated and modular building techniques are expected to accelerate construction timetables and bring down costs. In November 2016, Full Stack Modular delivered the first large residential modular building in the U.S. At 32 stories high, the apartment tower sits in the Pacific Park redevelopment in Brooklyn, New York. Costs and the time-to-development of this project exceeded original expected ones, unfortunately. However the company must be praised for advancing the American multi-family modular industry further along through its experimental period.

The Chinese builder Broad Group also has demonstrated the potential of prefab in tall buildings, by assembling the thirty-story New Ark hotel in the city of Chansa (Hunan Province) in the record time of 15 days. It has yet to be established whether modular and prefab approaches to large construction projects will deliver long-term quality improvements at a lower cost than conventional methods; currently we are going through a learning curve in their implementation.

A different strategy involves using modular prefabricated parts to build smaller "garden style" apartments or condos, which typically consist of clusters of six units within a two-story building. Swedish building company Skanska has teamed with furniture giant IKEA to push out its BoKlok concept. They use simpler prefab materials and modular, affordable components to build units on good—but not fully prime—sites. They also use easy-to-assemble furniture to fully-furnish them. This housing solution provides an affordable product in suburban locales. Also in Sweden, the company Lindbacks has brought affordable modular wood housing construction a step further into more densely urbanized areas, where it can build at six-story heights.

Other innovations are facilitated by the information technology revolution, which has allowed increasing global connectivity. The British NGO Wiki-House works on the collection and open-sourcing of ready-to-deploy CAD plans and BIM for affordable housing. Local promoters and architects will be able to streamline and accelerate the development of affordable housing by downloading existing plans, thereby reducing delivery costs. Soon socially minded architects and developers will be able to share their successful plans and techniques with thousands of entrepreneurs who are building affordable housing worldwide.

We are in a period of creative destruction, and some of the technologies, techniques, software, and materials that are appearing now may not survive as cost-effective ways to produce high-quality, affordable housing for the masses. However, within the flotsam of failed ideas, some innovations will change the landscape and make housing more affordable by reducing the cost of construction. These collections of new, successful ideas will not provide a one-size-fits-all solution but will give innovative developers and communities a set of techniques that can be adapted to local conditions.

Developing Rental Market Contracts and Organizations

Rental markets are key to providing economical shelter for working families and younger individuals. A robust rental market also facilitates economic and geographic mobility, thereby improving access to opportunity. The United States has a relatively fluid rental market, but in some metropolitan areas rentals are also becoming very expensive.

Available options to make rentals more affordable are somewhat contrived. Local rent control regulations, which have demonstrated their shortcomings in curtailing incentives to rental supply, are being abandoned throughout the country. Public housing is expensive to build and manage. In the United States, large housing projects have been widely perceived as reservoirs for social maladies. Providing good public housing is possible. However the fact that delivering high-quality housing services in their thousands represents a political risk for Mayors makes it unlikely that this option will experience substantial growth in the short run.

Section 8 program vouchers provide thousands of Americans with a checklike payment that can be used toward rental housing. The Section 8 program is an effective plan, but increasing the allocation funds for social policy at the federal level will continue to be challenging. Similar concerns affect the federal Low-Income Housing Tax Credit Program (LIHTC), under which developers raise funds to build and lease affordable rental units by selling federal tax credits to investors. Some additional concerns have been raised about how effectively the program increased supply. Some of the subsidies may accrue to developers who would have built the units anyway (Sinai and Waldfogel, 2005). In its current form, the LIHTC also has been criticized for disproportionately siting affordable housing buildings in low-income neighborhoods that provide poor access to jobs and social opportunities.

We envision potential opportunities in the growth of nonprofit organizations that are devoted to providing affordable rental homes. In the

Netherlands, 75 percent of that nation's 3 million rental units are provided by nonprofit housing associations. These associations purchase and develop apartments for rent. They compete with investors in the open real estate market. They also compete to provide high-quality services to their customers. These organizations are extremely agile, having to make investment and management decisions to survive in a competitive environment. Because they own the properties they rent, these organizations can deploy intelligent asset disposition and purchase strategies. They can, therefore, plow the gains from capital appreciation of their portfolio back into their social mission. At the same time, they syndicate their credit under a national government reinsurance guarantee, which makes them able to compete in the capital and property markets.

Other avenues for the further development of affordable units include the following: growth in the market for furnished rentals under more flexible contracts; the furtherance of rent-to-own structures; the development of mixed mortgage contracts, wherein the lender accrues some of the capital gains on home appreciation in exchange for lower financial payments (Shiller and Weiss, 1999); and the development of reinsurance markets to deal with tenant default risk.

3 The Impact of Technology on the Built Environment

In recent years, the manner in which real estate is delivered to consumers and workers has changed substantially. Innovations in hardware and software, data analytics, construction, and energy are affecting how people and companies work. This series of technological disruptions is driving well-positioned firms to reinvent their current service offerings and adjust to the changes in the demand for workplaces, buildings, and cities.

In this chapter, we identify some key examples where change and disruption are most prevalent and discuss their technological implications. We focus here on innovations that impact bricks and mortar directly or that will change our physical use of space.

3.1 Innovative Real Estate Products

Evolving Hotels

The hospitality sector is one of the areas that has been highly impacted by technology. The sharing economy (which we discuss below) has increased access to information, and the growing sophistication of the customer has made it harder to provide one-size-fits-all hotel concepts. Personalizing the guest experience is becoming critical at all stages—from the moment guests plan a trip to check-in, during their stay, and even after they leave. Consumers will be looking for on-demand amenities during their trip.

Several companies are adapting quickly to take advantage of the technological change. For example, Yotel is a luxury hotel concept that combines smaller, smart spaces with areas for co-working, social gatherings, and exercise. The company leverages the growth and adoption of mobile technologies to create a frictionless consumer experience. The company also integrates machine-learning algorithms to adapt to customer needs in real time. Examples of this include innovative ways to book, choose the layout of the room, and provide feedback after the stay. Yotel currently has ten city hotels primarily located in easily accessible urban centers across the United States as well as two airport properties, at Paris Charles de Gaulle Airport and Singapore Changi Airport.

The Henn Na Hotel in Tokyo illustrates this trend even more dramatically. As reported by the Japan Times: *"The reception desk is handled by robots that speak Japanese, English, Chinese, and Korean, as well as porter robots that help guests carry luggage to their rooms. Robots also handle tasks such as window-cleaning and vacuuming."* While eccentric to many, such experiences may cater to niches of faithful customers. More broadly, automation of

the check-in, check-out, and other services no doubt will become more prevalent.

Co-living

Co-living is an alternative form of housing wherein residents share living space and a set of interests and values. By granting amenities to the community, space to work, and affordability, co-living initiatives aim to provide an alternative to the traditional home rental and ownership models.

Co-living housing projects usually incorporate a mix of shared amenities and private spaces that have been specifically designed to encourage interactions among their neighbors. Although not meant to be permanent residences, they offer a high standard of service at a reasonable price for temporary or short-term accommodation.

Some examples of co-living include the Oslo apartments in Washington, D.C. and Common, which owns co-living apartments in San Francisco and Brooklyn (New York City). The Oslo apartments are specifically designed to make it easier to live with roommates. Instead of three or four people sharing one bathroom, each unit integrates some private space with shared living areas and a kitchen.

Common's developments differentiate themselves by offering joint activities for its tenants. For example, they provide furnished six-bedroom apartments, each with a shared kitchen, and communal activities led by a resident "house leader." Individuals enjoy separate living and communal spaces that can also be used for co-working. Renters, who are mostly students, pay around $1,800 to $1,950 a month (Cutler, 2015). Other examples of high-end co-living spaces include Pure House in Brooklyn and Krash in Silicon Valley.

Flexible Space in Retail

While technology poses challenges to retail businesses, it also offers new opportunities. Nowadays, retailers must find innovative ways to incorporate technology to provide unique value to customers. For some retailers, this means using analytics and incorporating customer management systems to provide a tailored experience through loyalty programs and in-store offers. For others, it means developing more sophisticated visual displays and ways to enhance the buying experience.

Access to new tools can help the consumer-goods industry reach, engage, and ultimately win over new customers. With the appropriate wireless

infrastructure in place, for example, retailers can offer personalized advertisements to customers who use a store's Wi-Fi system. Retailers can also provide wireless directories to help shoppers carefully search for products in big stores.

Despite the fact that e-commerce retailers are the primary beneficiaries of the rise in mobile devices, brick-and-mortar establishments will also take advantage of smartphone applications. Physical stores can differentiate themselves by making shopping entertaining and effortless, and by deploying tools that enhance business intelligence. Companies such as Bulleting, for instance, give online brands access to brick-and-mortar retail space without the cost or commitment of a traditional lease. It currently operates two locations, one in New York's SoHo and another in Williamsburg (New York City).

Similarly, retailers are deploying sharing-economy strategies in the areas of marketing and delivery. Some retailers are introducing programs that offer shoppers discounts in exchange for delivering orders to other customers. For example, UberRUSH is an on-demand network that facilitates peer-to-peer delivery at affordable rates.

Cities also are facilitating the creation of new kinds of retail that respond to new realities. London's Tech City, for example, has launched pop-up shops in Old Street station.[5] The city's transport authority is facilitating pop-up retail as a way to preserve place identity. Access to temporal stores lets retailers benefit from seasonal sales and better target each location to a particular audience by trial and error.

We foresee that periodic changes in the ecosystem of shops also will become commonplace in larger commercial properties. Malls will likely experiment with more seasonal or short-term offerings and rotate vendors across facilities. In properties that provide flexible programming, customers will enjoy a different environment every quarter or so. Retail centers may incorporate smaller artisan vendors, local products, and novel experiences. Space likewise will be flexibly allocated so that more successful vendors increase their footprint precisely at points in time when they are expected to sell more. A more flexible layout will require new ways of designing interior space in retail environments. It also will necessitate the sophisticated use of sales data and statistical thinking.

