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What Drives House Price Cycles? International Experience and Policy Issues†

John V. Duca and John Muellbauer with Anthony Murphy*

The role of real estate during the global financial and economic crisis has prompted efforts to better incorporate housing and financial channels into macro models, improve housing models, develop macroprudential tools, and reform the financial system. This article provides an overview of major, recent contributions to the literature in relation to earlier research on what drives housing prices and how they affect economic activity. Particularly emphasized are studies, both theoretical and more strongly evidence-based, that connect housing markets with credit markets, house price expectations, financial stability, and the wider economy. The literature reveals much diversity in the international and regional behavior of house prices and the need to improve data tracking key housing supply and demand influences. Also reviewed are studies examining how monetary, macroprudential, and other policies affect house prices and access to housing. This survey is designed to help readers navigate the plethora of recent studies and understand the unsettled issues and avenues for further research. The findings should be of interest to policy makers concerned with financial stability as well as those dealing with the role of housing in the wider economy (JEL E32, E44, E63, G01, G21, R31).

1. *Introduction*

The deep recessions that followed the housing-related global financial crisis (GFC) sparked renewed interest in what drives housing and associated credit cycles, how they affect macroeconomies and financial stability, and how policy should be formulated. The widespread failure of earlier macro models to forecast and account

* Duca: Oberlin College, Department of Economics, and Federal Reserve Bank of Dallas, Research Department. Muellbauer: Nuffield College, Institute for New Economic Thinking, and Leverhulme Centre for Demographic Science, University of Oxford. Murphy: Federal Reserve Bank of Dallas, Research Department. The views expressed are those of the authors and are not necessarily those of the Federal Reserve Bank of Dallas or the Board of Governors of the Federal Reserve System. We are grateful for comments from five anonymous referees, André Anundsen, Janine Aron, Vitor Constâncio on sections 6 and 7, Steven Durlauf (the editor), Diana Hackett, Christian Heebøll, Geoffrey Meen, Roxana Mihet, and Michael Weiss. David Aikman, Stijn Claessens, Matthias Drehmann, and Ilyhock Shim helped us interpret the macroprudential literature. Any remaining errors are our own.

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for the large swings in house prices both before and after the GFC has spurred new research. Pre-GFC mainstream macroeconomic models omitted satisfactory linkages between the real economy, credit markets, and asset prices. Missing a financial accelerator, in which worsening credit conditions amplify adverse shocks to the economy (see Bernanke, Gertler and Gilchrist 1996), they effectively ruled out the possibility of a global financial crisis. Much post-GFC research has addressed these deficiencies, as reflected in the tenth-anniversary-of-the-crisis issues of the *Journal of Economic Perspectives* and *Oxford Review of Economic Policy*. Gertler and Gilchrist (2018) and Mian and Sufi (2018) highlight the role of balance sheet constraints in what the latter authors term "the credit-driven household demand channel" and examine the role of large house price declines. Hendry and Muellbauer (2018) address these issues in the context of macroeconomic policy models used by central banks, while Blanchard (2018) gives a broad overview, recommending openness to more evidence-based macro modeling.

The damage caused to the financial system and economy by real estate losses during the GFC has prompted efforts to incorporate housing and finance into theoretical macro models (e.g., Favilukis, Ludvigson, and Van Nieuwerburgh 2017; and Gerali et al. 2010), and induced financial reform and the advent of macroprudential policies to prevent and treat crises. These, in turn, have altered post-GFC housing activity, and have prompted new models of the macroeconomy and housing (e.g., Benes, Laxton, and Mongardini 2016; Cesa-Bianchi, Ferrero, and Rebucci 2018; and Lambertini, Mendicino, and Punzi 2013).

This article surveys recent contributions to the literature on what drives housing price cycles, comparing and contrasting with the earlier literature, and addressing new policy issues. The particular focus is on empirical and theoretical studies that connect housing markets with credit markets, financial stability issues, and the macroeconomy. Section 2 reviews how the economic role of housing and associated credit markets has shifted over time and varies across countries. It emphasizes the role of housing in the financial accelerator, which amplifies and propagates shocks to the wider economy, especially if a banking crisis and possibly a related sovereign debt crisis results. Overhangs of housing supply and of debt, and the resulting deleveraging, could depress economic activity for considerable periods. The weaknesses of pre-GFC financial regulatory and conventional monetary policies are discussed in relation to housing and commercial real estate cycles, whose impact was especially deleterious in the GFC downturn.

Section 3 reviews the wide variation in international and regional house price behavior, and that in key housing supply and demand dimensions. This diversity partly stems from variation in housing supply elasticities at the metro (Saiz 2010; and Glaeser, Gyourko, and Saiz 2008) and national levels (Caldera Sánchez and Johansson 2013; and Cavalleri, Cournède, and Özsöğüt 2019). Important demand-side time series and cross-section variation has arisen from differences in mortgage finance (Cerutti, Dagher, and Dell'Ariccia 2017), financial liberalization, income growth, and demographic change. As Duca, Muellbauer, and Murphy (2010) stress, in the boom before the housing bust of the late 2000s, house price appreciation was faster where bolstered by a combination of strong income and population growth relative to the housing stock, lower interest rates, and easier credit standards. With global financial integration, international investors have further widened regional divergence in house prices within some nations and created important international spillovers (Cesa-Bianchi, Ferrero, and Rebucci 2018).

Section 4 reviews time series studies of house price cycles and illuminates the areas of consensus and disagreement on their causes, consequences, and policy implications. It introduces two theory-based empirical approaches to modeling house prices: the inverse demand approach from consumer economics and the asset pricing approach from finance. The former treats supply as given in the short run, and requires accounting for and modeling of supply variation, while the latter framework requires models and good data for market-determined rents. The limitations of reduced-form and ad hoc price models are also noted.

Capital gains expectations incorporated in "user cost" are crucial for both approaches. Owing to the tendency for agents to extrapolate past appreciation in forming expectations, housing markets can overshoot fundamentals (Abraham and Hendershott 1996). New studies on house price expectations (Barberis et al. 2018 and Glaeser et al. 2017) have major implications for analyzing housing in empirical and theoretical models. Also reviewed are salient issues for measuring and modeling risk premia and access to credit and their impact on house prices. The section ends with a discussion of dynamic stochastic general equilibrium (DSGE), overlapping generations, and agent-based models.

Section 5 summarizes major issues for measuring house prices, rents, and the housing stock. A review of research on how supply constraints vary by location is followed by an examination of residential investment models and what they suggest about variations in national housing supply elasticities. The section concludes with a discussion of demographic influences on housing activity and prices.

Section 6 reviews evidence from international, national, regional, and metro-level house price studies, including on the links between credit supply shocks and house prices, see Mian and Sufi (2018). A common overgeneralization in the literature that booms and busts are larger in countries where supply responsiveness is low is critically examined. Regional and metro studies support a more qualified view. Finally, evidence is summarized on the fundamental drivers of house prices. A more expeditious and accurate approach to detecting overvaluation and financial fragility is suggested than is provided by current house price models.

Section 7 considers how housing and credit markets affect macroprudential policy. In many advanced economies, bank stress-tests have become central to macroprudential policy. These and other macroprudential tools are discussed, as are the roles of monetary and macroprudential policies to enhance financial stability. There are further policy options to stabilize housing, including taxation, curbs on international money flows, regulation of rents, pension policy, and the relaxation of restrictions on construction and housing supply. These touch on the wider implications of housing-related policies, including labor mobility and intergenerational equity. The conclusion in section 8 provides perspectives on areas for further research.

2. *Housing and Financial Stability: International Comparisons*

Real estate collateral has played an increasing role in lending and crises in most advanced countries (Jordà, Schularick, and Taylor 2015) and many financial crises begin with a serious *overvaluation* of asset prices, especially of housing and commercial real estate, often funded by highly leveraged lenders making risky loans. Gross housing equity of households is substantial, usually exceeding 100 percent of GDP in advanced economies, but varying a great deal between countries and over time. We use the US subprime crisis of 2008–11 to illustrate financial accelerator channels that drove financial instability.

Since channels vary across countries, so does the degree to which they amplify or even dampen shocks. This variation points to the need to adapt stabilization policy to local circumstances.

2.1 *General Causes of Overvaluation of Housing and Real Estate Prices*

The literature generally views house price cycles as arising from notable exogenous shocks—typically related to the effective demand for housing (e.g., Mian and Sufi 2009, 2011)—and less to purely endogenous cycles of the sort developed by Geanakoplos (2010). Nevertheless, endogenous processes stressed in the latter strand of the literature played critical roles in making leverage and house price expectations more procyclical, thereby amplifying house price cycles.

More specifically, house price booms are usually set in motion by shifts in fundamentals (e.g., in interest rates, income, and credit standards), whose dynamic effects interact with supply conditions and can be magnified by a tendency for households to form house price expectations that are very different from the rational expectations associated with efficient markets.

More generally, asset price overvaluation can arise from exogenous macroeconomic shocks, shifts in fragile financial sector and fiscal fundamentals, and endogenous dynamic processes (see Muellbauer 2012). The first of these include deteriorating terms of trade, higher oil import prices, falling export demand, natural disasters, pandemics, higher interest rates, or tighter external credit supply.[1] Such shocks are arguably unforeseeable, though increased physical and transition risks from climate change should be expected, see Network for Greening the Financial System (2019) and Bolton et al. (2020).

Fragile financial fundamentals include a greater reliance on less stable, wholesale funding (e.g., mortgage funding subject to runs as in the United Kingdom, United States, and Ireland in 2007 or 2008), weak financial regulation allowing over-leverage, and problem loans arising from fraud and the misuse of securitization (e.g., the US subprime boom). Some countries were vulnerable from using foreign currency denominated external debt as in the GFC (the Baltic republics and Hungary) and the 1990s Asian Crisis (Indonesia and South Korea), or from unsustainable fiscal borrowing, International Monetary Fund (2003, 2011), as were several countries during the European Union's sovereign debt crisis.

A third source of overvaluation is endogenous, dynamic processes such as Geanakoplos' (2010) leverage cycle.[2] Leverage rises when house prices fall, thereby tightening leverage constraints, which can force investors to sell, causing prices to fall, which can give rise to a deflationary feedback loop. Similarly, positive news about house prices can set off an inflationary feedback loop. Another example is extrapolative house price expectations. In Abraham and Hendershott's (1996) equilibrium correction model, there are positive "bubble-builder" effects on house prices from *recent rises* in house prices and negative "bubble-burster" effects from *high levels of real house prices relative to fundamentals*. The former arise if many agents base expectations of future gains on recent gains, thus increasing housing demand. But house prices eventually fall when they become too high relative to fundamentals, such as incomes, mortgage rates, and the housing stock. If expectations are extrapolative enough, a series of positive

[1] External credit supply shocks for small open economies include the early 1980's Reagan fiscal shock and German unification in the early 1990s.

[2] Leverage is defined as the debt used to purchase an asset divided by the buyer's equity stake or down payment.

shocks can induce house price overshooting. Just the ceasing of positive shocks eventually induces house prices to fall, and possibly undershoot.

2.2 *The Consequences of Overvalued Housing and Commercial Real Estate Prices: the US Example*

Serious overvaluation eventually leads to falling prices. While endogenous, dynamic processes can give rise to overvaluation, they also *amplify* the impact of exogenous shocks. There may also be short-term contagion within the financial system (Gorton and Metrick 2012), and medium-term transmission from the financial system to the real economy, including feedbacks from the real economy to the financial sector and real estate prices. The power and direction of these channels depend on an economy's institutional structure.

Figure 1 depicts the US subprime crisis, triggered by declines in overvalued house prices in 2006 and commercial real estate prices in 2007. All three factors for overvaluation discussed above applied. First, macroeconomic conditions became less favorable. Real oil prices more than tripled from 2002 to their peak in 2008, acting like a rise in tax rates. Also, to contain inflation, the federal funds rate rose from 1 percent in mid-2003 to 5.25 percent in 2006, with markets and households surprised by the initial Fed signal that it would only slowly raise interest rates, and also by the final peak in rates (Taylor 2007). The path of mortgage interest rates, which initially helped push up house prices, put downward pressure on them by 2006 and 2007.[3]

A second source of overvaluation was the rising fragility of fundamentals: more highly leveraged banks and households made both more vulnerable to income and house price shocks. Bartscher et al. (2020) show that most of the rise in US mortgage debt from the 1970s, especially since the early 1980s, accrued to households below the top income decile whose real incomes stagnated while debt soared. Three regulatory changes boosted leverage. The Commodity Futures Modernization Act of 2000 gave priority to derivatives over other claims in bankruptcy, and they then were used to enhance subprime-backed securities. In 2004, bank capital requirements on investment grade mortgage-backed securities (MBS) were also cut (Stanton and Wallace 2018), and the Securities and Exchange Commission eased leverage limits on investment banks (Duca and Ling 2020).

A third source of overvaluation arose from endogenous dynamic processes. Large transactions costs amounting to 8–10 percent of the sales price (Ling, Ooi, and Le 2015 and Zillow 2020) plus time to sell (six months in an average market) and thin trading can induce serial correlation in excess returns (Stein 1995). Such frictions can make appreciation more predictable and induce the use of backward-looking, extrapolative expectations (DiPasquale and Wheaton 1994), which more recent studies have theoretically generated (e.g., Barberis et al. 2018) or empirically found (e.g., Case, Shiller, and Thompson 2012).[4] As a result, the effects of shocks, e.g., shifts in credit standards discussed below, are amplified (see Sommervoll, Borgerson, and Wennemo 2010 for a heterogeneous agent model with credit constraints).

Time series models of US house prices fit well only if they assume many buyers used extrapolative price expectations (Duca, Muellbauer, and Murphy 2011, 2016). A

[3] Many nonprime mortgages had low initial "teaser" interest rates that could later rise greatly and burden borrowers.

[4] Semi-rational forecasts from reduced-form time series models typically include terms in lagged appreciation and may not differ so much from simple assumptions about extrapolative expectations. See sections 4.3 and 4.4.

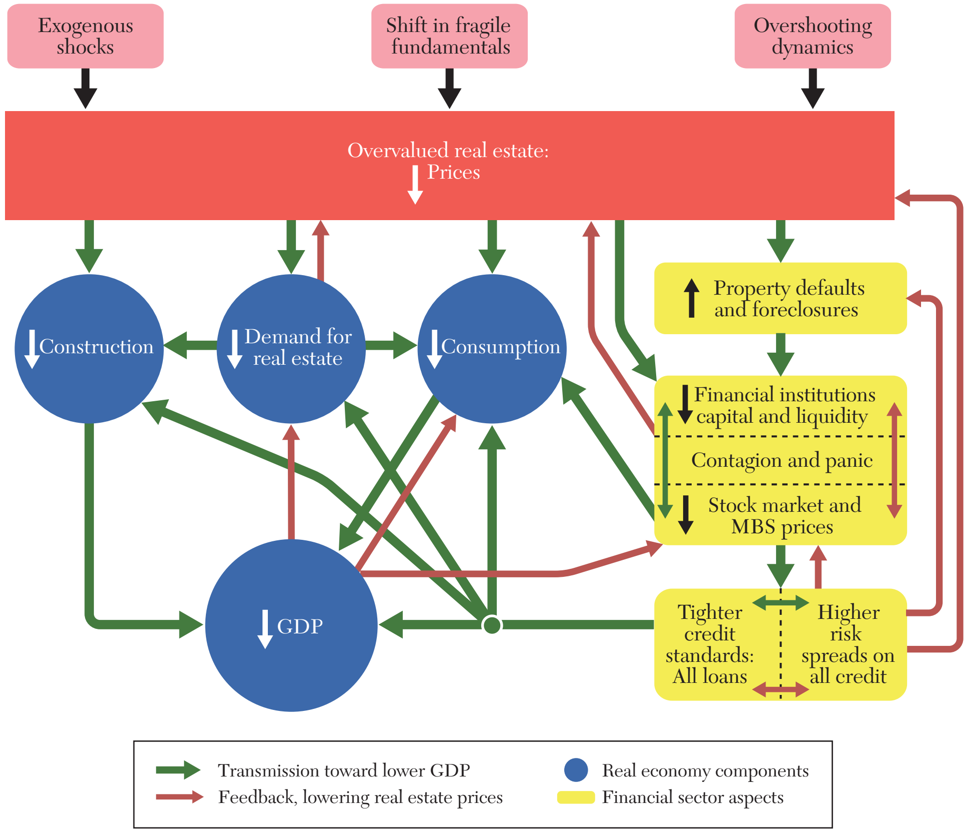

Figure 1. The Financial Accelerator in the US Subprime Crisis

Source: Devised and constructed by Janine Aron, John Duca, and John Muellbauer.

leverage cycle also plausibly contributed to overvaluation, made more extreme by the regulatory changes that permitted higher leverage (Geanakoplos 2010). Together, these sources of house price swings imply that it is important to distinguish between temporary overshooting given fundamentals, and the fragility of the fundamentals themselves.

The transmission channels from falling real estate prices to the real economy are on the left of figure 1. Lower prices directly reduce construction by lowering its profitability (far left) and indirectly by lowering extrapolative price expectations, thus reducing housing demand and increasing inventories.[5] Moreover, lower demand amplified earlier price declines (the brown feedback arrow from lower real estate demand to the top). A third channel is that lower house prices hurt consumption, for which housing collateral is a key driver in the United States (Aron et al. 2012).[6] Also, lower real estate

[5] In the short run, house prices are sticky so that part of the fall in demand directly lowers residential investment.

[6] Micro evidence favors a collateral over a classical house wealth effect in countries allowing home equity

demand lowers spending on real estate services and on durable good purchases linked to moving. Consequently, aggregate demand and GDP fell.

The transmission channels from falling real estate prices into the financial sector are on the right-hand side of figure 1. From the upward resetting of subprime mortgage interest rates and house price declines, mortgage delinquencies and foreclosures rose (the top yellow rectangle), which reduced the capital and liquidity of the financial sector (the second yellow rectangle). Real estate losses mounted at intermediaries, particularly on commercial (CMBS) and private-label mortgage-backed securities (PMBS), lowering the capital of banks, including lightly regulated shadow banks. Regulatory changes allowing higher leverage (e.g., cutting the capital needed to fund CMBS and PMBS) made the financial sector more sensitive to shocks. As mortgages failed, CMBS and PMBS prices fell and losses at financial intermediaries rose. Financial system contagion *amplified* these shocks (the lower half of the middle yellow rectangle).

The finance literature describes two direct (the counterparty and funding risk channels) and one indirect short-run contagion effect. The first occurs when the default of one firm causes financial distress to its creditors (see Jorion and Zhang 2009),[7] and the second, if a funding relationship between institutions ends, owing to a negative balance sheet shock to one (see Gai, Haldane, and Kapadia 2011[8] and Brunnermeier and Pedersen 2009).[9] Such breakdowns led to a liquidity crisis in the repo market, see Gorton and Metrick (2012), and liquidity hoarding that spread to all banks. Banks like Bear Stearns, Lehman,[10] Fortis, and Northern Rock were vulnerable to such a breakdown. Indirect contagion arises if asset fire sales by one firm lower asset prices, hurting the balance sheets of other firms holding such assets, see Cont and Schaanning (2019, forthcoming). These short-run effects amplified one another: funding constraints spread to other banks, amplifying feedbacks between funding constraints and asset fire sales. Bernanke (2018) describes the result as a panic (see lower half of the middle yellow rectangle in figure 1). Stock market and MBS prices fell sharply.

There were further effects on credit availability and risk spreads, shown by the transmission channel from the middle to the lower yellow rectangle. Bernanke (2018) explains that: "… as investors refused to fund even non-mortgage securitizations, driving up the yield on non-mortgage credit … the expansion of the panic to include non-mortgage credit as well as mortgages was arguably a turning point of the crisis, with broad ramifications for both firm and household borrowers." Thus, lower capital, contagion, and panic reduced financial asset prices and induced tighter credit standards and higher credit risk spreads. In figure 1, the horizontal arrow from the middle yellow rectangle depicts the financial wealth effect on consumption. The four sideways transmission arrows from the bottom yellow rectangle

withdrawal. See Hurst and Stafford (2004); Browning, Gørtz, and Leth-Petersen (2013); Windsor, Jääskelä, and Finlay (2015); Andersen, Duus, and Jensen (2016); and Berger et al. (2018). Stroebel and Vavra (2019) also find that house prices affect markups in local retail prices, while Mian and Sufi (2011) and Kaplan, Mitman, and Violante (2020) argue that price falls made credit constraints more binding. Berger et al. (2018) and Garriga and Hedlund (2020) provide a coherent foundation for the housing collateral channel in an optimizing framework with realistic budget constraints, the latter in a general equilibrium framework.

[7] Bear Stearns was hurt by the fall of Carlyle Capital, which held MBS to which Bear Stearns was heavily exposed.

[8] In their theoretical model, higher repurchase agreement (repo) "haircuts" worsened the liquidity condition of all banks funded through repos.

[9] Asset price declines cause margin calls and fire sales, lowering market liquidity and further depressing prices.

[10] Lehman failed when CMBS losses made it unable to roll over short-debt, see Gorton and Metrick (2012).

depict declines in real estate demand, construction, consumption, and GDP from the impact of tighter credit conditions. Gertler and Gilchrist (2018) agree with Bernanke on this key role of credit conditions in the dynamics of the GFC.

In addition, transmission operated through several feedback effects. As Bernanke (2018) remarks: "Powerful feedback effects operated throughout, for example, among the solvency of mortgage lenders, the supply of mortgage credit, household balance sheets, and house prices, with each affecting the others. There were also strong feedbacks [thin brown lines in figure 1] between financial and economic developments, as financial disruptions slowed the economy, which in turn worsened financial and credit conditions." Within the financial sector, reduced credit availability and higher risk premia fed back to real estate prices, defaults and foreclosures, because borrowers were less able to refinance to avoid foreclosure.

Important feedbacks linked the real and financial sector. Lower GDP fed back onto demand for real estate and consumption, which lowered real estate prices (the red box at the top of figure 1). By reducing profits at financial institutions, lower GDP fed back to lower their capital (the brown arrow to the middle yellow rectangle). Finally, there were sizable spillover effects from the United States that induced global collapses in asset prices, credit availability, and economic activity that fed back via lower net exports to the United States.

Figure 1 can also depict the *boom phase* of a US business cycle, with directions of movements reversed. Herring and Wachter (2003) argue that housing finance tends to ratify and amplify house price booms. Given the heterogeneity of housing, lenders use "comparables," based on current market values, to decide loan amounts, creating a positive feedback loop between increases in house prices and expansions of lending (Wachter 2016). Furthermore, higher real estate prices bolster consumption and construction. Higher bank profits and lower defaults boost capital in the financial sector, allowing it to ease credit conditions and reduce risk spreads, further bolstering consumption, construction, and GDP, and with feedbacks to real estate prices. However, transmission from house prices to credit is more muted in an upswing partly because when defaults are already low, further declines make little difference, in contrast to large jumps during a bust. Loss aversion and fear of bankruptcy may also be less salient in a boom than in a bust (see Bordalo, Gennaioli, and Schleifer 2012). This is consistent with evidence that business cycles usually have long upswings, punctuated by shorter and sharper contractions.

The impact of the COVID-19 recession on housing markets is very different from previous recessions, reflecting a number of factors. The initial shocks were radically different from the shocks that generated previous recessions, the non-shadow-banking system was well capitalized, and mortgage lending standards and the levels of household debt were less stretched than pre-GFC. In addition, once the pandemic hit, governments and regulators acted quickly and decisively, providing an unprecedented level of fiscal, monetary, financial and regulatory support to households, business, financial markets and the wider economy. The measures staved off a prolonged recession and financial crisis. Unlike in the GFC, house prices and construction did not collapse. Instead, house prices have surged higher, raising concerns about affordability and overvaluation.

For the United States, the initial, direct shock from overseas disrupted international supply chains and reduced the demand for exports. Government restrictions across the world then decimated travel and tourism. Measures to impose social distancing and lockdowns, as well as changes in individual mobility and social behavior, had an outsized impact on many sectors of the economy, and increased inequality, despite partial cushioning by an unprecedented support for firms, workers, and financial markets.

Regarding "shifts in fragile fundamentals," the pre-pandemic picture was mixed: while widespread macroprudential policy, tighter regulations and higher capital ratios at banks had left the banking system and associated mortgage markets less vulnerable, elsewhere vulnerabilities had arguably increased. Low interest rate monetary policy, carrying most of the burden of the countercyclical response to the GFC, had led to a gradual buildup of corporate debt and some decline in credit quality, high commercial real estate (CRE) valuations, and narrowing of risk spreads (IMF 2021). In the US, the share of financial intermediation by the shadow-banking system, including fintech mortgage lenders, had again increased since falling in the GFC (see Jiang 2020), and it was unclear how this sector would perform in a recession.

In terms of a graphic in the style of figure 1, a fundamental difference in the pandemic was that the exogenous shock at the top left transmitted directly to GDP, and was a combination of both a supply and a demand shock: thus, supply chain disruptions working through the input–output structure of the economy and expenditure multiplier effects dominated the short-term dynamics. Interactions of the small- and medium-sized enterprise (SME), corporate, and household sectors with the financial sector had the potential to trigger a financial crisis. Instead of property defaults and foreclosures at the top of the yellow financial system block shown in figure 1, business and consumer debt-payment problems and income losses would, absent the policy interventions, have become the main initial transmitters to real estate, with real estate defaults and stress on mortgage lenders lagging behind.

Aside from fiscal support, the policy interventions included conventional monetary policy actions to lower short-term interest rates, but also quantitative easing and forward guidance that reduced long-term government and mortgage interest rates as well as a range of measures to support market functioning and prevent a dramatic rise in corporate bond spreads. For example, in the United States, extended and expanded unemployment payments, large stimulus payments to households, widespread forbearance and loan modifications, government moratoria on rental evictions and repossessions of owner-occupied properties, plus other aid to mortgage borrowers prevented distressed home sales from dampening house prices (Anenberg and Scharelmann, 2021). New work-at-home patterns and social distancing by relatively affluent households has generated increased demand for space and for detached and non-rental housing that has generally bolstered house prices, except in some international tourist-dependent areas (see Duca, Hoesli, and Montezuma forthcoming; Gupta et al. 2021; and Ramani and Bloom 2021). Another result has been a radical narrowing of the land and house price gradient between urban centers and more peripheral locations (Gupta et al. 2021). In addition, supply chain disruptions and labor shortages have constrained the near-term supply response, magnifying demand effects on house prices. In sum, this upswing in house prices had spillover effects more typical of a boom, as discussed above. Nevertheless, because it is unclear how the pandemic will unwind or evolve and how households will respond in the long run, there are many uncertainties about the long-term effects of the pandemic on house prices and housing markets, which will be fertile grounds for future research.

The other major risk to stability with important real estate implications comes from climate change. Climate risk is especially severe because the global climate system is subject to destabilizing feedbacks analogous to those in figure 1, see the "cascade of tipping points" explained by Lenton et al. 2019. For real estate, there are four major issues. The first concerns the transition risk of large macroeconomic disruptions for economies with major fossil-fuel export sectors. A second source of a large economic disruption could occur through a global or regional climate shock such as a harvest failure following drought, a physical risk. The third concerns potential damage to financial institutions lending to the real estate sector, for instance banks that are also invested in stranded assets (a transition risk) or insurance companies subject to sharply higher insurance claims (a physical risk). Amplification of such risks can occur through the mechanisms illustrated in figure 1. Finally, there is the possibility of a direct impact on real estate values. Global carbon pricing is likely to lower prices of energy-inefficient real estate (a transition risk). Real estate values can be affected directly in regions impacted by rising sea levels, increased flooding and wildfires, heat extremes or lack of water—examples of physical risks—that make particular places unattractive to live in, and ultimately even uninhabitable. According to Abergel, Dean, and Dulac (2017), "Buildings and construction together account for 36 percent of global final energy use and 39 percent of energy-related CO_2 emissions when upstream power generation is included." Also "The energy intensity per square meter of the global buildings sector needs to improve on average by 30 percent by 2030 (compared to 2015) to be on track to meet… targets in the Paris Agreement."

