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11 Innovation and Entrepreneurship in Housing

Edward Kung

11.1 Introduction

In this chapter, I discuss innovation and entrepreneurship in housing as it relates to economic growth and productivity. There are two main issues that I seek to address here: (1) What is the impact of innovation and entrepreneurship as a driver of productivity and growth in housing? (2) What are the factors that facilitate or hinder innovation and entrepreneurship in housing? Since housing is such a large and important part of the economy, the answers to these questions have important implications for the impact of innovation and entrepreneurship on overall economic growth and well-being.

11.2 Overview of the Housing Sector

Housing is a large and growing sector of the economy. From 1980 to 2018, personal consumption expenditures on housing rose from 8.6 percent to 10.8 percent of GDP. Of the major household spending categories shown in figure 11.1, only health care grew at a higher rate over the same period.

Because housing is highly durable, most economic activity in housing is related to the leasing, sale, and management of existing housing stock (i.e.,

Edward Kung is an assistant professor of economics at California State University, Northridge.

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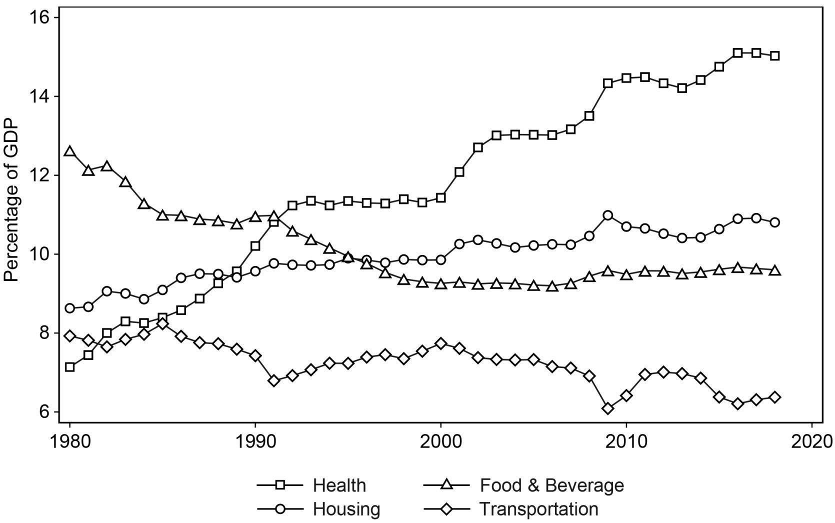

Fig. 11.1 Personal consumption expenditures on selected goods and services as percentage of GDP, 1980–2018

Source: BEA National Income and Product Accounts. Transportation includes vehicles, parts, gasoline, and transportation services.

the real estate industry). A relatively smaller share of the economic activity is related to the actual production of new housing (i.e., the construction industry). Figure 11.2 shows the size of the real estate, construction, and a few other industries in terms of gross output as percentage of GDP, as measured by the Bureau of Economic Analysis (BEA). In 2018, gross output from housing rents was $2.2 trillion, gross output from "other real estate" was $1.4 trillion, and gross output from residential construction was $681 billion.[1]

An important measurement issue that arises in housing is how to value the economic output of owner-occupied housing. A standard thought experiment illustrates the problem: Suppose that Annie and Betty own and live in identical houses next door to each other. Because each owns her own house, no rental payments are made, and no value of housing services is recorded. Now, suppose they switch houses without changing ownership. Instead, Annie pays Betty $1,000 in monthly rent and Betty pays Annie $1,000 in monthly rent. Annie and Betty are each no better or worse off,

1. Gross output from housing rents includes both the imputed rents of owner-occupiers and the rents paid by tenants. Gross output from "other real estate" includes all other activities related to residential real estate, including the activities of real estate brokers, appraisers, and property managers. "Other real estate" also includes all commercial real estate activities and rents. The BEA's Industry Economic Accounts do not separate commercial real estate activity from residential real estate activity.

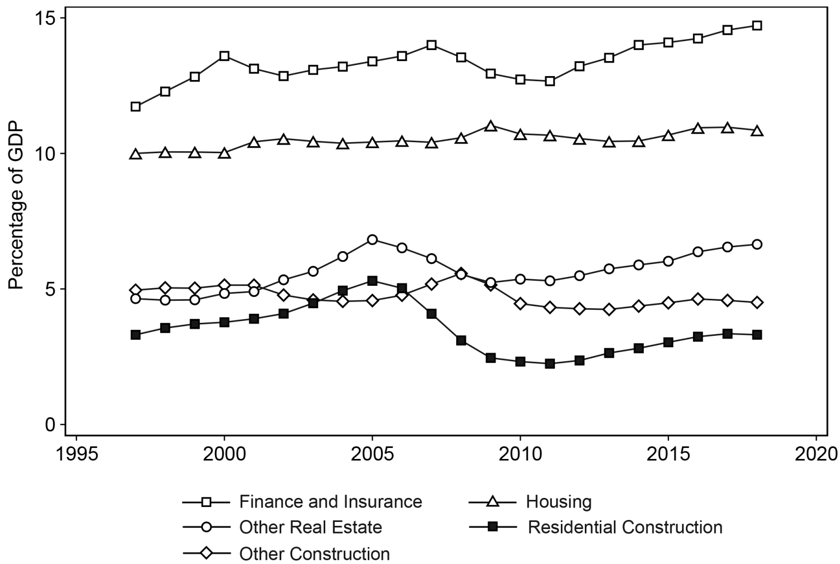

Fig. 11.2 Gross output of selected industries as percentage of GDP, 1997–2018
Source: BEA Industry Economic Accounts.

but economic output appears to have increased by $2,000 a month. Conceptually, economic output should not depend on whether Annie and Betty chose to live in their own homes or chose to rent from each other, and so national income accountants have developed methods for estimating what is known as the imputed rent of owner-occupied housing (BEA 2019). Roughly speaking, the imputed rent can be thought of as the rent that the owner-occupier would have to pay to rent a house of similar quality and characteristics. Imputed rents of owner-occupied housing form a large share of the measured economic output in housing. In 2018, imputed rents from owner-occupied housing were $1.6 trillion, while rents from tenant-occupied housing were $611 billion.

Although the National Income and Product Accounts measure a high level of economic output in housing, most of it does not come from firms. Table 11.1 shows industry statistics from the 2017 Economic Census for selected housing-related subsectors. Despite housing's relative importance in terms of total economic output, residential real estate is comparatively small in terms of firm revenue and employment. The discrepancy arises because most real estate rental payments are either imputed (for owner-occupiers) or paid to individuals not classified as firms.[2] Moreover, both residential real

2. The BEA estimates economic output in housing using all rental payments regardless of who the recipient is (including imputed rents for owner-occupiers). Thus, rental payments made to individual landlords or to firms not primarily engaged in the real estate business would be

Table 11.1 **Statistics for selected industries, 2017**

NAICS	Industry description	Number of firms	Number of establishments	Total revenue ($ billions)	Number of employees
531	Real estate	283,734	350,536	477.2	1,687,621
	Lessors of residential dwellings	52,243	71,552	120.2	361,997
	Offices of real estate agents and brokers	106,548	121,901	113.7	333,854
	Residential property managers	35,668	49,420	45.3	449,176
2361	Construction of residential buildings	170,510	171,901	342.1	690,798

Source: Economic Census.

Notes: Real estate includes both residential and nonresidential real estate. Construction of residential buildings does not include subcontractors (NAICS 2332) due to lack of data.

estate and construction are loosely concentrated industries at the national level, with the average firm earning $2 million or less in annual revenues. The disconnect between total economic output and firm revenues suggests that the social returns to innovation in housing may exceed private returns. I return to this thought later in the chapter.

Finally, it is important to note that housing consists of both structure and land—and related to land, location—hence the old real estate adage, "location, location, location." Innovations that affect the ability to produce structures on land and innovations that affect the ability to derive more value out of the same size or location of land both will affect economic growth and productivity in housing.

Structures and land have very different supply-side characteristics. The supply of structures is affected by the labor market for construction workers, materials costs, and topography. The amount of buildable land in desirable locations, however, is in fixed supply. In theory, the availability of buildable land does not by itself put any hard constraint on the quantity of housing if housing could be built as densely as desired, but in reality, most cities and neighborhoods in the US place restrictions on the density of residential construction. Figure 11.3, which is a reproduction of figure 19.1 from Gyourko and Molloy (2015), shows that growth in house prices has vastly outpaced the growth in the labor and material costs of construction—which has been flat—suggesting that most of the growth in house prices comes from growth in the price of land as opposed to structures. Thus, local land use policy is an important factor when discussing productivity and growth in housing,

counted in gross output (BEA 2009). In contrast, the Economic Census only measures the revenue received by real estate firms and establishments. Individual landlords will typically not be counted as firms in the Economic Census because the Economic Census counts non-employer firms based on business income tax filings, which does not include individuals' real estate rental income reported on 1040 Schedule E (US Census Bureau 2019).