[5] A pop-up is a shop, a restaurant, a collection of shops, or an event that opens quickly in a temporary location and is intended to operate for a short period (Leinbach-Reyhle, 2014).

Data Centers

Historically utilized to host people and storage goods, properties have recently welcomed a new guest: data. Server farms and remote data storage facilities host the physical realization of the ubiquitous cloud. These new real estate products come with novel requirements and specifications, including energy and cooling needs. Large firms that provide data security, storage, and retrieval such as Iron Mountain, and major tech companies such as Google, Amazon Web Services, have become major real estate operators of their own.

It is difficult to know what kinds of fresh "tenant" will emerge in the years to come. Quantum computers will gain in popularity, and they could require storage in spacious and extremely cold rooms. The fabrication and handling of nanomaterials may become more prevalent, requiring super-stable buildings with stronger foundations. New uses of space, hitherto unknown, will no doubt emerge and require entrepreneurial brick-and-mortar solutions.

Robots

Robotization is now having a measurable impact on America's labor markets (Acemoglu and Restrepo, 2017). Robots have become a common staple in industrial processes. But their penetration is bound to increase even in the old-fashioned property sector.

To the dismay of human workers, robots might learn to perform basic janitorial services, such as trash collection and cleaning. Companies such as Roomba already offer self-driven carpet cleaners for small spaces, while Intellibot's automatons specialize in cleaning larger ones.

Automatons equipped with video cameras could also beef up security in public spaces. The demise of Steve—an experimental vigilance robot that accidentally fell into the artificial pond at Washington Harbour Mall—was mourned by some in jest. Nonetheless, Steve's creators at Knightscope are very serious about developing robotic devices that can move around and (using intelligent detection algorithms) monitor and tape illicit behavior.

In the construction arena, robotic machines with rotating arms and artificial intelligence algorithms can now lay sequences of bricks and cement to build walls. Fastbrick Robotics, with its concept Hadrian X, and Construction Robotics, which deploys its Sam 100, represent early examples. Robots that assist in the storage and retrieval of items also are revolutionizing the logistics of online delivery. The use of robots indoors will pose new design

and architectural challenges. Some buildings will need to be retrofit. Others will be designed anew with their robotic dwellers and workflows in mind.

Self-Assembled Materials

Researchers at the MIT Self-Assembly Lab are imagining a future where construction materials can metamorphose in shape, color, or texture. Some of their applications involve 3D-printing specific patterns into materials so that their contours change with environmental conditions (e.g., humidity). Another "*approach is to pour the material into an airtight fabric container that can be vacuum packed. This generates the pressure that causes the material to jam into more or less any desired shape. A few years ago, engineers at the Technical University of Delft constructed a bridge using this 'deflatable' idea*" (arXiv, n.d.).

Self-assembly is particularly studied at the nanoparticle level, wherein alternating physical forces yield specific material configurations. Applications in architecture and engineering will be multiple: Subjecting nanoparticles to precise conditions yields surfaces and building materials that possess desired characteristics (porosity, ruggedness, etc.).

Vertical Cities

For cities to accommodate an increasingly urbanizing population, some land-constrained locations will need to become denser and taller. The 'vertical city' solution is a Tetris-like arrangement of interconnected towers specially designed to support higher densities (Robinson, 2016). The key difference between a vertical city building and a traditional tower is that the former provides all the necessary functions that a city typically possesses, including recreational venues, open public spaces, social and governmental services, education, energy, and food production (Howell, 2016).

A current trend is for architects and designers to create large, multifunctional buildings that combine residential, hotel, and retail functions. One of them is the 180-floor skyscraper designed by the Italian firm Luca Curci Architects in the United Arab Emirates. The project incorporates sustainable technologies into a population-dense environment. Rather than being a self-enclosed structure isolated from the natural environment, the edifice displays large hexagonal apertures that allow sunlight to flow in naturally.

Another example is the Shanghai Tower, which may be the closest architects have come to creating a vertical city. Designed by Gensler, the building consists of a spiraling trunk that includes homes, shops, offices, and galleries.

The vertical city proposition is controversial. On the one hand, its advocates claim that these high-density towers will save energy, support a growing population, and help preserve land for food production, recreation, and habitat conservation (Robinson, 2016). Moreover, they argue that these structures are more convenient since they can accommodate distinct types of spaces and functions all in one building. Because mobility within them is vertical, such structures, the argument goes, can help mitigate pollution by reducing the need for costly transportation.

On the other hand, vertical city critics contend that high-rises are not the only means of increasing urban density. They claim that super-tall buildings undermine the character, social fabric, and public health of cities. Most saliently, they argue, these buildings keep people away from the streets, thus reducing the number of casual encounters that are crucial to the liveliness of a city and the creation of social capital.

We do not know if mega-scaled vertical cities will abound in the years to come. However, the generic idea of improved vertical connectivity is here to stay. In creative sectors, firms are trying to cluster their employees closer together in order to foster social interactions and the exchange of ideas. New "vertical campuses" include elements such as visibility across floors, open staircases or ramps, small personal elevators, and even slide chutes across stories.

3.2 Green Real Estate

The significant human impact on environmental and climatic conditions is undeniable. The real estate industry is reacting progressively to this challenge. The growth in the number of green buildings—frequently certified with the LEED (Leadership in Energy and Environmental Design) designation—certainly will accelerate. The bevy of techniques, trends, and innovations in this arena deserve separate study and cannot be covered in depth here. Nonetheless, we offer some brief thoughts:

Certification Versus Outcomes. Official certifications are nowadays essential to validate and promote environmentally sound construction practices. However, if green building and consumption principles become more widely accepted, the emphasis may shift from certification to the measurement of outcomes and environmental cost-benefit analyses that are unique to each project.

Materials. The revolution in construction materials will accelerate, including the use of renewable, recyclable, and biodegradable inputs, and many more that we cannot imagine today. For instance, recently *"students*

at the Digital Matter Intelligent Constructions studio at Barcelona's Institute for Advanced Architecture of Catalonia (IAAC) (...) created a composite facade material of clay and hydrogel, which is capable of cooling building interiors by up to 6 degrees centigrade" (Stott, 2015).

Retrofits. Sometimes the greenest alternative may not be building anew but adapting existing structures. While not all buildings are currently cheap to retrofit, we expect substantial cost reductions and experimentation in this area. Energy Service Companies (ESCOS), which offer a 30-year model of providing upfront retrofitting services in exchange for a revenue share of the energy savings accrued, provide an excellent template.

Ecosystems of Buildings. More energy savings and a lower environmental impact can be achieved by thinking of groups of buildings—and even cities—as ecosystems rather than considering each edifice separately. Some buildings can use the excess heat generated by others, for instance. In addition, it may make more sense for a solar park to supply energy to a whole block rather than install panels in each building.

Passive Homes. Passive architecture is geared to reducing the consumption of energy with simple, minimalistic design interventions. Such low-energy residences use the energy from people's body heat, electrical appliances, air circulation, and sunlight. Passive real estate principles and knowledge will expand in the residential and commercial areas.

Adaptation. If the worst climatic change predictions come to pass, an excess or a lack of water will occur in some regions. In a few cities, rising tides and waves may require that buildings be retrofitted, built anew, or protected to avoid water intrusion. Other settlements that become too dry may have to be abandoned or serviced by water transfer mega-projects. Alternative, more benign scenarios imply softer adaptation strategies. Uncertainty in this area is high.

3.3 Transportation and Logistics Innovations and Real Estate

For more than 50 years, American land use has developed with the utmost reliance on personal cars. Vehicle sharing, automation, and electrification present new challenges and also great opportunities for real estate and urban planning practitioners.

Autonomous Vehicles (AVs)

The American urban landscape relies heavily on the assumption that people drive to work, to home, and to consume. Current research shows that

automation technologies are likely to impact three main areas: individual travel decisions, the public transit system, and transportation logistics.

It may take some time for self-driving technologies to reach mass adoption. Numerous experimental cars are already on the roads. However, machine-learning algorithms will take some time to improve. Likewise, security and regulatory issues will not sort out immediately. Yet there is no doubt that driverless cars represent the future of urban transportation.

What effect will AVs have on real estate? One of the most commonly held theories predicts that self-driving cars will reinforce the demand for central-city living. In this scenario, fewer driverless cars—some with several concurrent occupants using ridesharing apps—will indefatigably pick up and drop off passengers. Demand for parking ought to decrease. Moreover, on-street parking should be replaced with bike lanes and wider sidewalks, while residential programmatic uses should replace garages.

It is also possible that autonomous cars will stimulate a new wave of suburbanization. Passengers will be able to work and even rest during their daily commute. AVs could accelerate sprawl by increasing the distances people are willing to travel (Childress et al., 2015). This acceleration in sprawl is the natural next step for areas that rely on private car usage and are underserved by public transportation. Without policies that encourage ridesharing of autonomous vehicles, reductions in travel time and cost will likely increase the number of single-occupant vehicle trips and their distances in sprawling metropolises.

Thus, we forecast that AV adoption will have two impacts: It will facilitate densification in metros that have strong urban cores, but it will also aid in the expansion of decentralized 'edge cities.' Our view is that dense urban areas a sprawling suburbs will likely diverge further in form and function.

The adoption of AVs could radically reshape transportation networks. Sensors will allow cars to travel faster in proximity to one another. Hence, travel times can be reduced, which will increase the capacity of highways and *possibly* reduce congestion. Carlo Ratti—director of the MIT Senseable City Lab—predicts that vehicle automation will result in 80 percent fewer cars on any given highway (Lubell, 2016). Hence, swaths of urban land currently occupied by roads could become available for redevelopment. Some experts believe that the biggest impact of AVs will be on parking. In denser urban areas, the need for parking space may decrease dramatically. Cars today not only occupy approximately 30 percent of urbanized space, but they also continue to be a dominating factor that influences the location of retail, offices, and industries. Even in Washington, D.C., which has a significant mass transit system, parking takes up close to 45 percent of the

downtown area.