2.3 *Experience of Other Countries: Are the Transmission Channels Amplifying or Stabilizing?*

Across countries, transmission channels vary and can stabilize rather than amplify shocks, so reducing the risk of overvaluation and the damage done in busts. The GFC-era housing crises in Ireland, Spain, and, to a lesser degree, in the United Kingdom, shared many characteristics with the US and Scandinavian crises of the mid-2000s and early 1990s, respectively, that followed credit and house price booms.[11] However, while the US subprime crisis had negative global spillovers,[12] some countries suffered less owing to their banking and credit market structures that limited leverage and securitization. These and other differences in housing, pension, tax, and legal systems not only curtailed the transmission of shocks, but also prevented the pattern, in financially more liberalized economies, of real estate overvaluation in booms that ultimately gives rise to busts.

The mechanisms in figure 1 can operate in business cycle upswings, as mentioned earlier. The linkages between higher real estate prices and aggregate demand on the left-hand side of figure 1 (translated for an upswing) to higher construction vary. In countries where planning constraints are severe (e.g., the United Kingdom), this effect tends to be small. When construction responds strongly to higher house prices, there will be a long-run reverse feedback: as the housing stock expands relative to demand, demand for construction eventually diminishes, which can be stabilizing in slow upswings. However, in booms this stabilizing effect can be overwhelmed by expansionary forces, so that a stock overhang later emerges in a bust, as in the United States,

[11] Mortgage tax benefits and high marginal tax rates induced Scandinavian families to become highly leveraged after credit liberalization in the 1980s. Outside the United States, the smaller role of asset-backed securities implied less complex, but not always less severe, within-financial sector amplification, and international spillovers were smaller.

[12] Some European banks were destabilized when their holdings of US MBS were downgraded to junk ratings.

Ireland, and Spain, where construction was then slow to recover. It is one reason why Leamer (2007, 2015) argues that "housing *is* the business cycle" for the United States. It illustrates that the net impact on financial stability of potentially stabilizing transmission mechanisms depends on their lags relative to amplifying mechanisms.

Depicted by the second transmission arrow of figure 1, the impact of higher real estate prices on real estate demand depends on whether the "bubble builder" or "bubble burster" dominates. In the "bubble builder" mechanism, recent capital gains are extrapolated into future expectations, lowering the "user cost" of real estate. A series of shocks (e.g., to credit standards or interest rates) that raise house prices, later lower user cost and bolster housing demand, positively feeding back to prices. This amplification, consistent with Case and Shiller's surveys of house price expectations and a key contributor to mid-2000's US house bubble, depends on how much leverage is provided, which can amplify returns and risk. Amplification is thus time varying as loan conditions are eased and leverage rises (see Muellbauer and Murphy 1997 and Chauvin and Muellbauer 2018). The "bubble builder" mechanism is likely weaker in countries where regulations limit leverage, where the tax system does not favor debt, or where mortgages are full recourse. Then the potentially stabilizing effect on demand of higher real estate prices occurs more quickly in an upswing, lowering the risk of overvaluation. In jurisdictions basing property taxes on recent property values, such taxes help restrain after-tax returns and stabilize housing demand.

The third transmission arrow in figure 1 links house prices to consumption. This collateral effect varies with credit conditions in the United States and the United Kingdom, a potentially serious source of amplifying nonlinearity (Aron et al. 2012 and Duca and Muellbauer 2014). Berger et al (2018) show, in an optimizing model of a household facing collateral constraints and lumpy transactions costs, that the collateral effect of house prices on consumption increases as the down payment constraint is relaxed. In a credit supply boom, housing collateral effects tend to be greater, reflecting a *double effect* of credit, first on house prices, and a stronger effect of house prices on consumption. Garriga and Hedlund (2020) argue that part of the effect of easier credit on consumption works through a cyclical upswing in housing liquidity. In a credit crunch, the reverse of this *double effect* can be quite powerful, contributing to a rapid economic contraction. The collateral effect tends to be greater in countries with easy down payment constraints, high household leverage, easy access to home equity loans,[13] and high homeownership. Cross-country evidence finds that housing spillovers are larger where it is easier to access mortgages and use homes as collateral (IMF 2008). In Germany, where homeownership is low and home equity loans are rare, Geiger, Muellbauer, and Rupprecht (2016) find that higher house prices lower aggregate consumption, controlling for other major factors. This reflects that higher spending by homeowners is dominated by higher saving of renters for a down payment or because rising house prices signal future rent rises. In countries basing property taxes on recent real estate market values, such as Denmark (see Danmarks Nationalbank 2019), higher tax payments restrain consumption in rising markets.

[13] The Bank of England began tracking home equity withdrawal in the United Kingdom as early as 1982 (Bank of England 1982, 1985), raising the possibility of a link with consumption, also stressed by Muellbauer and Murphy (1990). Miles (1992) developed the first theoretical model showing how financial liberalization strengthened this link. Bartscher et al. (2020) find that home equity borrowing accounts for half of the rise in US household debt from the 1970s to 2007.

Another link is from house prices to debt and spending. Higher house prices induce more borrowing, eventually increasing the burden of debt. The US housing boom initially was dominated by the positive effect on consumption of higher housing collateral and easier credit. The burden of debt became more salient after house prices started to fall and credit supply contracted, then lowering aggregate demand (Duca and Muellbauer 2014). This shows again how apparently stabilizing forces *can* be destabilizing if delayed enough. In France, mortgages were liberalized from 1997 to 2007 and house prices rose. Chauvin and Muellbauer (2018) find that liberalization's positive effect on total consumption and the small effect of higher housing wealth on consumption were neutralized by the restraining effect of higher debt and greater saving by renters, thus stabilizing the French financial system, in contrast to the United States.

Institutional variations affecting leverage alter other transmission channels. Financial regulation and structure affect the *within-financial system* amplifying transmission channels (the right-hand side of figure 1). This could arise from a leverage cycle (Geanakoplos 2010). As house prices rise, lenders may be more willing to lend to new borrowers as collateral rises relative to bank capital; existing borrowers have greater housing equity, making new loans to them safer for lenders. Also, lending becomes more profitable as previous bad loans shrink, enhancing lenders' capital. As noted earlier, financial regulation, laws, and tax regimes that restrict incentives for leverage can mitigate the severity of such a leverage cycle.

Raising capital and liquidity buffers and imposing stress tests are key to the international banking regulations in Basel III. As discussed in section 7, they limit loan losses that would lower bank capital, affecting credit standards and risk premia, and thereby lower real estate demand, consumption, construction, and GDP (the arrows from the bottom yellow rectangle in figure 1). Limiting borrower leverage by capping loan-to-value (LTV) and debt service to income ratio (DSTI) reduces the bubble builder amplification of price effects on real estate demand shown on the left of figure 1. Such regulations accord with macro evidence that leverage and real estate contribute to financial instability (Cerutti, Dagher, and Dell'Ariccia 2017 and Mian, Sufi, and Verner 2017), and the role of credit shifts and debt overhang in the US subprime crisis (Mian and Sufi 2014). More broadly, the International Monetary Fund (2017) highlights the critical role of mortgage debt and nonlinearity, finding larger effects at high debt ratios and in countries with open capital accounts, fixed exchange rates, less transparent credit registries, and weak bank supervision. The International Monetary Fund (IMF) also finds that easy monetary policy during a credit boom exacerbates the subsequent downturn in a bust.

2.4 *Complications from Banking and Sovereign Debt Crises: The Recent European Experience*

Real estate played a major role in the European sovereign debt crisis. Eurozone investors, mainly banks, bore large losses on US MBS (Rey 2012), and German and French banks also incurred losses on cross-border loans funding real estate in Ireland and Spain, where many banks became insolvent. The fiscal costs of bank rescues and the macroeconomic downturns triggered by housing busts threatened the solvency and liquidity of governments, creating a banking sovereign debt "doom-loop" (see Acharya, Drechsler, and Schnabl 2014). As Lane (2012) and Shambaugh (2012) stress, other factors were uncontrolled (initially disguised) Greek public debt and declining economic competitiveness in the eurozone periphery. During the credit-fueled housing boom, resources shifted from innovative sectors to real estate, hurting future economic growth (Rey 2012) and the boom in the non-traded sector bid up wages, eroding their competitiveness and widening intra-European imbalances. In addition, the deadweight losses of output and the scarring effects of unemployment from housing-related financial crises may be yet more important.

2.5 *Weakness of Conventional Macro and Regulatory Policies*

The GFC dispelled the view that conventional monetary policy could address the macro-economic spillovers of financial crises. Pre-GFC regulation allowed too much leverage, gave a "too-big-to-fail" subsidy, and overlooked systemic risks in mortgage lending. Under the Basel II system of bank regulation, there was too heavy reliance on bank internal risk models, which generally ruled out the possibility of large, correlated declines in house prices. In addition, regulators downplayed or ignored the warning signals provided by many overvaluation and leverage indicators. Once the crisis was under way, these shortcomings were compounded by a public policy failure to limit spillover effects.

In Ireland, regulators did not stop several risky practices in the 2000s. These included lenders issuing high LTV home mortgages (see Kelly, McCann, and O'Toole 2018; Lyons 2018; and Waldron and Redmond 2014), being overexposed to commercial construction loans (Coffey 2017 and Whelan 2014), and over-reliance on runnable debt for funding (Whelan 2014). In Spain, regulation did not prevent some lenders from misreporting high LTV loans by using inflated appraised values in lieu of lower, actual transactions prices of homes. This was especially a problem at savings bank lenders (cajas) that, relative to commercial banks, were less regulated in other ways (see Rubio, Gouveia, and Álvarez 2017).

A major pre-GFC mistake was to ease capital requirements on investment-grade private label MBS (PMBS) and commercial MBS (CMBS) in 2004, which notably affected the United States where securitization had a larger role.[14] Although PMBS were backed by nonprime loans, financial innovations enabled the claims to loan payments to be tranched into different securities, the bulk of which were mis-rated as investment grade (Fostel and Geanakoplos 2012). As Blundell-Wignall and Atkinson (2008) discuss, the risk weight on AA- or AAA-rated bonds was cut to 20 percent, enabling commercial banks to hold them with 1.6 instead of 8 percent required capital. PMBS and CMBS issuance soared in the mid-2000s (Duca and Ling 2020), increasing the funding of real estate and other risky assets, see Fostel and Geanakoplos (2012) and the study by Michello and Deme (2012) for how synthetic credit default swaps (CDSs) contributed to contagion and counterparty risk during the GFC. As Stout (2011) argues, the earlier expansion of these securities was fostered by 2000 legislation giving bankruptcy priority to derivatives (mainly CDSs, see Bolton and Oehmke 2015), which provided faulty credit insurance on PMBS and CMBS.[15] Holdings of these assets and leverage also rose at the broker-dealer units of US investment banks after the SEC eased capital requirements.[16]

[14] Alternative-A (or Alt-A) loans are high LTV or debt service ratio loans to borrowers with credit scores above subprime. Alt-A loans grew with subprime mortgages, each 20 percent of 2006 home purchase originations (Zelman et al. 2007).

[15] Current law exempts derivatives counterparties from the automatic stay in bankruptcy, enabling immediate collection from a defaulted counterparty, giving them a senior claim over most other bankruptcy claimants.

[16] Lo (2012) notes that while leverage of brokerage units at most large investment banks jumped from 2004

The impact of these regulatory changes on home mortgages took the form of easier credit standards (e.g., higher LTV caps), reflected in a boom in subprime and Alt-A mortgages that were primarily funded by PMBS (Zelman et al. 2007).[17] Easier credit standards—amplified by expectations of faster house price appreciation—are needed to account for the US house price boom and bust in econometric models (Anundsen and Heebøll 2016; Duca, Muellbauer, and Murphy 2011, 2016; and Pavlov and Wachter 2011), and in agent-based models (Geanakoplos et al. 2012). In a calibrated two-country representative agent model, Ferrero (2015) also relies on easier credit standards to explain the data.

Regulation also overlooked that PMBS servicers lacked the legal right and funding to work out delinquent mortgages. In the crisis, default rates were higher on PMBS funded loans (Piskorski, Seru, and Vig 2010) and for servicers unaffiliated with the loan originator (Demiroglu and James 2012). Subprime loans having five times the serious delinquency rate of prime mortgages (Mortgage Bankers Association) faced greater impediments to being worked out, which worsened loan loss rates (Geanakoplos 2009, 2010).

Loans at banks could be worked out, as could loans insured and securitized by Fannie Mae and Freddie Mac, which funded half of home mortgages. However, because these agencies were at first unwilling to work out loans having negative housing equity, many nondelinquent borrowers could not refinance at lower interest rates, inducing some to default or cut consumption. Beraja et al. (2019) find that interest rate cuts stimulated consumption and refinancing less in areas with larger house price declines where households were less likely to qualify for refinancing. Within the United States, households with adjustable rate mortgages (ARMs) past their initial teaser rate periods particularly benefited from monetary policy actions to lower short-term interest rates (Di Maggio, et al. 2017).[18] Though helpful in the United States, this countercyclical benefit was stronger in other countries (many in Europe), where ARMs are more prevalent.

Deadweight losses and externalities were mitigated by government efforts to refinance mortgages through the Federal Housing Administration (FHA) and via Fannie Mae and Freddie Mac under the Home Affordable Refinance Program (HARP) and the Home Affordable Modification Program (HAMP). HARP modified nondelinquent loans to prevent arrears and defaults, while HAMP modified loans with payment problems to prevent foreclosures. Zhu et al. (2015) found that a 10 percentage point reduction in mortgage payments under HARP reduced the monthly default hazard by 10–11 percent, while Mitman (2016) and Agarwal et al. (2015) found that HARP lowered foreclosures and aided consumption by reducing borrower debt service. Agarwal et al. (2017) find similar qualitative effects of HAMP on defaults and consumer spending, but that it helped only one-third of borrowers targeted by the program, while Scharlemann and Shore (2016) find somewhat stronger effects on preventing defaults. Mayer et al. (2014) argue that HAMP's effectiveness was limited by strategic behavior, such as borrowers

to 2007, it had been higher earlier. Sirri (2009) argues that the definition of capital not the leverage ratio was eased by the SEC.

[17] The increased prevalence of higher leverage mortgages later resulted in higher foreclosures during the bust (see Corbae and Quintin 2015 for relevant findings from a calibrated, heterogeneous agent model).

[18] ARMs suffered far higher default rates than fixed rate mortgages. Based on a sample of New England mortgages, Foote et al. (2008) find that most subprime borrowers with ARMs defaulted well in advance of their reset dates. This may well have been because they knew that, with falling house prices, the expected refinancing opportunity on a rising market had vanished and that they could not afford the post-reset interest rates.

becoming delinquent, to qualify for HAMP. Blinder (2013) and Rose (2011) show that the United States was slower to help delinquent mortgagees in the Great Recession than in the Great Depression, when the federally funded Home-Owner Loan Corporation eventually bought and worked out 20 percent of home mortgages.

Through their externalities and the correlated risks of real estate downturns, these regulatory failures impaired financial intermediaries and security markets, weakening the power of monetary policy. As a result, conventional monetary policy could not prevent the downturn from deepening despite bailouts of many financial firms (see ProPublica 2019 for a list). To lower long-term interest rates, the Federal Reserve signaled it would keep future short-term interest rates low (Bauer and Rudebusch 2014) and bought large amounts of Treasury bonds and MBSs. The boost to mortgage supply by the FHA to counter mortgage rationing also stabilized housing (Passmore and Sherlund 2018). However, despite using fiscal stimulus more and earlier than in the Great Depression, the US stimulus scaled by GDP was more appropriate for a moderate than a great recession. Fiscal policy was also inadequate in Europe, where peripheral nations and the United Kingdom adopted fiscal stringency to address sovereign debt risk.

2.6 *Complications from CRE Cycles*

Although CRE busts lack collateral effects on consumption, they notably affect the macroeconomy and commercial banks, for whom, in the United States, 48 percent of assets are in home and CRE mortgages, plus CMBS and residential mortgage-backed securities (RMBS). Credit liberalization in the 1980s and 1990s fostered a residential and CRE boom that led to a bust and deep recessions in the Asian financial crisis of the late 1990s. Downturns were worse where (Thailand, Malaysia, and the Philippines) poor regulation allowed undercapitalized banks to amass large real estate exposures and were less severe where (Hong Kong, Singapore, and Taiwan) regulators ensured that banks were better capitalized and resilient to real estate losses (Collyns and Senhadji 2003). In Australia, credit liberalization and lax regulation allowed imprudent lending to fuel a CRE boom in the 1980s that led to a bust and Australia's last pre-COVID-19 recession in the early 1990s—its worst since the Great Depression (Carmichael and Esho 2003). A US CRE boom in the 1980s was fueled by tax incentives, whose ending was followed by CRE loan losses in the early 1990s that raised uncertainty about exposed banks. This induced a construction bust and a credit crunch (Bernanke and Lown 1991; Browne and Case 1992; Peek and Rosengren 1995; and Freund et al. 1997). As in housing busts, CRE downturns induce credit rationing and impair security markets, see the right side of figure 1.

The 2004 cut in capital requirements induced US commercial and investment banks to hold more CMBS and PMBS, which reduced CRE risk premia. This, in turn, lowered the discount rate on property and boosted CRE prices (Duca and Ling 2020), compounding a pattern for CRE securities to underprice default risk (Pavlov and Wachter 2009). The federal safety net plausibly accounts for systemic underpricing of default in CRE securities. Easier capital requirements and low interest rates fueled twin US real estate bubbles by 2006 that later burst and led to the Great Recession, reflecting interrelated and correlated macro risks. To an underappreciated extent, CMBS and CRE loan losses contributed to the recent crisis (Levitin and Wachter 2013), being about as important as losses on residential MBS and mortgages in inducing US bank failures (Antoniades 2015). Furthermore, losses triggering Lehman's failure were

TABLE 1
HOUSING AND MORTGAGE CHARACTERISTICS IN SELECTED ADVANCED ECONOMIES

	Home ownership rate 2016[1]	Mortgage interest tax deduction	Mortgage rate, amortization usually required?	Retail deposit funding of mortgages[2]	Mortgage debt/GDP 2007[3]	Mortgage debt/GDP 2016[3]
Australia	63	No	Adjustable, Y	Primary	80	96
Denmark	62	Yes	Adjustable, N	Tertiary	86	68
Germany	44	No	Mostly fixed, Y	Primary	42	38
Ireland	73	Yes	Adjustable, N	Primary	63	27
Japan	61	No[4]	Adjustable, Y	Primary	36	38[2]
Spain	77	Yes	Adjustable, N	Primary	60	49
United Kingdom	63	No	Adjustable, N	Primary	75	68
United States	63	Yes	Mostly fixed, Y	Secondary	78	63

Notes: [1] Shares of households owning with or without a mortgage using OECD data. [2] Sources HOFINET and Cerutti, Dagher, and Dell'Ariccia (2017). Among the 3 categories of funding: retail, mortgage bonds, and securitization, "primary", "secondary" and "tertiary" indicates that retail has respectively the largest, second largest and smallest share of the mortgage stock. Data refer to 2018. [3] Underlying data from HOFINET (Housing Finance Information Network), OECD, and central banks. [4] Very limited deductibility.

TABLE 2
HOUSE PRICE AND DEBT CHANGES IN SELECTED ADVANCED ECONOMIES[1]

	Boom			Bust			Price recovery	
	Δ Mort./GDP 1999–2007	Δ ln house price/inc. 1999–2007	Δ Const./GDP to peak[2]	Δ Mort./GDP 2007–16	Δ ln house price/inc. 2007–12	Δ Const./GDP peak to trough[2]	Δ ln house price/inc. 2012–17	Δ Const./GDP off trough[2]
Credit linked price boom and bust								
Denmark	25	43	2	−18	−38	−2.7	11	1
Ireland	36	48	1.9	−36	−79	−6.5	36	0.8
Spain	37	74	2.1	−11	−45	−5.7	2	1
United Kingdom	30	49	0.5	−7	−21	−2.1	15	1.3
United States	29	27[3]	0.8	−15	−40[3]	−3.5	17	0.9
Price boom								
Australia	35	25	0.9	16	−6	−2	25	0.9
No 2000s price boom								
Germany	−3	−21	−0.5	−4	0	−1.4	13	0.7
Japan	1	−35	0.2	3	−4	−1.9	5	0.1

Notes: [1] Price-to-income calculations based on OECD data. Underlying GDP and construction data are from OECD and the mortgage data are from national central banks. [2] Peak 2000–2007 ratio of residential construction to GDP minus 1999–2001 average ratio for the boom period; change in trough–peak ratio for the bust period; 2018 ratio minus the trough for the recovery period. All as percentage point changes. [3] US price-to-income 1998–2006 and 2006–12, respectively.

more concentrated in CMBS and other CRE exposures, than in subprime mortgages (Summe 2011). The CRE boom and bust has received far less attention than that in housing in part because banks tended to extend forbearance to distressed facilities due to the sheer complexity of loan structures and the financial regulators' 2009 policy statement on prudent CRE workouts (Federal Reserve et al. 2009).

2.7 *Main International Patterns Concerning Housing and Financial Stability*

Overall, in addition to affecting construction, housing has several financial accelerator channels through which it can affect the macroeconomy and financial stability. These channels vary across countries and time, depending on institutional practices and regulation, with especially strong effects in countries allowing mortgage equity withdrawal. Further, regulatory mistakes or shortcomings were particularly large in the countries most hurt by recent housing busts (Ireland, Spain, and the United States), where booms were marked by lenders that circumvented rules, engaged in regulatory arbitrage, and used very weak mortgage credit standards. In other countries where mortgage underwriting was better regulated and mortgage equity withdrawal was limited, macroeconomies were less affected by housing busts in the 2000s.

3. *The Diversity of International and Regional Experience*

3.1 *International Experience of House Price Cycles*

A major challenge in modeling international house price cycles is the sizable variation in the structure, financing, and tax treatment of housing and in time series patterns of house prices. Across eight advanced countries, table 1 reports institutional variation, including tenure, tax policy, mortgage funding sources, and mortgage debt-to-GDP ratios. Table 2 reports how changes in debt, house price valuations, and construction varied across countries during the housing boom of the early 2000s and subsequent bust and recovery. Within many countries, there are large differences in house price dynamics by region or city.

Two patterns stand out. First, as noted by Andrews (2010); Cerutti, Dagher, and Dell'Ariccia (2017); Duca, Muellbauer, and Murphy (2010); and Muellbauer (2012), house price valuations—as tracked by price-to-rent or price-to-income ratios—rose more in countries where mortgage liberalization bolstered housing demand than in those with stringent loan practices. As table 2 shows, across advanced economies larger run-ups in prices were followed by larger reversals in the 2007–12 bust.[19] Mortgage debt-to-GDP ratios tended to accompany larger rises in house prices in the early-2000s, but the bidirectional relationship limits simple interpretation of the patterns. The view that credit expansions have fueled housing booms is supported by more rigorous studies of particular countries (e.g., Mian and Sufi 2009, 2011, 2018 and Dell'Arricia, Igan, and Laeven 2012) and cross-country analysis (Andrews 2010 and Cerutti, Dagher, and Dell'Ariccia 2017), which finds that house price booms are more frequent and severe in countries with higher LTVs.

Another regularity is that the price effect of demand is greater where housing supply is inelastic. For example, in table 2, while the mortgage debt-to-GDP ratio rose 25 to 37 percentage points between 1997 and mid-2007 in six countries with liberalized credit markets, the price-to-income ratio rose the most in the United Kingdom, which was at the lower end of rises in mortgage debt, but also had the smallest rise in construction.[20] But if a demand surge lasts long enough, price increases in less supply-elastic

[19] An exception is Australia, which benefited from rapid in-migration and avoided recession in the last 25 years.

[20] In table 2, the fourth column lists the change in the residential construction share of GDP from its 1999 level to its peak between 2000 and 2007 for the boom; the seventh column lists the change in that share from that peak to the trough in the 2007–12 bust period, and for the

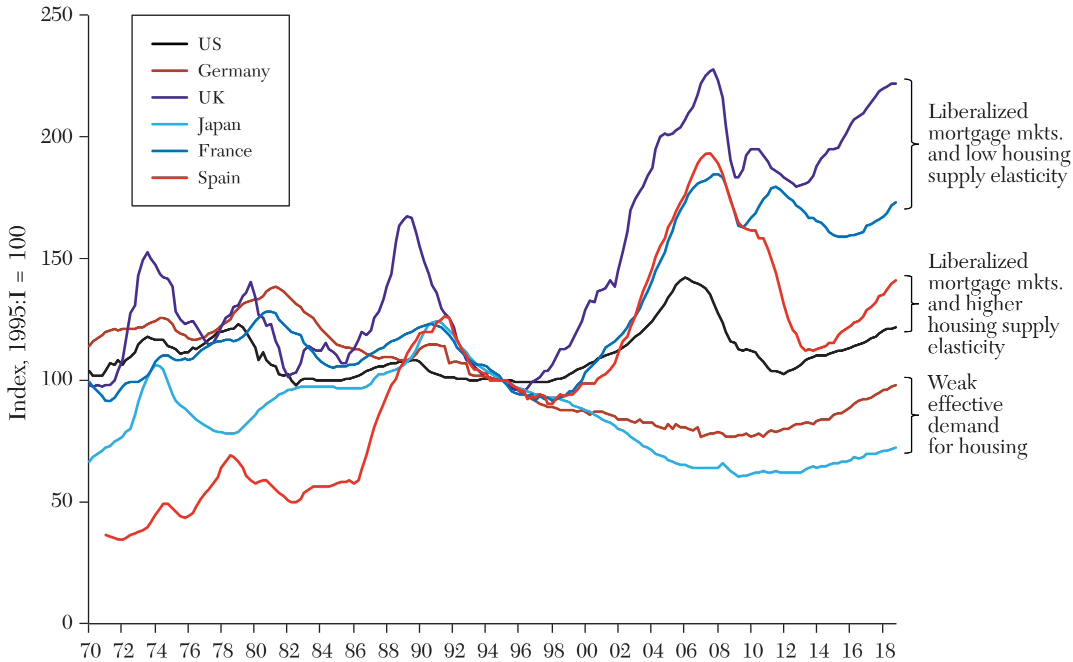

Figure 2. House Price-to-Rent Ratios in Major Advanced Economies Reflect Differences in Supply Elasticities and Longer-Term Demand

Source: Authors' rebasing of OECD data.

areas will be larger, which can offset the limited price elasticity and spur a building boom unless supply barriers are severe. In a bust, house prices can fall even when long-run supply is elastic, as new units built in a boom add to a supply overhang in a bust. Since housing is durable, its short-run supply curve is kinked at current supply. In a bust, the demand curve moves down the vertical part of the supply curve and prices can plunge as in the United States, Ireland, and Spain. By contrast, where mortgage and finance is not liberalized (e.g., Germany and Japan), price and supply responses were not abnormal in the early 2000s. This pattern holds for the price-to-rent ratio in the five largest OECD countries: France, Germany, Japan, the United Kingdom, and the United States. Of these, Germany and Japan have the least liberalized mortgage markets, and the United Kingdom and United States, the most, with the easiest mortgage credit standards in terms of caps on LTV and debt (service)-to-income (DSTI or DTI) ratios. France is in between. Also affecting demand is population growth, which was fastest in the United States and United Kingdom and slowest in Germany and Japan.

While factors that boost demand push up price-to-rent ratios, these gauges tend to

recovery period, the last column lists the 2018 ratio minus the trough.