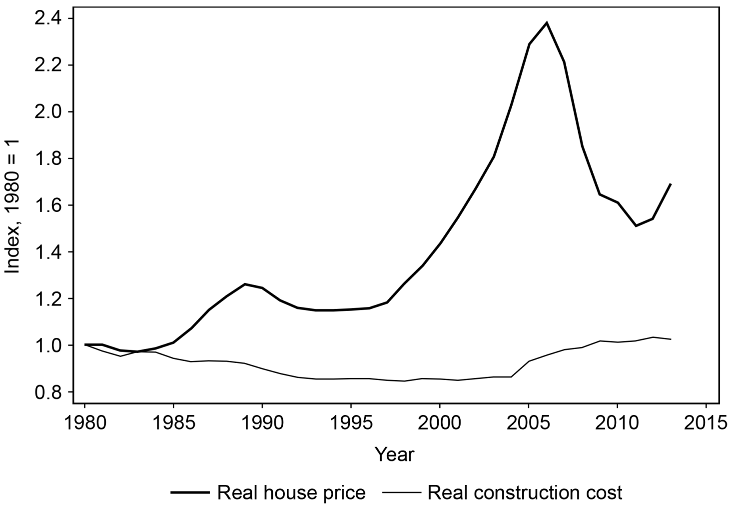

Fig. 11.3 Real construction costs and house prices, 1980–2013

Source: Reproduction of fig. 19.1 from Gyourko and Molloy (2015).

Note: Construction costs are the cost, including labor at union wage rates, of an economy-quality home from RSMeans deflated by the consumer price index. House prices are the repeat-sales index published by CoreLogic deflated by the price index for personal consumption expenditures, excluding housing services.

and it may be that innovations to policy would be more marginally productive than technological innovations in the housing industry. I return to this thought later in the chapter.

The rest of this chapter is organized as follows. In section 11.3, I discuss the existing data on innovation, entrepreneurship, and productivity in residential real estate and construction, and compare to other sectors. Based on R&D spending and patenting statistics, direct innovation inputs and outputs in real estate and construction are shown to be miniscule. However, the amount of venture capital investment in real estate technology companies is growing rapidly, especially from 2013 to 2019. The major waves of innovation in residential real estate from 2000 to 2019 are: (1) the growth of online portals for housing search, (2) the growth of home-sharing platforms that allow homeowners to use their homes as short-term rentals, (3) the growing use of property management software, and (4) the growth of companies using technology to compete directly with residential brokers. The best available statistics on labor productivity show that labor productivity has been roughly flat in single-family residential construction, but it has been growing recently in multifamily residential construction. Labor productivity in real estate has been growing, and this appears to be mostly explained by a deepening of software and information technology (IT) capital, as well as deepening of purchased services. The productivity statistics should be interpreted with caution, however, due to measurement issues that I discuss later in the chapter.

In section 11.4, I review the literature on how the Internet has affected housing search. In theoretical models, the growing use of the Internet in housing search has been modeled as either a decline in search costs or an increase in matching efficiency. The main theoretical prediction of a lowered search cost or increased match efficiency is that buyers and sellers will search more intensely, resulting in a higher number of visited homes and higher average transaction price due to higher surplus between buyer and seller. Empirical evidence is limited by the difficulty of isolating variation in Internet use, but the existing evidence appears to consistently show that Internet use by either the buyer or the seller results in higher prices, but not necessarily shorter search durations. If the main effect of increased search efficiency is higher match quality, but not necessarily shorter search durations or higher rates of sale, then the effect of Internet search on the productivity of housing may be hard to measure, because it is difficult to separate quality from price. The number of homes sold per hour worked in the real estate brokerage industry has not changed much over the past 30 years, and realtor commissions have not been driven down significantly by the growth of Internet search, though this may also be due to anticompetitive practices, which I discuss further in section 11.6.

In section 11.5, I review the literature on how the growth of home-sharing platforms like Airbnb has affected the housing market. Home sharing is one of the largest targets for venture capital investment in residential real estate over the past 10 years. Home-sharing platforms make it easier for homes that are traditionally supplied in the residential housing market to instead be supplied to the short-term rental market (or travel accommodations market). For homeowners, this increases the option value of spare capacity in housing, which should raise the price of housing. Furthermore, if some homeowners switch from supplying the residential market to the short-term rental market, then rental rates in the residential market will increase further. The empirical literature suggests that, in the short-run at least, home-sharing platforms have indeed caused reallocation from the long-term rental market to the short-term rental market, along with a corresponding increase in rental rates and house prices. It is still unclear what the long-run effects of home sharing will be. There could be an increase in the quantity of residential housing and a decrease in the quantity of hotel rooms, and there could be growth in the number of housing units built with spare capacity in mind, such as housing units with attached dwelling units or pieds-à-terre.

In section 11.6, I discuss the future outlook of innovation and entrepreneurship in housing, as well as our study of it. I discuss measurement issues in housing and how better measurement can help us to better understand the full impact of recent technological innovations. I discuss anticompetitive practices in the real estate brokerage industry, and how that may be hindering entrepreneurship and the adoption of new innovations. I discuss how land use regulations may be hindering economic growth—not just in housing but also in the economy as a whole. I discuss how innovations in other sectors can affect housing through their effect on locational preferences, amenities, and transportation costs. And I briefly discuss how housing can influence innovation and entrepreneurship in other sectors. Section 11.7 concludes.

11.3 Key Trends and Cross-Sectoral Metrics

11.3.1 Innovation Inputs and Outputs

Traditionally, residential real estate and construction are considered to be low-innovation industries. Writing for *Forbes*, David Snider and Matt Harris write that "up until a few years ago there were only a handful of significant U.S. real estate tech success stories" (Snider and Harris 2018). They attributed the lack of high-tech success in real estate to difficulties in creating "meaningful client value" and "competitive barriers" in a space that is defined by "real and physical experiences," as well as to landlords and developers who are "reticent to make significant investments." There is likely much truth to this, as the real estate and construction industries are loosely concentrated and dominated by very small firms (table 11.1), indicating perhaps a lack of economies of scale that would make significant investments worthwhile.

Data on actual innovation inputs and outputs seem to confirm this sentiment. Figure 11.4 shows R&D spending as a percentage of revenue for

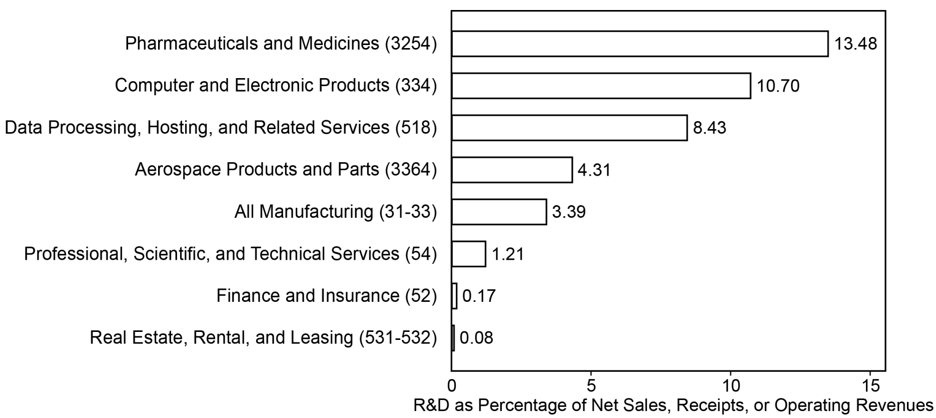

Fig. 11.4 R&D spending for selected industries, 2016

Source: R&D spending is from the NSF Business R&D and Innovation Survey. Manufacturing revenue is from the Quarterly Financial Reports, non-manufacturing revenue is from the Service Annual Survey.

selected industries in 2016. R&D spending in the real estate, rental, and listing industries (NAICS 531–532, the lowest industrial level reported in the Business R&D and Innovation Survey (BRDIS) is less than a tenth of 1 percent, compared to 3.4 percent for the manufacturing sector and 13.5 percent for research-intensive industries like pharmaceuticals. R&D spending is not reported for the construction industry, but it totals less than $930 million, which is again less than a third of 1 percent of construction industry revenues, and probably much smaller.[3] Data on measured innovation output, such as patents, is similarly miniscule. In 2016, the BRDIS reports that companies in the real estate, rental, and leasing industry (NAICS 53) filed for only 87 patents in total, and the number of patents issued was smaller than the disclosure threshold.

11.3.2 Entrepreneurship

The data on measured innovation inputs and outputs paints a picture of low innovation in the housing sector. However, this belies a general sense that the real estate business is being transformed by technology. Everyone is familiar, for example, with how Internet marketing of homes through websites like Zillow and Redfin has transformed the way people buy and sell homes. According to a recent report by the National Association of Realtors, 48 percent of real estate firms cited keeping up with technological change as one of the biggest challenges they currently face (NAR 2018).

Data on venture capital funding shows that there is indeed growing investor interest in real estate technology. Figure 11.5 shows the amount of venture capital funding for real estate and construction related companies, as reported by CrunchBase, a data vendor specializing in tracking startups and innovative companies. I focus on both residential and commercial real estate and construction, because the innovations and technologies driving both sectors appear to be similar, and because it is difficult to accurately distinguish between residential and commercial in the CrunchBase data. The data show that $900 million in venture capital was raised by real estate and construction related companies in 2000, but by November 2019, this number had grown to $5.8 billion. This growth is not an artifact of a shift in the total amount of venture capital funding in all sectors. Nor does it reflect spurious growth in the amount of data that CrunchBase collects: Figure 11.5 shows that venture capital in real estate and construction is growing at a rapid rate even when measured as a percentage of all venture capital funding reported in CrunchBase. Moreover, this growth is not driven by just a handful of superstar companies. WeWork and Airbnb are the two largest fundraisers through this time period, but even if they are excluded from the data, the

3. The BRDIS reports that total R&D spending for nonmanufacturing industries (including construction) was $119,690 million, and for the reported sub-industries (not including construction), the total R&D spending was $118,760 million, so R&D spending in construction was at most $930 million.