Leading architecture firms are starting to build garages with exterior ramps so that the structures can easily be repurposed into office space. In Los Angeles, for example, AvalonBay Communities Inc. has begun work on an apartment development in the city's arts district that has parking garages specifically designed to be convertible; the project anticipates a time when excess parking spaces may not be needed (Sisson, 2017).

Electric Vehicles (EV)

Developers are betting that electric cars will become even more popular with potential home buyers. According to a recent study from Bloomberg's New Energy Finance, EVs could become a more viable alternative to gasoline or diesel cars because of reductions in battery prices. The study predicts that sales of electric vehicles will reach 41 million by 2040, or about 35 percent of new car sales around the globe (Randall, 2016).

Across the U.S., high-end residential buildings are including electric vehicle charging stations as an amenity. In South Florida, for example, developer Mast Capital is building 3900 Alton, an eight-story condominium in Miami Beach. Designed by Spanish architect Ricardo Bofill, the 78-unit building will offer multiple EV charging stations.

Other initiatives like ReachNow are mimicking car-share programs such as Zipcar. Users book cars via an app and pay a flat fee per minute of use. The program offers access to high-speed chargers that make it easy to refuel. Beyond Manhattan apartments, this service will be feasible in other downtown commuting locations as well as near train stations (for weekend visitors). Electric cars anchored at docking stations are easier to share because they do not require constant trips to refuel. In the future, they may also work in large suburban housing developments as well as in urban areas that have commuter rail access but that are far from optimal intracity transport. They could thus help alleviate the last-mile problem associated with public transportation.

Drones

Unmanned aerial vehicles (UAVs), popularly known as drones, are revolutionizing warfare, transportation, and intelligence collection. Drone technology has enabled remarkable aerial imagery of real estate. One application developed at Wake Forest University deploys drones to assess

pollution levels. And in West Des Moines, commercial brokerage NAI Optimum offers its clients drone video footage so they can monitor the progress in the construction of new developments.

Beyond their key role in aerial surveillance, there are other interesting implications of UAVs for real estate. The utilization of drones in an urban environment will likely spur many quarrels in legal and policy arenas about air rights. Nonetheless, we believe that after the dust settles, the temptation to command a technology that allows users to send packages, letters, or consumer goods, or to retrieve a lost wallet—anywhere in the city, within hours—will prevail. Where will we store these urban drones?

UPenn Graduate School of Design students Mohammad, Zhao, and Zhu proposed a concept skyscraper, which they named the Hive, that would be used solely for parking and servicing drones. Their concept was awarded second place at eVolo Magazine's 2016 Skyscraper Competition. The idea may be difficult to implement in super-expensive markets, where alternative uses for land probably will prevail. Nevertheless, Amazon very recently patented a similar facility. Amazon's patent describes how:

"A multi-level (ML) fulfillment center is designed to accommodate landing and takeoff of unmanned aerial vehicles (UAVs), possibly in an urban setting, such as in a densely populated area. Unlike traditional fulfillment centers, the ML fulfillment centers may include many levels (i.e., stories, floors, among others) as permitted under zoning regulations for respective areas. The fulfillment center may have one or more landing locations and one or more deployment locations to accommodate UAVs." (US Patent No. US20170175413)

We may yet see some of these urban structures, abuzz with electronic drones, in the distant future.

Last-Mile Real Estate

The delivery of parcels by way of drones shoving off dedicated parking structures exemplifies a potential solution to the last-mile problem in retail and logistics. The growth in internet shopping creates the need to solve the problem of the massive and continuous delivery of merchandise around the city.

To make things even more complex, some downtown stores, like those of apparel retailer Zara, are adopting strategies such as quick product turnover, which requires smaller in-store inventories and more frequent, targeted deliveries. Massive distribution warehouses are built on industrial sites far away from city centers, where land is cheap and available as per zoning.

The issue, then, is how to quickly and cheaply deliver goods downtown and to remote suburbs (Rico, 2016).

Amazon Locker currently provides a scalable solution. Its locker kiosks (similar to those found in post offices) are placed in convenience stores. Amazon effects regular deliveries to these mini-facilities, and the consumers themselves carry the merchandise on the last mile back home. Amazon pays rent to the retailer that hosts its kiosk. We probably will see more downtown commercial space being tapped in a dual use that combines last-mile distribution with more conventional operations.

3D printing also has the potential to impact the logistics and retail landscapes. A future in which a portion of merchandise is delivered via production on-demand on-site (PODOS) is not improbable. PODOS will allow consumers in shopping malls to customize products—with assistance from the semi-artisan retailer's team—using CAD software. Their merchandise will then be 3D-printed on-site and subsequently picked up.

A young consumer may thus go to a sandal 3D printing "fab-shop" and work with its creative team to design a customized pair. While the 3D printer is at work, our consumer may hang out in the coffee bar or watch a movie in the theater. A varied ecosystem of PODOS fab-shops could add to the entertainment value of major retail surfaces, reintroduce artisan manufacturing production in our downtowns, and ameliorate last-mile delivery issues.

3.4 New Modes of Interaction With Spaces

Open Office Layouts

Changes in the office workplace have drastically impacted how we work and how we design spaces. In the early part of the 20th century, the design of workplaces was focused mostly on productivity and efficiency. In the 1980s, the personal computer transformed the workplace into a landscape full of cubicles of every shape and size.

In creative industries driven by innovation, the most significant disruption is the flexible office configuration—also called an "open floor plan." Even more dramatic is the concept of "hot desking," where workers do not own a fixed desk but are flexibly assigned a new spot every day.

Many office spaces are being designed to incorporate open layouts and collaborative environments, which include a variety of amenities to attract and retain talent. According to a new report from CBRE Group, Inc., shared workplaces can provide feasible and cost-effective alternatives to traditional

offices. At its core, the flexible workplace shifts away from assigned desks and private offices and into open layouts that incorporate shared productivity tools—meeting rooms, breakout spaces, phone booths—and shared amenities such as kitchens, a gym, and lounges.

The central goal of the flexible workplace is fostering collaboration. Architecture firms like Gensler are focused on understanding the relationship between workplace design and cooperation. The main theme of their work is the enhancement of workplace environments and helping people become more productive at work. In a recent study they report that *"higher performing, more innovative workplaces are 10 percent more collaborative than less innovative workplaces, and there is twice the amount of learning going on in innovative workplaces."* They also conclude that *"people socialize 13 percent more often in workplaces."* Their results have significant implications for workplaces since they show that design has the power to drive innovation forward in a measurable way (U.S. Workplace Survey 2016). An efficient workplace is not only about collaboration and well-being.

The most efficient offices provide a balance of resources for different modes of work: reflection, collaboration, learning, and socializing. Collaboration is crucial to innovation, and it is the focus of recent attention, but in practice, a dynamic workplace must align to every job type and work style. Perhaps one of the most advanced implementations of these ideas is in Amsterdam at a building called the Edge. According to Bloomberg's article on this unique structure, which headquarters the activities of the consulting firm Deloitte in the Netherlands:

"A day at the Edge in Amsterdam starts with a smartphone app developed with the building's main tenant, consulting firm Deloitte. From the minute you wake up, you're connected. The app checks your schedule, and the building recognizes your car when you arrive and directs you to a parking spot. Then the app finds you a desk. Because at the Edge, you don't have one. No one does. Workspaces are based on your schedule: sitting desk, standing desk, work booth, meeting room, balcony seat, or concentration room. Wherever you go, the app knows your preferences for light and temperature, and it tweaks the environment accordingly."

More prosaically, an additional advantage of flexible configurations is the ability to reduce space usage per worker, and therefore overall costs of occupancy. A substantial amount of space in conventional office layouts is not used at any point in time: Meeting spaces are not always booked; workers take vacations and fall sick; 9-to-5 workspaces remain unoccupied after hours; and employees with assigned desks spend time off-site talking

to clients or performing services.

There is considerable uncertainty about how office space utilization density in the workplace will evolve in the future. One clear pattern is that the heterogeneity in the conventional metric (square footage per worker) will grow (Miller, 2014). We may see some employers use open layouts to increase utilization and reduce costs. In other cases, the added square footage needed to provide the amenities that are required to attract workers may exceed any savings.

Biophilic Design

The need for human and natural connection in residential spaces and workspaces will generate a growing demand for biophilic architecture. Biophilic design in real estate refers to the development of spaces that capture features of the natural environment. The final objective is to improve the well-being and productivity of employees by surrounding them with a more natural and positive environment. After all, over the course of millions of years, our species and antecessors evolved to enjoy certain types of environments that increased the chances of survival.

The New York firm Terrapin—a thought leader in this arena—proposes the following 14 concepts for biophilic design (Terrapin Home, 2016)

BOX B1: BIOPHILIC REAL ESTATE DESIGN PRINCIPLES

Nature in the Space Patterns
1. Visual Connection with Nature. 2. Non-Visual Connection with Nature. 3. Non-Rhythmic Sensory Stimuli 4. Thermal and Airflow Variability. 5. Presence of Water. 6. Dynamic and Diffuse Light. 7. Connection with Natural Systems.

Natural Analogues Patterns
8. Biomorphic Forms and Patterns. 9. Material Connection with Nature. 10. Complexity and Order.

Nature of the Space Patterns
11. Prospect. 12. Refuge. 13. Mystery. 14. Risk/Peril.

Sharing Economy: Airbnb, Co-working, and More

The sharing economy is taking off from all kinds of niches, from ridesharing and apartment lending to co-working. The emergence of peer-to-peer platforms has enabled individuals to make use of underutilized assets by sharing at alternate points in time.

By far the most prominent sharing services in real estate are those based on accommodation. The best-known example is Airbnb, based in San Francisco, which provides an online community of people who are looking to rent their homes, and individuals who seek houses, apartments, or rooms as an alternative to traditional hotels.

As the sharing economy reaches a critical mass, some of its shadowy aspects have surfaced. In the accommodations sector, under-insurance issues are causing peer-rental services to run into regulatory barriers. Also, apartment-sharing rights are unclear under current zoning regulations and other rules that govern temporary rentals. In New York, for example, it is illegal to sublet a single-family home, apartment, or room for fewer than 30 days if you are not living there.