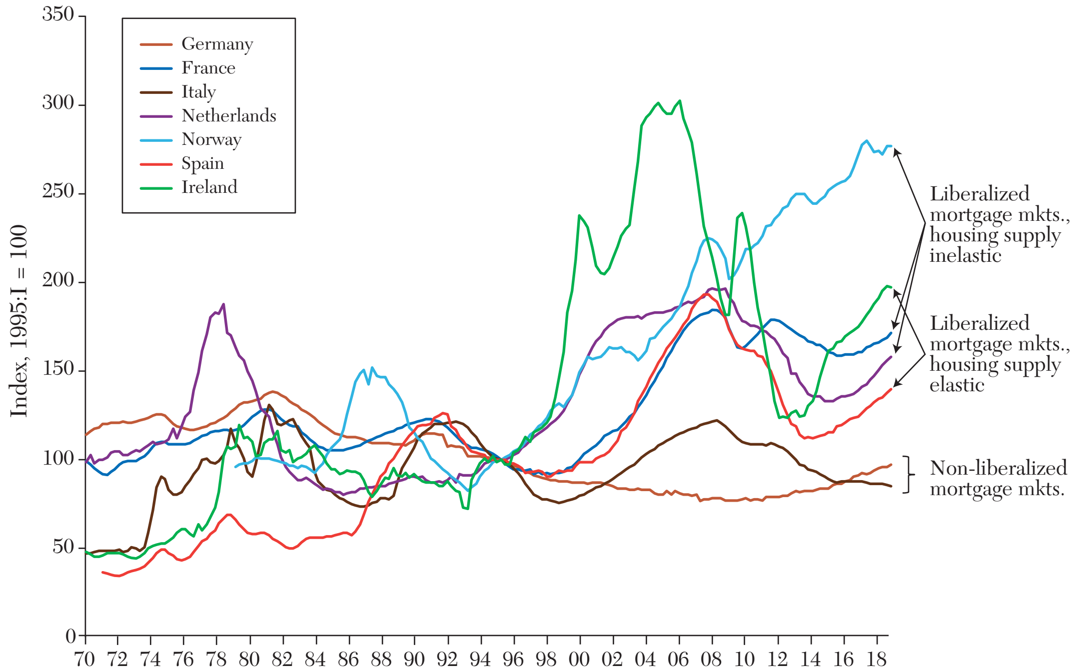

Figure 3. European House Price-to-Rent Ratios Also Reflect Differences in Supply Elasticities as Well as Changing Mortgage Lending Standards and Economic Conditions

Source: Authors' rebasing of OECD data.

rise more where housing supply response is limited by regulation. For the six countries in figure 2, Cavalleri, Cournède, and Özsöğüt (2019) rate the United States as by far the most elastic, and France, Germany, and the United Kingdom as relatively supply inelastic. The strongest price-to-rent rise is in the United Kingdom where strong demand (liberalized credit plus strong income and population growth) has pushed up against inelastic supply. France, with semi-liberalized markets, has the next highest rise in the price-to-rent ratio, with less elastic supply to allay rising pressures than Spain—which had the third highest rise—and then the United States. At the bottom are Germany and Japan, where finance was not liberalized and population growth was low. This pattern is also evident within the euro area (figure 3), although tendencies are partially obscured by differences in real GDP levels and growth rates, as well as the deep recessions in Ireland and Spain. Italy, like Germany, had little liberalization of finance and weak population growth. The Netherlands, like France, liberalized mortgage finance and has a low supply elasticity. Ireland and Spain liberalized finance in the context of relatively elastic supply, as did Norway. However, real house prices there did not fall, as Norway's rapid income and population growth continued through the past decade, given the vast growth of its energy wealth and sound fiscal management.

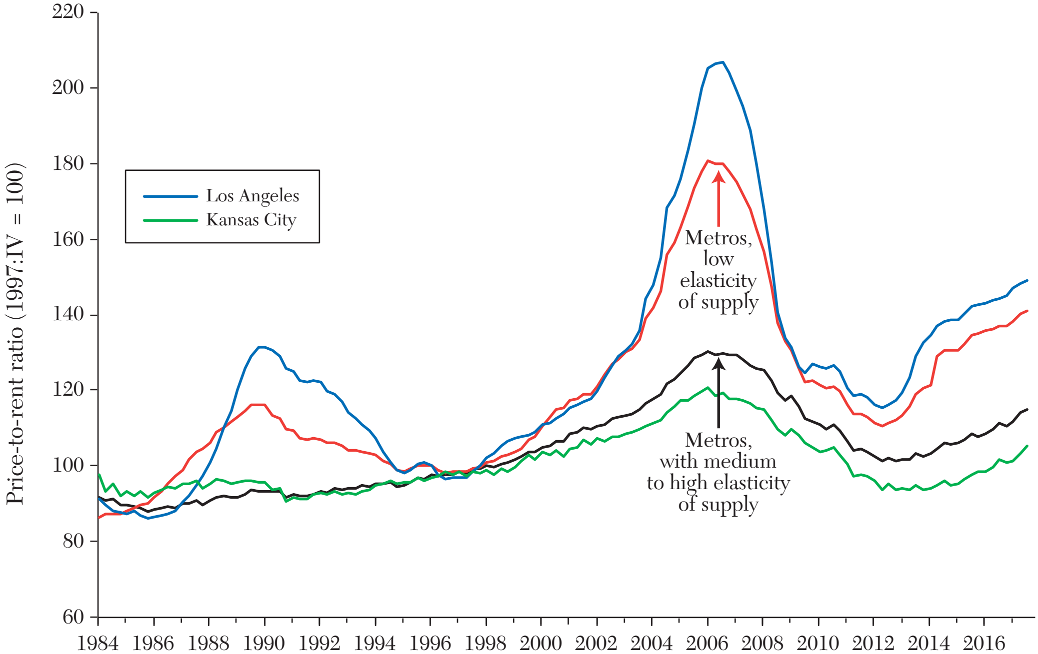

Figure 4. Price-to-Rent Ratios of US Metros Vary More for Cities with Low Elasticities of Housing Supply

Sources: Federal Housing Finance Agency; Bureau of Labor Statistics; Saiz 2010; authors' calculations

3.2 *Regional and City-Level House Price Cycles*

At the regional and metro level, house valuations trend up where housing supply is less elastic, as in the US Northeast and Pacific regions (Glaeser, Gyourko, and Saks 2005a; Saiz 2010), and London and the South East in the United Kingdom. At the local level, price-to-rent ratios have boomed and busted more in US metros whose housing supply elasticities are low (Saiz 2010), for example, Los Angeles, than where elasticities are high, for example, Kansas City (figure 4). These patterns also occurred in the milder cycle of the late 1980s and early 1990s that had inspired the seminal house price indexes of Case and Shiller (1989, 1990, and 2003).

Two differences between these episodes are that price falls were more rapid in the recent bust and also occurred in metros with high supply elasticities. This likely reflects the easing of credit standards in the 2000s boom, which, by raising housing demand and house prices over several years, spurred building (figure 5). When nonprime lending stopped in the bust, demand moved down inelastic short-run supply curves. Bigger price swings resulted in less supply elastic areas reflecting not only more steeply sloped supply curves, but also larger effective demand swings from shifting credit standards.[21] Differences across metros in the response of construction

[21] This difference could also make the initial demand curve steeper for the low elasticity areas.

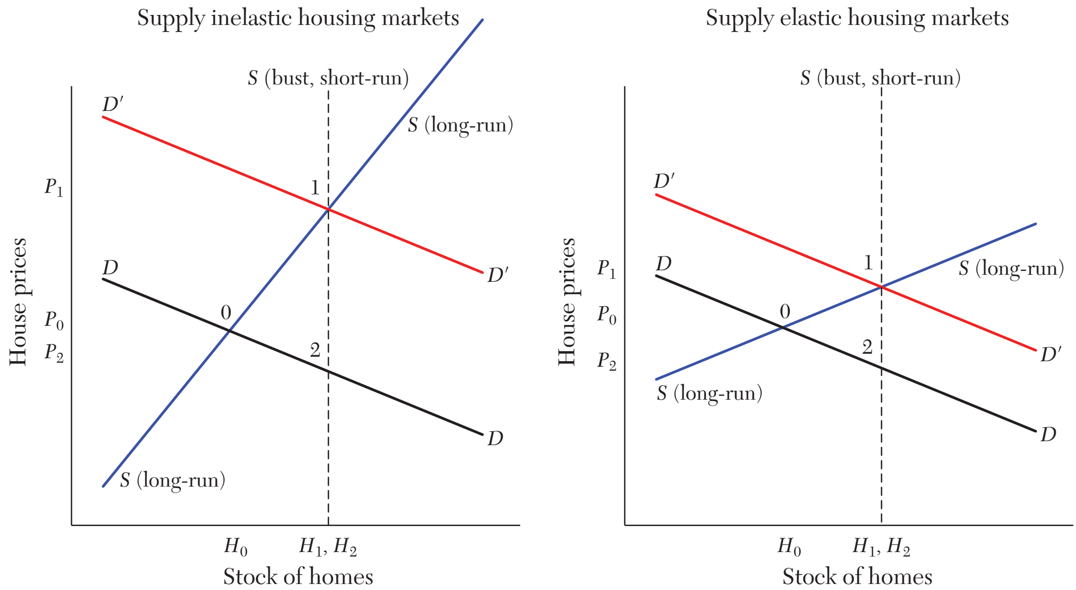

Figure 5. Housing Booms and Busts in Supply Inelastic and Elastic Markets

Notes: Point 0 is the pre-boom equilibrium, point 1 the boom equilibrium, and point 2 the post-bust, short-run equilibrium. Housing demand booms and later reverses in response to changes in drivers such as mortgage interest rates and credit standards. The swing in house prices is larger in supply inelastic markets, but changes in the housing stock can be similar, since the lifting of credit constraints may shift demand by more in those markets, Anundsen and Heebøll (2016). In the bust, the short-run supply curve is the vertical line below the point 1 given by the stock. In the long-run, depreciation helps the market return to the long-run supply curve and to point 0.

Source: Authors.

according to local supply elasticities found in the late 1980s boom were absent in the mid-2000s boom. Anundsen and Heebøll (2016), see their figure 3, attribute this apparent paradox to two factors.

First, before the boom, house price-to-income ratios and the incidence of credit-constrained potential first-time buyers were higher in very supply-inelastic metros, so the lifting of credit limits in the subprime boom bolstered housing demand and prices *more* in these areas.[22] Second, because the boom lasted several years and construction had time to respond, the rise in prices boosted construction sufficiently to offset the effects of a lower supply elasticity. Thus, between the larger financial accelerator effect on demand, extrapolative house price expectations, and the effect of greater rises in existing house prices in supply-inelastic areas, house price swings in the boom and bust were sharper in metros with low supply elasticities, but with few systematic

[22] The market share of nonprime Alt-A loans rose more than that of subprime loans from 2003 to 2005, and in 2005, was higher in California (30 percent), Nevada (32 percent), and Florida (24 percent) versus the United States (Zelman et al. 2007, pp. 19–23 and 33).

differences in construction volumes. This issue is further discussed in section 6.5.

House price dynamics also reflect legal differences. Cross-country studies find that house price booms are larger where borrowers do not face full recourse (e.g., Cerutti, Dagher, and Dell'Ariccia 2017). The evidence from US states is that the speed and cost of foreclosure matter for house price dynamics, as delinquent borrowers were twice as likely to be foreclosed in "nonjudicial states" where lenders do not need court permission to repossess than in "judicial" states. Comparing similar areas on different sides of state borders, Mian, Sufi, and Trebbi (2015) find that the likelihood of fire sales spawned by deficiencies in nonjudicial states resulted in sharper declines in house prices (and auto sales) in the recent housing bust. This accords with the findings of Anenberg and Kung (2014) and Fisher, Lambie-Hanson, and Willen (2015) that foreclosures lower the market value of nearby homes and of Campbell, Giglio, and Pathak (2011) that sales of foreclosed homes or "forced sales" to avoid repossession, occurred at deep discounts, and depressed sale prices of nearby homes in Massachusetts. US house prices reacted more to market conditions in nonjudicial states not only in the bust, but also in the early recovery. Mian, Sufi, and Trebbi (2015) find that from 2010 to 2012, house prices were quicker to stabilize and the real economy recovered more strongly in nonjudicial states, but from lower levels. From 2007 to 2012, the percent change in house prices was not significantly different between judicial and nonjudicial states.

For the United Kingdom, Meen (1999, 2001, 2002) and Cameron, Muellbauer, and Murphy (2006a) find that stronger demand from income and population growth in the London-centered South East England region, where housing supply is most limited, boosted house prices there more than elsewhere (see section 4). Local house price behavior is also diverse in emerging economies. Wu, Deng, and Liu (2014) and Wu, Gyourko, and Deng (2016) stress this is particularly true across Chinese metros where housing supply conditions, amenities and social status, and housing valuations vary greatly, the last being especially high in certain cities (e.g., Beijing and Shanghai) relative to cities further inland or in less prestigious areas.

3.3 *Main Aspects of the Diversity of the International and Regional Experience*

In summary, the international and regional experience highlights how house price cycles depend not only on interest rates and income, but also on time variation in credit constraints, housing supply, and institutional features. House price cycles are more extreme where housing supply is less elastic, institutional and regulatory practices (e.g., on financial liberalization) allow for riskier lending, and in thinner, emerging market economies where income and credit conditions change more rapidly. Paradoxically, the rise in housing construction during the US housing boom of the 2000s was not notably smaller in areas with lower supply elasticities. This reflected how common demand shocks induced a stronger rise in prices in less supply-elastic areas, as the easing of credit standards had a larger effect in such areas. Moreover, the housing demand shocks of the first half of the 2000s lasted long enough for construction to respond to higher prices.

4. *Modeling House Prices at the National and Regional Levels*

Time series models of house prices based on theory generally adopt one of two approaches.[23] Based on no-arbitrage and

[23]We focus on partial equilibrium models in which house prices depend on variables that are endogenous in general equilibrium models. Piazzesi and Schneider's

valuation models from finance, the house price-to-rent approach assumes that, absent agency costs and financial frictions, arbitrage between owner-occupied and rental housing implies the house rent-to-price ratio is a function of user cost, usually defined as the after-tax mortgage interest rate adjusted for expected house price appreciation, plus a risk premium. This approach has been widely used in the United States (Case and Shiller 2003; Duca, Muellbauer, and Murphy 2011, 2016; and Himmelberg, Mayer, and Sinai 2005; and a limited number of other countries, e.g., Ayusao and Restoy 2006, 2007 for Spain). This framework is useful when consistent time series data on the housing stock are unavailable, but "good," mostly market determined rent data exist. However, the approach is inapplicable to areas (e.g., New York City) or countries (Andrews 2010) with heavily regulated rents. One disadvantage is that this approach is silent about the role of housing supply. Another disadvantage is that house price-to-rent models, on their own, may not detect imbalances if rents and house prices similarly deviate from fundamentals.

4.1 *The Inverse Demand Approach*

An alternative framework inverts the demand for housing services, treating the housing stock as predetermined. The resulting inverted-demand equation implies that real house prices are driven by the user cost of housing, real incomes, and the housing stock. Kearl (1979) first fully articulated this approach, followed by Hendry (1984), Poterba (1984), and DiPasquale and Wheaton (1994). In practice, changes in mortgage borrowing constraints importantly alter the effective demand for housing and hence house prices, see Dougherty and Van Order (1982), Meen (1990, 2001), Muellbauer and Murphy (1997), Anundsen and Heebøll (2016), and Favara and Imbs (2015), inter alios. Critical to implementing this framework are good estimates of the housing stock and income, in contrast to the house price-to-rent approach.

Consider the demand for housing services, assumed to be proportional to the housing stock. The latter is fixed in the short run, and prices are solved by inverting the demand function. In a simple log-linear approximation, the log of demand, h_{ijt}, of household i in area j (considered in isolation) is:

$$(1) \quad \ln h_{ijt} = -\alpha_i \ln hp_{jt} + \beta_i \ln y_{it} + z_{it}$$

where hp is the real house price in location j, y is real income, and z denotes other demand shifters including the user cost of housing.[24] The own-price elasticity of demand is $-\alpha$, and the income elasticity is β. As Muellbauer and Murphy (1997) note, equation (1) may be derived from an explicit multi-period utility maximization problem where there are two goods—housing services and a composite consumption good (see Dougherty and Van Order 1982, for example). Then, y is a measure of permanent income or some combination of physical and financial wealth and current and future real income. Equation (1) also omits transactions costs such as real estate agent and legal fees and property transaction taxes, which in some countries can amount to 8 percent or more of the house price. The literature on investment with lumpy adjustment costs suggests that households will adjust their demand for housing in a discrete manner when some thresholds are crossed. However, since both households and the housing stock are heterogeneous, aggregate behavior is likely to be smooth (Bertola and Caballero 1990). For example, if income or another demand shifter rises, marginal households near the threshold where benefits equal transaction costs are

(2016) review stresses general equilibrium and multi-asset pricing.

[24] The price of housing services equals the product of the user cost of housing times house prices.

pushed over the threshold and will transact, raising demand. Equation (1) is static but, in practice, the response of house prices to demand shocks is likely to be drawn out since housing transactions take time and generally entail time-consuming search (Wheaton 1990 and DiPasquale and Wheaton 1994).[25]

Solving for housing prices, hp, involves aggregating the micro demands to a market demand schedule and inverting this to obtain a solution for average house prices at location j:

$$(2) \quad \ln hp_{jt} = (\beta \ln y_{jt} - \ln h_{jt-1} + z_t)/\alpha,$$

where y_{jt} is average real income in location j, h_{jt-1} is last period's housing stock in area j, z_t is the average of other demand shifters, and α and β are weighted averages of micro parameters.[26] This stylistic representation omits the lags resulting from transactions costs, and the demand equation (1) ignores household location choices.

Demand for housing at location j depends on both current residents and on those living elsewhere who could opt to relocate to j. Households living at j similarly can opt to relocate. This means that prices of housing at location j relative to other areas, along with the income earning potential and housing stocks of other locations relative to j, enter equation (1), see section 6.5. Aggregating to the national level, these local relative considerations tend to wash out. However, international relativities can matter, particularly for major cities where internationally mobile households tend to locate (Englund and Ioannides 1997).

An advantage of the inverted-demand approach is that it is well grounded theoretically, unlike "ad hoc" models. In addition, there are strong priors for key long-run elasticities, such as the "central estimates" in Meen (2001). For example, time-series estimates of the income elasticity of demand often find that β is near 1, in which case the income and housing-stock terms in equation (2) simplify to log income per property, $\ln y - \ln h$. However, the income elasticity of *house prices*, given the stock, is β/α, which often notably exceeds 1 since the own-price elasticity of demand for housing, $-\alpha$, is below 1 in absolute magnitude. Forecasts of house prices from this approach need to model construction (e.g., DiPasquale and Wheaton 1994 and Cavalleri, Cournède, and Özsöğüt 2019) as well as forecast income, interest rates, and credit availability.

The demand shifters (z) include the user cost of housing, demography, and credit availability. As housing is durable, intertemporal considerations imply that expected or permanent income and user costs are important. The latter considers that durable goods deteriorate, but may appreciate in price and incur interest and tax costs. Absent transaction costs and credit constraints, user costs are usually approximated as:

$$(3) \quad uc = (i + t_p)(1 - t_y) + \delta + \sigma - \Delta HP^e/HP,$$

where i is the nominal mortgage interest rate, t_p is the property tax rate, t_y is the relevant tax rate for the mortgage interest tax deduction, δ is the depreciation rate, σ is a (possibly time-varying) risk premium, and $\Delta HP^e/HP$ is the expected nominal rate of appreciation. Equation (3) reflects the

[25] Product heterogeneity and time-consuming search can make the sales time for a house long, variable, and difficult to attribute to demand swings or randomness (Chinloy 1980, Haurin 1988, and Wheaton 1990). In this environment, rapid price adjustments may not be rational (see Quigley 1979, Rothschild 1974, and Stull 1978).

[26] As individual demand functions are in logs, first-order approximations to equation (2) can be used to derive weighted average parameters for the α_i and β_i. These depend on the joint distributions of income, housing stocks, and other demand shifters, implying that the location of changes in these drivers matters for changes in national house prices.

deductibility of property taxes and mortgage interest payments from US income tax. Its derivation assumes houses are traded each period. DiPasquale and Wheaton (1994) stress, however, that the expected appreciation term should reflect planned holding periods, as transactions costs impede trading, and should not just refer to short-run appreciation.

The user cost is not the only channel through which interest rates affect housing demand. Kearl (1979) notes that typical mortgages stabilize nominal payments, which, combined with normally rising nominal income, generally implies a falling debt–service burden over time, with the tilt making mortgage payments more burdensome at first. For credit-constrained households, cash-flows matter so that the debt–service ratio affects demand. Moreover, the DSTI, along with LTV and DTI ratios, are used by lenders to set loan terms and decide whether or not to lend. Thus, as nominal mortgage rates fall, one of the lending criteria becomes less binding, thereby increasing credit supply.[27]

The user cost, first formulated for consumer durable goods by Cramer (1957), regards the durable good only as a consumption item. However, the structure and land components of housing are also major stores of value that compete with other assets. This means that relative returns and risks for other assets also affect housing demand. The relevance of low returns on other assets versus strong house price appreciation is particularly high in the current period of low bond yields. It also means that the positive effect of income growth expectations on housing demand—and hence on house prices that comes from thinking of housing purely as a consumption good—could be reversed if a major motive is the saving motive. Indeed, Campbell (1987) highlights how saving could rise in anticipation of future income declines. In Piazzesi and Schneider (2016), housing demand also reflects how much the marginal household values housing services and anticipated capital gains.[28] They, however, stress how such calculations are very complicated for housing versus standard securities because, for the former, its indivisibility and thinness of trading limit arbitrage.

The user cost term in equation (3) does not account for how leverage affects the relative returns to buyers using mortgages, see Muellbauer and Murphy (1997). Leverage amplifies returns and risks, implying that the coefficient of the user cost term in a house price equation may depend on how much leverage lenders provide to home buyers, and hence the general state of mortgage credit conditions.

4.2 *The Price-to-Rent or Rent-Arbitrage Approach*

Before delving into issues regarding expectations, risk premia, and relative returns, consider the other framework for modeling house prices, the price-to-rent or rent-arbitrage approach. Absent frictions and credit restrictions, it assumes that arbitrage between owner-occupied and rental housing equates the rent-to-house price ratio, where both rent and house prices (HP) are in nominal terms, with the user cost term *uc* in equation (3):[29]

$$Rent/HP = uc. \tag{4}$$

[27] In France, regulatory DSTI caps strengthen the effect of nominal interest rates (Chauvin and Muellbauer 2018).

[28] They note that higher home equity eases future credit access and the option of equity withdrawal affects housing demand, but conflate the down payment and home equity constraints, which can differ significantly across countries.

[29] Piazzesi and Schneider (2016, p. 1597) have a more general formulation based on a consumption capital asset pricing model. This implies that housing's attractiveness depends on the covariance of its returns with labor income, rents, house prices, and future house prices, so that housing can hedge against risk in all of these dimensions.

Inverting and taking logs of equation (4), implies:

$$(5)\qquad \ln(HP/Rent) = -\ln(uc),$$

where the elasticity of the price-to-rent ratio with respect to the user cost equals -1.

However, credit constraints (e.g., binding LTV caps) complicate the equilibrium log price-to-rent ratio as the marginal condition (4) is augmented by the shadow price on the credit constraint (Dougherty and Van Order 1982, Henderson and Ioannides 1983, and Meen 1990). With a binding LTV cap, equation (5) generalizes to:

$$(6)\qquad \ln(HP/Rent) = f(\ln(uc), \max LTV).$$

The shadow price of the credit constraint reflects the pervasiveness of such constraints, denoted by the max *LTV* term, approximating the underlying marginal condition. There are a number of other reasons why equation (5) does not hold in practice. Glaeser and Gyourko (2009) note that rented homes, often in multi-family buildings, tend to be very different from owner-occupied, usually single-family, homes, and that the household characteristics of renters differ from those of owner-occupiers. There are also substantial unobserved costs and benefits of owning relative to renting. Moreover, risk aversion and the volatility of house prices make it hard to arbitrage between renting and buying, for example, by delaying purchasing. Finally, given transaction costs, the time profile of future rents, and not just the current rent level, should affect tenure choice (Henderson and Ioannides 1983). This is yet another reason why equation (5) is a gross oversimplification, see also Glaeser and Nathanson (2015).

Duca, Muellbauer, and Murphy (2016) find that US rents adjust slowly to their long-run equilibrium interpreted in terms of equation (6), and that the elasticity of the price-to-rent ratio with respect to the user cost is far below 1 in absolute value even in long-run equilibrium. This finding implies that imposing a unitary elasticity in calibration exercises (e.g., as in Himmelberg, Mayer, and Sinai 2005 and Miles and Monro 2019) may yield incorrect conclusions.[30] House prices also dynamically adjust slowly to their long-run equilibrium owing to search-related and other transactions delays. Note also that for forecasting house prices, this kind of model requires an equation for rents and forecasts of interest rates and LTV ceilings.

4.3 *User Cost and Expectations*

The user cost of housing plays a key role in both the inverse demand and the arbitrage approaches to modeling house prices, for which tracking expected house price appreciation is key since the evidence does not support rational house price expectations. Although this suggests that regular surveys of house price expectations should have been a high priority before the boom and bust of the mid-2000s, surveys are sparse and intermittent. For example, the Michigan Survey of Consumers only added an expected house price question in 2007. Case and Shiller (1989), reporting on their 1988 survey, argue that: “People seem to form their expectations from past price movements rather than having any knowledge of fundamentals. This means that housing price booms will persist as home buyers become destabilizing speculators.”

Between 2003 and 2012, Case, Shiller, and Thompson (2012) conducted surveys of recent home buyers in four US counties, including two in California, that experienced

[30] Miles and Monro therefore claim that the 1985–2018 rise in UK house prices relative to income is explained by the fall in the risk-free interest rate and had little to do with supply constraints. A further problem with their argument is the assumptions of exogenous rents when rents must be affected by the supply–demand balance.

very rapid house price growth before 2008. They elicited the home buyers' expectations of one- and ten-year-ahead house price appreciation, finding that the longer horizon was more salient than the one-year horizon. During the five-year period before 2008, the respondents' forecasts of ten-year-ahead annual rates of house price appreciation (e.g., 13.2 percent in Orange County, CA) were roughly in line with the extremely fast house price growth seen before the surveys, but not the subsequent realizations. Historically, house price growth mean reverts, so expectations of high, continued price appreciation are unrealistic.

Hamilton and Schwab (1985), Case and Shiller (1989, 1990), Poterba (1991), Meese and Wallace (1994), and Englund and Ioannides (1997) find house price changes are positively correlated and that past information on fundamentals forecasts excess returns. DiPasquale and Wheaton (1994) include the last three years of appreciation or a semi-rational reduced-form vector autoregression (VAR) forecast of appreciation in their models of house prices.[31] Capozza and Seguin (1996) and Clayton (1997) find evidence against rational housing price expectations and De Stefani (forthcoming) finds extrapolative expectations of local house price appreciation in Michigan surveys.[32] Other studies documenting extrapolative house price expectations in the United States include Niu and van Soest (2014); Armona, Fuester, and Zafar (2019); and DeFusco, Nathanson, and Zwick (2017).

These empirical results are consistent with calibration findings from theoretical models with expectations prone to momentum[33] (Glaeser and Nathanson 2017 and Piazzesi and Schneider 2016). Extrapolative expectations or other forms of non-fully rational, backward-looking expectations (e.g., Gennaioli and Shleifer 2018), play a key role in most empirically plausible narratives of housing booms and busts, including the US house price boom and bust of the 2000s (Case, Shiller, and Thompson 2012; Glaeser 2013; Glaeser and Nathanson 2017; and DeFusco, Nathanson, and Zwick 2017).

Adding heterogeneity in how agents form and update expectations in calibration models yields house price volatility that is higher than under rational expectations, and closer to what is observed (Li and Meen 2016). Heterogeneity is important in the general optimizing framework of Piazzesi and Schneider (2016), since the indivisibility of housing units and thin trading imply that buyers do not use the same stochastic discount factor in valuation. Discontinuities in home valuations and frictions imply that marginal rates of substitution are not equated across time. As noted in section 2.2, transactions costs and thin trading can induce serial correlation in excess returns and induce the use of backward-looking, extrapolative expectations. As a result, the effects of shocks, for example, shifts in credit standards, are amplified (see section 2; Duca, Muellbauer, and Murphy 2011, 2016; and Sommervoll, Borgerson, and Wennemo 2010, inter alios).

Research on aggregate US house prices (Duca, Muellbauer, and Murphy 2011, 2016) finds that a user cost based on the average rate of appreciation over the prior four years to proxy for expectations works well for both

[31] Semi-rational forecasts from reduced-form time series models typically include terms in lagged appreciation and may not differ so much from simple assumptions about extrapolative expectations.

[32] Another finding against a pure rational expectations approach to modeling housing is that many consumers are confused by mortgage contracts (Woodward and Hall 2010, 2012).