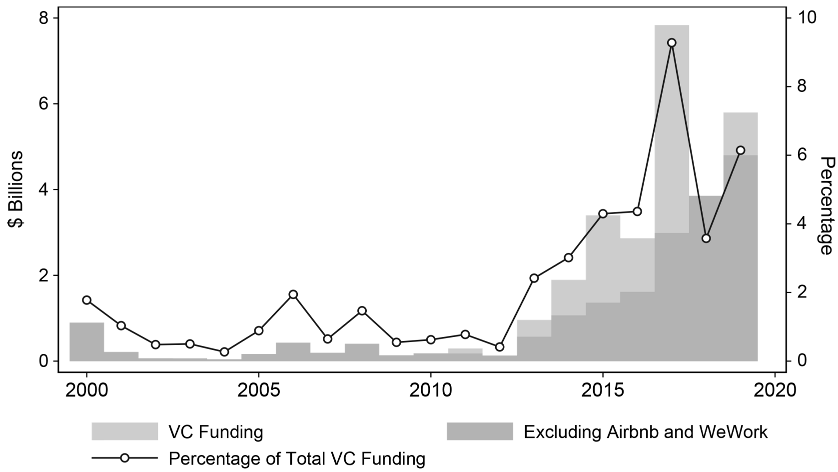

Fig. 11.5 Venture capital funding of real estate and construction related companies, January 2000–November 2019

Source: CrunchBase. Only companies headquartered in the US are included. Real estate and construction related companies are companies that CrunchBase has identified with at least one of the following category tags: "Real Estate," "Commercial Real Estate," "Property Management," "Property Development," "Home Improvement," and "Home Renovation." Short-term vacation rental companies like Airbnb were also included.

amount of venture capital funding for real estate and construction related companies still increased markedly after 2013, and it is steadily growing.

It is instructive to look at which of these companies received the most venture capital funding over the past two decades. Table 11.2 shows a selection of major venture capital fundraisers for each half-decade starting from 2000. The first wave of innovation occurred in the early 2000s with the movement toward the online marketing of homes via web portals. Interestingly, the initial wave of web portals were not necessarily the most successful ones in capturing the market. The second wave of online portals, including Zillow and Trulia, now command a larger share of real estate searches, and Zillow is the market leader in residential real estate today. Besides online portals, the 2000s also saw investments in developers of property management software, which suggests capital deepening in the real estate industry, as well as the beginnings of the nascent home-sharing industry with HomeAway.

By the first half of the 2010s, the online portal business appears to have matured, with fewer online portals raising significant amounts of venture investment. Zillow filed for an initial public offering (IPO) in 2011 and acquired Trulia in 2015, solidifying its position as the market leader in residential real estate portals. But the early 2010s saw the emergence of a number of new businesses harnessing technology to directly compete with traditional firms in related markets. Airbnb, a vacation rental platform that

Table 11.2 Major fundraisers among housing related companies, January 2000–November 2019

2000–2004	2005–2009	2010–2014	2015–2019
HomeGain.com $53 million raised Online portal	**HomeAway** $477 million raised Vacation rental	**Airbnb** $794 million raised Vacation rental	**Airbnb** $2.6 billion raised Vacation rental
RealPage $52 million raised Property management software	**Zillow** $87 million raised Online portal	**Houzz** $214 million raised Home design	**Compass** $1.5 billion raised Brokerage
Rent.com $47 million raised Online portal	**Trulia** $33 million raised Online portal	**Redfin** $178 million raised Brokerage	**Opendoor** $1.3 billion raised iBuyer
Homes.com $39 million raised Online Portal	**Redfin** $32 million raised Brokerage	**Cityscape Residential** $82 million raised Multifamily developer	**Vacasa** $527 million raised Vacation rental
ZipRealty $35 million raised Brokerage	**Appfolio** $30 million raised Property management software	**Compass** $73 million raised Brokerage	**Knock** $448 million raised iBuyer
2000–2004 $1,299 million raised	2005–2009 $1,349 million raised	2010–2014 $3,492 million raised	2015–2019 $23,755 million raised

Source: Crunchbase.

Notes: The companies are not exactly the five largest fundraisers in each half-decade, but all are in the top 10. The companies were chosen to be representative of innovative trends in housing.

allows homeowners to rent rooms or their entire houses to vacationers, is one of the most highly valued startups in the world and competes directly with the hotel industry. Houzz is an online platform for interior design and home improvement where people can share design ideas and match with contractors. RedFin and Compass bill themselves as technology-driven brokerages, believing that technology will give them a competitive advantage against more traditional brokers. Cityscape Residential is a multifamily residential property developer and is the only company on this list that does not appear to be explicitly technology driven. Its inclusion may highlight a potential trend in multifamily housing development, which I return to discuss later.

The late 2010s saw the emergence of a new type of technology-driven real estate business: the i-Buyer. i-Buyers are companies that want to cut out the middleman in housing transactions and simplify the home-selling process. They use machine learning to estimate the market value of a home, make offers to sellers so that sellers can circumvent the long and complicated selling process and avoid paying realtor fees, and then flip the house for a profit. They also collect fees like realtors, but they believe that sellers are willing to pay the fee for the convenience. i-Buyers have attracted significant investor interest, to the tune of over $1.7 billion in venture capital over the past

3 years. It is still too early to tell what effects this will have on the housing market.

11.3.3 Labor Productivity

The growth of online portals, property management software, and technology-driven brokerages suggests that technological capital and service inputs are becoming increasingly important for the real estate industry. Has this translated to an increase in labor productivity?

Unfortunately, measuring productivity in construction and real estate is a challenging task. The Bureau of Labor Statistics has only recently begun to produce official estimates of labor productivity in the residential construction industry (Sveikauskas, Rowe, and Mildenberger 2018) and still does not produce any official estimates of productivity in the residential real estate industry. One of the main difficulties is that buildings vary widely in their quality and characteristics, making it difficult to construct reliable output price deflators. Another difficulty, especially as it pertains to real estate, is accounting for the depreciation of structures, as well as the treatment of owner-occupied housing and non-firm entities that receive rental payments, as discussed earlier. Nevertheless, it is instructive to look at trends in labor productivity with the measures that are available.

11.3.3.1 Labor Productivity in Residential Construction

In 2018, the BLS began publishing official estimates of gross output-based labor productivity separately for residential and nonresidential construction. The advance is attributed to improved producer price indexes for the separate construction sub-industries, also published by the BLS.[4] Figure 11.6 reports these estimates separately for the single-family residential construction industry and the multifamily residential construction industry. Labor productivity in the manufacturing sector is also shown for comparison. Labor productivity in single-family construction has been roughly flat for the past two decades, consistent with the evidence in Gyourko and Molloy (2015) (figure 11.3) that the real construction cost of single-family housing has not changed much. Labor productivity in multifamily construction is a much different story, with productivity gains that track more closely with the manufacturing sector, especially in the past 15 years. Because data on capital expenditures for multifamily construction is not readily available, it is not immediately clear whether these gains are due to increases in total factor productivity or capital deepening. Another issue is that these measures do not reflect subcontractor hours. Sveikauskas, Rowe, and Mildenberger (2018) show that accounting for subcontractor hours significantly reduces

4. The new producer price indexes are not based on the sale prices of actual buildings. Instead, the BLS establishes a building with standardized features and collects cost information from many builders. The cost data is then supplemented with information on profit margins beyond these costs. See Sveikauskas, Rowe, and Mildenberger (2018) for a further discussion.

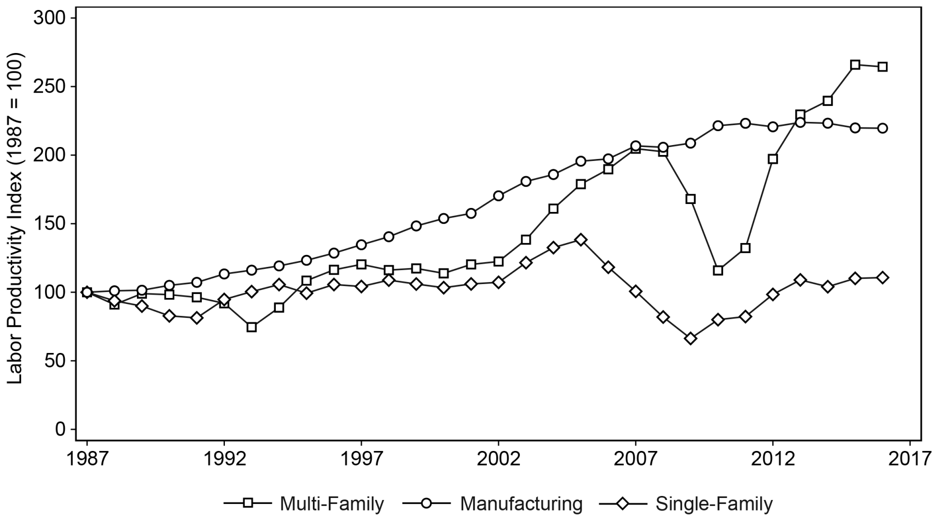

Fig. 11.6 Labor productivity in residential construction, 1987–2016
Source: Bureau of Labor Statistics, Office of Productivity and Technology.

the gains in multifamily labor productivity, though the overall trend is still that it is growing at a much faster rate than single-family labor productivity.