In the office sector, co-working spaces—such as WeWork or Carr Workspaces—have become prevalent. They will keep growing as alternative work environments for mobile workers, freelancers, and startups. While our cherished public libraries have hitherto served as flexible working spaces for many and will keep on doing so, co-working spaces combine better locations with improved workplace design and access to professional services. Co-working facilities lay at the intersection between hot-desking and the sharing economy. Subscriptions that allow regular access to these shared, flexible spaces and their amenities are sold monthly or by the day.

There are at least three economic models of shared office-space utilization. All these models are bound to thrive, although each will do so for different reasons. The first model is based on lease arbitrage: Here the overall lease costs to the operator (the original tenant) are less than the sum of the fees received from the users. Use of this model will continue to grow opportunistically as operators search for locations where arbitrage is likely to happen. Of course, in some co-working prime locations, operators who entered into low-cost lease agreements in a recessionary period may be unable to outbid regular office tenants during booming times.

A second economic model for co-working entails direct investment. Here, the owner of the building customizes the space to offer a bundle of services and flexible floor plans. Customers may be corporations that want the option of increasing or shrinking their footprint, or they may want

shorter-term leases.

For instance, an engineering company may want to engage in a 2.5-year lease in a city far from its headquarters. Since it does not know how much space it will need as its construction project develops or whether the project will be delivered on time, it signs a 5,000 square-foot lease on a hot-desk basis with the possibility (a call option) of adding another 2,000 square feet and extend the lease for an extra year. Of course, the rent is higher because the lease is flexible. Hundreds of different contracts may simultaneously be signed within this "flex" building. We will likely see an explosion in the typologies of such contracts. For landlords, the major issues associated with this model will be how to manage risk from the shorter leases, option pricing, and tenant turnover.

A third economic model taps underutilized space and converts it into co-working areas. Chinese real estate giant SOHO has launched its co-working concept 3Q. Some of the 3Q spaces are in buildings where most tenants are stable and long term; co-working hot desks occupy contiguous spaces that have been underused and otherwise could represent an eyesore. Hot desks add vibrancy to the whole environment.

An explosion of creativity also is freeing up spaces in other settings, a trend that will continue in the future. For instance, the company Spacious rents short-term working space in bars and restaurants. The same tables that cater to dining patrons at night are used by mobile workers during morning hours. Breather, another shared-economy company, makes working and meeting space available on an hourly or daily basis. Another concept proposed by Dayuse.com and Hotelsbyday.com is to rent hotel rooms by the hour and by the minute.

It is hard to forecast future innovation in this area or identify which of the current models will survive the marketplace. It is clear, nevertheless, that further development of the shared economy in real estate will require innovative and well-defined contracts, evolving design, institutions for dispute resolution, and new management practices, together with reasonable local regulations.

4 Smart Buildings and the Internet of Things

The ability to connect physical objects to the internet has profound implications for society and the economy. Internet-connected devices can support data-driven decisions by turning any object into a source of information about itself and its surrounding environment. Today, sensors capture an abundant amount of data from sources such as vehicles, roads, manufacturing plants, household appliances, city spaces, and many others.

During the next decade, the Internet of Things (IoT) is poised to change the way we go about our daily lives, with projections of over 50 billion connected devices by 2020, compared with the 7 billion devices just six years previously (Bagley, 2014). Furthermore, IoT is already having an impact on how products are made, distributed, and serviced.

BOX C1: Internet of Things Definition

> The term "Internet of Things" refers to physical objects that can use the Internet backbone to communicate data about their condition, position, or other attributes. Sensors can track features such as motion, air pressure, light, and temperature, among others.

Key technology improvements have come together to enable the rise of smart televisions, connected thermostats, and advances in health care and retail. First, sensors and wireless networking components are becoming smaller and less costly, making internet-connected devices more accessible to users and making a wider range of IoT applications practical. McKinsey's Global Institute report predicts that by 2025 IoT will have a total potential economic impact of $3.9 trillion to $11.1 trillion per year (Surabhi and Saurabh, 2016).

Second, thanks to rapid advances in data storage and computing power, the data from sensors can be analyzed more efficiently, often in real time, making it easier for companies, cities, and consumers to derive actionable insights. The applications to real estate are numerous: "Smart buildings," which incorporate sensors and other data-collection devices, and programmable algorithms will allow managers and users to improve operational efficiency and the enjoyment of space. In this chapter, we outline trends in and the challenges of IoT adoption, and we provide key examples of solutions that exist today.

Smart Building Automated Performance

IoT has impacted virtually every industry, and several of its most prominent applications are transforming how buildings operate. Through the automation of heating, ventilation, air conditioning, lighting, security, and other systems, buildings now can collect data and provide feedback loops in real time on how they are performing. Ultimately, IoT applications in buildings aim to reduce: energy consumption, maintenance costs, and administrative expenses while enhancing tenant satisfaction and providing new revenue-generation opportunities. Building owners can use the data collected by sensors that measure occupancy and motion inside the building to regulate air-conditioning and lighting in real time, reducing energy costs and optimizing the internal environment for its intended purpose.

For instance, the Capital Tower building in Singapore has a set of sensors that measure carbon monoxide levels in its parking garage. A computerized system activates an exhaust fan system whenever pollution levels reach certain thresholds. This response mechanism helps cost-effectively mitigate health hazards while it reduces wasteful energy spending when garage traffic is low and external air quality is good. In the U.S., NoiseAware can install sensors in an apartment to capture its sonic attributes. Property managers receive real-time information about noise problems in specific units, allowing them to work with occupants or neighbors to mitigate problems or make unit-specific investments in insulation.

The continuous monitoring and predictive ability of IoT-enabled buildings can let building managers move toward predictive maintenance rather than preventative maintenance. This will make building management more efficient and cost-effective. Predictive maintenance is predicated on forecasting the behavior and preferences of occupants and proactively providing comfort solutions.

Consider Nest, a domestic thermostat operated entirely by smartphone. Nest learns about the regular temperature schedules of occupiers. By efficiently adjusting to temperature preferences, as predicted by the homeowner's previous behavior, this technology can lower heating and cooling bills.

Research of Statistical Patterns

The Internet of Things is not just about gathering information and automating environmental responses. It is also about data analysis. Incorporating data analytics capacities can result in lower asset risk and enhanced building portfolio management. For example, monitoring the flow of people within

a building can enable property managers to study occupant behavior and space usage patterns. This information might help managers identify excess capacity and develop action plans for peak hours, ultimately resulting in more efficient management of the space. Smart buildings are therefore empowering smarter data analysts to mine the data they collect in order to generate strategic insights.

Bitsence, an environmental and human sensing technology company spun out of the MIT Department of Urban Studies and Planning, is using easily deployable sensors to collect information on how shared spaces are being used. This information is helpful for property managers looking to assess a space after a design intervention, identify underperforming spaces, improve seating layouts, or allocate resources more efficiently. Another example is Nantum, which uses an operating system that memorizes the operations of a building. Machine-learning algorithms can predict and prescribe the building's performance in the future, potentially leading to increased savings and comfort.

IoT-enabled building management systems also are using sensor-generated data to enhance the user experience, all the way from buying an asset to occupying it. For example, some companies seek to improve the brokerage and leasing process by openly sharing environmental data generated by IoT sensors, such as building noise levels and luminosity, and neighborhood data, such as traffic and crime. By incorporating such information, these systems provide buyers with a more thorough picture of the neighborhood.

Smart Homes

The IoT has the potential to make homes safer, more energy efficient, and more comfortable—from devices that alert about high levels of carbon monoxide to humidity sensors that detect when the house is damp. Roughly one in every four U.S. internet users currently owns a smart-home product or device (PricewaterhouseCoopers, 2017). Business Insider expects the number of smart-home devices shipped to grow from 83 million in 2015 to 193 million in 2020 (Meola, 2016).

Smart appliances could also improve the quality of life of vulnerable populations. For instance, devices that could save energy and reduce care costs include smart heating systems; sensors that identify inactivity in the homes of older people; and blood-pressure monitors that send data directly to hospitals.

Another major opportunity lies in automating domestic chores. In the

United States alone, household activities (such as cleaning, washing, preparing food, gardening) and purchasing home goods and services require 230 billion labor hours per year (Aharon et al., 2015). Household chores have an enormous impact on how people spend time and money. Smart-home appliances are starting to gather data about daily work patterns to determine household preferences and help them schedule work routines.

Which of the emerging smart-home applications and gadgets will be successful? We believe that beyond their more or less ephemeral "cool-factor," the ability of each specific IoT technology to reduce household expenditures will contribute critically to the extent of its adoption. For instance, Sense is a home energy monitor that detects devices by identifying their unique electrical signals. The company can accurately disaggregate 80 percent of home energy use. It can detect a microwave oven through its electrical signal, a washing machine, refrigerator, and even garage door openers. As it identifies the different appliances, it allows the user to shut off equipment at critical peak times or to better align their household usage with household solar power generation.

Another key and currently unresolved issue is how to integrate the growing number of separate applications and devices. Similarly, there are valid concerns about the lack of a common IT infrastructure and standards to utilize the high volumes of data being produced.

While the explosion of smart-home startups and solutions will continue, we expect forthcoming industry consolidation into a few major providers. Integrating lighting, sound, voice, energy, temperature, appliance, sensor, security, phone, and other smart-home applications into one simple, comprehensive solution will create significant value. Large IT conglomerates, perhaps in joint ventures with building industry partners, are well-positioned to take advantage of this opportunity.

Retail Environments

In the retail segment, companies are studying ways to gather and process data from thousands of shoppers as they journey through stores. Prominent applications of IoT in retail seek to build relationships with customers and strengthen tenant engagement. By using sensors, property managers can offer targeted services and deals to their customers in a more agile way. Moreover, combining environmental data, such as temperature and air quality, with movement data from motion sensors could allow building managers to determine optimal ventilation and temperature levels.