[33] Though Gelain and Lansing (2014) and Gelain, Lansing, and Natvik (2018) replace the rational expectations assumption by a form of adaptive expectations, they assume it for the *level* of house prices. In a rising market, people then expect house prices to fall, the opposite of a momentum effect.

the inverse demand and the rent arbitrage approaches. This horizon is close to the five-year window of Himmelberg, Mayer, and Sinai (2005). Cameron, Muellbauer, and Murphy (2006a) estimate a UK regional house price system and test for an asymmetry between appreciation and depreciation phases. They also find that a four-year memory of house price depreciation yields the best fit. For France, Chauvin and Muellbauer (2018) find that a mix of one- and four-year lagged appreciation gives the best fitting user cost term, suggesting that there is not a simple universal law of how house price expectations are formed. A multiyear memory importantly implies that a series of positive shocks such as the subprime mortgage boom and the fall in interest rates of the mid-2000s, which caused US housing prices to rise, will induce further appreciation over a long period even if the fundamentals do not change further or unwind.

There is also evidence that nonlinear "frenzy" effects may operate in countries with volatile housing prices. Hendry (1984) first used the cubic of recent house price appreciation to model this phenomenon in the United Kingdom. The user cost approach suggests an intrinsic source of nonlinearity in housing price dynamics. Equations (5) and (6) suggest that the log of the user cost term *uc* is a plausible functional form for explaining log house prices. The function has the property that $\log x$ tends to minus infinity as x tends to zero, thereby amplifying the effect of user cost as it becomes small—as can happen in house price booms. The user cost, absent a risk premium, can be negative if rates of capital appreciation in house price booms exceed interest and other costs of owning. Since the log of a negative number cannot be defined, this is potentially a problem. One solution could be if expectations, averaged over households, have the form (for real house prices):

$$(7)\quad \Delta \ln hp^{e} = \theta const + (1-\theta) avg\left(\Delta \ln hp\right)_{t-h}^{t-1}$$

where $0 < \theta < 1$, *const* is a positive constant, and $avg\left(\Delta \ln hp\right)_{t-h}^{t-1}$ is a measure of house price appreciation in recent years. This specification clearly reduces fluctuations in implied expected house price appreciation.

4.4 *Risk Premia*

A time-varying risk premium offers another solution to negative user costs if it is always large enough to make equation (3) positive. It is plausible that the risk premium is increasing in volatility and in the deviation of prices from economic fundamentals, see Muellbauer (2012). Piazzesi and Schneider (2016) come to a similar conclusion, arguing that house price volatility exceeds that implied by rational expectations, unless the marginal rate of substitution negatively co-varies with house price appreciation (so that risk premia depend on recent valuations) or investors' risk premiums are inherently time varying. Meen, Mihailov, and Wang's (2016) asset-pricing model, a special case of models in Piazzesi and Schneider (2016), has a risk premium containing four time-varying factors. The risk premium falls with the variance of financial asset returns and increases with the real value of housing wealth, the correlation between housing and risky financial assets, and the volatility of house price returns. Relatively high housing wealth can reflect prices being above fundamentals signaling a higher risk premium. In a house price boom, recent volatility tends to be high, and as the deviation from fundamentals widens, both raise risk premia. For user costs incorporating multiyear, extrapolative expectations, the rising risk premium offsets the momentum effect of past capital gains. As appreciation slows, either from the rising risk premium or from the end or reversal of the positive shocks driving the boom, user cost rises and if house prices then fall, recent capital losses sharply raise user cost further, contributing to further falls in house prices. Since risk premia should increase with leverage, high-leverage booms are especially prone to this source of instability. Operationalizing models with robust, time varying risk premia is likely to be an important research area.

Barberis et al. (2018) generate overshooting of this type in a model of heterogeneous traders with extrapolative expectations, which accords with the "bubble-builder/bubble-burster" approach of Abraham and Hendershott (1996). In such models, a positive housing demand shock further drives house prices up by raising lagged house price appreciation, thereby lowering real user costs. Later, house prices become high relative to fundamentals, and bubble-burster pressures mount. That there is an element of equilibrium correction in the sophisticated version of user cost that incorporates a risk premium raises identification issues. The same is true for standard dynamic house price specifications. In particular, the bubble-burster mechanism implies that the risk premium embedded in the real user cost should rise as house prices exceed their fundamentals. This makes it difficult to identify a time-varying risk premium and the coefficient on the error-correction term. The potential resolution may lie in the nonlinearity of a log user cost specification and in models that constrain the form taken by extrapolative expectations and of drivers of risk premia. Since user cost also depends on taxes, shifts in tax rates could help identify user cost. Thus, gains could arise from carefully specifying user costs, rather than estimating more reduced-form linear models.

4.5 *Shifts in Mortgage Credit Availability*

There is broad historical evidence that shifts in credit availability have fueled general asset price booms and busts (Schularick and Taylor 2012), including those in land prices. For example, Rajan and Ramcharan (2015) find that, during the farmland price boom and bust before the Great Depression, credit availability directly inflated land prices. Credit also amplified the relationship between positive fundamentals and land prices, leading to greater indebtedness. When fundamentals soured, areas with higher credit availability suffered a greater fall in land prices and had more bank failures. Controlling for a range of factors, they find that the number of banks operating in a US county in 1910 was significantly and positively related to the county level of farmland prices and per capita debt in 1920—which were boosted by the World War I boom in agricultural exports—and to the depth of the bust in land prices even in 1940.

The recent US housing bust was also preceded by strong debt growth, reflecting financial innovation induced by changes in regulation and technology (e.g., Green and Wachter 2007). Revolving and installment credit spread between the 1960s and the 2000s. The government-sponsored enterprises (GSEs)—Fannie Mae and Freddie Mac—were tasked with underwriting mortgages in 1968. Deposit interest rate ceilings were lifted in the early 1980s, and falling IT costs transformed credit screening systems in the 1980s and 1990s.[34] Partly to offset reductions in mortgage lending by the closure of insolvent savings and loan institutions in the late 1980s, the GSEs actively promoted the issuance of RMBS. The RMBS market was also aided by the Basel 1 Accord, which imposed the same 50 percent risk weight for capital requirements on bank holdings of GSE RMBS as on prime

[34] Earlier variations in Regulation Q ceilings had the unintended consequence of inducing more non-price rationing of mortgage and consumer credit in an era of limited securitization.

home mortgages held in portfolio by banks. Deregulation of state banking between 1994 and 2005 increased mortgage supply (Rice and Strahan 2010). More revolutionary was the expansion of subprime mortgages in the 2000s—driven by the rise of private label securitization spurred by an easing of capital requirements and backed by credit default obligations and swaps as discussed in section 2.4. This induced higher first-time buyer LTVs and higher house prices. After 2007, falling house prices, worsening loan quality, and tighter lending standards caused a severe credit crunch, later moderated by greater access to FHA-backed mortgages.[35] In addition, the Federal Reserve's quantitative easing purchases of mortgage-backed securities helped stabilize mortgage conditions (Fieldhouse, Mertens, and Ravn 2018).

In the United Kingdom, shifts in regulations and technology also induced large changes in mortgage credit standards. The United Kingdom abandoned exchange controls in 1979 and the regulatory "corset" on bank lending in 1980, after a decade of negative real interest rates and quantitative controls on bank and mortgage lending.[36] The High Street banks rapidly entered the mortgage market, challenging the then-dominant position of building societies (mutual savings banks). Centralized mortgage lenders gained market share in the late 1980s by offering better loan terms via mortgage brokers who earned fees on loans whose later default losses they did not bear. Unregulated competition induced poor lending practices. A major credit and house price boom resulted. A jump in interest rates in 1989–90 led to a mortgage crisis and a credit crunch.[37] After 1996, credit was liberalized for the buy-to-let market, and via greater securitization, increased funding from money markets and the advent of centralized lenders operating via financial intermediaries or online. This started reversing in 2007, when a credit crunch was triggered by the drying up of money markets, whose effects were later amplified by falling house prices and re-regulation of lenders. The Bank of England's Funding for Lending Scheme and other measures eased mortgage credit conditions somewhat after 2011.

Tracking mortgage credit standards is difficult, as most nations lack data on time variation in non-price terms of mortgage credit.[38] Although central banks have increasingly instituted surveys, the time span or coverage of most surveys is limited, and they can be biased by financial innovation occurring outside of surveyed banks.[39] Different approaches are used to measure mortgage credit standards when they are not directly observed. Some (Mian and Sufi 2009, inter alia) instrument cross-section variation in mortgage availability with earlier readings on the share of borrowers with subprime credit scores. These studies find that areas with low credit scores saw both higher credit growth in the early 2000s and higher later default rates, which cannot be attributed to cross-sectional variation in expectations of future income or house prices. Similarly, Adelino, Schoar, and

[35] While higher first-time buyer LTVs are likely to be correlated with easier access to home equity loans, future work should check whether the latter has a separate effect on house prices.

[36] The "corset," the Supplementary Special Deposit Scheme introduced in 1973, imposed penalties on banks whose interest-bearing deposits grew faster than a preset limit. See Bank of England (1985) on changes in UK housing finance in the early 1980s.

[37] Because of the exchange rate mechanism (ERM), UK interest rates responded to higher German interest rates due to unification, and monetary policy tightening, reacting to an overheated economy from the credit and house price boom. Only after the United Kingdom left the ERM in 1992 could domestic monetary policy relax.

[38] While the Housing Finance Information Network reports cross-national data on mortgage credit characteristics, the website depends on incomplete datasets compiled by national authorities.

[39] Federal Reserve survey data on bank credit standards for some loan categories are continuous only since the mid-1990s and European Central Bank (ECB) data begin only in 2003.

Severino (2015) track differences in firms' access to real estate collateral from geographic variation in earlier mortgage application denial rates, while Adelino, Schoar, and Severino (2012) use changes in conforming loan size limits to identify the effect of mortgage availability.

Favara and Imbs (2015) use variation in state banking deregulation between 1994 and 2005, as tracked by Rice and Strahan (2010). The deregulation only covered banks, and not thrifts, credit unions, and independent mortgage companies. Since all lenders should react to a demand increase, the differential response, by location, of deposit-taking banks indicates a supply shift in mortgage credit, a useful natural experiment. Favara and Imbs (2015) find that these credit supply shifts significantly affect local housing activity and house prices, with house prices rising more in areas with inelastic housing supply. Di Maggio and Kermani (2017) exploit cross-state variation in the 2004 federal preemption of national banks from local predatory lending laws to gauge credit supply effects on the real economy in 2004–06. The differential shifts in credit strongly and significantly affected house prices and loan volumes.

For time-series research, some papers use changes in mortgage credit or growth in subprime lending. Duca, Muellbauer, and Murphy (2011, 2016) proxy US mortgage standards using American Housing Survey data on the median LTV for first-time home buyers, a gauge that soared in the 2000s. There was also a rise in measured DSTI ratios for first-time buyers, but measurement error for income is greater than for the recent transaction-based value of a home. While this makes the LTV the preferred gauge, there may still be useful information in the measured DSTIs. The evidence is that defaults are linked *both* to household cash flow, for which the DSTI is the more relevant risk indicator, *and* net housing equity, for which the LTV is the more salient risk indicator (Aron and Muellbauer 2016; Elul et al. 2010; and Foote, Gerardi, and Willen 2008, 2012).

LTVs for first-time home buyers are less prone to endogeneity than are LTVs for repeat buyers, which are affected by prior housing capital gains. Consistent with Fuster and Zafar (2016), tracking overall credit constraints for first-time home buyers is critical, as they are the marginal home buyers. Indeed, increased US homeownership during the 2000s was concentrated among those under age 40. By contrast, the prime mortgages securitized by Fannie Mae and Freddie Mac are predominantly to repeat home buyers, whose LTVs dipped in the mid-2000's house price boom as they rolled over capital gains into down payments on their next home. This endogeneity likely misled researchers who relied on LTVs on prime loans (e.g., Glaeser, Gottlieb, and Gyourko 2010) into missing an easing of credit standards for marginal buyers.

To track UK mortgage conditions, Fernandez-Corugedo and Muellbauer (2006) use microeconomic data on LTVs and DTI ratios for first-time buyers from a quarterly survey by the Council of Mortgage Lenders on mortgages advanced by member building societies (thrifts) and banks. The shares of loans with LTVs above 90 percent and DTIs above 2.5, splitting households into younger and older and the United Kingdom into north and south, is combined with information on aggregate mortgage and non-mortgage debt into a ten-equation system. Extensive controls include demography, interest rates, income, asset and house prices, and risk factors. As a result, the common factor, otherwise unexplained, can be interpreted as a mortgage credit conditions index. Trends in this indicator fit the qualitative history of UK credit conditions discussed earlier.

Gauges like median LTVs for first-time buyers are best seen as time series proxies of overall credit conditions for marginal home buyers. Kelly, McCann, and O'Toole (2018) find that LTV and DSTI ratios for first-time borrowers moved together in the recent Irish housing boom and bust, but comparable evidence is lacking for most other countries. The share of "subprime" home buyers with low credit scores is often used to track US credit conditions. Although the subprime share boomed in the early 2000s, the boom in high LTV/DSTI ratio Alt-A mortgages was as large (Zelman et al. 2007). The subprime boom was also accompanied by greater issuance of highly leveraged jumbo and investor mortgages. The latter are riskier than owner-occupier loans, as investors are more apt to default since they earn no rent from vacant homes, whereas owner-occupiers consume imputed housing services (Albanesi, De Giorgi, and Nosal 2017). For this reason, and because government aid to troubled borrowers was to owner-occupiers, mortgage default rates were higher for investor loans in the recent US bust. Nevertheless, overstressing investor loans as driving the US housing crisis ignores the large swings in homeownership among the young.

While first-time buyer LTVs measures are helpful in accounting for US house price swings, new regulations may have altered their usefulness. Before the late 1990s and the rise of nonprime mortgages, US mortgage underwriters limited DSTI and LTV ratios, with the latter being relatively stable in this era (Duca, Muellbauer, and Murphy 2016).[40] Using 1980–81 American Housing Survey data, Rosenthal, Duca, and Gabriel (1991) found that both constraints bound for nongovernment-insured mortgages. Credit standards have evolved since the 2010 Dodd–Frank Act, designed to prevent a repeat of the 2008 financial crisis. New rules allow the securitization of nongovernment guaranteed mortgages with DSTI ratios up to 43 percent, and protect lenders from borrower lawsuits, but do not impose LTV caps. At first glance, this change might imply that DSTI ratios may be a more useful future gauge of US credit conditions than LTVs, but also that the interest and income sensitivities of housing have risen, as Greenwald (2016) suggests. However, LTVs are likely to remain relevant: new rules allow mortgages guaranteed by the FHA, Fannie Mae, and Freddie Mac—the dominant players in the US mortgage market—to be securitized, and these entities limit *both* DSTI and LTV ratios, with Fannie Mae and Freddie Mac levying higher fees for guaranteeing higher LTV loans.

It can be critical to account for government interventions in mortgage markets to understand shifts in overall mortgage credit conditions. For example, the mortgage-market share of government-guaranteed FHA loans in the United States fell from 13 percent in 1996 to below 4 percent in 2006 during the subprime mortgage boom, but subsequently rose to 19 percent in 2010 when significantly expanded FHA loan limits were used to counteract tighter credit standards on non-guaranteed mortgages.

[40] The use of median LTVs for first-time buyers is meant to track time variation in mortgage credit standards facing the marginal buyer of owner-occupied housing. One could object that with mortgages administered by the US Department of Veterans Affairs (VA mortgages), defaults are low even though they have low down payments. However, VA mortgages are limited to veterans who have a limited lifetime cap on mortgage principal that can be guaranteed by the government. For this reason, VA mortgages are unlikely to impart time variation in the median LTV for FTBs. The loan performance of other high LTV loans is worse than for VA mortgages, reflecting that the later entail tougher other aspects of credit standards (mainly limits on DSTI ratios and minimum credit scores—a point made by Goodman, Seidman, and Zhu 2014). Time series data on FICO scores of mortgage borrowers are limited and do not span enough housing cycles to make identification practical.

4.6 *DSGE Models and Agent-Based Models*

Heterogeneity, trading and search costs, asymmetric information, and credit constraints are rife in housing markets, see Glaeser and Nathanson (2015). This limits the potential usefulness of including housing in micro-founded representative agent DSGE models. A more useful approach is to follow Kiyotaki and Moore (1997) and use a two-representative-agent DSGE approach. For example, Iacoviello (2005), Iacoviello and Neri (2010), and Ferrero (2015) use this approach to analyze home prices, stressing shifts in credit constraints. The two types of agents are patient households providing credit, and impatient households, who borrow to invest in housing as much as patient ones allow.[41] A nonhousing sector produces consumption and business investment with capital and labor, and the housing sector produces new homes using capital, labor, and land.

These studies are informative but make many simplifying assumptions. In Iacoviello and Neri (2010) these include no banks, no defaults, a closed economy, infinitely lived households, rational expectations, market efficiency, no rental market, no heterogeneity, no transactions costs, and instantly adjusting house prices while wages and goods prices are sticky.[42] The absence of defaults omits a key aspect of the financial accelerator, while the closed economy assumption implies that aggregate home equity withdrawal, often positive in the United States before the GFC, must always be negative. Assuming infinitely lived households rules out saving for a down payment, an important driver of saving for the young in advanced economies.

The standard DSGE assumptions do not accord with empirical evidence on the drivers of mortgage defaults and on the short-term stickiness and long-term volatility in house prices. The main driver of house prices and residential investment in the model is a "preference shock."[43] Iacoviello and Neri (2010) compare the correlation between consumption growth and house price growth in their calibrated model. The correlation is 0.099, the result of the common influence of the shocks on house prices and consumption. Allowing for frictions associated with a maximum LTV constraint, the correlation rises to 0.123. From this, one could erroneously conclude that financial frictions have only a small macroeconomic impact.

Justiniano, Primiceri, and Tambalotti (2019) note that mortgage debt and house prices rose together and real mortgage rates fell in the 2000–2006 boom in US house prices. They use a simple, general equilibrium model with patient and impatient agents, a collateral constraint limiting the ability to borrow against real estate, and a lending constraint impeding the flow of funds to the mortgage market. They argue that the stylized facts of the housing boom are best explained by a progressive relaxation of the lending constraint, rather than a relaxation of the collateral (LTV) constraint. This conclusion is questionable.[44]

In a richer DSGE framework with defaults, Landvoigt (2016) finds that the US

[41] Kiyotaki and Moore (1997) instead have "farmers" and "gatherers" and farmland instead of housing.

[42] In Ferrero (2015) the economy is open, but housing supply is fixed.

[43] Ferrero (2015) includes a credit shock as well as a preference shock in his open economy version of the model. He notes that, in the absence of other information, these are observationally equivalent in his model.

[44] They contrast their view with an apparently alternative "popular view that attributes the housing boom only to looser borrowing constraints associated with lower collateral requirements, because they shift the demand for credit." That view would confuse a shift in the demand function for credit with a shift in the volume of credit. However, lower collateral requirements set by lenders reflect NOT a shift in the demand for credit but a shift in credit supply, which shifts the *derived demand for housing.*

subprime boom (and bust) can be generated with a combination of looser (tighter) LTV limits and a higher (lower) willingness of lenders to make riskier loans.

In another step forward, In't Veld et al. (2011) use a calibrated general equilibrium framework with a richer specification, including an open economy with international capital flows, a banking sector, credit shocks, mortgage defaults and default shocks, and non-fundamental bubble asset price dynamics for housing and equities. Their model has three representative agents: savers, investors/equity holders, and debtors. Savers do not directly invest outside of housing but save in the form of deposits and corporate bonds, earning interest income from financial assets and receiving net wages. Investors own the bank and non-financial corporations and make corporate investment and loan supply decisions. The paper argues that US housing and equity price dynamics cannot be explained by fundamentals: stochastic bubbles are needed. Moreover, a savings glut feeding capital inflows into the United States alone cannot explain the boom-bust of the 2000s.

Eschewing representative agents, Sommer, Sullivan, and Verbrugge (2013) devise a stochastic life-cycle heterogeneous agent housing tenure model with incomplete markets, uninsurable idiosyncratic income shocks, endogenous house prices and rents, exogenous LTV caps and interest rates, and no default. The rental and owner-occupied markets clear instantly. They compare steady states with alternative interest rates and down-payment constraints, and discuss a perfect foresight transition path between steady states. Varying these fundamentals as in the 2000s boom increases house prices but not rents. However, their model explains only one-half of the price/rent boom, suggesting a key role for over-optimistic expectations.

Favilukis, Ludvigson, and Van Nieuwerburgh (2017) assume rational expectations, market clearing, and no mortgage defaults, but replace infinitely lived households with overlapping generations with variable bequest preferences, capable of generating plausible wealth heterogeneity. They allow for potential capital inflows and aggregate business-cycle and idiosyncratic income risk. As a result, the aggregate time-varying housing risk premium can be important. Credit liberalization takes the form of relaxing the LTV constraint and lowering transaction fees. They suggest that such liberalization affected house prices more than the interest rate declines in the 2000s. In their model, all agents are owner-occupiers, which limits the need to save for a down payment, though variations in precautionary saving can be important. Housing investment is endogenized, giving another channel for shock transmission. But the absence of housing frictions and defaults, combined with rational expectations, makes it hard to obtain an endogenous house price crash.

In an important advance, Garriga and Hedlund (2020) construct a heterogeneous agent model with a frictional housing market, heterogeneous houses, idiosyncratic income risk, and long-term fixed-rate mortgages with a default option from banks who therefore need to price default risk. The model contains renters and owner-occupiers with a search and matching mechanism, generating a cyclical liquidity channel. The model gives an account of the forces driving the housing bust in the GFC, with a particular emphasis on the role of endogenous housing liquidity and household balance sheet composition, implying large distributional effects between savers and borrowers. Changes in credit conditions and downside earnings risk are major drivers of cyclical liquidity. Several assumptions dampen responses to shocks, including infinitely lived households (precluding a down payment saving motive), a construction sector in which land prices play no role, and an ex ante zero-profit condition for banks with the assumption that banks can recoup unanticipated losses from defaults by raising mortgage pricing. This introduces some feedback from defaults back onto the new mortgage and housing markets, but does not fully capture the severe contraction in credit conditions in the financial accelerator discussed in section 2.2.

While there has been progress in the development of DSGE models, the tendency, with the exception of the last two DSGE models discussed, has been to focus on one or a few features that capture elements of real-world frictions or institutional features to derive stylized conclusions. Models that are consistent with the full range of national and international evidence on house prices discussed so far remain to be developed.

An alternative to rational expectations models with fully optimizing heterogeneous agents are calibrated agent-based models (ABMs), with general equilibrium features, such as Geanakoplos et al.'s (2012) study of Washington, DC. Here, agents follow simple heuristics to choose housing tenure and loan size given the distribution of LTV and debt-to-income ratios, and whether to refinance a mortgage, make mortgage payments, or default. The empirical joint distributions of income, wealth, age, and marital status capture major aspects of household heterogeneity. User costs embody expected appreciation linked to the previous year's appreciation, and house prices are endogenous. Model simulations for 1997–2009 that keep the distribution of LTVs at pre-boom levels imply far less house price appreciation to 2006. Simulations that allow the LTV distribution to rise to actual levels, but keep interest rates at pre-boom levels result in a major house price rise, though with the peak 12–15 percent below that resulting from actual LTVs and interest rates. Geanakoplos et al. (2012) conclude that greater leverage was more important as a cause of the housing boom than lower interest rates.

Li and Meen (2016) simulate an ABM asset-pricing model for housing with heterogeneous nonrational expectations and learning. Their model generates greater house price volatility than representative agent rational expectations models. Moreover, under heterogeneous expectations, house prices need not converge to the rational expectations solution, and can reach a temporary self-fulfilling equilibrium. Agent-based housing models incorporating behavioral insights are likely to be a major research tool in the future.

4.7 *Main Findings on Modeling House Prices at the National and Regional Levels*

In summary, the two main, theory-based approaches to modeling house prices are the house price-to-rent and inverted-demand approaches. The applicability of the price-to-rent approach is limited by widespread rent controls outside the United States and the unrealistic theoretical assumptions underlying the basic no-arbitrage equation (4) above, while the inverted-demand approach is often limited by the non-availability of measures of the stock of housing. The user cost of housing and mortgage credit conditions feature prominently in both approaches. In general, a consensus has emerged that time variation in credit standards has played a significant role in countries experiencing more severe housing market instability, and that expectations of future house prices changes contain an extrapolative component, deviating substantially from the representative agent, rational expectations, and fast market-clearing paradigm. The latter limit the usefulness of current DSGE models to long-run analysis, even those making progress in including multiple agents and credit constraints, while agent-based models need to incorporate more realistic decision-making in lieu of mechanistic simplifications. New efforts to incorporate time-varying risk premia in internally consistent ways into housing analysis are promising.

5. *Measurement Issues, Supply Constraints, and Demography*

We have reviewed measures of credit constraints and house price expectations in section 4, and turn next to surveying the literature on measuring house prices, rents, and the housing stock. A discussion of supply constraints and demographic factors concludes this section.

5.1 *House Price Indices*

While major international databases track national house prices (e.g., the Bank for International Settlements (BIS), OECD, and Federal Reserve Bank of Dallas), there are complications that multicountry studies often ignore. UK national indices based on transactions start in 1968, and can be spliced to other data back to the 1950s. OECD quarterly house prices begin in 1970 for some countries, but some data are not consistent. For example, the Spanish index splices national data with pre-1987 data for Madrid, which is more volatile and upward trending. German indexes interpolate annual data, overstating stickiness, with true quarterly data starting in 2003. The French index splices interpolated annual data until 1996, with quarterly hedonic data thereafter.[45]

Despite advances, house price indices are limited, even though the broad movements in different national and local indices are often similar. On the one hand, hedonic methods have improved (see Hill 2011 and Hill and Scholz 2018). Incorporating nonlinearities and interaction effects is more feasible with bigger datasets and more powerful software, while the adjacent-period method (Triplett 2004) allows market evaluations of house characteristics to evolve.[46] On the other hand, because hedonic methods (de Haan and Diewert 2013; Diewert, de Haan, and Hendriks 2015; Hill 2011; and Wallace and Meese 1997) require detailed property characteristic data, which are often only recently available,[47] hedonic indexes often have shorter samples than repeat-sales indexes, which use historical transactions, see de Haan (2013) for a primer. Repeat sales indexes for the United States were popularized by Case and Shiller (1989), who spawned more comprehensive measures (e.g., Freddie Mac, the Federal Housing Finance Agency (FHFA), and CoreLogic).

However, repeat sales indices are biased as they omit prices of infrequently sold homes (de Haan 2013), and do not fully capture renovations, which are more common during booms and in high cost areas. Indeed, Bogin and Doerner (2019) find that renovation bias distorts values by up to 15 percent in city centers. Finally, repeat sales indices assume homes are maintained, which is less likely during housing busts and in areas that are more depressed or have a greater incidence of foreign investors (see Geanakoplos 2010).

As Eurostat (2013) notes, house prices differ if they are unit sales based (e.g., FHFA and CoreLogic) or sales-price weighted transactions indices (e.g., Case–Shiller), with the latter being more volatile due to larger price swings in costlier areas. Repeat sales indexes differ by mortgage type, area, and transaction tracked. The CoreLogic index covers homes bought with mortgages securitized by subprime, private label MBS and swung more in the 2000s than the FHFA index for homes bought with only GSE mortgages.

[45] Annual data are from repeat-sales data of Friggit (2008, 2010) and quarterly data are from INSEE.

[46] This method pools data on prices and characteristics for two adjacent periods and regresses the log price on characteristics and a time dummy, whose coefficient tracks the quality-corrected overall price change.

[47] To the extent that hedonic information comes from listings rather than transactions, sales delays can distort hedonic indices (Anenberg and Laufer 2017).

CoreLogic prices rose 133 percent from 1997:I to 2006:II, and then fell 31 percent in the bust from mid-2006 to mid-2012, while FHFA prices rose and fell by smaller 90 percent and 18 percent, respectively.