11.3.3.2 Labor Productivity in Real Estate

Currently, neither the BLS nor the BEA publish official estimates of labor productivity in the residential real estate industry. The BEA does publish an estimate of labor productivity in real estate as a whole (NAICS 531), through its Integrated Industry-Level Production account (KLEMS account).[5] The KLEMS data must be interpreted with caution, however, because of the discrepancy in how gross output is measured and how inputs are measured. In the KLEMS account, gross output in real estate includes all rental payments made, including to firms not primarily classified as real estate and to non-firm landlords. The imputed rents of owner-occupiers are also included. Data on inputs, however, are typically measured from surveys of real estate firms and establishments (see BEA 2009). Thus, there is a difference in the entities from which gross output is measured and from which inputs are measured. It is likely that a significant amount of both labor and capital input goes unmeasured in real estate, such as the amount of time individual landlords and owner-occupiers spend managing their properties, and the equipment, software, and services they employ to help them.

Nevertheless, I present in figure 11.7 labor productivity estimates as

5. Available at https://www.bea.gov/data/special-topics/integrated-industry-level-production-account-klemshttps://www.bea.gov/data/special-topics/integrated-industry-level-production-account-klems. "KLEMS" stands for capital, labor, energy, materials, services.

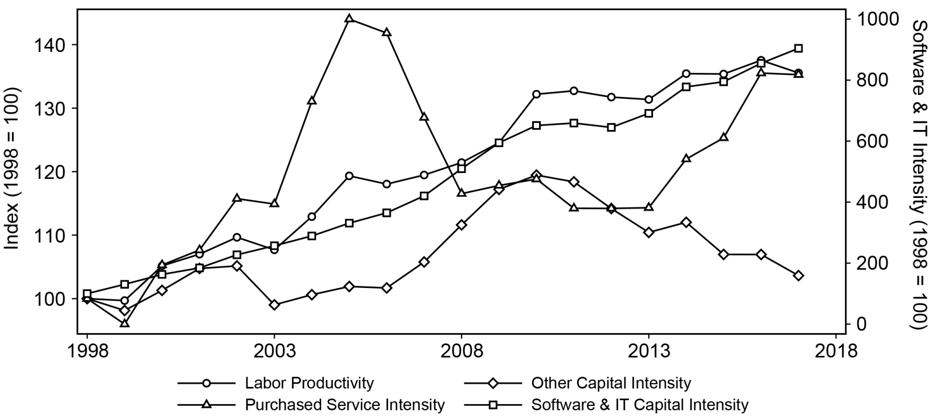

Fig. 11.7 Labor productivity and capital and service intensity in real estate, 1998–2017

Source: BEA-BLS Integrated Industry-Level Production Accounts. Intensity is the quantity of the input divided by the quantity of labor.

reported in the BEA's KLEMS accounts. According to BEA KLEMS data, labor productivity in real estate has been steadily rising since 1998. Over the same period, software and IT capital intensity rose by over 900 percent. By contrast, other non-software and non-IT capital intensity did not rise by nearly as much. The intensity of purchased services also increased, though it exhibits much more cyclicality than the intensity of software and IT capital.

11.3.4 Summary

I now summarize the information presented in this section on sectoral trends and metrics.

1. Real estate and construction firms perform little research and development.
Data from the NSF Business R&D and Innovation Survey shows that real estate and construction firms spend very little on R&D and produce very few patents. This is not surprising and does not imply that real estate and construction firms do not innovate. Instead, whatever innovation does occur is not reported as R&D on the BRDIS, or perhaps the R&D is not conducted by real estate firms themselves but by software and technology companies that service the real estate industry.[6]

2. There is growing investor interest in real estate technology companies.
Venture capital funding for real estate technology companies has increased rapidly since the early 2000s. Investment activity in these companies reveals the major waves of innovation in real estate. In the early 2000s, the focus

6. For example, Zillow, in its SEC filings, is classified with SIC code 7389: "Business Services, Not Elsewhere Defined."

was on online platforms for the digital marketing of homes over the Internet and on software companies that built tools for property management. These companies provide supportive services to traditional firms in real estate, rather than act as direct competitors. The late 2000s to early 2010s saw the growth of more companies harnessing technology to directly compete with traditional firms in multiple areas, such as Airbnb competing in the hotel space and RedFin competing in the brokerage space. A new trend that emerges in the late 2010s is the growth of i-Buyers, companies that aim to buy homes directly from sellers and then sell them for a profit, thus competing directly with brokers but also promising to transform the way real estate is bought and sold.

3. Software and IT capital has been increasing rapidly in real estate, along with labor productivity.
Consistent with the growth in real estate technology companies, data from the BEA KLEMS accounts reveals that software and IT capital intensity has increased very rapidly in real estate, along with labor productivity. By contrast, the intensity of other non-software and non-IT capital has not increased nearly as much.

4. Labor productivity growth in single-family construction has been slow but may have increased recently for multifamily construction.
The best available data for labor productivity in construction shows that labor productivity in single-family residential construction has been mostly flat over the past three decades. This is consistent with previous findings on the real cost of constructing single-family homes (Gyourko and Molloy 2015). On the other hand, labor productivity in multifamily residential construction appears to have increased markedly over the past 15 years. It is not immediately clear what is driving the trend in multifamily construction, and I leave this question to future research.

5. Measurement issues continue to be a problem.
The productivity data need to be interpreted with caution because of measurement issues. One of the difficulties in measurement is the reliability of price deflators when buildings vary widely in their quality and characteristics. Another difficulty, especially as it pertains to real estate, is the discrepancy between how outputs and inputs are measured. I discuss measurement further in section 11.6.

11.4 Internet Search and the Housing Market

One of the major technological trends affecting housing in the past two decades has been the movement of housing search from a primarily offline activity to the Internet. According to the National Association of Realtors, 44 percent of home buyers in 2018 began their search for a home online,

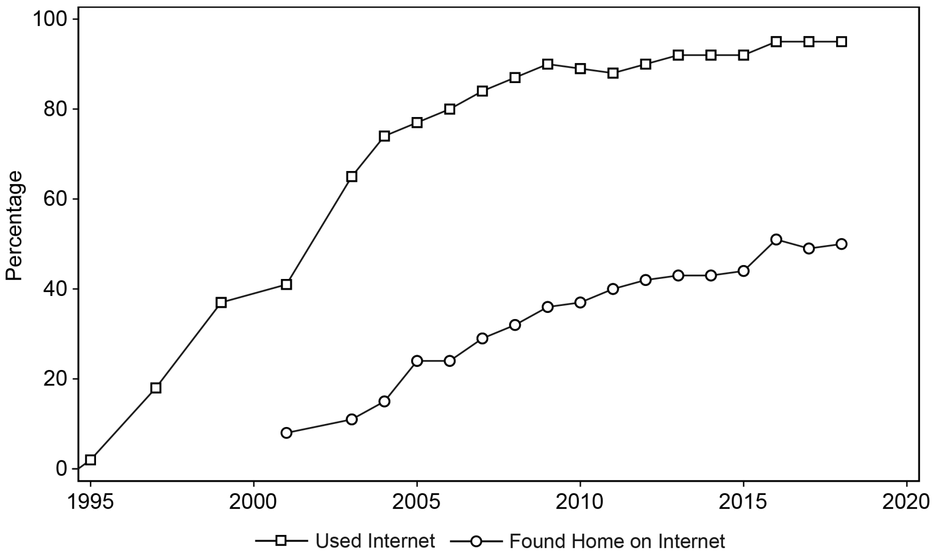

Fig. 11.8 Internet use by home buyers, 1995–2018
Source: National Association of Realtors Profile of Home Buyers and Sellers.

95 percent used the Internet at some point in their search, and 50 percent found the home they ultimately purchased online; 100 percent of home buyers rated online websites as a useful source of information for the home buying process. In contrast, in 2001, only 41 percent of buyers used the Internet at some point in their search, and only 8 percent found their homes online (figure 11.8). The three largest housing-tech IPOs in the past 10 years were RedFin, Zillow, and Trulia, all three of which offer Internet-based search as one of their primary services. Today, prospective home buyers can search for homes anywhere in the US, look at pictures, and take virtual tours, all from the comfort of their own home and without ever speaking to a real estate agent.

11.4.1 Theoretical Effects

How has the Internet affected the efficiency of housing search? Has it made search more efficient, or has old activity simply moved to a new medium? Economic models of housing search follow models of labor market search developed in Diamond (1982), Pissarides (1985), and Mortensen and Pissarides (1994), in which search is modeled as a frictional process through which buyers and sellers meet and learn about match quality.[7] There are

7. See Wheaton (1990), Novy-Marx (2009), Genesove and Han (2012), Ngai and Tenreyro (2014), Head, Lloyd-Ellis, and Sun (2014), Guren (2018), and Anenberg and Kung (2018) for some examples of economic housing search models.

three major components to housing search models: (1) search costs—it is costly in terms of time and effort to search, and therefore both buyers and sellers in a housing search market pay costs for each period in which they are searching, (2) match function—the match function is the rate at which buyers and sellers meet in the market and is typically modeled as a reduced-form object,[8] and (3) match quality distribution—once buyers and sellers meet, they find out the quality of their match, which is drawn from a distribution. There is heterogeneity in match quality, because some buyers prefer some features of a home more than others. Match quality is unknown prior to the buyer and seller meeting, because some features of the home are not observed until personally inspected by the buyer. In this way, the traditional home visit or other ways of transmitting information about the home to a prospective buyer is an important part of the search process. If the surplus generated by a match between the buyer and seller exceeds the sum of their reservation values, then the buyer and seller will transact.