Beacons exemplify a growing technology deployed in retail. Such sensors are small and relatively inexpensive Bluetooth devices sending messages to the cell phones of customers who sign up. When patrons arrive at the shopping mall, they may find their cell phones buzzing with customized offerings and discounts. The Boston-based company Swirl Networks is one of the leaders in this arena. Its data algorithms can now link in-store behavior to online browsing patterns. Beacons allow retailers to collect data based on their clients' indoors movement. In addition, they allow willing customers to receive sales notifications based on their preferences and in-store behavior.

Because in the U.S. these technologies require voluntary participation, they will be successful inasmuch as they deliver a better experience and value to customers.

Offices

Offices have already started to incorporate sensors and devices for workforce management. Research by Professor Sandy Pentland at the MIT Media Lab shows that interactions and engagement decrease with the physical distance between work groups. In a series of experiments deploying sociometric badges on office workers, Pentland was able to identify the key elements of successful communication: exploration (interacting with people in many other social groups), engagement (interacting with people within your social group), and energy (interacting with more people overall). Results from these studies suggest that spaces designed to promote these activities increase the likelihood of productive "collisions." Thus, remote teams do not perform as well as those in physical proximity.

Sensors can also be deployed in internal research projects to study worker mobility and productivity. They also can check workers into newly assigned spaces as they arrive, as in the Edge building in Amsterdam.

IoT initiatives in the workplace will be successful only insofar as they find support among the employee base. For instance, the Mediated Atmospheres project—also at MIT's Media Lab—works on experimental technologies to make office environments more pleasant for workers. The researchers have created a workspace prototype equipped with modular real-time control infrastructures, integrating biosignal sensors and controllable lighting, projection, and sound. Lighting, colors, and background-noise conditions change with the mood of the occupant or in set patterns during the workday. Office occupants also can change these parameters to reflect their current tasks (e.g., darker blue lights for writing memos).

City Services and Predictive Analytics

The vast volumes of data produced by citizens hold tremendous potential. Leveraging these data may allow cities to drive improvements in infrastructure, respond to citizens' needs, and allocate public resources more efficiently. Ultimately, governments can use predictive analytics to develop innovative solutions to contemporary urban challenges.

BOX C2: Predictive Analytics Definition

> "Predictive analytics is the use of historical data to look for patterns and identify trends that can be used to reorganize service delivery, anticipate future needs, and prevent potential problems."

Major metro areas from Los Angeles to Singapore are using smart technology to manage traffic and conserve water and energy. In New York, for example, IoT is helping track residents and environmental data to monitor pedestrian traffic flow, while in Barcelona waste management is being streamlined with smart bins that tell garbage trucks when to collect.

In Boston, the city analytics team aims to improve the delivery of services. The team has launched dozens of successful projects to improve city performance, which range from monitoring potholes to reducing homicides. Similarly, the city of Chicago has piloted a predictive analytics project to enhance operational outcomes, including the targeting of a rodent plague. A team from its Department of Innovation and Technology documented the relationships among 311 call types that historically correlated with rat infestation problems (Goldsmith, 2016). It then mapped specific neighborhoods for intervention and discovered the largest infestation area. This experimental approach allowed the government to improve its responsiveness to citizens' concerns.

The Internet of Things holds great promise for policy applications. Yet technical and ethical challenges must be tackled prior to its wider adoption. In particular, governments must address data privacy and security concerns raised by the collection of personal information (Goldsmith, 2016).

Connected Urban Infrastructure

As cities increasingly turn to network-based applications to manage services such as water or waste, streetlights have come into focus. Beyond the obvious cost savings from LED, we are now adding other capabilities

to the streetlights themselves. For example, cities have used streetlights to measure changes in temperature, weather, and air quality. Lights can similarly produce real-time data for applications that monitor traffic, publicize parking availability, or assist in emergency response. Street lamps also can be outfitted to provide connectivity services such as wireless internet.

Songdo, a new master-planned city in South Korea, was conceptualized as a connected city from inception. The city was privately developed by POSCO, a South Korean conglomerate and building company, and Gale International, a U.S.-based developer, on land reclaimed from the Yellow Sea. A high-powered Wi-fi network is functional in all corners. The residences at Songdo are wired to a system of videoconferencing, allowing citizens to directly connect with city services, take classes from local schools, and talk to each other. A subterranean network of pipes collects the trash disposal directly from the chutes in each residence and moves it into a processing facility via suction. The energy that results from incineration of waste is used to heat the city.

Citizen Engagement

One approach to boosting the adoption of IoT is by incentivizing neighborhood-scale demonstrations. Some key examples include the Kansas City Startup Village. This project aims to advance the city's startup ecosystem by providing entrepreneurs with access to Google Fiber. Another pioneering case is led by the city of Chattanooga (Tennessee), which connected over 150,000 homes and businesses to one gigabit-per-second internet speeds (Bagley, 2014).

The Array of Things (AoT) in downtown Chicago is a first attempt to deploy a full-scale project at the citywide level. By installing 500 nodes that each have 20 sensors, the city can identify traffic patterns by detecting the number of vehicles in the vicinity of each sensor. Also, some nodes collect environmental counts on temperature, humidity, allergens, carbon monoxide, light, and other variables. One key advantage of this project lies in its research focus. Rather than answering one particular question about the city, it offers a platform to collect a diverse data set. This approach will allow for the study of an extensive set of issues, ranging from the health of residents to the migration patterns of birds.

Similarly, in 2016, the city of Boston partnered with The Local Sense Lab—a research consortium formed by three MIT companies. The city deployed real-time sensors for a variety of purposes as directed by private stakeholders, including citizens and developers.

5 Real Tech: Thinking Outside the Box

In Chapter 3 we learned about transformational innovations in the design and use of real estate. Chapter 4 illustrated how sensors, IT networks, and computers are embedded into buildings, thereby making them smart. There is a third, parallel technological wave hitting the built environment. And this one does not necessarily involve any changes in the brick and mortar.

New technological applications powered by online connectivity are transforming how we transact, perceive, invest, and manage existing properties—all without fundamentally changing their physical attributes. We denominate this trend "Real Tech."

Transactional Websites and Software

The information revolution brought by the internet has allowed buyers and sellers of real estate to acquire information about millions of properties. Realtors® Multiple Listing Service (MLS) consolidates data about properties for sale that listing agents provide. Websites such as Realtor.com or Zillow.com aggregate information from regional MLS, facilitating access to information about each property in all markets. Zillow's subscription model allows real estate agents to obtain leads or preferential placement in exchange for a fee. The most prodigious aspects of this "transactions revolution" in residential properties have been its speed and ubiquity. Searching for vast numbers of properties on the internet has become the norm. The future no doubt will bring further integration of existing and new databases into the search records and statistical analysis of market information in real time. For instance, prospective buyers may be able to see 3D renderings of a home's interior and, given the history of recorded clicks, obtain forecasts of the probability of an offer being made on a property in the next three days.

Listing and finding apartments for rent today is easier than ever, thanks to listing data aggregators such as Craigslist, Zillow, Apartments.com, rent.com, forrent.com, apartmentguide.com, and many others. Property advertisement has become a crowded field in the *Real Tech* arena. Thus, new entrants are aggressively seeking differentiation. For instance, Zumper.com offers direct and fast online rental applications, while Sumu.io and RentalBeast.com use machine-learning techniques to help improve the matching process between apartment seekers and brokers.

In the commercial arena, CoStar has become one of the major repositories of commercial real estate data. Its internet listing service LoopNet serves a similar role to that of the MLS—this time with respect to commercial

property rentals and sales. Brokers leasing or selling commercial properties have a clear incentive to list their properties at LoopNet. CoStar links its listings to an extensive proprietary property record database. Brokers can purchase premium listing placement, and investors can buy customized data access to the platform.

Other players, such as Xceligent, 42 Floors, and Real Massive, have similarly entered this market. Likewise, the always complicated process of subletting commercial space or finding a company to assume an unexpired lease will be facilitated by online platforms such as Flip.com.

Further integration between listings data and all sorts of other information about commercial buildings—legal documents, mortgages, and encumbrances, energy usage, pedestrian traffic, geographic information systems (GIS) data, user ratings, and much more— will continue to expand. Many firms, such as Megalytics or Reonomy, are in the business of consolidating data from disparate sources to provide comprehensive property information above and beyond sales or rental information.

The growth of *Real Tech* applications online also includes the provision of services to brokers and professionals involved in transactions. Apartmentocean.com, for example, provides chatbot services to agents and property owners. A chatbot uses artificial intelligence (AI) algorithms to imitate human conversational skills. Chatbots can swiftly address simple questions about available units and rental terms from hundreds of prospective renters 24/7.

An other example of new apps targeting professionals in the property business is Proposal.net. Its software facilitates the tenant representation process by combining comparable property information (comps) and building data, together with customizable applications that create successive lease proposal and counterproposal documents that specify the desired terms and conditions of the contract.

Software and data solutions probably will become mainstream in site selection. Many companies, such as StateBook, ZoomProspector, and PiinPoint, are active in this expanding segment. So are the internal departments of large organizations involved in retail and logistics. Their immediate objective is to sort through large quantities of data to identify land sites that have desired characteristics. To improve selection criteria, they may in the future use more sophisticated algorithms to match site features to the actual ex post facto performance of firms.

The use of crowdsourcing, or direct input from users or parties in transactions, will keep continue to grow as a source of data. Compstack is an early innovator in this area, having established a repository of data about

real estate leases that has been partly crowdsourced from lessors, lessees, and brokers. Contributors exchange their data for information about comparable properties. Alternatively, crowdsourcing contributors can volunteer information only, as with ApartmentRatings.com or travelocity.com. In the former website, potential apartment users provide opinions about the property and the performance of the management company. The latter has become one of the primary tools for travelers to share experiences about hotel amenities or a lack thereof.