5.2 *Rents*

Several issues arise about the accuracy of rents. First, rent indexes in the US consumer price index (CPI) and personal consumption expenditure (PCE) deflators track the average, not the marginal, cost of renting, the latter being better suited to house price-to-rent models (Verbrugge 2008). Second, US rents are sticky, as half of units have annual leases, one third have leases under one-year, and under one-sixth lack leases (Crone, Nakamura, and Voith 2010). Further, a large share of rents are unchanged after contracts expire[48] and US rents are also stickier for single- than multi-family units (Genesove 2003 and Gallin and Verbrugge 2019).

How official statistics handle tenant turnover is important. Before methodological changes were made in the mid-1980s (Crone, Nakamura, and Voith 2010), the index tracking rents in the US CPI was distorted by units being dropped from the sample when tenants changed. When rents are set to rise, tenants are more likely to move and dropping such units downwardly biases rents. Landlords may find it easier to raise rents for new than for existing tenants. Ambrose, Coulson, and Yoshida (2015, 2018) show how current US methods make CPI and PCE rent inflation less cyclical than a repeat rent index. That said, their data start in 2001, limiting their usefulness, and more research is needed to improve repeat rent indexes.

Other measurement issues center on utilities and neighborhood differences. Since rent in many contracts covers some utilities, official shelter costs for owner-equivalent rents (OER) (but not for rental units) net out included utilities. Owing to energy price volatility, such adjustments add noise to shelter cost components. However, Verbrugge and Poole (2010) find that, while utility adjustments can cause OER and the rent index to diverge, most deviations arise from owner-occupied and rental units being located in different areas. Another issue concerns divergences between OER and user costs incorporating forecasts of house price inflation. Garner and Verbrugge (2009), using microdata, find that forecasts of house price inflation account for most deviations between the user cost measure and rents.[49]

A last issue is variation in rent regulations. Owing to its arbitrage assumptions, the price-to-rent approach to model house prices requires data on market-determined rents. However, in the United Kingdom, for example, rents in private units have only been unregulated since 1988 and below-market rents prevail in social housing, accounting for about 17 percent of tenures (compared with 20 percent in the market rental sector). A number of major US cities have rent controlled tenancies (e.g., New York, Los Angeles, and San Francisco), so the inverted-demand approach to modeling house prices may be more appropriate than the rent arbitrage approach. Regulations may also affect the length of rental tenancies and homeownership rates. In Germany, where renters have more legal protections and tax

[48] Rent stability may partly owe to landlords trying to retain good tenants. Gallin and Verbrugge 2019 argue this is insufficient to explain rent stickiness, stressing that asymmetric information about renters induces bargaining, creating a tendency for rent to remain unchanged in a new contract on the same unit. Rents are even stickier in Japan, where 90 percent were unchanged each year between 1986 and 2008 (Shimizu, Nishimura, and Watanabe 2010).

[49] In the 2004–07 period of the study, forecasts of high house price inflation would have reduced user costs, but landlords did not pass these on by lowering rents. This could also reflect their superior bargaining power over credit constrained tenants who could not take advantage of higher returns from owner-occupation.

laws make the rental market deep, the rental tenure share is four times that in the United Kingdom (Davies et al. 2017) and the average length of rental tenancy is 11 years (Fuchs and Fitzenberger 2013) versus 2.5 years in the United Kingdom (Davies et al. 2017).[50] Better data on rental regulations and the development of latent rent indices in areas with rent controls could benefit research.

5.3 *Modeling Rents*

For the rent-arbitrage approach to modeling house prices (section 4.2) to be usable for dynamic simulations, the house price-to-rent equation must be complemented by an equation for rents. This is a very under-researched topic for national time series data, particularly given the large weight of residential rents in the US CPI and PCE deflator indices. For example, the Federal Reserve's macroeconometric model, FRB-US, uses the rent-arbitrage approach to determine house prices, albeit with a low speed of adjustment, while the rate of change of real rents is specified merely as a function of the prior quarter's rate of change.

Dias and Duarte (2019) examine how monetary policy shocks affect rents in a VAR, finding that a positive federal funds rate shock raises rents and lowers house prices. While a more general model is needed to examine the interaction of rents, house prices, and the housing stock, there are some useful pointers in the reduced-form US rent equation in Duca, Muellbauer, and Murphy (2016). They model rents relative to the PCE deflator, the largest driver of rents. They find positive long-run effects of real incomes and house prices on rents, and a negative effect of user costs, which incorporate lagged house price appreciation. Since a rise in interest rates raises user costs both directly through the interest rate term and indirectly by reducing house price appreciation over time, these results accord with those of Dias and Duarte (2019).

5.4 *Housing Stocks*

Modeling house prices with the inverted housing demand approach (section 4.1) requires consistent time series on the housing stock. Unfortunately, consistent, subnational housing stock data are often unavailable owing, for example, to changes in US Census area definitions. Measuring the housing stock over time also poses index number challenges. With annual data on housing characteristics, one could construct quality adjusted, constant price indices for the stock. A simple count of housing units not adjusted for space and home improvements is usually inadequate. A simpler alternative is the constant price measure of the residential capital stock in national accounts. This is generally derived from constant price data on residential investment, including improvements, using the perpetual inventory method. Usually, such data are available only at national and not regional levels, and some OECD countries do not publish even national data. If one regards the housing stock as a composite of land and structures, available national accounts measures do not incorporate variations in the ratio of the two since only structure investment is recorded.

A general problem with national data on the aggregate housing stock, even for studying national house price developments, is that the location of housing matters. Expanding supply in high-demand locations will have a different effect on national house price indices than expanding in low-demand locations.

5.5 *Supply Constraints and Land Prices*

The elasticity of housing supply affects house price behavior across and within

[50] Historically, rental sectors were decimated in high-inflation countries (United Kingdom, Spain, and Italy) having rent controls. The large German rental sector reflects low inflation and controls permitting gradual adjustment to market rents.

countries, but earlier had been insufficiently appreciated, see Rosenthal (1999) and Glaeser and Gyourko (2018).

Local difference in supply elasticities.— Studies have found differences in the elasticity of housing supply across metro areas since Malpezzi (1996), Green, Malpezzi, and Mayo (2005) in the United States, and since Cheshire and Sheppard (1989, 1998), Bramley (1999), and Bramley and Leishman (2005) in the United Kingdom. More consensus has arisen on, and more attention has been devoted to, estimating supply elasticities across metro areas—where differences in planning or zoning regulations and geography and variation in local demand shocks help identification—than across countries and over time.

Hilber and Vermeulen (2016) examine how supply constraints affect house prices, using a panel dataset of 353 English local planning authorities and direct information on planning decisions to measure regulatory restrictiveness. They find that house prices respond more to changes in income in supply-inelastic locales. Variations from a policy reform, as well as party political vote shares and densities, identify the exogenous constraints. They conclude that regulatory constraints significantly raise the house price-earnings elasticity, the effect of land constraints is confined to highly urbanized areas, uneven topography is less important in the United Kingdom, and the effects of supply constraints are greater in booms than busts.

Green, Malpezzi, and Mayo (2005), building on Mayer and Somerville (2000a, b) and Capozza and Helsely (1989), find that the price elasticity of housing supply varies greatly across US metros and is affected by the cost of capital, transportation costs, population, and other factors linked to density (taxes, regulation, and geography). Using a solved-out function for the housing supply elasticity, they regress supply elasticities on several explanatory variables. While population levels matter, land use regulation (using Malpezzi's 1996 pioneering index) and population growth are the most important regressors, with small roles for population levels and taxes.

There is variation in the ranking of metro housing supply elasticities. A comparison of the estimates in Green, Malpezzi, and Mayo (2005) and Mayer and Somerville (2000b) with those in Glaeser, Gyourko, and Saiz (2008); Glaeser, Gyourko, and Saks (2005a, b); Saiz (2010); and Liu (2018) is instructive. The studies all control for local regulations, especially for land use, a key factor explaining variation in supply elasticities across metros. However, Saiz (2010) and Glaeser, Gyourko, and Saiz (2008) add geographic limits on land use, based on Saiz (2010) and earlier versions. Supply elasticity estimates vary greatly across cities, ranging from −0.3 for Miami to 29.9 for Dallas according to Green, Malpezzi, and Mayo (2005). Saiz (2010) finds a much narrower range of 0.60 for Miami to 5.45 for Wichita, Kansas, and the estimated elasticity for Dallas is 2.18. One factor that could help account for the differences is the addition by Saiz (2010) of physical constraints to the regulatory constraints tracked by Green, Malpezzi, and Mayo (2005).

Differences also arise from the period over which the supply elasticities are measured. The longer the period, the higher the supply elasticity. Analyzing changes in supply from 1997 to 2007, Liu (2018) finds far lower elasticities than Saiz (2010), who uses census data to compare supply over the 30-year period 1970 to 2000. Liu (2018) argues that space (square footage) better measures housing services than a count of heterogeneous units, and finds that the supply elasticity of space exceeds that of the number of units.

Saiz's (2010) contribution is not without controversy. Cox (2011) argues that, given large differences in metro size, the invariant 50km radius used by Saiz (2010) to track geographical constraints may be too crude, and that the Saiz supply elasticity measures may understate the aggregate impact of regulations due to the interaction between geographical and regulatory constraints. Davidoff (2013) challenges the view that differences in supply elasticities by metropolitan statistical area (MSA) account for differences in the severity of the 2000s housing boom and bust in the United States. However, Davidoff's (2013) analysis does not account for financial accelerator and house price expectation channels, which Anundsen and Heebøll (2016) show crucially affect the impact of demand shocks on house prices and housing supply. Gyourko and Molloy (2015) also stress that Davidoff's (2013) findings do not rule out that persistent deviations of house prices from costs can still be driven by regulation owing to the sluggish response of housing supply to changes in demand. In a later paper, Davidoff (2016) questions whether some proxy variables for metro supply elasticities are valid instruments, showing that some reflect demand, such as amenities from living near mountains and water, which raise housing demand while limiting land supply.

Ihlanfeldt and Mayock (2014) study 21 years of annual housing stock and price data for Florida counties, enabling them to estimate county-level supply elasticities using the DiPasquale and Wheaton (1994) specification for construction. They find that the Saiz measure of the percent of undevelopable land does not explain the cross-county variation in elasticities, but that alternative indicators such as the minimum lot size (an aspect of regulation), local planning expenditures, and the pre-sample average house price do. While Ihlanfeldt and Mayock (2014) find few links between the housing supply elasticities and the drop in prices during the bust, it is important to analyze the role of supply elasticities controlling for shocks to and shifts in housing demand, as implied by other sections of this literature review.[51] Also reassuring about Saiz's (2010) contribution is that his measures have been replicated by Anundsen and Heebøll (2016), who successfully use such measures to forecast house prices. In addition, using different methods, Albouy and Ehrlich (2018) find similar patterns in supply elasticities as Saiz (2010).

One shortcoming of many metro housing supply indicators is the implicit assumption of time invariance. However, the unexpectedly slow and muted recovery of US single-family construction after the Great Recession, coupled with notably higher prices, is suggestive of a decline in the elasticity of US housing supply. This could reflect that local zoning or environmental and other regulations have become more severe, implying a need for more timely and time-varying measures of regulations. Indeed, Huang and Tang (2012) find that "more restrictive residential land uses restrictions and geographic land constraints are linked to larger booms and busts in housing prices" from 2000–2009, in contrast to an insignificant role found by Glaeser, Gyourko, and Saiz (2008) in the 1989–96 period. Consistent with Huang and Tang (2012), Aastveit, Albuquerque, and Anundsen (2019) estimate lower housing supply elasticities for US metros in the recent (post-bust) 2012–17 recovery than over 1996–2006. They acknowledge that additional factors could include the loss of building capacity, including skilled labor, in the crisis. Cosman and Quintero (2018) suggest that the bankruptcy of many small builders and tighter credit constraints resulted in increased monopoly power of large firms with incentives to build more slowly to preserve their market power.

[51] Our discussion of the model by DiPasquale and Wheaton (1994) below notes defects in these respects.

Land prices.—Differences between the land and structure components of house prices are large (Davis and Heathcote 2007). Since structures are reproducible, their supply is elastic, unlike land in urban centers. As a result, house price appreciation and volatility are more driven by land than structure costs at the national (Davis and Heathcote 2007), metro (Nichols, Oliner, and Mulhall 2013), and local levels (Kurlat and Stroebel 2015 for Los Angeles and Li and Yavas 2017 for Orange County, California). Across 14 advanced economies over 1870–2012, Knoll, Schularick, and Steger (2017) find that house price trends are dominated by land prices, which account for 80 percent of the post–World War II global boom in real house prices.

Of the two approaches to tracking land prices, the more common residual method (Davis and Heathcote 2007; Davis and Palumbo 2008; and Nichols, Oliner, and Mulhall 2013) tracks land prices as the residual between total property prices and estimates of structure costs. This is practical in established areas with many transactions for housing and few for land parcels. Diewert (2013) explains a hedonic methodology, based on the residual approach, for decomposing a house price index into land and structure price indices. See Diewert, de Haan, and Hendriks (2015) for an empirical application. Using the transactions-based approach, Albouy, Ehrlich, and Shin (2018) find that land prices are less volatile and higher than implied by the residual approach, with both methods indicating that land prices have risen faster than overall house prices.[52] As US population growth has outstripped investment in transportation infrastructure, commutes have lengthened; by reducing the substitutability of land further from urban cores, this raises the attractiveness of living closer to urban cores, pushing up the land share of house prices. As Green, Malpezzi, and Mayo (2005) suggest, these patterns imply that declines in the US elasticity of housing supply were occurring before the GFC.

Deviations of land from structure costs could affect estimates of housing supply elasticities in other ways. Glaeser, Gyourko, and Saiz (2008) estimate metro supply elasticities using a Tobin's q proxy for market prices relative to replacement costs ("minimum profitable production cost"). They track replacement costs as a markup on land and structure costs. However, if land prices are poorly measured, doing so allows shifts in the relative cost of land and structures to introduce measurement error into replacement costs. Rising relative land costs, along with the lower land-intensity of rental versus detached houses, also undermines the perfect substitutability assumption of arbitrage-based price-to-rent models of house prices.

Models of residential investment and variation in national housing supply elasticities.—As Ball, Meen, and Nygaard (2010) and others have noted, housing demand is much better understood than housing supply, and there are a wide range of estimates for the price elasticity of housing supply in the literature. The different estimates reflect variations in samples and data, as well as variations in methodologies, for example, reduced form equations versus direct estimates of housing supply equations. For dynamic simulations of house prices based on the inverted-demand approach, a model of construction is needed to track the evolution of the housing stock.

DiPasquale and Wheaton (1994) model US housing starts over 1963 to 1990 using a stock adjustment framework in which starts

[52] Blending the best aspects of the two approaches, Davis et al. (2017) find that Washington neighborhoods with lower land prices in 2000 saw the biggest boom and bust in house prices. This may reflect the greater credit access the subprime boom gave to households in poorer locales, which later reversed in the subprime bust.

depend on the gap between the desired and lagged stocks. The desired stock is supply oriented, depending on house prices, construction costs, land prices, and a real interest rate. However, the speed of adjustment is low, construction costs and (farm) land prices are insignificant, and adding growth in employment and time to sell homes (demand side variables) greatly improves the fit. They report a price elasticity of new starts of 1.2 to 1.4. Using a supply side interpretation of the desired stock is problematic, as builders should not care about the existing stock of homes, apart from its influence on new home prices.

Muth (1960) argued for a demand view of the desired stock and the resulting reduced form approach is preferred by Malpezzi and Maclennan (2001). Construction, or flow demand $\left(\Delta h^d\right)$, partially adjusts in the short run to the deviation between the log of the desired stock h^*, and the log of the actual stock, h_{-1},

$$\Delta h^d = \lambda\left(h^* - h_{-1}\right), \tag{8}$$

where λ is the speed of adjustment $(0 < \lambda < 1)$. The desired housing stock (h^*) depends on real house prices (hp), income (y), all in logs, and other demand shifters (z):

$$h^* = \alpha_0 + \alpha_1 hp + \alpha_2 y + \alpha_3 z. \tag{9}$$

From the supply side, residential construction, is given by (all in logs):

$$\Delta h^s = \beta_0 + \beta_1 hp. \tag{10}$$

Assuming market clearing, a reduced-form, house price equation is a linear function of y, z, and h. Conditional on estimates of the elasticity of supply to prices (β_1) and the income and own-price elasticities of demand, the supply elasticity β_1 is inferred from the coefficient on y: $\lambda\alpha_2/(\beta_1 - \lambda\alpha_1)$. Plausibly assuming that the speed of adjustment λ is 0.3, the income elasticity of demand α_2 is 1, and the price elasticity of demand α_1 is -0.5, they estimate a postwar supply elasticity for the United States of 2.8 and 0.3 for the United Kingdom. However, for both countries, the lagged housing stock and population have counterintuitive positive and negative coefficients, respectively, in the construction equation. Moreover, the house price index used is the residential construction deflator, which understates the land component of existing house prices. Other US supply elasticity estimates range from 0.5 to 2.3 in Poterba (1984), 1.0 (short run) to 3.0 (long run) in Topel and Rosen (1988), 1.2 to 5.6 in Malpezzi and MacLennan (2001), and 0.8 and 3.7 in Blackley (1999).

Mayer and Somerville (2000a) suggest two reasons why home building may respond not to the level but to the rate of real house price appreciation (and construction costs), which may help account for variation in housing supply elasticity estimates. The first is based on urban growth theory, with land inelastically and structures elastically supplied in the long run. In this setting, a one-off increase in demand results in a one-off rise in the long-run housing stock and house prices, but not a permanent increase in new construction (analogous to investment a Tobin's q framework). Their second, more technical argument is that, according to their US evidence, residential construction is stationary while real housing prices are nonstationary, so that they argue that a co-integrated relationship cannot exist, explaining the former by the latter. However, their argument is incorrect since construction *could* depend on a $I(0)$ linear combination of $I(1)$ variables, such as with the ratio of house prices to replacement costs (Tobin's q).

Before Caldera Sánchez and Johansson (2013) was published, housing supply elasticities covered few countries; Ball, Meen, and Nygaard (2010) compare estimates for Australia, the United Kingdom, and the United States. There are several studies of the United Kingdom and United States, and fewer on the Netherlands (Vermeulen and Rouwendal 2007) and Sweden (Hort 1998), while Mayo and Sheppard (1996) estimate elasticities for Malaysia, Thailand, and South Korea. Even for this subset, there is disagreement, and estimates are somewhat dated. While the variation reflects differences in sample periods and explanatory variables, it also reflects whether housing supply is measured in terms of counts of units, completions or starts, or gross investment.

Caldera Sánchez and Johansson (2013) estimate housing supply (residential investment) elasticities for 21 OECD countries in a common specification and Cavalleri, Cournède, and Özsöğüt (2019) extend this to 25 countries with updated data, using a heterogeneous panel model with a general multifactor error structure. Long-run residential investment depends on lagged real house prices, and on construction costs, proxied by the residential investment deflator, and the coefficients are estimated using co-integrated relationships, thus rebutting the argument of Mayer and Somerville (2000a). The short-run relationship includes lagged changes in these drivers and provides estimates of the speeds of adjustment. They also check for and find some evidence for simultaneity using joint estimation of house price and residential investment equations.[53]

Neither OECD study includes the lagged housing stock in the supply equation so, unlike Malpezzi and Maclennan (2001), there is no direct role for past over- or under-building. Ball, Meen, and Nygaard (2010) allow for such an effect in a UK housing starts equation by including the lagged gap between desired and actual housing stocks, a "disequilibrium" term. The former is derived from the inverted demand equation for real house prices. While empirical evidence suggests that house prices adjust gradually to supply–demand disequilibria, it is not clear that adding such a disequilibrium term to a residential investment equation is necessarily correct. For a start, house price changes themselves signal such disequilibria, and studies rightly include lagged house price changes in investment equations. Secondly, since demand is far more volatile than supply, the surprises to which supply is adjusting may be best proxied by changes in demand variables such as income, credit conditions, and interest rates. Omitting such effects, because of their correlation with house prices, is likely to bias up estimated supply elasticities.

The literature on investment emphasizes the cost of capital as measured by a real interest rate. Ball, Meen, and Nygaard (2010) find a significant negative real interest rate effect on housing starts in three countries: the United Kingdom, the United States, and Australia. Since real interest rates are also key drivers of house prices, their omission from the residential investment equations in the two OECD studies also likely biases upwards the estimated supply responses—attributing to house prices what is really due to interest rates. However, if real interest rate effects are broadly similar across countries, this may not seriously distort country rankings of supply elasticities.

Caldera Sánchez and Johansson (2013) find that their estimated supply elasticities are negatively correlated with population

[53] The mean group estimates, which average heterogeneous country-specific coefficients, suggest an average supply elasticity of 1, with coefficients near 1 and −1, respectively, on log real house prices and log real construction costs.

density, time to obtain building permits, and the severity of land-use restrictions. Similarly, Cavalleri, Cournède, and Özsöğüt (2019) find that the more habitable land per head, the greater ease of construction (proxied by the past expansion of built-up areas), and less severe land-use restrictions boost the price elasticity of housing supply.[54] Bétin and Ziemann (2019) confirm the last finding with regional cross-country data.

Aspects of Caldera Sánchez and Johansson (2013) and Cavalleri, Cournède, and Özsöğüt (2019) suggest areas for future research. Some of the estimated speeds of adjustment of construction to long-run equilibrium levels are implausibly low, especially for the United States and Spain, which saw major building booms and busts. Low elasticities suggest omitted variable bias, and, as noted above, omitting real interest rates and short-term demand shocks are plausible culprits. Another omitted variable could be somewhat longer lags of house price growth justified by extrapolative expectations that look back more than one quarter, and time-to-build lags. But perhaps the most serious problem concerns the scarring effects of the GFC on the building industry in countries such as the United States, Ireland, Spain, and the United Kingdom, where many building firms, especially SMEs, and firms in the supply chain went out of business. With smaller capacity and a more concentrated industry structure, the structural relationship between residential investment and house prices has likely changed. It seems plausible that there are really two margins of adjustment: one is of the capital stock embedded in the industry itself, and the other is in the output of the industry given its capital stock.

[54] They also find that tighter rent regulation tends to reduce the supply elasticity.

There is also a need to assess supply elasticities in emerging markets and developing economies (EMDEs). China is of much interest, given concerns about over-building and speculation. As in Malpezzi and Maclennan (2001), Wang, Chan, and Xu (2012) estimate an average supply elasticity, pooling panel data on the 35 largest cities, but standard errors are large. City-level supply elasticity estimates from a housing starts equation vary much, with Shenzhen, Beijing, and Shanghai at the bottom. Wang and Zhang (2014) use a production function approach and find an average housing supply elasticity of just over two, given land supply.

Housing Supply Estimates Using Microdata.—A growing literature estimates housing supply elasticities using granular microdata. For example, Epple, Gordon, and Sieg (2010) use micro cross-section data for Allegheny County, Pennsylvania, and a dual approach to estimate the production function for housing. Their estimates of the (long-run) supply elasticity are quite high at above four. Combes, Duranton, and Gobillon (forthcoming) find a supply elasticity for new houses in France of around 0.8, given land. As in Wang and Zhang (2014), this does not take into account land supply constraints and depends on the substitution possibilities between land and structures, and on the supply elasticities of labor, capital, and materials. For example, where land is very expensive, more non-land inputs can be used to build height or higher quality.

Murphy (2018) estimates a dynamic, forward-looking microeconometric model of the timing and nature of housing supply in the San Francisco Bay Area. He finds that geographic and time-series variation in costs are key to understanding where and when construction occurs. Procyclical costs induce some landowners to build before cost peaks.

Results indicate that landowners actively "time" the market, which reduces the elasticity of supply, especially in "hot" markets. The price dynamics found in most aggregate housing supply studies likely reflect expectations of future house prices. Murphy's (2018) estimated development elasticities—akin to new housing supply elasticities—are also quite high at about seven for the period 1988 to 2004. Reconciling housing supply estimates from data using different spatial scales and levels of granularity are important topics for future research.

5.6 *Demography*

The links between demography, housing demand, and house prices are controversial.

The Mankiw–Weil debate.—Mankiw and Weil's (1989) claim that real US house prices would fall 47 percent between 1987 and 2007 from the fading of the baby boom generation was rightly criticized. They relied on national cross-section correlations between the value of houses in which individuals live and their age to deduce aggregate time variation in housing demand from a changing age structure. They find that house values fall after age 40, and children do not affect the cross-section values of housing, perhaps as the poor tend to have more children. However, their findings are not robust. Cross-section variation in values also reflects variation in land prices, and that high-income families often sort into costlier places. Green and Hendershott (1996) note that the study confounds differences by age with differences between cohorts, and conclude that the fall in housing demand for those over 40 is illusory: later cohorts have higher education and income that will likely sustain housing demand. Moreover, Mankiw and Weil omit other demand drivers such as income and the user cost of housing, specify a crude supply side, and suffer parameter instability (Engelhardt and Poterba 1991 and Hendershott 1991). The pre-2007 boom in credit supply was another reason why Mankiw–Weil's prediction of falling prices before 2007 was wrong.

Eichholtz and Lindenthal (2014) use UK cross-section data on housing and household characteristics and panel data on income dynamics to separate the cohort effect from the cross-section relationship between demand for housing and age. Housing demand generally rises with age until retirement, then declines only slightly. Household income and size strongly affect most housing quality indicators, though there is much heterogeneity in the response of different hedonic factors to household characteristics. A US study by Green and Lee (2016) comes to similar conclusions, arguing also that the aging of the baby boom generation, by itself, is unlikely to lead to a future housing crisis.

Home building and demography.—Strong demographic effects on demand are found by Holland (1991) for the United States, Lindh and Malmberg (2008) for Sweden and OECD countries, and Monnet and Wolf (2016) for 20 OECD countries for 1980 to 2015. Monnet and Wolf argue that the ratio of residential investment to GDP is strongly affected by the growth rate of the population aged 20 to 49, which outperforms other demographic indicators. They include fixed effects and controls for the real long-term interest rate, the *current* growth of real disposable income, real house prices, real credit growth, and the change in the unemployment rate. The demographic effect is robust (private communication) to including lags, relevant as housing completions lag income and other demand indicators. One issue for further research is the changing relationship between the number of units built and residential investment, as both household and unit size have fallen in most OECD countries.

House prices and demography.—Some inverted-demand house price models incorporate demographics by specifying a per capita or per household real income measure and using the ratio of households to housing units. Since the number of households is potentially endogenous, Buckley and Ermisch (1982) suggest instrumenting the number of households by the headship rate for each age group in some base year, as do Muellbauer and Murphy (1997) and Meen (1998). However, the numbers of housing units are aggregates and do not account for size. This is why, absent space measures of the housing stock, it may be better to use the constant price residential capital stock per head from the national accounts together with the age composition of the population.

For time series models of house prices, while comprehensive controls are needed to robustly estimate demographic effects, the risk of spurious regression remains since age shares are often persistent with few turning points, except over long samples. Many studies omit demographic variables other than total population altogether. Since many common factors drive the demands for mortgages and housing, and there is substantial life-cycle variation in mortgage debt levels, joint estimation of demographic effects in house price and a mortgage debt equation should help to reduce the risk of obtaining spurious results. Even then, Chauvin and Muellbauer (2018), in their study of France, prefer to calibrate at the lower end of confidence intervals around freely estimated demographic effects, which tend to be implausibly large. As in Eichholtz and Lindenthal (2014), the ratio of children to adults and the proportion of adults 40 to 64 years of age affect real house prices and mortgages in the long run, the latter suggesting a saving motive in the demand for housing. The change in the proportion of adults aged 25–39 helps explain mortgage debt growth. Nevertheless, demographic effects are likely to vary by country, reflecting different institutions, housing finance systems, and apparent preferences for owning versus renting.

Migration, house prices, and residential mobility.—An important aspect of demography is migration, whose connection with house prices is complex and bidirectional. Most studies find that immigration raises house prices, according with the notion that given the housing stock, higher population increases demand and thus house prices. For example, Saiz (2007) finds that net immigration equal to 1 percent of a US city's population is associated with an average price increase of 2.9 percent to 3.4 percent. Similar-sized effects are found by Degen and Fischer (2017) for Switzerland and Gonzalez and Ortega (2013) for Spain. On the other hand, Sá (2015) argues that immigration of low earners lowers *local* UK house prices because natives and high earners relocate elsewhere, generating a negative income effect on local house prices.