The literature has primarily interpreted the effect of the Internet as reducing the cost of searching (Ford, Rutherford, and Yavas 2005) or increasing the match rate (Genesove and Han 2012). The main prediction of either effect is that equilibrium match quality and reservation value will be higher, and therefore equilibrium transaction prices will be higher. Reservation values increase, because a lower search cost and a higher match rate both increase the expected returns to rejecting an offer and continuing to search for a better match. A higher reservation value results in more rejected offers, but the transactions that do happen will have higher surplus on average. The number of offers looked at should increase on average, but the predicted effect on time-on-market is ambiguous, because the Internet may make the time cost of acquiring information lower.

11.4.2 Empirical Evidence

Empirical evidence on the effect of the Internet on housing search is limited due to significant identification challenges. One early study by Ford, Rutherford, and Yavas (2005) used data from a North Texas multiple listing service (MLS) in 1999 to regress price and time-on-market as an indicator for whether or not the property was listed on the Internet in addition to being on the MLS. They found that homes listed on the Internet sold at 1.9 percent higher price and took 6 days longer to sell. A limitation of their results is that the decision of whether to list on the Internet is endogenous, which the paper only controls for using a Heckman selection equation. While helpful, the Heckman procedure may not be valid if the observable controls used to predict Internet listing are related to sale price and time-on-market in non-linear ways. Moreover, only 7 percent of their sample was not listed on the

8. There have been attempts to provide microfoundations for the match function. See Petrongolo and Pissarides (2001).

Fig. 11.9 Buyer search duration and seller time on market, 1987–2018
Source: National Association of Realtors Profile of Home Buyers and Sellers.

Internet, which further raises endogenous selection concerns. Nevertheless, this was one of the first attempts to estimate the effect of the Internet on housing search, and it found results consistent with theoretical predictions.

On the buyer side, Zumpano, Johnson, and Anderson (2003) use data from the National Association of Realtors' 2000 Home Buyer and Seller Survey to study the relationship between buyer Internet use and search behavior. They find no effect of Internet use on the total buyer search duration, but they did find a statistically significant increase in search intensity, defined as the number of properties visited per week, which is again consistent with theory. To control for the endogeneity of Internet use, Zumpano, Johnson, and Anderson (2003) also use a Heckman selection equation. An interesting finding in the selection equation was that out-of-town buyers and first-time home buyers were more likely to use the Internet.

Related to these findings are results presented in Genesove and Han (2012). Using National Association of Realtors (NAR) survey data across multiple cities and years, they found that at the city-year level, the fraction of buyers who reported finding their home on the Internet is positively associated with buyer time-on-market and on the number of home visits that buyers conduct; the fraction is negatively associated with seller time-on-market. In the aggregate, buyer search durations have indeed been increasing, while seller search durations have fallen (figure 11.9).

Han and Strange (2014) document a secular increase in the probability of bidding wars (defined as sale price above list price), from 3.5 percent of transactions being a bidding war in 1986 to 10 percent in 2010. To explore whether the Internet may have played a role in increasing the frequency of bidding wars, they use NAR survey data to regress whether a listing was sold in a bidding war on an indicator for whether the buyer found the home through the Internet. They found that the buyer's use of the Internet is associated with a 4.3 percent higher probability of a bidding war. As with Genesove and Han (2012), the focus of Han and Strange (2014) was not specifically on the Internet, and so no further causal analysis was attempted. Still, this finding is consistent with the possibility that the Internet increased the match rate between buyers and sellers, as bidding wars can only happen when multiple buyers vie for the same property. Since bidding wars tend to result in higher prices, the finding is also consistent with the result in Ford, Rutherford, and Yavas (2005) relating Internet listing to higher sale prices.

11.4.3 Implications for Economic Growth and Productivity

If Internet search is increasing equilibrium match quality, then some of the recent observed house price increases may be due to improvements to match quality rather than basic supply and demand factors. Assuming that gross output measures should be adjusted for quality changes, this implies that real growth in the output of housing may be understated due to quality increases being misattributed to the price deflator. Standard hedonic methods for estimating constant-quality price deflators in housing typically only control for the observed physical characteristics of a home; they do not account for unobserved match quality between the buyer and the house.[9]

Is there a limit to the efficiency gains due to reductions in search frictions? After all, search frictions cannot fall below zero. The answer is that it depends on how important learning about match quality is to the search process. If search is primarily "frictional" (meaning that it takes time and effort for buyers and sellers to meet and transact), then an instantaneous match rate would simply reduce the equilibrium vacancy rate to zero without a corresponding increase in the expected surplus of any match.[10] The upper bound on the search efficiency gain would simply be the vacancy rate multiplied by the economic output of occupied homes. Since the current gross output of housing is \$2.2 trillion, and the current home vacancy rate (including both rental and owner occupied) is 3.3 percent, this implies an upper bound on search efficiency gains of \$73 billion.

If learning about match quality is also important, then the potential efficiency gains due to more efficient search may be much higher. If $\bar{S}$ is the upper bound of the support of the match quality distribution, then as search cost goes to zero or the match rate becomes instantaneous, the vacancy rate goes to zero, and the expected surplus on every match approaches $\bar{S}$.[10] The efficiency gains will be a combination of the increase due to fewer vacancies

9. Unobserved differences in match quality could arise due to commute times, heterogeneous preference for neighborhood amenities, or distance to friends/relatives, among potentially many other things.

10. See the appendix for a derivation.

and the increase due to higher match surplus. Since we do not know how far away current match surpluses are from $\bar{S}$, it is impossible to say what the maximum efficiency gains from search might be. If the support of S has no upper bound, then the gains are potentially unlimited, and the equilibrium vacancy rate may be positive in the limit even as matching becomes instantaneous.

The possibility that efficiency gains are showing up in price increases due to higher quality matches is a broader issue that applies to all search markets, not just housing. Martellini and Menzio (2018) argue that this may explain why the labor market has not experienced significant declines in job vacancy and unemployment rates despite known technological improvements in job search. Martellini and Menzio (2018) showed that if the match quality distribution is Pareto, then unemployment, job vacancy, job-finding, and job-loss rates remain constant even as the efficiency of search grows over time. Improvements in search technology show up in productivity growth. Applied to the housing market, this suggests that improvements in search technology will show up in house price growth, and not necessarily in lower vacancy rates or lower search durations. Accounting for how match quality increases have contributed to the growth in productivity of housing seems like an interesting area for further research.

11.4.4 Impact on Real Estate Agents and Brokers

How has Internet search affected the market structure of the real estate brokerage industry? Early speculation on the effects of the Internet on real estate agents theorized that the Internet would lead to disintermediation by making it easier for buyers and sellers to market their homes without the help of brokers, and that there would be an unbundling of services where listing would be untied from other services that brokers provided (Baen and Guttery 1997). This result was seen as desirable due to a long line of research documenting inefficiencies in the brokerage industry, centering on a lack of price competition due to fixed commission rates (Barwick and Pathak 2015; Han and Hong 2011; Hsieh and Moretti 2003) and incentive misalignment between broker and seller (Bernheim and Meer 2013; Hendel, Nevo, and Ortalo-Magné 2009; Levitt and Syverson 2008).

In the aggregate, it does not appear that growing Internet use has led to disintermediation. Data from the NAR shows that the use of real estate agents has actually gone up over the past two decades, and the percentage of homes sold by the owner without an agent has actually gone down (figure 11.10).

The growing importance of the Internet in housing search does not appear to have affected the productivity of real estate agents. Although the BLS does not publish official estimates of labor productivity in the real estate brokerage industry (NAICS 53121), it does estimate the number of hours worked. This data can be combined with NAR estimates of the number of

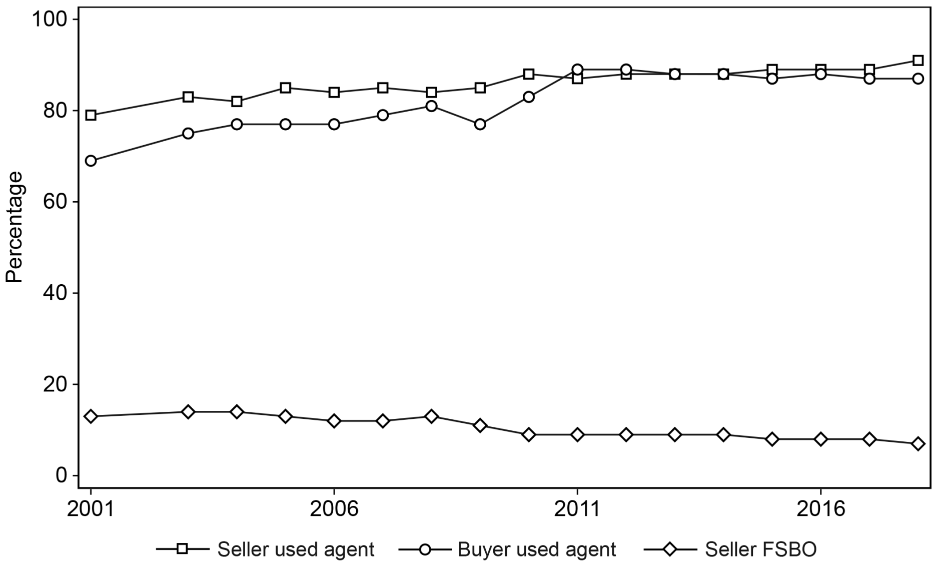

Fig. 11.10 Real estate agent use by home buyers and home sellers, 2001–2018
Source: National Association of Realtors Profile of Home Buyers and Sellers.

existing homes sold each year, and Census estimates of the number of new homes sold each year, to calculate an index of the number of homes sold per hour worked.[11] Clearly, the number of homes sold may not be an accurate measure of the quantity of brokerage services being supplied—for example, the amount of service required to sell a unique, luxury mansion may be very different from the amount of service required to sell a standardized condo in a planned community—but this measure can still give us a sense of productivity trends in the brokerage industry under the assumption that the distribution of services provided per home has remained relatively stable. Figure 11.11 shows the result of this calculation. The number of homes sold and the number of hours worked are highly cyclical, following the house price cycle closely, with the number of hours worked lagging a few years behind, but there does not appear to be any long-run trend in the productivity of real estate agents and brokers, at least by this metric.