Quid pro quo crowdsourced data models are relatively easier to manage as they require user registration, focus on predetermined metrics, and tend to be easier to verify. Users are incentivized to provide useful information since they expect to obtain similarly reliable data in exchange. Challenges with freely volunteered information revolve around the quality of opinions and the self-interested motivations of contributors. Although the analysis of volunteered data in the case of single properties may not provide conclusive results, the use of these data will grow in statistical applications that link property attributes to average user satisfaction.

Automated Valuation Models, Risk Underwriting, and Market Benchmarks

Computer power, expanded data input, and the laws of large numbers have collided in the 21st century to make real estate markets more transparent than ever.

We can perhaps point to the simple spreadsheet as the prelude to this trend. The use of spreadsheets has facilitated the analysis of cash flows associated with real property and has yielded as byproducts large quantities of data. Professionals in real estate finance have become deeply familiar with the analysis of data. More sophisticated cash-flow analysis software, such as Argus, has become an industry staple.

While thousands of professionals use spreadsheets and Argus independently, we hope to eventually see better data integration across users. We should likewise expect further data linkages to subsequently verify property cash flows. Hence, an analyst could get access to statistical—but not individual—information about the financial models of other users in exchange for her data. She may also be able to compare her underwriting assumptions with actual cash flows of similar properties. Our future financial analyst may garner the power of big data to carefully study deviations between previous users' model assumptions and their real accrued cash flows, thus avoiding errors committed in the past.

While real estate prices will keep on fluctuating cyclically, technologies to better underwrite asset values will steadily continue to improve. Computer-based automated valuation models (AVM) allow for recurrent and ubiquitous mark-to-market underwriting of property values in the U.S. AVMs use data about actual market transactions of real estate assets to predict the prevailing price of unsold properties if they were to trade. To make predictions, AVMs use statistical techniques, such as econometric forecasting, repeat sales, hedonic pricing, comparable matching, machine learning, or a combination thereof. Good models tend to make small errors: As a property ultimately sells at arm's length, the value predicted by the model is very close to the actual transaction price. By minimizing such errors and improving existing algorithms, AVMs are getting progressively more accurate. AVMs are already an everyday staple in housing markets. Firms like Zillow offer free "Zestimates®" to anyone interested in learning about the value of almost any home in the U.S.

A significant portion of conventional home mortgages is ultimately securitized or insured by the government sponsored agencies (GSAs)—Fredie Mac and Fannie Mae. The GSAs use AVMs to pre-qualify loans, in addition to the common human-made property assessments at closing. For instance, Freddie Mac's Home Value Explorer® can be used by qualified lenders during the underwriting process to facilitate the ensuing assumption of the loan by the GSA.

For better or worse the data revolution associated with AVMs has enabled phenomena such as massive private mortgage securitization and the emergence of non-bank lenders. The implementation of AVMs in the residential market will therefore not be scaled back. On the contrary, new and better models that use broader sources of information will develop. In our view, the frontier in AVMs is the provision of models that predict future prices rather than simply mark to current market conditions. As was all too clear during the housing bubble of the mid-2000s, contemporaneous housing values are not necessarily those that could be expected from long-term supply-and-demand equilibrium fundamentals. In other words, housing markets make mistakes. Forthcoming best-in-practice models should be able to assess the likelihood of over- or under-heating by providing individual housing price forecasts at different maturities (e.g., one, five, or ten years in the future).

Implementation of AVMs in the commercial real estate arena no doubt will move forward, albeit more slowly. Current limitations are mostly due to data availability and different proprietary standards. Dissemination of information about commercial returns has heretofore relied on statistical

indexes. In the United States, the Russell-NCREIF index, which commenced in 1978, has consolidated as a keystone for market transparency. While such indexes cannot estimate the precise value of a particular property, they do track representative price changes in the market. They are thus critical for institutional and private-equity investors to benchmark the performance of real estate portfolios.

The Price Dynamics Platform (PDP) is a collaboration between Real Capital Analytics (RCA) and the MIT Center for Real Estate. RCA is one of the industry leaders in the provision of commercial property data, and it is a primary sponsor of basic research in this area. MIT's PDP no doubt will become an innovation leader that provides market valuation tools and actionable intelligence for investment benchmarking.

Other tools that combine software and statistical techniques are being applied to underwriting risk. similar to the way FICO scores work in the personal credit and mortgage markets, new products and firms will evolve to assess the riskiness of renters, commercial real estate borrowers, and other transaction counterparts. One such enterprise, RE Meter, is providing data-based solutions that check the financial stability of tenants and forecast default or early termination probabilities. Similarly, Credifi uses commercial real estate loan data to assess the economic viability of current investments in a property, given its credit situation, tenant history, and any reported liquidity issues.

Crowdfunding

Investments in real estate are capital intensive. Therefore, the usual practice in the industry has been to pool capital resources from several investors for property or portfolio acquisitions. Many structures have arisen historically to satisfy such shared capital needs, such as tenants in common, private equity structures, corporations, commingled funds, REITs, and others.

The combined power of the internet and new legislation has made it possible for crowdfunding to become an additional option. Crowdfunding websites, such as Realty Mogul, Fundrise, and Prodigy Network, offer the opportunity for savers to commit smaller-scale investments to single-asset real estate equity or mortgage debt. MIT-founded company Neighborly allows individuals to invest in civic projects through municipal bonds. The best-in-business of such platforms provide prior vetting of investment opportunities and full financial transparency throughout the investment period; they also provide payment collection services, and all of this in exchange for a fee.

For general partners, promoters, or borrowers, crowdfunding may provide access to capital markets for projects that are too small or not institutional grade.

The proliferation of such web-based investment platforms means that we are in the midst of a battle for reputation and credibility. The most consistent players, accruing a track record of successful investments, will endure and become large capital exchange platforms. But we will also hear some bad stories about failed investments by a few of these websites before their inevitable exit.

A future potential path for this industry is securitization. Some investors may be willing to take on larger notes ($1-10 million) backed by dozens or hundreds of participations in crowdfunded projects. Since such investors would be playing the laws of large numbers, they may allow for a bit more risk-taking on each particular project, probably in exchange for lower transaction costs. The trend toward the minimization of management fees, as applies for most other investment vehicles, will inexorably take off once the main industry players are consolidated.

Another interesting avenue is community-based crowdfunding. Developers and investors can obtain financial support from neighbors, who thus may feel more invested in their community's redevelopment. For instance, the new startup Small Change raises funds for community redevelopment projects that will have a substantial social impact.

The possibility of having neighbors fund local projects could ensure that local feedback is taken more seriously from inception. In exchange for losing some initial discretion, developers could get broader support from the local community, sections of which would now have a financial stake in their project's success.

Blockchain

A blockchain is a decentralized and transparent log of a sequence of contractual agreements between parties. Each entry in the series—new contracts, modifications to existing ones, monetary exchanges between parties—is simultaneously recorded by hundreds of computers and servers around the world. Therefore, the chance that any part of the whole chain of recorded events will be deleted or manipulated is next to nil. Moreover, the information contained therein flows freely.

Since real estate is high in transactional costs, there is a need for contractual activities to be recorded (sales, leasing, tax, mortgages, easements, contractors' services, asset management). To this end, Blockchain could

make the industry more transparent and reduce transaction costs.

A first discernible application is the automation of public real estate records (Spielman, 2016). The Cook county Recorder of Deeds recently engaged startup Velox.RE and successfully performed a pilot program to *"officially reference conveyances and other instruments recorded in a blockchain"* (Karen A. Yarbrough, 2017). The Department of Land Development in Dubai has gone a step further and announced the full transition of its real estate records to blockchain.

The second domain of disruption for blockchain resides in its potential for disintermediation. The technology can disseminate widely and transparently the history of contracts and encumbrances associated with a property. It also allows for direct interfacing between contractual parties. The hope is that more transactions will be done more cheaply and without recourse to professional intermediaries.

The third broad area of application of blockchain is in so-called smart contracts. These instruments link the fulfillment of contractual obligations to automated concrete actions by the counterparty. For instance, a refund of monies previously in escrow could be automatically credited to a lessee's bitcoin ledger upon the expiration of a period mutually negotiated in advance with the lessor.

A recent report by the Deloitte Center for Financial Services identifies a number of concrete business opportunities for the deployment of blockchain-based distributed ledgers and smart contracts in real estate (Deloitte Development LLC, 2017).

BOX B3: DELOITTE'S REAL ESTATE BLOCKCHAIN OPPORTUNITIES

1. Improve the property search process.
2. Expedite pre-lease due diligence.
3. Ease leasing and subsequent property and cash flow management.
4. Enable smarter decision-making.
5. Smarter and relatively cheaper property title management.
6. Enable more efficient processing of financing and payments.

Source: Blockchain in commercial real estate The future is here! – Deloitte Center for Financial Services

While the promise of blockchain is immense, some considerations about the extent of its implementation are in order.

In the foreseeable future, we will still entrust governments to legislate a legal environment for real property. We will similarly continue to delegate the enforcement of contracts and the safeguarding of the rule of law to federal, state, and local governments and courts. This means that any advantages of blockchain as accepted, legally enforceable mechanisms to establish contractual and property rights and obligations will rely on governmental adoption, federal and state legislation, and evolving case law.

Interestingly, some of the work of real estate blockchain startups occurs in collaboration with local governments, such as Ubitquity.io's announced project with local land registry bureaus in Brazil. The full impact of blockchain could be unleashed more aggressively in emerging markets that have fragile legal enforcement mechanisms, with contractual dispute resolution handled in safe offshore jurisdictions.

The potential for disintermediation is there, but it may also be limited by legislation, case law, and the need for common standards and systems expertise. Setting up blockchain-based exchanges—for example, a sublet market within the portfolio of a major office REIT—will require lawyers, programmers, and experts. A myriad of startups and IT departments are unlikely to coordinate on simple, shareable technologies (e.g., a collection of sample contracts and market structures freely available on GitHub).[6] Hence, real estate firms will have to subcontract blockchain app development to a few intermediary market-making firms that have the wherewithal to impose technical standards. For instance, ABN Amro recently announced a commercial real estate blockchain experiment in the Netherlands *in collaboration with IBM*.