Housing is strongly linked to residential mobility. Andrews, Caldera Sánchez, and Johansson's (2011) study of household surveys from 25 OECD countries finds that, controlling for household and country-specific characteristics, mobility is higher in countries with lower transaction costs, more elastic housing supply, lower rent controls, and lower tenant protection. Moreover, mobility is typically higher for people in the private rental sector than for owner-occupiers, or those in public rentals with below-market rents. Owner-occupiers with a mortgage are more mobile than those without, and mobility tends to be higher in areas with greater access to credit. Updating and extending this study with household survey data for 2007–12, Causa and Pichelmann (2020) confirm these findings, and control for other factors such as job protection policies, social expenditure on housing, business dynamism, and trade exposure. They spell out the implications of their findings for different socioeconomic groups such as renters versus owner-occupiers, and workers in different income and educational brackets. At the national level, van Ommeren and van Leuvensteijn (2005) and Hilber and Lyytikäinen (2017) find strong effects of transfer costs on residential mobility in the Netherlands and the United Kingdom, respectively, while Fritzsche and Vandrei (2019) find that the German transfer tax notably reduced home sales.

Some studies assess whether negative housing equity deterred homeowners from moving to areas with better job prospects in the Great Recession. Research often finds little or no effect, which does not contradict Engelhardt's (2003) earlier finding from National Longitudinal Survey data that house price declines deter moves not because homeowners have negative equity, but because of aversion to selling at a nominal loss, confirming Genesove and Mayer (2001). Valletta (2013) found no difference in the duration of unemployment between renters and owners in the Great Recession, while Farber (2012) found that those who lost jobs were just as apt to move if they owned rather rented. Others, using representative samples but with more housing details, find little or no effect of homeowner distress on mobility. Molloy and Shan (2013) find that foreclosure did not affect the probability of making a long-distance move, in line with Molloy, Smith, and Wozniack's (2011) finding that the downtrend in US internal migration is widespread across different age and other demographic groups.

Other studies use detailed data on negative net equity. Using American Housing Survey data, Ferreira, Gyourko, and Tracy (2010) claim that homeowners with negative equity are one-third less likely to move. However, Schulhofer-Wohl (2012) finds no effect when his sample includes owners who rent or leave their home vacant, a group omitted from Ferreira, Gyourko, and Tracy's (2010) sample. Schulhofer-Wohl (2012) notes that the zero net migration effect could reflect the offsetting impact of foreclosures forcing people to move versus lock-in effects for others with negative net equity. Using tax data, Modestino and Dennett (2013) find that out-migration rates are lower from states with higher shares of homeowners having negative net equity, but that the effects on national migration and unemployment rates are small, as Kothari, Saporta-Eksten, and Yu (2013) also conclude. Using Survey of Consumer Finances data and controlling for household characteristics and income shocks, Bricker and Bucks (2016) find that negative net equity is associated with higher migration, but not when foreclosed households are omitted, implying that foreclosures linked to negative net equity force people to move. Coulson and Grieco (2013) also find that negative equity increases the propensity to move, especially in high foreclosure states, using 1999–2009 PSID data. However, for prime working-age-headed families, Foote (2016) shows that negative equity had no effect.

Econometric studies find that better earnings and job opportunities induce migration, while high relative house prices deter it. Examples include Gabriel, Shack-Marquez, and Wascher (1992) for the nine US census regions; Potepan (1994) for 52 US metros; Jeanty, Partridge, and Irwin (2010) for local Michigan census tracts; and Plantinga et al. (2013) at the household level. Early UK research that ignored housing, e.g., Pissarides and McMaster (1990), found only small effects of earnings and unemployment differentials on regional migration. Cameron and Muellbauer (1998) and Cameron, Muellbauer, and Murphy (2006b) modeled net migration for a panel of UK regions from 1978 to 1995 and 1975 to 2003, respectively, and found highly significant effects of differentials in housing cost, expectations of capital appreciation, and downside house price risk. With these additions, effects from relative unemployment rates and real earnings become large and highly significant. Following Jackman and Savouri (1992) they examine commuting between adjoining regions, showing that it relieves some of the pressure of housing on regional labor markets. For adjoining regions, house prices have opposite-signed effects on commuting than for migration, reflecting a trade-off between commuting and migrating. For example, workers commute, rather than migrate to an adjoining expensive region, to pursue high relative earnings while limiting shelter costs. Such links between regions and the impact of expectations help explain regional spillover effects discussed in section 6.

5.7 *Key Literature Findings on Measurement Issues, Supply Constraints, and Demography*

While house price indices can be improved, more research is needed to measure rents, land prices, and the elasticity of housing supply. Better data on newly determined rents and gauges of rent controls are needed to estimate house price-to-rent models, while data limitations have hampered the creation of good time series measures of residential land prices. Considerable progress has been made in measuring housing supply elasticities, but further work is required to track changes in supply elasticities over time. Unfortunately, many time series models of house price dynamics ignore the important role of housing supply. Finding robust estimates of effects of demography on house prices has proved to be a minefield, but given rapidly aging populations in industrial countries, is ever more important. Research needs to take into account both the current consumption and asset-accumulating roles of housing.

6. *Reviewing the Empirical Evidence on House Price Cycles*

Empirical studies of national house prices are reviewed before discussing studies of regional and metro house prices, and then the role of bubbles and fundamentals as drivers of house prices.

6.1 *Real House Prices in Advanced Economies: Income-Based and Inverted-Demand Models*

Many recently published models of national house prices estimate real house prices as a function of real income and other factors. Of these models, some estimate versions of an inverted-demand framework conditional on the lagged stock of housing, see section 4.1. Others—particularly country panel studies—cannot identify long-run relationships. A tabular summary of 12 studies appears in table 1 in the online appendix. Igan and Loungani (2012) use a common model to estimate real house price changes in 22 advanced economies with quarterly data as early as 1970 and ending in 2010. However, data limitations (which they acknowledge) prevent them from controlling for the housing stock (they use changes in construction costs), credit standards (they use real private bank credit growth), and tax-adjusted user costs (they use short- and long-term government interest rates). Although they include the lagged ratio of house prices to income to proxy for price deviations from their equilibrium level (an error-correction proxy), this proxy is insignificant for many countries (including the United States) and when significant, implies implausibly slow speeds of adjustment. This likely reflects bias due to the omitted controls above, and indeed Igan and Loungani (2012) note that some omitted factors, particularly differences in mortgage finance and borrower recourse, may mask house price vulnerabilities.[55]

Meen (2001) reviews cross-section and time series studies using the inverted-demand approach in different countries.[56] As noted in section 4.1, time series estimates of the income elasticity of demand for housing tend to be around 1, while cross-section estimates are usually less than 1, probably because measured current income is not the best income measure. Time series estimates of the price elasticity of demand tend to cluster around −0.5, while cross-section estimates are often a little higher in absolute value. His estimates for the United Kingdom (Meen 2002) are consistent with this broad pattern, though for the United States he finds implausibly low values of both elasticities.

Caldera Sánchez and Johansson (2013) estimate quarterly house price equations for 20 OECD countries using the inverted-demand approach, including real income, the housing stock in units, a real interest rate, and the population share of those aged 25 and older. They use the two-step Engle–Granger (1987) method to estimate long-run coefficients and short-run dynamics. While most long-run income elasticities of house prices exceed one, the estimated responses to the stock of housing (measuring the inverse of the price elasticity of demand) are erratic, interest rate effects are mostly insignificant, and speeds of adjustment are implausibly low. This reflects problems, including omitting shifts in mortgage credit availability, the use of a non-mortgage interest rate, omitting lagged house price growth (reflecting extrapolative expectations), and using a count of dwellings instead of the preferable net residential capital, see section 5.3.[57]

Housing income elasticities of demand of 1 are not rejected in studies of France (Chauvin and Muellbauer 2018), Germany (Geiger, Muellbauer, and Rupprecht 2016), and Canada (Muellbauer, St-Amant, and Williams 2015), with careful controls for mortgage credit conditions, extracted from equation systems including mortgage debt and consumption. Their estimated elasticities of house prices with respect to income are 2, 1.3, and 1.8 respectively, implying respective price elasticities of housing demand of −0.5, −0.77, and −0.56. The higher elasticity for Germany may reflect a more diverse economy with greater spatial choice. In each country, nominal mortgage rates are significant and user costs based on extrapolative house price expectations matter in France and Canada, with age composition more relevant in France and Germany than in Canada. While national models are useful for examining macro trends, the impact of spatial aggregation bias is unresolved since greater spatial mismatch should raise aggregate house prices. Hence, if housing is disproportionately built in lower demand areas, the aggregate housing stock will less accurately track supply most relevant to house prices.

6.2 *Price-to-Rent Models of House Prices in Advanced Economies (AEs)*

With perfect arbitrage and no credit constraints, the house price-to-rent ratio and a

[55] Lacking good error-correction properties, such models seem unreliable for detecting deviations of house prices from equilibrium; indeed, their heat map (p. 33) seems to understate the downside risk for the United States.

[56] Meen controls for the removal of mortgage rationing, real wealth, and a structural break in the United Kingdom using an indicator for increased income inequality since the 1980s. The US equation omits controls for structural shifts.

[57] Cavalleri, Cournède, and Özsöğüt (2019) estimate a similar house price specification for OECD countries for 1995 to 2015, with better measures of the mortgage interest rate. Their pooled mean group estimates of average responses incorporate interactions between the elasticity of house prices with respect to per capita income and cross-country variation in the supply elasticity (lower income elasticity) and tax relief for mortgage interest (higher income elasticity).

standard measure of real user costs should be cointegrated, with a long-run coefficient of minus unity on the user cost term. In practice, however, the unity restriction is rejected and a strong form of the model does not hold in countries where credit standards have notably shifted. For example, Gallin (2008) could not identify a significant and stable co-integrating relationship between real user costs and the price-to-rent ratio using US national data. The problems with this highly restricted framework arise from the assumptions of perfect credit markets, rational expectations of house price appreciation, the absence of transactions costs, the equivalence of rental and owner-occupied housing, and the comparability of owners and renters, see section 4.2 above. Indeed, relaxing the first two assumptions, Duca, Muellbauer, and Murphy (2011, 2016) combine information on time-varying credit constraints (proxied by LTVs for first-time buyers) with extrapolative house price expectations and find that both are needed to estimate models of the US price-to-rent ratio having sensible long-run (co-integration and short-run (error-correction) properties. Similarly, Lyons (2018) finds that time variation in LTVs is needed to sensibly model the house price-to-rent ratio in Ireland.

6.3 *The Role of International Spillovers in Advanced and Emerging Market Economies*

The experience of the GFC and sharp house price swings in many countries inspired new research into the role of international spillovers in driving house prices as well as broader effects. Indeed, the pre-GFC real estate boom in Ireland was intertwined with an unsustainable expansion in mortgage lending that was fuelled by inflows of, mainly short-term, international funding (Baudino, Murphy and Svoronos, 2020). This departure from Ireland's traditional reliance of mortgage funding on domestic retail deposits (see Table 1) illustrates how shifts in finance pose challenges to macroeconomic and financial stability. In their cross-country study, Cerutti, Dagher, and Dell'Ariccia (2017) find that real exchange rate appreciations—and to a lesser extent current account deteriorations—are linked to credit booms that are positively linked to house price booms. In a VAR panel study allowing for property prices to have different sensitivities to capital inflows, Tillmann (2013) finds that such flows account for a notable share (10 to 25 percent) of the variance in real house prices in six emerging Asian economies, roughly twice the estimate Sá, Towbin, and Wieladek (2014) found for a panel of advanced economies.

As in Tillmann (2013), Cesa-Bianchi, Cespedes, and Rebucci (2015) find—using more countries and a more exogenous measure of global liquidity than capital flows—that global liquidity shocks affect house prices more in emerging than in advanced economies.[58] In their richer theoretical model, international financial intermediation is conducted via collateralized borrowing, allowing for differences in exchange rate regimes and other country characteristics. In their panel vector autoregression (PVAR), a positive international credit supply shock triggers rises in house prices, consumption, and the real exchange rate, and a decline in the current account. These impacts are greater in countries where higher mortgage leverage is allowed and domestic debt is foreign currency denominated.

One limitation of these studies is that they do not control for cross-country differences in the sensitivity of housing supply. Through

[58] The effects of such shocks operate in advanced economies more through domestic borrowing by affecting housing collateral, and in emerging economies more via exchange rates and altering the international borrowing capacity of a country.

conventional interest rate channels, shifts in monetary policy, by affecting user costs and house price expectations, plausibly induce long-term uptrends in house prices particularly in countries with inelastic supply. Given supply heterogeneity, time fixed effects common to all countries will not avoid such omitted variable bias. Another important limitation of some cross-country studies is that they may not adequately account for exchange rate regimes. For example, Ferrero (2015) stresses that exchange rate policies were critical to the international transmission of shocks to several Asian countries which, via dollar pegs, imported boosts to their house prices from low real US interest rates.

Another shortcoming is that existing studies do not allow for likely time variation in LTV limits in many countries. For example, in the United States, before the housing boom of the 2000s when the LTVs of first-time borrowers rose as noted in section 4.5, sharp house price booms and busts were limited to a few metros, such as Boston and Los Angeles, with inelastic housing supply (Glaeser, Gyourko, and Saiz 2008 and Green, Malpezzi, and Mayo 2005). Before the 2000s, real interest rates, income, and expected house price appreciation accounted for the bulk of swings in house prices. Controlling for several factors, including time-varying credit effects proxied by central bank surveys of bank credit standards, Favilukis, et al. (2013) find that international capital flows, real interest rates, and aggregate activity played a minor role in the recent US housing boom and bust. Instead they find that it was largely driven by domestic credit supply effects. Despite reaching a similar conclusion regarding US credit conditions, Ferrero (2015) finds that international shocks have larger effects on other countries, particularly EMDEs. If time-varying measures of credit conditions and better controls for interest rate factors were available for more countries—particularly for EMDEs—cross-country studies could better identify the impact of international shocks and the effectiveness of macroprudential tools.

6.4 *Other Studies of House Prices in Emerging Market and Developing Economies (EMDEs)*

Analysis of house prices in EMDEs has been hampered by the lack of critical data.[59] Using an indicator of land supply along with real GDP (to proxy for income), real mortgage interest rates, and the trend ratio of real mortgage credit-to-GDP as a proxy for nonprice mortgage credit constraints, Glindro et al. (2011) estimate a pseudo-inverted-demand model for nine Asia-Pacific countries, seven of which are EMDEs. In their 1993–2006 sample, they find evidence of overvaluation in 2006 for only two of the nine countries. In general, their demand variables are significant with the expected signs, though the effect of real GDP is small and barely significant. The land supply proxy, an index of building permits, has a significant, counterintuitive positive long-run effect, suggestive of a seriously misspecified long-run solution. Building permits measure the construction *flow* rather than the *stock* of housing, which would be relevant in an inverted-demand framework.[60] Construction is very endogenous and expected to be *positively* correlated with high or rising house prices, with causation from the latter to the former. The use of overall inflation rather than past house price appreciation in defining real mortgage interest rates is also problematic.

Motivated by a DSGE framework, Bian and Gete (2015) use a structural VAR approach to estimate the impact of several housing supply and demand factors on real national Chinese

[59] For data on housing markets in China, see Chivakul et al. (2015).

[60] Other empirical models also have similar problems, such as the Chinese house price study of Zhang, Hua, and Zhao (2012), whose land supply proxy is the price of land, which they use as an explanatory variable.

house prices. They find that the relative contributions are sensitive to the price index used, and that official price indexes tend to report less house price appreciation than private ones. In general, they find that total factor productivity growth, tax policies, and savings glut effects (a high savings rate, with housing being a major investment vehicle) are the three most important factors driving house price growth, with credit shocks (a rise in the role of shadow banks with easier credit standards than banks) playing more of a role in recent years. However, the lack of a user cost channel in their model significantly hampers comparisons with other studies.

That said, assessing the downside risks to Chinese and other highly valued EMDE house prices using standard advanced economy frameworks is challenging for several reasons. First, EMDE households often face constrained portfolio choices, especially from capital controls. For example, Chen and Wen (2017) argue that there may be a rational bubble in Chinese housing because low returns elsewhere created a high demand for housing as a store of value. Second, some studies suggest that high valuations in some EMDEs may not be unreasonable given the high catch-up rates of productivity growth in many EMDEs (e.g., see Glaeser et al. 2017). Over the next few years, researchers will be able to assess the plausibility of these arguments.

Third, if spatial mismatch of supply and demand accounts for a significant share of the estimated 55 million vacant homes in China in 2015, the explanatory power of this potential measure of aggregate over-supply is likely limited. Finally, and perhaps the biggest challenge to gauging house price valuations in EMDEs, are data limitations such as uncertainty over the accuracy of price and housing stock measures and short sample periods marked by considerable heterogeneity in house prices across different metro areas (see Wu, Gyourko, and Deng 2012, 2016).

6.5 *Regional and Metro House Price Models*

Regional and metro house price dynamics can be evaluated using a dynamic version of the simple log-linear two-area model that formalizes the discussion in section 4. Consider a two-region economy ($j = 1,2$) generalizable to several regions. As commuting and migration affect location decisions, housing demand in region j depends on house prices at j and the relative price at alternative location r. Let h be the log housing stock per head, y be log real income per head, p be the log real house price index, and z be a demand shifter capturing other influences. Then the log-linear demand at location j is:

$$(11)\quad h_{jt} = -\alpha_j p_{jt} - \alpha_{jr}\left(p_{jt} - p_{rt}\right) + \beta_j y_{jt} + \beta_{jr} y_{rt} + z_{jt} + \mu_r z_{rt}.$$

Reversing subscripts r and j gives the corresponding housing demand function in region r. Solving the two equations for p_{jt} and p_{rt} as a function of regional incomes, housing stocks, and demand shifters yields the inverse demand functions.[61] These answer the question: given housing stocks, incomes, and other regional factors, what house prices equilibrate supply and demand? Partial adjustment dynamics around long-run solutions yield estimable equations. Demand shifters in z_{jt} should include credit conditions, interest rates, user cost, and demography, not confined to region j: for example, relative expected appreciation based on lagged house prices affects migration (see Cameron and Muellbauer 1998; Cameron, Muellbauer, and Murphy 2006b) and regional UK house price dynamics (Cameron, Muellbauer, and Murphy 2006a).

[61] See Deaton and Muellbauer (1980, pp. 56–57) and Theil (1976) on systems of inverse demand functions and, for an empirical application, Barten and Bettendorf (1989).

An alternative formulation allows a lagged, rather than instantaneous, response to relative house prices:

$$(12) \quad h_{jt} = -\alpha_j p_{jt} - \alpha_{jr}\left(p_{jt-1} - p_{rt-1}\right) + \beta_j y_{jt} + \beta_{jr} y_{rt} + z_{jt} + \mu_r z_{rt}.$$

The spillover coefficients α_{jr}, μ_r, and β_{jr} are likely stronger for contiguous and economically connected locales, and migration flows could be used to parameterize these coefficients.

Such formulations give content to the spatial correlations often reflected in equation residuals. Many studies use rather complex estimation procedures to "correct" models developed for single locations—"islands"—for spatial correlations that reflect omitted variables arising from spillover effects.[62] "Island" studies of US metros include Hwang and Quigley (2006) and Follain and Velz (1995), as well as Abraham and Hendershott (1996); Malpezzi (1996); Capozza, Hendershott, and Mack (2004); and Green, Malpezzi, and Mayo (2005) who use "island" based equilibrium correction models. Glaeser, Gyourko, and Saiz (2008) provide an influential explanation of nonrational house price bubbles or overvaluation. They argue that overvaluation episodes are most likely in areas with low supply elasticities, the same areas that experienced the largest downward house price corrections after the mid-2000s boom.

Later studies using new measures of regulatory and other supply restrictions accord with Glaeser Gyourko, and Saiz (2008). A tabular summary of 7 studies, and one each for the United Kingdom and China, can be found in table 2 of the online appendix. Oikarinen et al. (2018) use advanced panel econometrics, allowing for spatial heterogeneity and cross-sectional dependence in nonstationary but cointegrated data, to test for spatial differences. They analyze the relationship between the price elasticity of housing supply and the income elasticity of prices, as well as the size and duration of house price booms. They estimate inverse demand, error-correction equations allowing for momentum from lagged appreciation. They assume that local prices depend only on local income, local construction costs, and the national mortgage interest rate. They estimate heterogeneous parameter models using quarterly data on the 70 largest US MSAs over 1980–2015. They conclude that the long-term income elasticity of house prices generally is greater in the more supply-inelastic metros, and show that bubble size and duration are inversely related to the supply elasticity, consistent with Glaeser, Gyourko, and Saiz (2008). In addition, short-term momentum and reversion dynamics show substantial spatial heterogeneity. They argue that conventional panel estimators that ignore cross-sectional dependence can yield overestimates of the house price momentum effect, implausibly slow adjustment to long-run equilibrium levels, and incorrect parameter signs. Nevertheless, they report an average income elasticity of house prices of only 0.81 and an average quarterly speed of adjustment below 0.05. The former could result from conditioning on construction costs and not the stock of housing, and also from omitting incomes at other economically interconnected areas. The latter shortcoming likely arises from omitting important explanatory variables, most obviously credit conditions.

Anundsen and Heebøll (2016) address these specification issues, with data on 247 US

[62] Serial correlation can be statistically fixed, but including omitted variables that induce it improves our understanding. Meen (2016) notes, "Spatial econometric techniques are good at capturing the nature of spatial interactions, typically through spatial weights matrices but, perhaps, have made less progress in explaining the causes of the interactions."

MSAs, albeit over the short period 2000–2010. They estimate a three-equation model for the 2000–2006 boom, adding equations for the housing stock and cumulative subprime loan volumes, to capture shifting credit conditions. Heterogeneity in supply elasticities is tracked using the Wharton Regulatory Land Use Index of Gyourko, Saiz, and Summers (2008)—which measures MSA regulatory supply restrictions inclusive of obstacles to obtaining building permits—and a measure of topographical supply restrictions—the UNAVAL index of Saiz (2010).

Lagged price appreciation, a proxy for extrapolative expectations, has consequences for the house price and credit equations, and hence for the financial accelerator because households and lenders increase credit volumes in strongly appreciating areas. Evidence suggests that tighter supply restrictions lead to a larger house price booms and busts (e.g., Glaeser, Gyourko, and Saiz 2008). In Anundsen and Heebøll (2016), this owes to supply-restricted areas being much more exposed to a financial accelerator effect and a stronger price response: since house prices and credit are mutually reinforcing, tighter supply restrictions lead to a stronger financial accelerator that amplifies increases in prices and quantities. Their equations are estimated in differences and, as with most metro studies, do not incorporate regional spillovers. Spatial heterogeneity enters only through the crucial impact of variations in regulation. In a related paper on asymmetric house price responses to monetary policy shocks, Aastveit and Anundsen (2017) confirm the larger response in supply restricted metros. In inelastic markets, the absolute effect of expansionary shocks exceeds that of contractionary shocks. The opposite occurs in elastic MSAs. They argue that the differences in asymmetry across MSAs reflects a momentum effect that is more important when house prices are rising, especially in inelastic markets as suggested by Anundsen and Heebøll (2016).

Spatial coefficient heterogeneity has been used to model regional house price dynamics to examine the "ripple" effect, where a leading location has house price changes before others. UK studies, where London's leading role has been long evident, include Meen (1999); Cameron, Muellbauer, and Murphy (2006a); Cook (2003, 2012); and Cook and Watson (2015). US studies include Gupta and Miller (2012a, b); Holmes, Otero, and Panagiotidis (2011); Barros, Gil-Alana, and Payne (2012); and Chiang and Tsai (2016). Holly, Pesaran, and Yamagata (2010) find significant spillover effects for US states from house price changes in adjacent states. Studies elsewhere include Berg (2002) for Sweden; Tsai and Chiang (2019) for China; Stevenson (2004) for Ireland; Liu (2019) and Luo, Liu, and Picken (2007) for Australia; Shi, Young, and Hargreaves (2009) for New Zealand; Chen, Chien, and Lee (2011) and Lean and Smyth (2013) for Malaysia; and Teye et al. (2017) for the Netherlands.

DeFusco et al. (2018) use a large proprietary dataset on transactions in 99 US metros to examine local contagion effects in house price dynamics. They find effects only from adjoining areas, but large enough to account for up to 30 percent of the appreciation in some localities. However, they find little evidence for local contagion in the bust. One interpretation is that the bust was overwhelmed by the common shock of the credit crunch, as opposed to the more heterogeneous and gradual way the credit boom developed.

Cameron, Muellbauer, and Murphy (2006a) expand the framework in equation (11) to incorporate spillovers between London and other regions, controlling for mortgage credit conditions and expectations of appreciation using annual data from 1972 to 2003. Muellbauer (2019) applies the framework to model house prices in Paris and France, finding a larger price response in Paris than in France to interest rates, credit conditions, and a measure of risk. For the United Kingdom, regional heterogeneity includes a stock market price response of London, given its role as financial center (and to a lesser extent the nearby South East area), but not of other regions. But the effect is asymmetric, probably since negative stock returns improve relative housing returns. Downside housing risk induces another asymmetric response as prospective home buyers appear to have a memory of up to four years for negative returns in housing. This delayed the house price recovery from the early 1990s crisis. London also responds more strongly to income and interest rate shocks than other regions.

Nearby locales are directly impacted by London's spillover effect; those further away are affected by spillovers from nearby regions, and hence indirectly by London. This gives rise to a ripple effect: national shocks from interest rates, stock prices, and income and population growth drive London, and later affect other regions, together with their direct regional impacts.[63] Results suggest that home building broadly kept pace with demand before 1997, but later lagged it, especially in Greater London, driving up real house prices. Given supply constraints, house prices in 2005 were not notably overvalued. However, a more explicit treatment of global financial investment is needed to account for London prices, which benefit from a safe-haven demand linked to foreign political and economic crises (see Badarinza and Ramadorai 2018).

More generally, in contrast to most other regional house price models where the spatial dynamics are kept in the structure of the residuals, Global VAR models, introduced by Pesaran, Schuermann, and Weiner (2004), explicitly include, for each region, a weighted average of prices and incomes in other related regions. These weights can be static or dynamic, and they can be estimated or chosen using different proxies. Two applications are Vansteenkiste (2007) for US regions, and Vansteenkiste and Hiebert (2011) on eurozone countries. Another is Heebøll (2014), who finds ripple effects from Copenhagen to nearby locales much like those from London discussed above, and important effects of financial deregulation.

For a deeper understanding of long-term developments, inverted-demand frameworks that condition on housing stocks should be supplemented by models of housing supply and forecasts of income, interest rates, and credit conditions. The importance of the last factor is supported by Dell'Ariccia et al.'s (2012) findings that house price appreciation was significantly faster in US metros where mortgage denial rates were lower, and that subprime lenders had lower denial rates and approved loans with much higher DTI ratios than prime lenders. The evolution of metro income is critical for the superstar city phenomenon highlighted by Gyourko, Mayer, and Sinai (2013), in which city-level income and its within-city distribution are endogenous. As population, average income, and income inequality rise, absolute and relative house prices in superstar cities—desirable areas with limited housing supply—are bid up. Lower-income families are gradually pushed out, inducing faster per capita income growth in superstar cities like London, New York, Sydney, and Vancouver, in addition to other plausible factors such as economies of agglomeration.

6.6 *Bubbles and Fundamentals: Assessing Overvaluation and Triggers for Boom and Bust*

Three major causes of overvaluation of house prices—large macro shocks, shifts in fragile fundamentals, and endogenous

[63] Meen (2002) finds no evidence of a substantial "ripple effect" across US census regions using pre-2000 data.

dynamics–-were discussed in section 2. We now briefly review studies of early warning indicators of financial crises and recessions before turning to measures of house price overvaluation. Such indicators play a crucial role in developing macroprudential policies—see section 7—to reduce the risk of financial crises.