Real estate agent commission rates do appear to be falling slightly. RealTrends reports that between 2012 and 2017, average commission rates fell 20 basis points from 5.32 to 5.12.[12] Investors have made big bets that technology would disrupt the real estate brokerage industry, as seen by the big invest-

11. NAICS 53121 consists of both residential and commercial real estate brokers. NAICS does not separate real estate brokerage by residential and commercial.

12. Source: https://www.realtrends.com/blog/whats-going-on-with-brokerage-profitability/https://www.realtrends.com/blog/whats-going-on-with-brokerage-profitability/.

Fig. 11.11 New and existing homes sold and hours worked in real estate brokerage, 1987–2018

Source: Bureau of Labor Statistics, Census Bureau, and National Association of Realtors. NAICS 53121: Offices of Real Estate Agents and Brokers.

ments in RedFin, a discount brokerage that charges listing commission rates of 1 to 1.5 percent, compared to an average of 2.5 to 3 percent. The advent of i-Buyers promises to disrupt this market further. However, the overall effect of new technologies on the real estate brokerage industry may be currently limited by certain anticompetitive behaviors from the incumbents, which may be limiting the ability of new entrants to gain market share. I discuss these anticompetitive practices further in section 11.6.

11.5 The "Sharing Economy" and the Housing Market

A second major innovation affecting housing markets is the growth of online platforms like Airbnb that allow homeowners to "share" space with travelers by renting out a spare couch, a spare room, or even an entire home when the owner is not present.[13] Since its founding in 2008, Airbnb has experienced remarkable growth. According to data in Barron, Kung, and Proserpio (2019), by 2016, over 1 million listings in the US had been placed on Airbnb across more than 700,000 unique hosts. Investors have surely taken notice, and Airbnb was the second largest venture capital fundraiser among

13. A similar phenomenon is happening in commercial real estate, with the growth of shared workspaces and the growth of "pop-up" restaurants, hotels, and other retailers.

real estate related companies in the past 20 years (the largest was WeWork). Other home-sharing and vacation-rental companies like HomeAway and Vacasa have also attracted significant attention from investors. Although these companies most directly compete with hotels and bed and breakfasts in the market for travel accommodations, they also have an impact on the housing market, because they draw some of their supply from residential housing.

11.5.1 Theoretical Effects

Traditionally, the market for short-term accommodations, which serves travelers, and the market for residential housing, which serves local residents, have been strongly segmented. The segmentation arises from the different needs of the consumers in each market (e.g., short-term demanders may only require a bed and a bathroom, while long-term demanders may also require a kitchen and living area) as well as differences in the regulatory environment (e.g., residential tenants are typically afforded rights and protections not available to short-term visitors). Because of these differences, the marketplaces for long-term rentals (housing) and for short-term rentals (accommodations) have historically evolved along separate paths.

The advent of home-sharing platforms has blurred the segmentation on the supply side. It is now much easier than in the past for owners of traditionally residential homes to also supply the short-term rental market.[14] What might we expect the effects to be? First, some owners of residential homes might reallocate from the long-term rental market to the short-term rental market. By "reallocate," I mean an owner who was previously supplying a long-term tenant and now supplies a short-term renter after the advent of home-sharing. The degree to which this reallocation occurs depends on various factors, including relative prices in the long- and short-term markets, relative costs of maintaining a short-term rental property vs. a long-term rental property, and the flexibility of keeping a home primarily for short-term use vs. the stability of having a long-term tenant. The propensity to reallocate also depends on the owner's intended personal use of the home. Owner-occupiers by definition do not reallocate from long- to short-term rental, because they can be considered both the landlord and the tenant in a long-term rental transaction. However, they may still participate in the short-term rental market by selling spare capacity, such as spare rooms, a spare couch, or the entire home when they are not present.[15] Vacation home owners who participate in the short-term rental market would also not be considered as reallocating if the vacation home would not have been rented to a long-term tenant anyway, perhaps due to the restrictiveness of long-

14. See Einav, Farronato, and Levin (2016) for a discussion of the technological innovations that reduced transactional frictions and gave rise to these new markets.

15. However, if they were previously renting a spare room to a roommate and then decide to use that room for short-term rental instead, this would constitute a reallocation.

term leases. Landlords of residential renters may therefore be most at risk of reallocating, and this decision depends on their personal preferences as well as relative prices and costs.

Since housing and hotel supply are inelastic in the short run, reallocation reduces the supply of housing units available in the residential market and increases the supply of rooms available in the short-term rental market. This pushes up rental rates and house prices in the housing market, and it drives down prices in the short-term rental market.

In the long run, the supply of housing and of hotels may also be affected. The quantity of homes that can supply both the long- and the short-term rental markets would be expected to increase, and the quantity of hotel rooms that are only able to supply the short-term market would be expected to decrease. The characteristics of the housing stock may change as well. For example, by increasing the option value to having spare capacity, home-sharing may cause future homes to be built with spare capacity in mind. There may be an increase in the supply of homes with accessory dwelling units that are optimized for delivery to short-term renters with the main unit simultaneously being occupied by the owner.

Besides reallocation, the increased option value of spare housing capacity would also be expected to have direct effects on house prices and rents. The increase will depend on the degree to which capacity is currently underutilized due to the frictions that are being resolved by the home-sharing platform. An increase in house prices and rents due to increased option value from home-sharing represents real growth in the productivity of housing.

Finally, home-sharing may entail positive and negative spillovers. On the negative side, neighbors may complain about noisy and unpleasant guests. Concern over neighbors has proven to be a salient point in public debates about home sharing. On the positive side, home sharing may help bring in revenue for local businesses, and it may help tourists discover new destinations and experiences that they had previously not known about.

11.5.2 Empirical Evidence

There is a growing body of literature studying the effects of home sharing on housing market outcomes. Barron, Kung, and Proserpio (2019), Garcia-López et al. (2019), and Horn and Merante (2017) all find that home-sharing drives up rental rates and housing costs, using various research designs and data from various markets. Horn and Merante (2017) examine the effect of Airbnb on rental rates in the Boston housing market from 2015 to 2016. Barron, Kung, and Proserpio (2019) study the effect of Airbnb on house prices and rental rates using data from the entire US from 2011 to 2016. Garcia-López et al. (2019) study the effect of Airbnb on the Barcelona housing market. Estimates of the effect of a one-standard-deviation increase in the number of Airbnb listings on the percentage increase in rental rates range from about 0.4 to 0.6 percent.

Barron, Kung, and Proserpio (2019) present additional evidence on the channels through which home-sharing affects housing markets. They present direct evidence for housing supply reallocation, showing that growth in Airbnb listings is causally associated with a decline in the number of rental housing units and an increase in the number of housing units that are classified as vacant for "seasonal or recreational use" (which is how units held for short-term use would be classified as by the US Census Bureau). They also show that the size of the reallocation depends on the share of owner-occupiers. Zip codes with a greater share of owner-occupiers experience a smaller amount of reallocation and correspondingly a smaller effect on house prices and rents, consistent with the theory that owner-occupiers are less likely to reallocate from the long-term rental market to the short-term rental market.

All these studies estimate only short-run effects. To my knowledge, there is not yet any research on the long-run effects of home sharing on house prices and the housing supply. This is likely because home sharing is a relatively new phenomenon, and is it still too early to look for long-run effects.

Besides the housing market, some papers also study the effect of home sharing on other markets. Zervas, Proserpio, and Byers (2017) and Farronato and Fradkin (2018) study the effects of home sharing on the hotel market. Zervas, Proserpio, and Byers (2017) shows evidence that Airbnb entry drives down hotel revenue, and Farronato and Fradkin (2018) show that Airbnb expands the supply of hotel rooms during times of peak demand, which leads to significant welfare gains for travelers. Alyakoob and Rahman (2018) find a positive relationship between Airbnb entry and restaurant employment. These papers suggest that home sharing may have welfare implications beyond their effects on the housing market.