Arguably, and if one is willing to trust large IT providers, encrypted systems that reside in private clouds may nonetheless suffice for many registries and market-making applications.

In our view, the development of smart contacts capable of contingent, automated behavior is the most revolutionary promise of the blockchain technology in real estate. They could work presently for smaller transactions—for instance, a party that receives automatic dollar-indexed bitcoin payments from a blockchain-based escrow account upon third-party verification of the provisioning of a service.

Larger transactions may still be subject to conventional litigation: If disagreements arise ex post facto, counterparties can always sue and claw back on automated payments made to the wrongful party. Arguably, such possibility negates some of the advantages of blockchain adoption.

[6] GitHub is a popular repository of open source software programs and routines.

Our expectation, therefore, is that blockchain real estate exchanges may develop slowly for some time, perhaps over a decade or more. As suitable legislation, expertise, and case law develop and mature, smart self-executing contracts and exchanges that use distributed ledgers—*or that are directly reliant on cloud-based, trusted, proprietary servers*— may become more prevalent.

3D Renderings, Augmented and Virtual Reality

The ability for people to visually inspect a distant property, or an as-yet-unbuilt one, has the potential to transform the human experience with regards to the built environment. Virtual reality (VR) systems offer accurate three-dimensional graphic representations of real or imagined built spaces. Augmented reality (AR) techniques can add to or modify them.

Matterport is one of the leaders in the generation of 3D computer renditions of spaces. Its proprietary camera and software generate accurate representations at high image resolutions. Users immersed in the interactive online models produced with this technology feel as though they are walking through the property of interest, like the experiences in first-person video games.

The most immediate application of 3D simulated environments is in marketing. Online-based brokerage platforms such as Apartments.com and Redfin incorporate Matterport technology so that prospective renters or buyers can virtually visit every nook and cranny of the properties that interest them, anytime and from their homes.

Another critical application of VR/AR pertains to the design of spaces. The software developed by IrisVR allows architects, designers, and engineers to transform their 3D plans into VR/AR environments. Equipped with VR audiovisual headsets, they can virtually visit their designs and move around the environment they created. The application allows designers to change lighting conditions and other parameters of their virtual model.

The use of VR/AR promises to be singularly suitable to facilitate communication between architects, designers, and their customers. Space users or investors will be able to virtually visit their properties before construction and suggest upgrades or customize finishes. In the interior design arena, creators and customers will be able to modify the finishes, colors, furniture, and decor of their rooms in the virtual world, which then will be automatically reflected in the plans.

Development, Zoning, Design, and Construction

Many software solutions may likewise eventually transform the real estate development process from inception to building completion.

Market research, for instance, is likely to become more reliant on the statistical analysis of big data. Ventures such as Enodo Score and Rentrange's online platforms already provide intelligence about specific markets to underwrite prospective investments. New technology and digital engineering also can empower us to consider the social impacts of development, as illustrated by AutoCase. AutoCase's software provides "triple bottom line" calculations on development projects.[7] Combining financial and additional design information might allow developers and practitioners to calculate the long-term life cycle cost of an asset.

The Building Information Modeling (BIM) software revolution, whereby the very complex architectural and engineering aspects of buildings and infrastructures can be simulated and portrayed in 3D, already has allowed us to design and build structures that could only be dreamed about 30 years ago. BIM models and applications no doubt will become more sophisticated and all-encompassing in the years to come.

In the pre-development process, ARCHITEChTURES, and Parafin3D have developed software that simulates different building configurations quickly. Parafin3D offers simultaneous programmatic and financial simulation. Given construction cost dynamics and general programmatic features (e.g., rent per square foot in each potential use), the software calculates financially optimal property-use mixes and basic architectural configurations. ARCHITEChTURES's algorithms allow the simulation of financial and basic design parameters for whole developments. Its application can export the preferred configurations directly into BIM software so that architectural drawings follow quickly from preliminary master plans.

The BIM revolution will similarly transform the construction management process. This phenomenon is illustrated by Synchro's 4D software, which inputs 3D BIM plans and allows construction managers to add the fourth dimension: time. The planning and timing of each development process are coded into the software, which allows for better execution and for the recognition of problems before they materialize in the field. Dynamic renderings of the construction project, with moving parts and elements evolving in time, make it easy to communicate the execution plan and its pace to multiple stakeholders, who may not have coordinated otherwise.

[7] "Triple bottom line" refers to achieving positive returns in three dimensions: financial, social, and environmental.

Further technological enterprises will be devoted to zoning and project approval processes. Any advances here will be limited by the pace of adoption by local governments. However, there are some opportunities within the existing framework.

For instance, software developed by Zonar allows the simulation of alternative scenarios for a development given the primary current zoning constraints. Users can obtain more realistic views of how the project will evolve from inception, given alternative design and program options as allowed by the zoning constraints inputted into the application. Another startup in this arena is Envelope, whose software—presently focusing on New York City—allows users to visualize potential alternative building configurations available under current zoning. For every single parcel of the city, one can contrast the optimal configuration with the existing building footprint, which can help investors identify redevelopment opportunities.

Building Operations and Asset Management

Due to the large size of the property market, there are great opportunities to develop *Real Tech* solutions to manage and operate buildings. In the previous chapter we discussed technologies that use sensors and the IoT. Nevertheless, existing data can be employed even in the absence of devoted appliances.

The company Cozy.co, for instance, provides property management software and services to residential landlords. Using this product, landlords calculate fair price points for their apartments, list properties, screen tenants, automatically set up rental payments, and deal with insurance. In the commercial arena, the recently merged ventures Hightower and VTS provide consolidated leasing and asset management solutions for the day-to-day financial operations of property owners or their fiduciaries. Honest Buildings similarly provides software for building services, allowing users to better manage information about tenant improvements and contractors.

With regards to residential owners, Mycoop.com is in the business of deploying social media to establish and sustain local communities. As is usual in major cities, most people who live in the same apartment or co-op block do not know or talk to one another. The idea is to create private social networks in large buildings. Once residents are aware of the existence of an internet platform to exchange information, trade goods and services, or organize activities, they may interact socially with their neighbors. Only interested people need to engage actively, but the rest of the community benefits from the information and exchanges. Thus,

the platform circumvents coordination problems that could prevent the spontaneous formation of social networks in major anonymous buildings.

Other solutions center on optimizing space utilization and user satisfaction are provided by Rifinity, REoptimizer, Crodwcomfort, and BIM 360 Ops. Some use real-time feedback from users (for instance, via smartphone apps) to immediately inform facility managers or contractors of any problems.

Compatibility, Integration, and Industry Consolidation

This chapter has illustrated some of the innovation in the *Real Tech* arena. We have, however, inevitably overlooked many other emerging products, websites, applications, and exchanges powered by media and information technologies. We are in a period of a great fertility when it comes to ideas and businesses.

Discerning readers will notice, however, that a real estate investor or owner-operator would have to subscribe to a great many disparate services and incompatible applications to fully adopt all available technologies. In our view, widespread adoption will require platform integration. We conclude, therefore, that we are likely in a transitional period that will take us from proliferation to consolidation. We offer five potential scenarios for startup applications to converge into more comprehensive solution platforms.

The first path is via the adoption of common standards and the transferability of data and software across applications. Data from a construction application could then be transferred to marketing, property management, and asset management solutions, which could exchange information with one another in real time. Given the fragmentation of this market, this path seems to be a difficult one.

The second path involves mergers and acquisitions between existing players. Many full-solution providers could arise in the different areas: development, construction management, sales, property management, asset management, investments, etc.

A third path could materialize through the acquisition of several *Real Tech* startups by existing well-capitalized firms that specialize in technology. Such companies could use their financial wherewithal and programming expertise to produce all-encompassing blockbuster software for real estate services.

The fourth path involves consolidation through acquisition by traditional integrated-services players. Firms such as Jones Lang Lasalle, CBRE, Cushman and Wakefield, Colliers, Newmark Knight Frank, and others are

active in many areas where disruptive technology can have an impact: site selection, development, research, advisory, sales, leasing, tenant representation, acquisitions, property management, asset management, investments, and others. While *Real Tech* could turn out to represent a challenge to these large firms, it also could furnish new opportunities. Large commercial services providers are in a singularly good position to consolidate the different apps into integrated solutions that satisfy their strong existing customer base.

The fifth path for consolidation represents a combination of the third and fourth path. A new integrated-services company might arise from the startup or IT world to compete with established consolidated companies, which may have to adopt new technologies to compete.

In all cases, the future no doubt will bear such exciting technologies to make property buyers, sellers, managers, operators, and investors more productive and connected to each other.

6 Real Trends to Watch

In this report, we have embarked on an intellectual voyage through the trends that may shape the real estate sector for years to come. We are in a period of accelerated technological and social change. A great many of the innovations, ideas, and technologies that we have described will have an impact on the industry and on all of us, its users. Many already have. A few others will unavoidably end up in the trash bin of forgotten experiments.

Venturing guesses about the future is always a risky business—more so when innovative concepts stem from inventors, owners, and investors who advocate on their behalf and promote them, sometimes to the point of hype. We could not be immune to chasing after a few shooting stars in a report that tries to picture the evolution of an all-encompassing industry in the next half century. Nonetheless, we are especially intrigued about the following trends, which might deserve special attention.

Demographic trends tend to be among the most solidly predictable. The primary source of uncertainty here pertains to the evolution of immigration policies down the road. The aging of the American population, however, is certain. We will require ways to house our elderly by retrofitting existing homes and urban spaces. We also will need to provide assisted living facilities for those with reduced mobility. The demand for inpatient and outpatient health facilities will not wane anytime soon. As dependency ratios increase, the labor force participation of the working-age population may

similarly trend upward. Working couples will need housing, workplaces, and urban solutions that allow them to juggle jobs, leisure, and caring for others.

Disproportionate growth of the American population in "red" states, which have elastic housing supplies, will continue—at least for a while. And creative, beautiful cities will keep on thriving. In inelastic supply markets, home values will become even more expensive until a political consensus more favorable to large-scale real estate development arises.