Early warning indicators for financial crises and recessions.—A plethora of multi-country econometric studies forecast the probabilities of financial crises and recessions. Borio and Lowe (2002) find that the credit-to-GDP gap and asset price gaps predict banking crises.[64] Later research (e.g., Drehmann and Juselius 2012, 2014) examines the predictive usefulness of the deviation of debt–service ratios from long-run averages, sometimes in combination with other indicators. Edge and Meisenzahl (2011) find that such credit-to-GDP gaps are not useful in real time owing to data revisions.

Research at the IMF, particularly "second generation" post-GFC studies of early warning indicators, is reviewed by Chamon and Crowe (2013). In an update, Basu, Chamon, and Crowe (2017) summarize a suite of early-warning models to assess the distinct probabilities of growth, fiscal, and financial crises in advanced and emerging market economies. These models use a rich set of indicators and an interaction effect between house price growth and the household debt-to-GDP ratio. Models for the probability of a financial crisis estimated on advanced economy panel data up to 2007 do not perform well in the GFC, probably because of the central role of spillover effects from the US financial system in the GFC. In contrast, models for emerging market and developing economies hold up much better.

[64] They noted that a lack of systematic historical data on house prices limited the crises their study was able to cover.

Jordà, Schularick, and Taylor (2016) examine longer historical data, finding for 17 countries since 1870, that high levels of growth of private debt are linked to subsequent financial crises. After, but not prior to World War II, strong growth of residential mortgage debt helps forecast financial instability. Moreover, busts that have followed mortgage booms have much slower GDP growth, irrespective of whether a financial crisis occurred or not. For the same data, Richter, Schularick, and Wachtel (2021) show that rapid credit growth alone does not always signal financial crises, but the combination with unusually high house prices (often arising from financial liberalization) improves forecasts. Also, Aldasaro, Borio, and Drehmann (2018) find that household debt–service ratios (or other credit indicators including household or aggregate credit-to-GDP gaps and cross-border credit flows), combined with property price gaps, improve predictions of bank crises.

However, as noted in section 2, there is considerable heterogeneity across countries and over time in macroeconomic vulnerability to exogenous shocks, and in the nature of short- and long-term transmission that can amplify shocks and generate overshooting dynamics. Mian, Sufi, and Verner (2017) show that for a panel of 30 countries, rising household debt-to-GDP ratios—but not business debt-to-GDP ratios—predict slower GDP growth and higher unemployment in the medium run, though not in the very short run. The relationship is stronger for countries with less flexible exchange rates. The IMF's October 2017 "Global Financial Stability Report" provides more evidence on the latter, stressing the key role of mortgage debt and nonlinear effects, finding larger effects at high debt ratios and for countries with open capital accounts, fixed exchange rates, less transparent credit registries, and weaker financial supervision. The IMF also found that easy monetary policy during a credit boom likely exacerbated the subsequent downturn when booms turn into busts.

A complementary approach using quantile regression analysis focuses on "growth at risk" (Adrian et al. 2018; Adrian, Boyarchenko, and Giannone 2019; and IMF 2019a), which has the advantage of avoiding the need to define a financial crisis, instead examining risks of a large fall in GDP. Financial conditions indices (FCI)[65] are developed for each of 22 sampled countries, and these and their interaction with a credit-to-GDP gap predict the probability of large declines in growth over horizons up to three years. Results show that loose financial conditions promote growth and lower the risk of large falls in GDP over short horizons, but over longer ones (five or more quarters) they signal a greater risk of large declines, especially when combined with a credit boom. Work continues on improving indicators for macroprudential policy, including developing real estate and mortgage indicators and early warning indicators to fill gaps.[66]

Indicators of house price overvaluation and busts.—Much multi-country econometric modeling examines the incidence of overvalued house prices and forecasts the probability of house price busts. In 2008, the IMF attempted to estimate "house price gaps"—the degree of overvaluation—for each country based on econometric models of real house prices (IMF 2008, see box 3.1). With the exception of Ireland, subsequent house price developments in most countries did not correspond well to the estimated gaps. The omission of the supply side was a critical problem, making no distinction, for example, between Ireland, Spain, and the United States, where housing supply expanded greatly, and the United Kingdom where it had not. The imposition of a long-run income elasticity of 1 for house prices without justification was another serious problem. Shifts in credit conditions and in the age structure of the working-age population played no role, the former being a particularly crucial omission. Furthermore, no distinction was drawn between temporary overshooting given fundamentals and the fragility of the fundamentals themselves. Finally, no account was taken of feedback loops between housing and the wider economy.

Cerutti, Dagher, and Dell'Ariccia (2017) address some of these shortcomings. They analyze an (unbalanced) panel dataset of 50 countries for 1970–2012 and find that house price booms are more likely in countries with higher LTV ratios and mortgage funding based on wholesale sources or securitization. This is consistent with section 2's discussion of leverage. They note that most house price booms end with a recession, and that such downturns tend be deeper and longer when preceded by booms in both residential mortgages and other private debt, and with reliance on non-retail deposit funding that can cause duration mismatch on lenders' balance sheets.

Philiponnet and Turrini (2017) study European house price gaps using Bayesian model averaging to pool information from an econometric model and from house price-to-income and price-to-rent ratios. They specify long-run real house prices as a function of population, real per capita income, the level of residential investment (with a positive coefficient) and a real long-term interest rate. Except for freely estimating the income effect, their model has defects similar to those of the 2008 IMF

[65] The FCIs are derived in a dynamic factor model for GDP growth and CPI inflation, where the FCI in each country is a latent variable constructed from up to 17 market indicators.

[66] See Financial Stability Board (2017). The IMF's (2019a) international database of financial soundness indicators became available in 2008, in time for the GFC. Coverage of indicators and countries was further extended in 2013.

study. In an advance, the ECB's November 2015 Financial Stability Review (box 3) incorporates the housing stock in the long-run house price solution, mortgage debt growth in the short-term dynamics, and Bayesian estimation with plausible priors. However, joint modeling of mortgage debt and house prices would have enabled further progress.[67]

Geng (2018) studies the long-run determinants of house prices in a 20-country panel to estimate the degrees of overvaluation for different countries. The paper follows the model of Caldera Sánchez and Johansson (2013), finding plausible responses to per capita income and the housing stock augmented with interaction effects to capture key variation in institutions across countries. For example, the elasticity of house prices with respect to per capita income of 1.6 for countries without favorable tax treatment of mortgage interest rises to 2.1 for the Netherlands, with the most favorable tax rules. The elasticity with respect to the per capita housing stock is lower where rent controls are more prevalent, for example, in Sweden. Finally, the response of house prices to the real mortgage rate is highest in Switzerland and the lowest in the United States, the countries with the lowest and highest respective estimated supply elasticities of housing in the sample. However, no account is taken of credit conditions, and estimated speeds of house price adjustment to equilibrium are not reported.[68]

Extending the growth-at-risk approach, Adrian, Boyarchenko, and Giannone (2019) and IMF (2019b) derive a measure of "house prices at risk," which deteriorates with a tightening of financial conditions, lower real GDP growth, higher credit growth and with house price overvaluation, as proxied by the deviation of the ratio of house prices-to-GDP per capita from its long-run average. Adding the house-prices-at-risk measure to growth-at-risk models and financial-crisis-prediction models enhances predictive power. The sharply contrasting approaches of Geng (2018) and Adrian, Boyarchenko, and Giannone (2019) suggest scope for cross-fertilization.[69]

6.7 *Important Patterns in the Empirical Evidence on House Price Cycles*

In summary, the econometric evidence has several important patterns and implications. Income elasticities of house prices, given the lagged housing stock, exceed unity, while time variation in interest rates and non-price terms of credit critically affect house prices, as do ripple effects from major cities to surrounding locales. These demand influences tend to have larger effects on house prices in areas with less elastic supply, but more research is needed to comprehensively track geographic and time variation in supply elasticities. Better measures of the

[67] Muellbauer and Williams (2011) for Australia; Geiger, Muellbauer, and Rupprecht (2016) for Germany; Muellbauer, St-Amant, and Williams (2015) for Canada; and Chauvin and Muellbauer (2018) for France jointly model house prices, mortgage debt, and consumption to extract mortgage credit conditions in a latent variable approach. This has the further advantage of detecting whether amplifying feedback loops via consumption are present.

[68] The accuracy of estimated coefficients will also be overstated given a high degree of residual autocorrelation.

[69] At-risk studies based on individual country data neglect international spillovers. The ECB supports an approach to include such spillovers (Detken, Fahr, and Lang 2018 and Constâncio et al. 2019). This combines a domestic systemic risk indicator (d-SRI) for each country with an external risk indicator (e-SRI) that measures its exposure to external risks based on an average of d-SRIs for 45 countries. Evaluated on quarterly data for EU countries for 1970 to 2016, d-SRIs based on a composite of six indicators, most based on 2- or 3-year growth rates or changes in variables including the bank credit-to-GDP ratio, real total credit, the household DSTI, and the house price-to-income ratio, predict best. The combination of e-SRIs and d-SRIs to address international spillovers to construct composite systemic risk indicators suggests avenues for improving on the current state of quantile regression-based "at-risk" research.

housing stock and land prices are needed, as well as house price-to-rent models that relax the strong assumption of perfect substitution between owner-occupied and rental housing. Housing spillover effects on the financial sector and macroeconomy can be substantial, with newer indicators of bubbles increasingly recognizing the key roles of both house prices and mortgage debt. Nevertheless, the multidimensional and nonlinear nature of house price dynamics highlights the need to develop indicators of financial stability and macro spillover effects that better incorporate information from structural models of house prices, which account for supply and credit market influences in place of simpler, and often misleading, gauges of house price valuation.

7. *Financial Stability, Real Estate, and Macroprudential Issues*

To begin, we review the use of macroprudential policy for financial stability, discuss what is in policy makers' toolkits, and compare the merits of macroprudential and monetary policies. Section 7.2 reviews evidence on the effects of real-estate-linked macroprudential tools, while a wider set of tools is discussed in section 7.3. The use of granular information and models in section 7.4 is followed by a discussion of DSGE models. How complementary policies that are not usually in the toolkit of financial regulators could aid financial stability is the subject of section 7.6.

7.1 *The New Consensus and Areas of Debate on Macroprudential Policy*

A widely held, pre-GFC view was that, since asset bubbles are hard to accurately identify in real time and monetary policy is too blunt or too costly a tool to address them, monetary policy is best used to "clean" up any damage from asset bubbles, rather than to "lean" against asset prices (Mishkin 2007). The post-GFC consensus is that macroprudential policy should address the systemic risk of financial instability and that central banks add macroprudential tools to their traditional bank-supervisory function and microprudential toolkit (e.g., Constâncio 2016a).[70]

The macroprudential toolkit includes setting countercyclical total and sectoral capital buffers or minimum total loan loss provisions on banks, specifying minimum liquidity ratios, stress-testing systemically important parts of the financial sector, setting capital flow or foreign exchange (forex) liability-related reserve requirements in small open economies, and using several real estate-centric tools. The last set of tools include capping LTV and DSTI ratios, limiting non-standard amortizing or interest-only mortgages, and increasing capital requirements on riskier mortgages (Claessens 2015, IMF–Financial Stability Board–Bank for International Settlements 2016, Bank for International Settlements 2018). The Basel Committee on Banking Supervision recommends using the credit-to-GDP gap to set the countercyclical capital buffer (CCyB) under Basel III, though, given evidence reviewed in section 6.6, many central banks now use a wider set of signals. Complementary interventions, typically outside the control of central banks, include adjusting mortgage and other tax incentives, changing property taxes, realigning incentives to securitize mortgages, and altering the legal framework governing the treatment of debt and the degree of recourse open to lenders. Macroprudential measures can help improve the intertemporal risk-return trade-off since easy monetary policy lowers short-term downside risks to growth, but increases medium-term risks (Adrian et al. forthcoming). Boar et al. (2017) argue that countries that more frequently use

[70] For more on the evolving toolkit for monitoring financial stability, see Blancher et al. (2013). For an excellent discussion of market failures justifying regulatory and macroprudential intervention, see Gai (2017).

macroprudential tools experience stronger and less volatile growth, albeit with the proviso that nonsystematic macroprudential interventions tend to be detrimental to growth. Kim and Mehrotra (2019) examine the effects of a broad set of macroprudential instruments on credit growth and macroeconomic outcomes using a quarterly structural VAR for a panel of 32 economies in 2000–2014. They show that, although the macroeconomic effects of macroprudential shocks are similar to those of monetary policy, the transmission of the macroprudential shocks occurs mostly via residential investment and household credit, rather than the wider economy.

There is still considerable debate over policies to address financial stability, including what signals to examine when calibrating macroprudential tools, and which tools to use. Borio and Shim (2007) and others advocate augmenting macroprudential tools with "a lean against the wind" monetary policy to prevent bubbles, which Miao, Shen, and Wang (2019) show reduces bubble volatility and is optimal in a rational bubble model with serially correlated bubble shocks and adaptive learning. Others, such as Svensson (2017), argue that the welfare losses of using monetary policies outweigh their benefits, and view macroprudential policy as an extra tool to avoid the Tinbergen problem of matching objectives with tools. Consistent with Svensson (2017), Chen and Columba (2016) find, in a DSGE model for Sweden, that macroprudential tools can more effectively limit household debt than monetary policy.

Svensson (2018) examines empirical evidence, mainly microeconomic, on the amplification of house price shocks via the housing collateral channel. He finds that this channel is weak in Sweden, which supports his argument that monetary policy was too tight there in 2010–11. Given this evidence for a weak financial accelerator, he further argues that subsequent *macroprudential* policy, tightened in June 2016 (after the policy rate reached minus 0.5 percent in February 2016), and again in March 2018, was too restrictive. Svensson focuses on the negative consequences of macroprudential policy, particularly making it more difficult for poorer and younger households to become homeowners. He points to major distortions in the Swedish housing market including rent controls, planning restrictions, and the ill-advised removal of national property taxes. He convincingly argues that in Sweden, macroprudential controls were a third-best response, pointing to the need to reduce distortions and to coordinate housing policy across policy makers.

Stress tests of systemically important financial institutions are now worldwide, and have been central to US macroprudential policy since 2009, focusing on bank capital (Anderson 2016). Edge and Lehnert (2016) and Anderson (2016), inter alia, describe the US Dodd–Frank Act Stress Tests (DFAST) and Comprehensive Capital Assessment Review (CCAR), which focus on the ability of the largest bank and international holding companies in the United States to absorb significant losses under adverse scenarios (a severe recession and collapse of residential and other assets prices) while sustaining lending. The Bank of England and ECB stress tests, for example, combine top-down macroprudential with bottom-up microprudential approaches, and can result in resetting bank-specific CCyBs as risks evolve. [71] Although real estate scenarios are used in stress tests, neither the ECB nor the Federal Reserve controls real estate limits on borrowers (e.g., LTV and DSTI caps) that are widely used elsewhere. One concern with bank stress testing is that more risky financial

[71] A distinction is needed between ECB stress tests for internal use, see Constâncio (2016b), Budnik et al. (2019), and Constâncio et al. (2019), and published tests done by the ECB under the European Banking Authority methodology, following a static balance sheet approach, excluding feedbacks and contagion effects. The more sophisticated internal tests take feedbacks and contagion into account.

activities (e.g., involving real estate) may move from regulated banks to the growing nonbank finance sector (Domanski 2018), where regulation is light or absent altogether.

7.2 *Real Estate-linked Macroprudential Tools*

The burgeoning research on macroprudential tools is summarized in IMF–Financial Stability Board–Bank for International Settlements (2016), BIS (2018, 2020), Valencia et al. (2020), and European Systemic Risk Board (ESRB) (2018), inter alios. We review the empirical evidence first from large panels and then from studies of countries or very small panels.

Evidence from large panel studies.[72]—A panel study of 57 economies by Kuttner and Shim (2016) finds that DSTI limits are more effective than LTV caps for slowing real house price growth, but both are effective in curbing real housing credit growth. This concurs with the panel studies by Claessens, Ghosh, and Mihet (2013) and Cerutti, Claessens, and Laeven (2017). One issue with such panel studies is that macroprudential policies are endogenous, and that credit and house price growth also depend on other factors. For example, if tightening occurs amid high credit growth owing to optimism about future income, this could attenuate, that is, underestimate, the effect of tighter LTV or DSTI caps on credit growth in empirical models excluding income expectations. Most recently, Alam et al. (2019) build a comprehensive database—the Integrated Macroprudential Policy (iMaPP) database—to summarize stylized facts and assess earlier studies of the effectiveness of macroprudential policies. By comparing simpler methods with those correcting for endogeneity, they suggest that attenuation bias led earlier studies to underestimate the effects of macroprudential policy.

The iMaPP database amalgamates five databases with national sources, including countries that adopted macroprudential policies before the GFC, and data on actual LTV caps as opposed to simple dummies. LTV caps are the most common tool for advanced economies (AEs)—mainly concerned about housing sector vulnerabilities—with limits on forex positions more popular in EMDEs, where external shocks are preeminent (Cerutti, Claessens, and Laeven 2017).[73] Alam et al. (2019) estimate panel regressions with fixed effects and use an augmented inverse-propensity-score weighting method to address endogeneity, placing lower weights on observations where endogeneity seems stronger. They use quarterly data from 1990 to 2016 for 34 AEs and 29 EMDEs. They find that “loan-targeted, demand-side tools” (e.g., LTV, DSTI, and DTI caps) as well as “loan supply-side” tools (e.g., regulating credit growth and loan loss provisions) significantly affect household credit growth in EMDEs jointly with demand-side tools, but are not individually statistically significant for AEs. For AEs and EMDEs, supply-side tools are more effective in curbing household credit and consumption than are demand-side tools.

These results are broadly in line with other studies, although most do not distinguish AEs from EMDEs.[74] Alam et al. (2019) also

[72] A plethora of country studies have appeared recently but, owing to space constraints, we can only discuss a few. Other interesting papers include Cantú et al. (2020); Dobson (2020); Kim and Mehrotra (2018); Wijayanti, Adhi, and Harun (2020); Wong, Tsang, and Kong (2016); and Yao and Lu (2020).

[73] The iMaPP database covers 134 countries from January 1990 to December 2016 and amalgamates the underlying databases of Lim et al. (2011, 2013), the 2013 Global Macroprudential Policy Instrument (GMPI) survey by the IMF, Shim et al. (2013), the European Systemic Risk Board (ESRB), and the IMF’s Annual Macroprudential Policy Survey.

[74] These are: Cerutti, Claessens, and Laeven (2017) and Kuttner and Shim (2016), as well as those of Lim et al. (2011); Arregui et al. (2013); Crowe et al. (2013); Krznar and Morsink (2014); and Jácome and Mitra (2015).

examine the potential nonlinearity of LTV limits, finding that the effects of tighter LTV limits on household credit growth are dampened when the initial LTV limit is "tight," while the effect of an additional tightening on consumption is then stronger. They also find that loan-targeted tools have weaker effects on house price growth than on credit growth, consistent with Kuttner and Shim (2016) and Cerutti, Claessens, and Laeven (2017), as well as Ciani, Cornacchia, and Garafalo (2014); Crowe et al. (2013); Dell'Ariccia et al. (2012); Jácome and Mitra (2015); and Lim et al. (2011). Loan-targeted tools limit house price growth more in AEs than in EMDEs. For AEs, Alam et al. (2019) find that tax-related policies significantly affect house price growth (as do Kuttner and Shim 2016 who do not distinguish AEs from EMDEs), with weak, insignificant effects on household credit growth.[75]

A number of recent papers have examined the costs and benefits, as well as the leakages and spillovers, from housing related macroprudential policies. Richter, Schularick, and Shim (2019), using a detailed narrative identification approach and data for 56 countries, quantify the effect of changing LTV caps on output and inflation. They find that tightening LTV ceilings significantly affects house prices and the growth of total household debt and mortgage debt in a pooled sample of economies. They also find little effect on inflation and output in AEs, and a significant but small output effect in EMDEs for tightening, but not for loosening.

An important issue with studies of macroprudential policy effectiveness is that, absent regulation, many lenders and/or borrowers would likely want to limit their risk and restrain their LTVs and DSTIs. Thus, the net effect of tightening regulations depends much on prior practices, which not only vary with borrower heterogeneity, but also tend to be poorly measured in time series surveys of lending conditions.

In addition to the endogeneity of many macroprudential policies, another issue with many panel studies is specification error due to omitted country heterogeneity.[76] Vandenbussche, Vogel, and Detragiache (2015) find little effectiveness of loan-targeted tools across Eastern and Central European countries, perhaps because of the high incidence of foreign currency-denominated loans. Nevertheless, in a study of six East Asian and Eastern European countries, Jácome and Mitra (2015) find that such limits reduce nonperforming loans, thus improving financial stability. In reviewing research on EMDEs, Arslan and Upper (2017) stress variation in institutional, regulatory, and market conditions.

Evidence from country studies.—As Kuttner and Shim (2016) show, the most widely used macroprudential tools directed at housing are LTV and DTI or DSTI limits. Some Asian countries have employed these tools for about 30 years, whereas advanced economies have only introduced these tools in recent years following the GFC. Widely cited are Igan and Kang's (2011) results for South Korea that lower LTV and DTI limits were associated with a decline in house price appreciation and transaction activity. Furthermore, they find that the limits also altered (survey-based) expectations, which play a key role in bubble dynamics.

The evidence suggests that higher LTV limits curb household leverage and credit

[75] For the case against stamp duties on efficiency grounds, e.g., limiting labor mobility, see Mirrlees and Institute for Fiscal Studies (2011).

[76] In a panel of 20 OECD countries, the early study of Andrews (2010) finds that LTVs and Abiad, Detragiache, and Tressel's (2008) financial reform index positively and significantly affect house prices. However, such indexes include non-housing related reforms and omit relevant country-specific changes in regulations.

growth in most countries, especially those with more volatile house prices. However, the effects on house price growth of tighter LTV and DSTI limits are more heterogeneous. A comparison of 16 individual and small-panel country studies (summarized in table 3 of the online appendix) highlights the role of institutional differences. In Canada, for example, LTV polices had a larger impact on demand and defaults than policies targeting the debt–service ratio, such as limiting the term of mortgages (Allen at al. 2020). Gross and Población (2017) draw the opposite conclusion for European countries, where lending practices were more conservative, house price-to-income ratios were lower and less volatile, and fewer households were near the LTV constraint.

Some studies have examined spillover effects. Agarwal, Badarinza, and Qian (2018) find that banks in Singapore responded to a 2010 cut in the maximum LTV and an increase in the cash down payment requirement for second loans by reallocating credit to a potentially riskier pool of second home borrowers with high DTIs. In Malaysia, tighter restrictions on individuals induced firms to buy homes, causing lending restrictions to be extended to firms (see Wong et al. 2011). In Ireland, banks most affected by the introduction of DTI and LTV limits on residential mortgages in 2015 increased their risk taking in their securities and corporate portfolios, two asset classes not targeted by the policy (see Acharya et al. 2020). In Switzerland, extra capital requirements on residential mortgages led to higher growth in commercial lending, along with higher interest rates and fees (see Auer and Ongena 2019). In Israel, more stringent LTV limits induced first-time buyers to buy cheaper homes and to move farther from high demand areas to lower socioeconomic neighborhoods, as found by Tzur-Ilan (2019).

When LTV or DSTI caps are circumvented, broader measures are needed as in the case of Malaysia. Another example is borrowing from difficult-to-regulate shadow banks, such as unregulated off-balance-sheet subsidiaries of banks or wealth management firms in China. These examples highlight the case against over-relying on any one tool, and for monetary policy to reinforce macroprudential policy. Indeed, several Latin American central banks found that macroprudential measures are more effective in damping the credit cycle if supported by countercyclical monetary policy (Arslan and Upper 2017). Flexibly combining LTV and DSTI limits helps control leakage from the use of a single tool, and is consistent with double-trigger models of mortgage default. These models empirically find that defaults are linked to negative net equity (mainly from house price shocks) and high debt service burdens (from income and adjustable interest rate shocks). Stress tests, rigorous supervision, and active monitoring across the financial system by macroprudential authorities also help control leakage and regulatory arbitrage (European Systemic Risk Board 2016).

Political sensitivities may curtail using LTV or DSTI caps (Tucker 2018). For example, in EMDEs, limits may work against the desire to widen financial participation (see Villar 2017). "Supply-side loan" tools with a more diffuse impact on individual households are then often an attractive alternative to "loan-targeted, demand-side tools." The former include increased loan loss reserves, for example, dynamic provisioning, when making loans to cover expected future losses. Although Spain adopted dynamic provisioning in 2000, it still suffered a deep recession and many bank failures. However, disentangling the effects of different factors, Jiménez et al. (2017) analyze Spanish dynamic provisioning rules using credit registry data, finding that the rules limited credit cycle swings and helped sustain firm survival and employment. Adjusting risk weights for high-LTV or high-DSTI mortgages is another credit supply tool utilized in Belgium, Switzerland, Ireland, and Spain. It has the advantage over blanket caps on LTVs or DSTIs that lenders can take more account of information on individual borrowers, such as credit scores or income security, when making loan decisions. The Bank of England uses another credit supply tool, limiting each bank's exposure to high DTI loans, and requiring banks to ensure depositors can cope with a 3 percentage point rise in the mortgage rate. Meeks (2017) suggests that linking UK capital requirements to house prices and mortgage spreads would have moderated the rise in house prices and mortgage lending growth in the early 2000s.

To conclude, it is important to acknowledge the fact that, despite great progress in implementing and understanding the effectiveness of different macroprudential tools, controversies remain, for example, regarding the context dependence of their effectiveness. Further, the spheres of responsibility of macroprudential authorities are often limited, and macroprudential policies often face political economy challenges. As a consequence, in the United States and some other countries, no regulator has the clear authority to implement rules that constrain borrowers' access to credit (see Forbes 2019 and Kashyap and Lorenzoni 2019).

7.3 *Other Tools Limiting the Risk of Funding Real Estate Loans*

An important feature of the GFC was the inability to roll over maturing debt by lenders relying on runnable funds, transforming a liquidity into a solvency crisis when lenders liquidated collateral in fire sales (Gorton and Metrick 2012). "Runs" on investment banks, money market funds, and uninsured commercial bank debt triggered and amplified the US recession, as discussed in section 2. In Ireland and the United Kingdom, bank reliance on short-term money market debt was a key vulnerability when these markets dried up in 2007, in contrast to Australia and Canada, where cautious lending and funding practices enabled banks to remain profitable. The small literature on liquidity requirements, such as the liquidity coverage ratio and net stable funding ratio, is concerned with aggregate, rather than real estate-specific, liquidity regulations (e.g., De Nicolò, Gamba, and Luchetta 2014, Covas and Driscoll 2014, and deBandt and Chahad 2016). While Basel III's new liquidity requirements may dampen the macroeconomic cycle, for mortgages there is less scope for tailoring liquidity regulations than there is for capital and lending requirements.

The international transmission of shocks is analyzed in the collateralized borrowing framework of Cesa-Bianchi, Ferrero, and Rebucci (2018). In a calibrated model, with supporting empirical evidence from a panel VAR model, they find that house prices and the macroeconomy are more sensitive to international shocks when LTV constraints are easier and debt is denominated in foreign currency. Their findings support setting capital flow or forex liability-related reserve requirements in small open economies.

Before the 1980s, under the "originate-to-hold" model, banks had incentives to originate high-credit quality loans. The rise of securitization and the "pooling" of assets gradually resulted in an "originate-to-distribute" business model in which lenders could originate loans and quickly sell them into securitization pools. While this allowed lenders to free up regulatory capital and, thus, extend more credit, it also shifted credit risk to investors holding securities (see Bord and Santos 2012, Elul 2016, and Rosen 2010).

As discussed in sections 2.5 and 4.5, in combination with the easing of capital requirements, these developments drove the US nonprime boom and bust. To reduce risky lending, the Dodd–Frank Act now requires that originators retain the first five percent of losses on privately securitized loans and that all securitized mortgages meet minimum underwriting criteria.