11.6 Future Outlook

11.6.1 Measurement Issues

In section 11.2, I noted the discrepancy between gross economic output and firm revenues in residential real estate. In 2017, gross output from housing rents alone was \$2.1 trillion, \$1.5 trillion of which was owner-occupied housing. By comparison, revenue for all real estate firms in 2017 (including both residential and commercial) was only \$477 billion. The discrepancy itself is not concerning, as gross output and firm revenues are meant to measure different concepts. However, the discrepancy does suggest that a significant amount of housing services is being supplied by non-firm entities, such as owner-occupiers (who supply themselves), and individual landlords who are not counted as firms. Because data on labor, capital, material, energy, and service inputs come from surveys of firms or establishments, a significant amount of input in real estate may go unmeasured, such as the labor hours that owner-occupiers and landlords spend managing their properties and the labor hours that home buyers and home sellers spend on the search process. More accurate measurement of these inputs would help us better understand the impact of technological innovations on the efficiency of these activities. Questions on the time spent and the cost of managing properties or searching for homes could be included on the American Housing Survey, for example.

Another measurement issue that arises in housing is how increases in the efficiency of search should be measured and accounted for. This may be especially salient, given that the last major wave of technological innovation in real estate was the movement of housing search to the Internet. As discussed in section 11.4, improvements in the efficiency of search will show up in higher prices and higher match quality, but not necessarily in a higher rate of transaction or a reduced vacancy rate. Since an increase in match quality represents growth in the real economic output of housing, attributing gains in match quality entirely to the price deflator may cause us to understate the amount of real output growth in housing. Methods to estimate how much of price gains can be attributed to higher match quality would help us better understand how improvements to search technology are affecting productivity growth in real estate.

11.6.2 Barriers to Innovation and Entrepreneurship

In addition to measurement issues, the relatively small role of firm revenues in the gross economic output of housing suggests that the potential social returns to innovation may be much higher than the private returns. Aghion et al. (2005) have shown evidence of an inverted-U relationship between industry concentration and industry innovation, so low concentration in real estate and construction suggests a possible reason for why direct innovation by real estate and construction firms is low. It may also explain why many of the main innovators in real estate technology, including the initial wave of online portals and software developers, have been primarily upstream firms that supply the real estate industry with software and services, rather than direct providers of real estate services.

Of course, this has not stopped innovative firms from directly competing with industry incumbents. RedFin, for example, offers particularly low listing commission rates relative to the rest of the market. Despite this, commission rates appear to be falling only slightly. As mentioned in section 11.4, RealTrends reports that between 2012 and 2017, average commission rates fell 20 basis points from 5.32 to 5.12. Thus, despite the presence of low commission brokers, they do not seem to have gained significant market share.

The impact of innovation and entrepreneurship on residential brokerage may be limited by certain anticompetitive behaviors. In 2005, the National Association of Realtors was sued by the US Department of Justice over its "virtual office website" (VOW) policy, as Internet-based listings websites were known back then. The VOW policy allowed traditional brokers to discriminate against VOWs by withholding listings information from them, in violation of standard MLS rules governing data sharing between brokers. In 2008, a settlement was reached in which the NAR agreed to repeal its old VOW policy and replace it with a new one that does not discriminate against VOWs.

The new policy applied only to websites operated by actual brokers who participate in a local MLS and not to listing aggregators like Zillow that do not directly provide brokerage services. Thus, non-broker websites that want to provide listings information still need to purchase listings information directly from brokers, MLSs, or national listings syndicators. Speaking at a FTC conference on competition in residential brokerage, industry journalist Brad Inman noted that, "our ability to aggregate a national database of listings is very, very expensive . . . it only costs $2 million to license data and normalize it and publish it, [but] $2 million is a lot of money for an entrepreneur starting out with his or her credit card . . . [and] the reality is $2 million will get you in, but how much do the portals currently spend just schmoozing with MLS executives, not to mention the teams and the maintenance and everything that goes into it" (Inman 2018). Thus, the cost of acquiring and maintaining listings data may still be a significant barrier to entry for firms that want to provide real estate related services but not necessarily be brokers themselves.

In addition to protectiveness over data, real estate brokers may also engage in another anticompetitive practice known as steering. The Department of Justice (DOJ) describes steering as any action taken by a broker or agent to avoid cooperating with a particular competitor (DOJ 2007). For example, a buyer's agent may avoid showing a house listed by a competitor's agent, or by a discount brokerage, despite knowing that the house would be well suited to the buyer's preferences. Barwick, Pathak, and Wong (2017) showed evidence of steering using data from Massachusetts from 1988 to 2011. They showed that properties listed with lower commissions were less likely to sell, and that this was best explained by buyers' agents steering away from low-commission properties, rather than by buyer preferences. This kind of behavior may make it harder for brokers to compete on price, and it may explain why realtor commission rates have not fallen more despite the growing ease of housing search. Of course, this is only possible if significant information asymmetry exists between buyers and their agents, but the empirical evidence strongly suggests that this information gap exists, likely because most people only buy and sell homes a few times in their life.[16] Thus, better education for buyers and sellers of real estate or stronger fiduciary

16. See Hsieh and Moretti (2003), Levitt and Syverson (2008), Hendel, Nevo, and Ortalo-Magné (2009), Han and Hong (2011), and Bernheim and Meer (2013) for evidence of information asymmetries in residential brokerage.

requirements on the part of agents may be helpful in boosting the overall impact of innovation and entrepreneurship in housing.

11.6.3 Land Use Regulation

As noted in section 11.2, land use regulations are an important factor to consider when thinking about growth and productivity in housing, especially as it pertains to construction and the housing supply. To what degree are restrictive land use regulations limiting the quantity of housing supply, and what are the implications for economic growth and productivity?

Gyourko and Molloy (2015) provide a comprehensive review of the literature on how land use regulation affects housing supply. To summarize, nearly all studies find a positive correlation between the degree of land use regulation and house prices, and a negative correlation with construction. However, interpreting the magnitudes of the effects is difficult, because land use regulation is a patchwork of laws and regulations, and there is no single well-defined measure of it. Nevertheless, a robust result in many housing studies, as exemplified by Saks (2008), is that house prices respond more vigorously to demand shocks in locations with stricter land use regulations, while construction responds less vigorously, suggesting that tighter regulations reduce the elasticity of the housing supply curve.

An exact quantification of the impact of land use regulation on economic growth and productivity is still an open question. Viewing land as an input to the construction of housing, both Glaeser and Gyourko (2018) and Albouy and Ehrlich (2018) noted the effect of land use regulation as an increase in the cost of housing relative to (non-land) input costs. Glaeser and Gyourko (2018) documented an increase in the price of housing relative to input costs, especially in high-wage urban areas with knowledge-intensive industries. Using a model that also allows land use regulation to potentially have a quality-of-life benefit, Albouy and Ehrlich (2018) estimate that the welfare cost of higher housing costs do not exceed the quality-of-life benefits that land use regulations provide, thus reducing welfare on net.

Hsieh and Moretti (2019) argued that restrictive land use regulations can also deter workers from moving to the most productive locations. Using a structural model, they estimated that inelastic housing supply may have reduced GDP by as much as 9 percent in 2009, and reduced GDP growth by 36 percent from 1964 to 2009. If we roughly estimate the efficiency gains of housing search as at most 3.3 percent of housing output due to the elimination of vacancies, plus 1.9 percent of housing output due to increased match quality (Ford, Rutherford, and Yavas 2005), the result is still less than the potential gain of 9 percent of total output from more efficient labor allocation if we eliminated restrictive housing supply regulations.

A limitation of both the Albouy and Ehrlich (2018) and the Hsieh and Moretti (2019) is that the effect of land use regulations operates through the housing supply curve, but we do not yet have a full understanding of exactly how and which types of regulations translate to reduced housing supply elasticity (again, see the discussion in Gyourko and Molloy 2015). Nevertheless, it is a distinct possibility that innovations to housing policy may currently be more marginally productive in driving growth in the housing sector than even technological innovations. One such policy innovation may be to move control of land use policy from the local level to the state or even federal level, acknowledging that local incumbents often have an incentive to restrict housing production to raise their own asset values. An attempt was made in California to reduce local control of zoning policy (California SB50), but it ultimately failed. It remains to be seen whether other, similar attempts may eventually succeed, and what the impacts might be.

11.6.4 Innovation and Urban Economics

When a house is purchased or leased, part of what is being transacted is the right to occupy the land that the property sits on. This enables the occupants to live in closer proximity to their workplace or to other desirable or productive amenities. Innovation that affects transportation (and thus the demand for proximity) and innovation that affects local productivity or the value of local amenities therefore also affects the housing market. It is therefore important to consider the spatial aspect of housing and how innovations in other sectors may be affecting it.

A well-documented trend is that housing is becoming more expensive nearer city centers (Couture and Handbury 2019), and especially so in cities with intensive knowledge-based industries (Moretti 2013). While some of this price growth is undoubtedly due to restrictive land use regulations, these regulations change much less from year to year than do house prices, and so most of the year-to-year growth in prices can be attributed to growing demand to live near city centers.

Has technological innovation contributed to the growing demand to live near city centers and in major metropolitan areas? The key question is whether these technological innovations are complements or substitutes to urban density. The existing evidence seems to suggest that they are complements. Jaffe, Tratjenberg, and Henderson (1993) showed that patent citations are geographically localized, which means that geographic concentration might be becoming more important as more of the economy moves toward knowledge production. Gaspar and Glaeser (1998) showed that improvements in telecommunication technology, rather than substituting for face-to-face meetings, actually increases the number of face-to-face interactions, thus suggesting that IT complements geographic proximity. Other papers showing evidence for complementarity between urban density and technology include Sinai and Waldfogel (2004), Anenberg and Kung (2015), and Anenberg, Kuang, and Kung (2019). The latter two papers focus on how IT reduces informational uncertainties that may be especially prevalent in urban areas, such as information about traffic and parking conditions, and about the quality of local restaurants when there are too many to learn about by personal experience. Couture and Handbury (2019) also find limited evidence that technology may have contributed to the growing preference among young, high-income households to locate in more urban areas.