Housing affordability issues in our most expensive cities will be partially tackled by adapting buildings and land to more intensive residential uses. Urban infill, especially in the multifamily sector, will require concerted bipartisan efforts to mute NIMBY pressures. Some of our ailing industrial cities within otherwise thriving mega-regions will be repurposed to provide workforce housing.

Co-living arrangements will mute some of the housing budgetary impacts of recent changes in family composition. New materials and construction techniques, including modular and off-site construction, will be geared toward provisioning affordable, good-quality, new construction. Moreover, a new breed of for-profit, socially conscious entrepreneur will spawn affordable housing solutions that can be feasibly scaled up in both financial and logistical terms. Some of these solutions will be shared online and will expand from local to global much more rapidly than in the past.

Shopping centers will experience major changes, with artisan and local-products merchants increasing their roles. Flexible programming of retail spaces will mean changing seasonal experiences and more experimentation. Advanced 3D printing may bring production and consumption together in the new experience-driven mall.

The growth in green real estate concepts and solutions will keep apace and will be more focused on building-specific environmental cost-benefit considerations than on certification per se.

Autonomous electric vehicles are likely to have a disparate impact. In denser central cities they will facilitate car sharing, reduce car dependence, promote walkability, and act as a factor for densification. In suburban-like environments, they could extend the reach of the American edge city. Robotization will prompt us to think about new ways to facilitate the movement and operations of automatons as occupiers of space. In addition, we ought to be on the watch for the rising role of robots in building operations, including janitorial work.

Open office layouts and hot-desking arrangements will become commonplace. Biophilic design will turn our workplaces closer to the natural

environments that evolution has designed for us to thrive in. While probably occupying a market niche, space-sharing contracts and solutions will consolidate. Sensors and data will play a major role in commercial buildings and private homes alike. Programmable feedback loops in building systems will use sensor and operations data to improve the user experience. The proliferation of gadgets, internet-connected chattel, and software applications will make the consolidation of smart-building solution providers difficult to avoid.

Real estate crowdfunding platforms will become more prevalent, especially in mezzanine investments outside of trophy assets. More so if banking regulations make it more difficult to originate high loan-to-value loans on class B and C buildings. The crowdfunding industry may slowly move toward models that combine larger investment pools and lower management fees, with basic project underwriting services and transparent performance benchmarking.

Automated valuation models will incorporate predictive capabilities so that banks and investors will obtain both estimates of the current value of a property and its likely evolution in the years to come. Big data will make real estate financial performance ever so much more transparent to investors and policymakers.

Augmented and virtual reality technologies will dramatically transform the ways in which we purchase, design, and decorate real properties. And the proliferation of software packages that aid in or even automate parts of the development, construction, asset management, leasing, zoning, and underwriting services will keep apace. In due time, comprehensive online platforms will consolidate these applications, led by current major real estate service providers and perhaps a few entrants from the IT world.

Some of the other trends we have discussed may come to pass as well. Nonetheless, as these changes come to fruition, the immutable tangibility of real estate—bricks and mortar, cement, wood, composite materials—will continue to anchor our perception of the urban environment. It is thus that a time traveler from the past re-materializing in 2050 would appreciate the changes we have described herein but also would recognize as touchingly familiar the shapes of homes, workplaces, and civic buildings of the city to come.

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Appendix: Conflicting Goals in Affordable Housing

Technological innovation and creative solutions may help us alleviate some of the issues related to housing affordability. For some, affordable housing provision entails the maximization of the amount of affordable shelter offered to low- and middle-income populations; for others, it also involves achieving residential integration of poor people into mixed-income neighborhoods. The second conflict of interpretation regarding the affordable housing definition has some advocates focusing on improving the conditions of particular places or communities; others advocate that we should concentrate on the outcomes of specific individuals and families, facilitating their choice and mobility. Finally, there is a degree of ambiguity about who and why specific populations are "deserving" and whether unaffordability in the most expensive cities is indeed problematic for mobile households.

Affordable Housing Versus Income Mixing

The goal of achieving mixed-income residential neighborhoods and maximizing the amount of affordable shelter may be hard to achieve simultaneously. This could happen, for instance, while providing homes for low-income individuals in highly costly luxury units in ritzy neighborhoods. Such endeavors might divert funds that could have otherwise been directed to supplying inexpensive shelter in convenient middle-class neighborhoods. Conversely, a focus on mass production at lower costs could entail sacrifices in quality.

Policymakers and practitioners have turned to mixed-income developments as an approach to address problems associated with concentrated poverty and neighborhood disinvestments, such as joblessness and drug-related violence. In theory, mixed-income developments offer low-income residents a chance to move up the socioeconomic ladder and to attain a better education. Vale and Shamsuddin (2017) propose four key dimensions to characterize mixed income housing projects:

- Allocation: The proportion and range of incomes included in projects.
- Proximity: The spatial scale at which income mixing is intended.
- Tenure: The balance between rental housing and homeownership units.
- Duration: The amount of time projects remain mixed income based on funding restrictions.

Most mixed-income housing projects have three, not always compatible, goals: to alleviate poverty, reduce economic segregation, and revitalize cities. However, there is disagreement about their benefits. On the one hand, pro-development proponents see mixed-income developments as a stepstone toward building better neighborhoods that ameliorate poverty by supplying housing products that foster socioeconomic mixing. Pro-development observers also claim that mixed-income developments improve the quality of housing, services, and amenities, and provide a safer environment relative to what is available in most homogeneously poor areas. Motivated by these theses, the federal and local governments have encouraged the development of affordable homes in poor and middle-class neighborhoods. Examples of programs that incorporate an economic desegregation goal include HOPE VI.

On the other hand, mixed-income developments have faced significant pushback from some affordable housing advocates. Critics suggest that, rather than achieving balanced development that adequately addresses the problems of concentrated urban poverty, these developments have exacerbated gentrification and disproportionately benefited land owners.

Despite their stated objectives, mixed-income developments alone have not been enough to ensure economic desegregation, poverty alleviation, and urban revitalization. The question remains of how to combine mixed-income initiatives with other policy instruments to address housing affordability. A first necessary step is to think holistically about housing affordability. Offering a diverse range of owning and renting mechanisms is fundamental to foster a sustainable housing ecosystem. Also, securing the right location is crucial to guarantee a successful mixed-income housing community. Rather than projects being built in separate complexes or isolated areas—which makes it difficult for communities to adjust and integrate—they should be made where residents can reach jobs in reasonable commuting times. Moreover, families should have access to schools and vital services, and users should be able to connect with the surrounding society. Current funding initiatives sometimes incentivize high-cost projects in segregated neighborhoods over lower-cost developments in integrated ones. Finding appropriate and available land on which to build best-practice apartments will continue to be a challenge.

Affordable Housing Versus Local Economic Development

In some areas, affordable housing efforts are conflated with local economic development policies—focusing on improving the physical and business

conditions in particular communities. In others, housing policies concentrate on families and their outcomes. The former policies tend to emphasize investments in local infrastructure, while the latter tend to favor financial and behavioral support to family choice and mobility. There is considerable debate and uncertainty about how particular neighborhood and household housing dynamics interact, albeit recent thinking seems to be re-focusing on to helping families move to better communities. While reasonable observers may disagree on the benefits of each type of housing policy, we should all agree on their costs. Siting affordable subsidized buildings in high-poverty areas—such as high-rises in the inner cities of the major cities—may be more costly than building more popular products in middle-income areas—such as garden apartments in transport-oriented suburban locations.

Regardless of the costs, whether building subsidized housing does revitalize neighborhoods is by no means an assured outcome and is contingent on the project. Ellen (2008) argues that affordable housing in newly developed rental buildings will have a more positive impact on the destination community if: 1) the project replaces an existing disamenity; 2) the neighborhood is not already afflicted by extreme concentrated poverty; 3) the project is sizable enough to spur revitalization, but not large enough to allow segregation of low-income neighbors; and iv) the project is sited and developed with municipal, as opposed to federal, assistance.

Targeting Policies and "Deserving" Populations

Other potential conflicting goals in affordable housing have to do with the income level that should be targeted by developers, policies, and laws. Some people believe that efforts to provide affordable housing should put emphasis on low-income populations, while others extend their reach to "workforce housing" in the lower-middle through upper-middle income. For instance, a substantial amount of federal expenditures to assist families with high housing costs go through the somewhat regressive mortgage interest deduction (Albouy and Hanson, 2014). Also, policies and laws that means-test based on *current* income may be helping young, upwardly mobile individuals with considerable lifetime wealth with respect to net present value (NPV).

Another conceptual issue has to do with regional mobility. Some areas in the United States have become more attractive to many, due to their natural scenery, historical accumulation of good urbanism, better job markets, stronger educational opportunities, walkability and access to exceptional amenities. Other things being equal, mobile households should be willing

to pay a higher proportion of their incomes to live in metropolitan areas with better quality of life. Consider, for instance, two very similar young childless couples with the same education level and income prospects. One of the couples recently moved to San Diego (California) where the median housing price is $537,200; the other to Birmingham, Alabama, where the median home retails for $203,700. Assume that the previous couples pay 45 percent of their income on housing, while the latter only around 20 percent. Much of the price difference between these two areas is driven by the relative perception of their attractiveness. To what degree are the couple of new Californians entitled to help, given that they chose to live in the more expensive region? Should residents in other cities pay higher taxes to assist those who move to more 'glamorous' ones? Is residing in San Francisco, New York, Boston, or San Diego a social right? If so, who qualifies for such right?

These are hard questions because local populations include a mix of highly-mobile households—able to make conscious choices about where they live and how much income they spend on housing—and less-mobile folks, who feel powerless to counter rising housing costs. Less-mobile families may face devastating losses in social networks from moving out of their current cities. Inasmuch as one believes that housing affordability in the most expensive markets is an important issue, a consensual view might spouse: 1) that policies and laws to ameliorate unaffordability issues should focus on the poor and the least mobile; 2) that priority should be given to long-term residents, who have stronger roots and a more established right to the city.