Since macroprudential tools are imperfect, some countries impose multiple restrictions. In the United States, loans insured by Fannie Mae, Freddie Mac, the FHA, and VA (subject to DSTI caps) can be securitized under the Qualified Mortgage (QM) rules of the Dodd–Frank Act.[77] Other loans can be securitized if the DSTI ratios are below 43 percent, the loans do not have high fees or very adjustable interest rates, and lenders verify that borrowers will likely meet debt payments. Qualified mortgages shield lenders from borrower lawsuits and are exempt from the "skin-in-the game" requirement, a concern as DSTI caps do not fully address default risk. Also, LTV caps are not lowered for house values with a high land share component that is prone to booms and busts (see Davis and Heathcote 2007; Nichols, Oliner, and Mulhall 2013; and Kurlat and Stroebel 2015). Li and Yavas (2017) advocate adjusting LTV caps for the land share, although it is not clear how to account for regional differences, secular trends, and the systemic risk from land prices.

A prominent US study finds only small aggregate effects from tighter postcrisis regulation. DeFusco, Johnson, and Mondragon (2020) examine how the 2014 Dodd–Frank "ability-to-repay" rule affected the price and availability of credit in the US mortgage market, finding significant quantity effects. They argue that the new policy eliminated 15 percent of the affected market completely, and reduced leverage for another 20 percent of remaining borrowers. While the policy succeeded in reducing leverage, they claim that this effect would have only slightly reduced aggregate default rates during the housing crisis. However, their claim can be challenged.[78] General equilibrium effects of regulations on house prices likely involve externalities, spillovers, and interaction effects with changing background variables that are hard to fully capture with such difference-in-difference studies of microdata. Moreover, rigorous implementation before 2007 of the Dodd–Frank rule would have prevented many "liar" or low-documentation loans without proper income checks, although overly strict rules could induce suboptimal credit rationing of the self-employed and small firms (Ambrose, Conklin, and Yoshida 2016). The subpar pace of business formation and small business lending in the United States and Europe may be a negative feature of postcrisis reforms (Bordo and Duca 2018).

7.4. *The Timing of Macroprudential Policy: Models and Information*

Analysts concur that early action helps address systemic risk, requiring banks to raise capital or tighten credit standards. Gauging the macroprudential risk of housing entails analyzing whether house prices are overvalued and credit is overextended. It is useful to distinguish between house prices overshooting from higher demand pushing up against inelastic housing supply, amplified by extrapolative expectations, versus

[77] While Fannie Mae and Freddie Mac account for both LTVs and DSTIs in approving and pricing loans, the marginal lender, FHA, has a high LTV cap of 96.5 percent, so the binding constraint is generally the DSTI limit of 43 percent.

[78] DSTIs are inevitably measured with error, which may attenuate their estimated effects, and LTVs are not controlled for, even though negative equity is an important factor in many defaults. Their sample is also quite restrictive—fully amortizing, fixed-rate 30-year non-FHA mortgages for which a complete set of indicators was recorded. In terms of policy conclusions, finding a weak effect of DSTI caps on defaults, even if correct, does not imply the ineffectiveness of jointly capping LTV and DSTI ratios.

overshooting from shifts in fragile fundamentals (e.g., lending standards) that could unwind, as discussed in section 2. Because the amplifying role of real estate and credit market dynamics reflects key institutional aspects of credit market architecture and regulations that vary across countries and over time, policy makers should eschew overly stylized models omitting such influences. Models need to incorporate the heterogeneous and state-dependent links between credit conditions, house prices, consumption and residential investment discussed in section 2. Partly owing to data limitations, many country-specific housing models do not sufficiently account for factors such as the price elasticity of housing supply and shifting mortgage credit conditions, although interpreting the latter is complicated by financial innovation at nonbanks.[79]

Financial regulators need microdata on mortgage conditions. For example, since many first-time buyers have limited funds for downpayments, they are very sensitive to credit conditions. The Bank of England's Product Sales Database has gathered micro-data since 2005,[80] succeeding an earlier survey by the Council of Mortgage Lenders (CML) initially of building societies and later banks used by Fernandez-Corugedo and Muellbauer (2006) to track mortgage credit conditions, see section 4.5. For risk management, lenders and regulators need to track the performance of each mortgage over its life, as well as credit and market conditions that can help gauge future loan performance and risk. For regulators, tracking aggregate as well as microdata on credit conditions is important for macro stress testing since the financial accelerator linking the financial sector and the real economy is both affected by, and affects, credit conditions.

7.5 *Insights from DSGE Models*

DSGE models with rational expectations and a focus on intertemporal substitution quickly become complicated when realistic housing finance, household accelerator, and other features are included. Important dimensions across which economies can differ include whether the exchange rate is fixed or floating, mortgage equity withdrawal is allowed, mortgages are full recourse, and mortgage interest rates are fixed or floating. Ignoring these differences limits how relevant individual studies are to economies with different institutions, regimes, and practices, especially where extrapolative expectations, an important part of the financial accelerator discussed in section 2, prevail. Nevertheless, progress has been made.

For example, relying only on a constant LTV limit has the drawback that, in a house price boom with only moderate income growth, DSTI and DTI ratios can rise, which would relax credit conditions in the absence of self-regulating behavior by lenders using their own borrower-specific LTV and DSTI caps to control credit risk. In contrast, constant DSTI and DTI limits automatically tighten as house prices rise.[81] In a DSGE model, Benes et al. (2016) show that the above drawback of LTV limits is mitigated by imposing a countercyclical capital buffer on lenders and using smoothed prices to calculate LTV caps. Greenwald (2016)

[79] Surveys of mortgage market conditions have been conducted by the US Federal Reserve since 1990, by the ECB since 2002, and by the Bank of England since 2007.

[80] This includes data on buyer type (e.g., investor), personal characteristics (e.g., income), loan maturity, interest rate, house price and characteristics, whether the mortgage is securitized, and lender characteristics.

[81] DSTI's are informative about the role that interest rates play in affecting the ability of households to service debt. DTIs are informative about the buildup of debt relative to income, which can have larger effects on household spending if future interest rates change and mortgage interest rates are adjustable.

assesses the effectiveness of LTV and DSTI caps in a DSGE model for the United States that has fixed mortgage interest rates. In line with the emphasis of US reforms on DSTI limits, Greenwald finds that such caps are better than LTV caps in containing house price booms. Baptista et al. (2016) similarly find that DTI caps can limit house price swings in an agent-based model of UK housing. Also, DSGE models with explicit financial intermediaries and financial frictions find that financial stability can be improved if LTV caps are lowered when credit growth or aggregate debt-to-GDP ratios are high (see Brunnermeier and Sannikov 2014; Lambertini, Mendicino, and Punzi 2013; and Rubio and Carrasco-Gallego 2014). To date, there are no published DSGE models that endogenize the self-regulating behavior of lenders, using credit criteria to control credit risk.

Though central banks and other regulators are primarily responsible for ensuring financial stability, the prominence of housing and housing finance raises a potential role for complementary housing policies, which are now discussed in the wider context of interactions between housing and the economy.

7.6 *Complementary or Alternative Policies*

The risk of house price booms may also be lessened by legal factors. Cerutti, Dagher, and Dell'Ariccia (2017) find house price booms are less likely in countries where borrowers face downside risk from full recourse. While altering recourse might lessen the frequency of boom-busts, the net effect is limited by lenders applying less stringent mortgage standards in creditor-friendly legal environments (see Pence 2006).[82] Also there is a perception that in US states with full recourse, lenders rarely pursue defaulters—other than domestic investors—because the costs often exceed the assets that can be recovered.[83]

Taxation is another, albeit politically unpopular, tool to limit house price swings. By raising after-tax user costs, higher proportional property taxes, capital gains taxes, or property transactions taxes and lower mortgage interest rate deductibility make user costs less sensitive to nominal mortgage interest rates and dampen housing cycles. In a general equilibrium analysis for the United States, Sommer and Sullivan (2018) find that eliminating the mortgage interest deductibility lowers house prices and mortgage debt and *increases* homeownership. Property taxes based on recent market values can be an automatic stabilizer, as Muellbauer (2005) argues and Klein et al. (2016) show for Denmark.[84] Across US locales, Poghosyan (2016) finds that higher property tax rates lower house price volatility. Consistent with these results, Naess-Schmidt et al. (2017) find that large property tax cuts in 2008, which were not subsequently reversed, helped push up Swedish house prices to possibly overvalued levels. Since local authorities in many countries set property taxes, changes in such taxes, including their timing, may ignore macroprudential considerations.

Examining an example of countercyclically adjusting property or transactions taxes, Best and Kleven (2018) find that a temporary reduction in the UK's housing transaction tax (stamp duty) from late 2008 to late 2009 helped stabilize home sales in a severe downturn. Similarly, Hembre (2018) find that a temporary US first-time home buyer tax credit boosted lower-end house prices in

[82] In a pre-subprime bust study, Pence (2006) compared loan applications in adjacent census tracts located in different states and found that loan sizes were smaller in states with foreclosure laws that favored defaulters over creditors.

[83] US bankruptcy laws shield pension assets—including annuities and defined contribution plans—from creditors.

[84] Both agree that capital gains taxes on housing are far less satisfactory, and may even be destabilizing.

2009 and 2010. In examining the imposition of modest property taxes in Chongqing and Shanghai, Du and Zhang (2015) find mixed evidence, with taxes lowering property values in the former but having no significant effect in the latter. They did find that limits on the number of property purchases by households restrained increases in Beijing house prices. Curtailing or ending the deductibility of mortgage interest can also make user costs, and thus house prices, more sensitive to interest rates as Damen, Vastmans, and Buyst (2016) find in a model where after-tax cash flow costs of housing are critical for housing demand. In Australia, where the tax system has favored buy-to-let investors, tax reform could discourage high leverage and risk taking. In Ireland, well-intentioned but misguided tax breaks for first-time homebuyers in the early 2000s helped fuel a boom by being quickly capitalized into higher house prices, ultimately exacerbating housing affordability.

The postcrisis era of low interest rates and large international capital flows—particularly from newly wealthy Asian investors—has bolstered property prices in global cities. The growing affordability crisis for local residents has become at least as important a social issue as risks to financial stability, inducing some countries to more heavily restrict (e.g., New Zealand) or tax (e.g., Canada) property purchases by foreigners.

A well-developed rental sector, flexibly regulated to balance the needs of landlords and tenants, could improve financial stability. Professional landlords with deeper pockets than many households can better withstand swings in house prices if leverage is contained, reducing the financial accelerator feedback onto the economy. A high share of renters also reduces the procyclical link between house prices and spending. Nevertheless, in many countries, homeownership is perceived as a superior alternative to long-term renting and receives very favorable tax treatment.

As housing is an asset, if nonhousing returns and mortgage interest rates are low, many may lever up and invest in housing, as in the recent real estate boom in China (section 6.4). In the United Kingdom, where asset managers' fees have reduced pension returns, this has likely contributed to the United Kingdom having the largest post-1970 rise in real house prices among the Group of Seven (see Muellbauer 2018). Competition policy and regulation of asset managers that raised household returns on pensions and other long-term investments could ease the portfolio demand for housing. Another likely result of large property price swings is path dependence in portfolio decisions. Ample evidence of extrapolative expectations (sections 4.3 and 6) implies that swings in house price appreciation can induce socially inefficient portfolio shifts between housing and other assets.

Property taxation has major implications for efficiency and equity (see Mirrlees 2011), as can other policies. Evidence reviewed in section 5.6 found strong effects from housing transfer taxes on labor and residential mobility. Restrictions on labor mobility can impede the flexibility and efficiency of an economy. Planning restrictions further restrain investment and growth and can be a vehicle for discriminatory social engineering. Property rights giving landowners all or most of the benefits of zoning changes raise land prices and make it harder to fund complementary infrastructure investment, impeding growth (see Muellbauer 2018).[85]

Institutional practices that collectively result in larger cyclical swings in property prices and high land values, as in countries such as the United Kingdom, New Zealand, Australia, and Sweden, likely affect the

[85] Kaganova (2011) reviews experience with public sector land-banks, including that of South Korea, under which land-value capture for infrastructure investment and expansion of the residential land supply is enabled.

structure and performance of the building industry. The speculative nature of the UK industry has promoted high concentration and slow productivity growth, in contrast to Germany, where house prices have been more stable and land prices lower (see Muellbauer 2018). Returns to UK home builders are mainly generated from capital gains on land, see section 5.4. The *volatility* of prices for housing and residential land increases the investment risks for home builders. A *high* fraction of land costs in homebuilding means that builders take on higher debt, which increases risk. In Germany, working capital in the form of materials and labor input, is a higher fraction of overall costs, and is more easily financed from turnover instead of debt. Given lower and stable land prices, German builders focus on containing costs and delivering quality.

Finally, as argued in Resolution Foundation (2018), the pronounced rise in UK house prices relative to income has disadvantaged cohorts born after 1980 compared to earlier ones. The UK pattern of large historical generation-on-generation gains, followed in recent years by weak income, lower homeownership rates and much lower accumulation of wealth distinguishes the United Kingdom. Nevertheless, similar patterns have emerged in New Zealand and Australia, and to a lesser extent in some Scandinavian economies and Canada. Furthermore, when housing (effectively land) is very expensive relative to incomes, the more restricted access to housing increases social exclusion for those without wealthy parents, as high local house prices reflect greater access to public goods such as good transport, education, and a healthy environment.

To sum up, there is much variation in macroprudential tools and approaches across countries, which not only affects the sensitivity of house prices to interest rates, income, and borrowers' ability to meet credit standards, but also affects how much house prices have spillover effects on the financial sector and the macroeconomy. The effectiveness of these tools also varies with the coverage of the policies. Moreover, many of the tools are relatively new and have not been tested by a deep recession and we cannot say how much these policies will dampen future housing booms and busts. The effective use of macroprudential policy also requires using housing and macroeconomic models that accurately track housing cycles and evolving risks rather than overly stylized models that ignore important dimensions and feedback channels. Finally, macroprudential tools are not always the first-best policies as noted by Svensson (2018), and more structural policies are often desirable as an alternative or complement, for example reevaluating zoning restrictions and tax policies.

8. *Overview and Implications for Future Research*

The housing booms and busts of the early twenty-first century have catalyzed a burgeoning of recent research on the drivers of house price cycles and their wider implications. Important progress has been made in analyzing the broader macroeconomic impact of house price cycles, as well as incorporating roles for nonrational house price expectations, regulations, and non-price terms of credit in theoretical (e.g., DSGE and ABM models) and empirical (e.g., equilibrium-correction) models. Other advances in econometric modeling better account for planning and land supply restrictions and incorporate the measurement of other key factors affecting home building and prices.

A striking aspect of recent research is a growing consensus that credit supply shifts are a principal driver of house prices and that household balance sheets and their interaction with lending practice are central elements of the financial accelerator, for example, Mian and Sufi (2018) and Gertler and Gilchrist (2018). Mian and Sufi are far from alone in providing microeconomic and cross-country panel evidence on credit effects. Greater evidence-based agreement has emerged that housing markets are far from efficient and that many agents extrapolate recent gains when forming expectations. This calls into question the usefulness of models imposing instantaneous market clearing for analyzing housing dynamics, limiting their potential relevance to long-run outcomes. Some structural optimizing housing models now depart from convention and assume nonrational expectations and allow for nontrivial transactions costs and thin trading of heterogeneous properties. Incorporating heterogeneity into DSGE models and improving heterogeneous ABM models are fruitful areas for new research. Incorporating bounded rationality and search frictions into structural optimizing housing models could bring these approaches closer to the ABM models, which incorporate simple heuristics, for example, between owning or renting, fixed or adjustable interest rate mortgages, and defaulting or not defaulting. Evidence-based research could bring ABM models closer to reality, for example, on expectations-formation where such heuristics are often oversimplified.

At the local, regional, and national levels of analysis, there is scope for incorporating time-varying risk premia, accounting for heterogeneity in the agents' use of fundamental or momentum approaches, as well as controlling for time-varying credit standards. Risk premia could depend, inter alia, on recent volatility, leverage, and on how far prices deviate from estimated long-run equilibrium levels. As noted in section 4.4, incorporating risk premia via the user cost term provides a way to explain how house price booms can end endogenously.

Real estate linked financial crises typically begin with over-valued real estate prices. As explained in section 2, large macroeconomic shocks, shifts in fragile fundamentals, and endogenous dynamics can lead to the collapse of overvalued prices, amplified by the financial accelerator (the drivers of which are summarized in section 2.2). Plentiful research has estimated the extent of overvaluation in country panels, but scope remains for incorporating institutional differences across countries and over time, which alter the magnitude of the financial accelerator, but which are not fully captured by including country fixed effects. An important aspect of heterogeneity between countries comes from distributional differences in income, household balance sheets, housing tenure and social safety nets; see Causa, Woloszko, and Leite (2019) for a mine of such cross-country comparisons drawing on the Survey of Consumer Finances and corresponding surveys in other countries. Such differences have implications for household vulnerabilities and financial fragility. Models of house prices should take more account of country heterogeneity; differences in household leverage, for instance, are likely to generate different overshooting dynamics. Mortgage credit conditions, though often neglected, vary by country and over time. This suggests joint estimation of latent credit standards with equations for mortgage debt and house prices, to capture the joint effect of credit conditions on both. Supplementary data could be used, where available, such as survey data on credit conditions and spreads, distributions of LTV and DTI ratios for first-time buyers, and institutional aspects of financial regulation.

To model residential investment with a financial accelerator requires adding a housing supply equation to the above system, to be jointly estimated for each country. While the residential construction models of Caldera Sánchez and Johansson (2013) and Cavalleri, Cournède and Özsöğüt (2019) are major steps forward, they should be augmented by the inclusion of real interest rates and short-term demand shocks. They should also test for longer lags of house price growth to account for extrapolative expectations looking back beyond a quarter and time-to-build lags. More fundamentally, as noted in section 5.5, the GFC in some countries has curtailed industry capacity and altered competitive structures, which has likely changed the empirical relationship between residential investment and house prices. This suggests the need to consider a two-stage model, first of industry capacity and then of home building conditional on capacity.

The above joint model can be applied to panel data to assess degrees of overvaluation. With long data series, national house price studies can reflect country heterogeneity; in panels, interaction effects with the main institutional features can capture and help interpret heterogeneity. The potential degree of national overvaluation can be gauged by the deviation of current house prices from equilibrium prices in the model and augmenting it by the degree of endogenous overshooting, the deviation of credit conditions from historical patterns, and the risk of negative macro shocks.

Such an approach can be used to forecast house prices and could also improve the overvaluation gauge in the recent "house-prices-at-risk" models (Adrian, Boyarchenko, and Giannone 2019, IMF 2019), which currently use the deviation of the ratio of house prices to per capita GDP from its long-run value. Better measures of the fundamental drivers of the long-run solution should enhance the ability of house-price-at-risk models to predict GDP-at-risk, which is an input into models predicting financial crises.

After the GFC, stress testing has become the most important macroprudential tool in the United States and Europe. Information systems at private financial institutions and their monitoring by regulators have greatly improved, but major lenders should also track the performance of each loan and share this information with regulators. Europe has followed the US Survey of Consumer Finances with its own Household Finance and Consumption Survey, allowing its stress testing to incorporate assessments of the distribution and extent of household vulnerabilities. Stress testing has top-down as well as bottom-up aspects, and micro integration is necessary with appropriate macro models to investigate feedbacks between the financial and nonfinancial sectors under different scenarios. Amongst these, climate and pandemic risks are likely to be more prominent in the future, see respectively, the Network for Greening the Financial System (2019) and Bolton et al. (2020), and the Financial Stability Board (2020) and IMF (2020). Such models should capture linkages between the financial, household, and construction sectors, incorporating the insights of micro research on heterogeneous agents faced with uncertainty and liquidity constraints, as reflected in the "credit-driven household demand channel." The models should incorporate household balance sheet data, endogenize asset prices, and endogenize household portfolio choices, disaggregating at least into safe liquid financial assets, risky financial assets, debt and housing, and control for non-price credit conditions. This review's assessment of house price and residential construction models, coupled with their data needs, should strengthen stress-testing processes, and significantly clarify the role of real estate in the transmission of monetary policy.

The link between commercial real estate dynamics and financial crises (section 2.6) is more sparsely researched than the equivalent link with residential housing. Nevertheless, the common implications for residential and commercial real estate prices of financial deregulation and of the rapid contraction of credit conditions resulting from bad loans have been studied. Changing credit conditions is one way in which the two sectors can interact. Another important connection is through arbitrage relationships, which are the foundation of the asset-pricing approach to house price modeling, linking prices with rents (section 4.2). Land-use zoning and planning controls affect the degree of separation between single and multifamily residential, retail, office and industrial land markets. The potential for rezoning creates substitution possibilities and local demand shocks can propagate between these markets. There is negligible research on the dynamics of these relationships, perhaps owing to the dearth of data on land prices.

Research on metro and local house prices has been plentiful, but mostly, as noted in section 6.5, treating each location as an island unconnected to others, though some models account for the complex spatial correlations of error terms. Research on "ripple effects" between locations has more explicitly analyzed spatial interactions. However, greater insight into the drivers of ripple effects is needed; it could be gleaned from complementary models of migration and of commuting that account for expectations and risk premia. Research on housing and labor market interactions has focused on the potential effect of negative equity on labor mobility, though undistinguished by the destination of migrants. Explicitly examining migration between areas should illuminate the roles of negative equity and factors such as perceptions of risk and housing returns. This could add important housing dimensions to our understanding of the evolution of regional economies (Blanchard and Katz 1992).

Research on the interaction between local owner-occupied housing and rental markets challenges the arbitrage theory of house price and rent determination. In line with the critique of Glaeser and Gyourko (2009), the micro approach of Garner and Verbrugge (2009) finds poor matching between rents and user costs, with the latter incorporating forecasted house price appreciation, see section 5.2. At the aggregate level, Duca, Muellbauer, and Murphy (2011, 2016) show that shifts in credit conditions strongly affect the US house price-to-rent ratio, and that in the long-run, the ratio is far from that implied by the arbitrage theory. Assessing the relative strengths of alternative explanations for the failure of the arbitrage theory remains a research challenge. Moreover, as noted in section 5.3, the determination of national rent levels is a woefully under-researched topic, despite its relevance for understanding inflation dynamics. However, for countries with historically large market rental sectors, the rent-arbitrage approach as modified by Duca, Muellbauer, and Murphy (2011, 2016) through the inclusion of credit shifts in the model and addition of a model for rents can provide a useful addition to the toolkit for forecasting house prices and assessing their overvaluation.

Models of national house price indices should also benefit from research on metro and regional house price determination. The log-linear inverted-demand model of local house prices, outlined in section 4.1, suggests that the degree of supply and demand mismatch should affect national house prices. Empirical evidence suggests that the elasticity of house prices with respect to income, given the housing stock, is likely to range between 1.5 and 2.5. This implies that in countries where local incomes are growing more strongly in low supply elasticity areas, national house price models based on average income and the aggregate housing stock will not fully track increases in national house prices without proper accounting of metro or regional mismatch. Developing such measures should be an important research area, requiring metro or regional data on income, population, and home building and should complement research in spatial housing models.

An important policy area where progress has been limited is understanding how demographic factors affect the demand for housing. As indicated in section 5.5, in time series data, the age distribution of the population tends to evolve slowly. Relationships found in cross-section data are unlikely to hold up over time since variation in cohorts may differ greatly from that in cross-sections. New family formation, and hence the share of adults in the under-45 age group, should affect the demand for shelter as a consumption good, but consideration of the portfolio demand for rental and owner-occupied housing widens the scope for other demographic effects. To make progress, long panels of country data and, where they exist, of household panels with good controls for other factors, are needed.

Last but not least, we emphasize the importance of the real estate and credit data. There are at least seven areas where data improvements could aid research and policy. The IMF and the Financial Stability Board were tasked by the 2009 Data Gaps Initiative of the G20 and the central banks to identify and address the main data gaps for financial stability. The BIS has recognized the importance of real estate indicators in this context, particularly after the GFC (Tissot 2016 and Dierick et al. 2017). In its report on real estate data gaps for financial stability monitoring and macroprudential policy in the European Union, the European Systemic Risk Board (2016) highlighted: "the lack of availability of comparable, high-quality data for residential real estate (RRE) credit standards indicators, such as the loan-to-value (LTV) ratio, the debt-to-income (DTI) ratio and the debt service to income (DSTI) ratio. The absence of sufficient and harmonized data on these metrics affects both the financial stability surveillance of the R sector and the implementation of borrower-based macroprudential instruments targeting RRE vulnerabilities." For international comparability, harmonized data on aggregate housing wealth, including land owned by households would also be advantageous. Filling these data gaps would help efforts to better integrate commercial and residential real estate analysis, and to better model residential real estate in multi-equation systems that model construction and prices consistently.

A second, closely related data gap concerns shifts in credit conditions. While researchers have mined US state variation in financial deregulation to identify credit supply shifts and their impact on local house prices, consumption and debt, measurement of the aggregate effects of such shifts over long timespans is lacking. To address some gaps in US data, the National Mortgage Database (NMDB) program is creating an integrated database to track large samples of first-lien mortgages, and now surveys loan originators and borrowers about mortgage conditions (Avery and Borzekowski 2019).

A third data gap concerns time variation in housing supply responsiveness. While metro and cross-country analyses show a major role for supply in affecting house prices, such measures are generally static. As a result, the time-variation in housing supply has not been adequately analyzed, amid growing concerns that housing supply has become less elastic in tier-1 cities in China, in many US metros (see Aastveit, Albuquerque, and Anundsen 2019) and in much of Western Europe. A fourth gap is the need for more neighborhood-level data—amid an increased preference for urban living before the COVID-19 pandemic (see Bogin, Doerner, and Larson 2019)—and data on homebuyer resources, such as interfamily transfers that help first-time buyers meet their mortgage credit constraints (see Bickle and Brown 2019).

Fifth, more survey-based measures of household and lender expectations of house prices with long series would help researchers who often need to impose strong theoretical priors or develop expectations proxies, and help financial regulators improve the early warning indicators. Sixth, better indices and measures of house prices and rents are widely needed. Macro models with implications for financial stability require accurate house price indices. From the microperspective, a handle is needed on the variation in rental contracts, stickiness in rents, thin trading, and heterogeneity of housing, to improve the accuracy of models and inform policy. While private sources have developed some measures, increased public expenditure on data is needed, as acknowledged by the G20 Data Gaps Initiative. Finally, hedonic methods for constructing separate price indices for land and for structures (Diewert 2013) deserve far wider application by national statistical agencies. As noted in section 5.5, variations in the supply and pricing of land are fundamental to understanding house price dynamics.

Given their depth and complexity, the interactions between housing and the wider economy affect many interconnected aspects of public policy. For example, housing has major implications for job-matching and labor markets. Mobility-restricting policies such as high transaction taxes, severe land-use restrictions, or "locking" tenants into nontransferable social housing, may trap workers in unemployment or low-productivity jobs. Restrictions, such as those on building height, urban growth boundaries and other types of zoning, can make housing less affordable. These promote urban sprawl, with its consequences for air pollution, energy use and carbon emissions, and ultimately conflict with global climate goals. In this regard, the OECD Horizontal Project (OECD 2019) is a welcome development. It has developed holistic, evidence-based policy to address issues "that cut across many policy areas, including social housing, urban land use regulation, financial regulation, taxation, local public finance, welfare support, transport policies, housing standards, rental regulation and the enforcement of competition in related activities (e.g., construction, real estate)" (OECD 2021). Building on earlier work, data improvements include more granular, internationally comparable data on house prices, across regions and within countries. Comparable data on rents and land-use regulations, taxation, energy efficiency, data pertaining to affordable housing and homelessness, and data on the contribution of housing to wealth inequality make it possible to benchmark policies to develop better outcomes.

Much has been learned from the GFC about the nature of housing cycles and their broader economic implications. Improvements have been made to theoretical and empirical models that not only can help analysts and researchers better understand housing cycles, but also aid policymakers in tempering the severity of such cycles and their economic fallout. In coming years, housing research will likely benefit not only from major improvements in data from national and international initiatives such as the NMDB in the United States and the OECD's Horizontal Project, respectively, but also from advances in incorporating heterogeneity and interactions between housing actors. Understanding and addressing the housing implications of the COVID-19 pandemic will likely entail dealing with many of the factors and transmission mechanisms highlighted in our survey. These include housing vulnerabilities, credit shocks, collateral effects and housing-related macroprudential policies, although researchers will need to carefully account for the myriad of fiscal, monetary, and regulatory policies that have been enacted after the GFC.

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