The literature on how technology interacts with urban density may have lessons for how we expect near-future technological innovations in transportation to affect housing markets. Normally, one expects innovations that reduce the cost of transportation to reduce the demand for proximity to jobs and amenities, and thus reduce the demand for urban living. However, it may be that the most promising current and forthcoming technologies in transportation, such as self-driving and self-parking cars, and the wide availability of mapping and routing software, have a larger effect on reducing the cost of congestion. Anyone who has driven around in a big city knows how much time finding parking adds to the trip, so the promise of self-driving and self-parking cars includes the ability to no longer have to do that ourselves. If the upcoming innovations in transportation primarily reduce the cost of congestion in dense areas, then this would further increase the demand to live in urban areas, and thus raise house prices in those areas.

11.6.5 Housing's Impact on Innovation and Entrepreneurship

Thus far I have focused on how innovation and entrepreneurship affect housing. Now, I briefly discuss whether housing can affect innovation and entrepreneurship. I already mentioned the paper by Hsieh and Moretti (2019), which showed the impact of supply restrictions on aggregate output. This can also translate to reduced innovation and entrepreneurship, if it leads people to avoid moving to places with the best potential for these activities. House prices themselves can also affect innovation and entrepreneurship. Adelino, Schoar, and Severino (2015) showed that from 1998 to 2010, small business employment grew faster in areas that experienced greater house price increases, and that this effect was more pronounced in industries that need little startup capital and for which lending based on housing collateral is relatively more important. Thus, improvements in the ability of homeowners to borrow against the collateral value of their home (such as through better financial technology) may spur greater entrepreneurship.[17]

11.7 Conclusion

Housing is a large and growing sector of the economy. Economic activity in housing consists of primarily two industries: real estate, which involves the leasing and sale of existing housing, and construction, which involves

17. Thus far I have avoided discussing financial technology and other innovations in finance (despite a clear relevance to housing), because I believe that topic is best left to a chapter on innovation and entrepreneurship in finance. Although housing demand and mortgage finance are tightly linked, it is perhaps more appropriate to think of financial innovations that increase household borrowing ability as a demand shock to housing, rather than an increase in the productivity of housing services or of construction per se.

the production of new housing. Because housing is highly durable, the stock of housing is much larger than the flow, and accordingly, the size of the real estate industry is much larger than that of the construction industry. Most productivity in housing therefore comes from better ways to transact and manage existing homes, while improvements to the physical quality and construction of homes will take a longer time to be reflected in the stock.

Both real estate and construction are highly competitive industries and do not appear to invest much in R&D. However, there is growing entrepreneurial interest in companies that provide innovative software and business services to the real estate industry, and in companies that harness technology to directly compete with real estate industry incumbents. Labor productivity appears to be growing in real estate, along with growing intensity of software and IT capital, but caution must be used when interpreting these results due to measurement issues. Labor productivity in single-family housing construction appears to be flat, whereas labor productivity in multifamily residential construction appears to be growing, especially during the past 15 years.

Two recent technological innovations highlight some important issues in how we are measuring economic growth in housing. First, the movement of housing search to the Internet has presumably improved the efficiency of how buyers and sellers find each other. Economic search theory predicts that one of the main effects of an improvement to search efficiency is higher quality matches, which shows up in higher transaction prices. If the most important technological innovation in residential real estate over the past 20 years has its primary effect on increasing match quality, then this would be difficult to detect by methods that do not account for unobserved match quality in the price deflator. Similarly, the introduction of home-sharing platforms may have increased the option value of residential housing, as owners can now use the property either in the housing market or in the travel accommodations market. And they can even use it for both, using part of the space for housing and selling part of it in the short-term rental market. Increases to the option-value of housing would again show up primarily in prices and again be difficult to detect by standard economic accounting methods. The analysis suggests that we need improved methods for measuring output, growth, and productivity in housing if we are to fully understand how recent innovations have impacted the efficiency of housing markets.

The future of housing markets is likely to be shaped by three important factors. First, many economists suspect that stringent land use regulations are responsible for significant inefficiencies in the current level of housing production. Before considering how technology can improve efficiency in housing markets, it may be more useful to first consider how better policy can improve efficiency in housing markets. Second, researchers have documented anticompetitive behaviors in the residential brokerage industry that may limit the impact of innovation and entrepreneurship on making the housing market more efficient. For the impact of new technologies and business practices to have their full effect, barriers to entry and to price competition must be broken down. Finally, new technologies and the movement of the US toward a knowledge-based economy may be rapidly increasing the demand to live in denser, more urban, and more educated areas. This trend has implications for the spatial distribution of housing and house price growth and further emphasizes the need to reexamine land use policy, since many of the most stringent policies are located precisely in the cities that are experiencing the greatest productivity growth.

Appendix

Increasing the Match Rate in Search Models

A standard economic model of housing search is described by two equations:

$$rV_s = -c_s + q(\theta)\beta E[S - y \mid S \geq y]G(y) \tag{1}$$

$$rV_b = -c_b + \frac{q(\theta)}{\theta}(1 - \beta)E[S - y \mid S \geq y]G(y) \tag{2}$$

Equation (1) describes the value function of a seller searching for a buyer, and equation (2) describes the value function of a buyer searching for a seller. In these equations, r is the discount rate, and $q(\theta)$ is the match function that describes the instantaneous rate at which sellers meet buyers. It is assumed to depend on θ, which is the *market tightness*, or the ratio of buyers to sellers. If the match rate for sellers is $q(\theta)$, then the match rate for buyers is $q(\theta)/\theta$. The variable y is defined as the sum of reservation values for buyer and seller, and is equal to $y = V_b + V_s$; S is a random variable representing the surplus generated from the match; $G(y)$ is the survivor function for the distribution of S, and thus $G(y)$ is the probability that the match surplus exceeds reservation value y. The rate at which a seller successfully finds a buyer to transact with is therefore $q(\theta)G(y)$, and the rate at which a buyer successfully finds a seller to transact with is $q(\theta)G(y)/\theta$. The net surplus generated is $S - y$, which is split via Nash bargaining, so the sellers get β share of the net surplus, and buyers get $1 - \beta$ share. The search costs for the seller and for the buyer are c_s and c_b, respectively.

Now suppose that instead of $q(\theta)$, we write the match rate as $AQ(\theta)$ to consider the effect of $A \to \infty$. Equations (1) and (2) then become

$$rV_s = -c_s + Aq(\theta)\beta E[S - y \mid S \geq y]G(y) \tag{3}$$

$$rV_b = -c_b + \frac{Aq(\theta)}{\theta}(1 - \beta)E[S - y \mid S \geq y]G(y) \tag{4}$$

To isolate the effect of increasing match efficiency without a change in match quality, I first consider a setting in which all matches give a surplus of $S \geq y$, where S is fixed and is not a random variable. The equations become

$$rV_s = -c_s + Aq(\theta)\beta(S - y)$$

$$rV_b = -c_b + \frac{Aq(\theta)}{\theta}(1 - \beta)(S - y)$$

Combining the two equations gives

$$ry = -c_s - c_b + Aq(\theta)\left[\beta + \frac{1-\beta}{\theta}\right](S - y)$$

$$S - y = \frac{ry + c_s + c_b}{Aq(\theta)\left[\beta + \frac{1-\beta}{\theta}\right]}$$

Taking the limit as $A \to \infty$ means that $S - y \to 0$.[18] Thus, the reservation value becomes exactly equal to S, and the match rate becomes instantaneous. Therefore no vacancies occur, and every match generates a surplus of S. When $A < \infty$, y is less than S, and the difference depends on the search costs and the match rate.

Now consider a setting in which the upper bound of the support of the match quality distribution is $\bar{S}$. Further, for simplicity, assume that $G(\bar{S}) > 0$ (so there is a positive probability that S is exactly equal to $\bar{S}$). Combining equations (3) and (4) gives

$$E[S - y | S \geq y]G(y) = \frac{ry + c_s + c_b}{Aq(\theta)\left[\beta + \frac{1-\beta}{\theta}\right]}$$

Taking the limit of $A \to \infty$ means that $E[S - y | S \geq y]G(y) \to 0$ in the limit. Thus, $y \to \bar{S}$. Since $G(\bar{S}) > 0$, $Aq(\theta)G(y) \to \infty$ as $A \to \infty$, and thus the vacancy rate approaches zero. If $G(y) \to 0$ as $y \to \bar{S}$, then it may be possible for the vacancy rate to remain positive as $A \to \infty$, as not all vacancies are immediately filled.

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18. Note that it doesn't matter what θ approaches, because $Aq(\theta)[\beta + (1 - \beta)/\theta] \to \infty$ as $A \to \infty$ regardless of whether θ is finite or approaches zero or infinity.

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Comment Jessie Handbury

Introduction

Over the past decade, venture capital funding of real estate and construction-related companies in the US has increased dramatically, outpacing growth in other industries and more than doubling its market share. Real estate technology firms, such as WeWork and Airbnb, have seen meteoric growth, and the home search process has been revolutionized with all home purchases reporting that they conducted some of their search online, an option unavailable to them 20 years ago. However, labor productivity

Jessie Handbury is an assistant professor of real estate at the Wharton School at the University of Pennsylvania, and a faculty research fellow of the National Bureau of Economic Research.

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