CHAPTER 3

HOUSE PRICE SYNCHRONIZATION: WHAT ROLE FOR FINANCIAL FACTORS?

Summary

Rising house prices have been a feature of the economic recovery in many countries since the global financial crisis. But recent increases have also been occurring in an accommodative monetary policy environment in many advanced economies, raising the specter of financial instability should financial conditions reverse and simultaneously lead to a decline in house prices.

This chapter analyzes whether and how house prices move in tandem across countries and major global cities; that is, the *synchronicity* of global house prices. On the one hand, higher house price synchronization and deeper global links in housing markets may be beneficial. On the other hand, higher synchronization may be the result of global financial conditions influencing local house price dynamics and housing markets, thereby propagating local economic and financial shocks. The analysis in this chapter aims to inform the views that policymakers ought to take on the synchronicity in house prices.

Strikingly, the chapter finds an increase in house price synchronization, on balance, for 40 countries and 44 major cities in advanced and emerging market economies. The chapter's analysis suggests that countries' and cities' exposure to global financial conditions may provide an explanation for the increase in house price synchronization. Moreover, cities in advanced economies may be particularly exposed to global financial conditions, perhaps owing to their integration with global financial markets or to their attractiveness for global investors searching for yield or safe assets.

Thus, policymakers cannot ignore the possibility that shocks to house prices elsewhere may affect domestic markets. While house price synchronization in and of itself may not warrant policy intervention, the evidence presented in this chapter suggests that heightened synchronicity of house prices can signal a downside tail risk to real economic activity, especially when taking place in a buoyant credit environment. The chapter finds that macroprudential policies seem to retain some ability to influence local house price developments even in countries with highly synchronized housing markets, and that macroprudential policy measures put in place to tame rising vulnerabilities in a country's financial sector may have the additional effect of reducing a country's house price synchronization with the rest of the world. These unintended effects are worth considering when evaluating the trade-offs of implementing macroprudential and other policies.

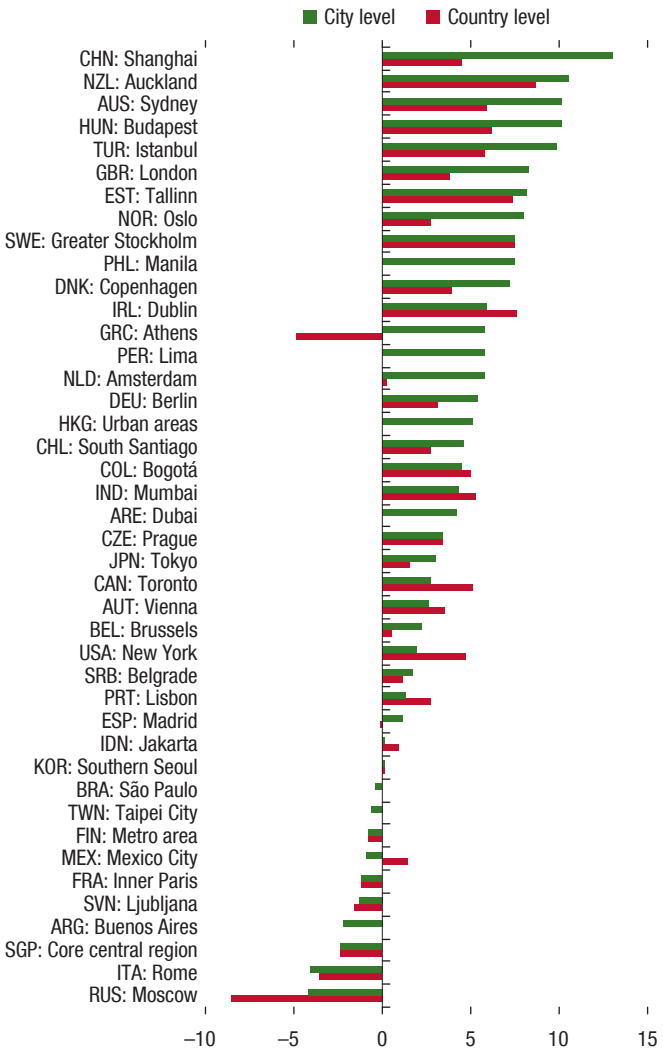
Introduction

Rising house prices have been a feature of the economic recovery in many countries since the global financial crisis (Figure 3.1). House price gains have been widespread and, in some markets, brisk. Indeed, in recent years, the simultaneous growth in house prices in many countries and cities located in advanced and emerging market economies parallels the coordinated run-up seen before the crisis (Figure 3.2).

House prices may comove across countries and cities because economic activity has picked up at similar times. During 2017, there was a pickup in growth in 120 economies, accounting for three-quarters of world GDP, which was the broadest synchronized global growth upsurge since 2010 (IMF 2018a). The widespread boost to economic growth may support additional housing demand across many countries, leading to upward pressure on house prices.

Global financial conditions—that is, those prevailing in major financial centers—and cross-border capital flows may also explain the comovement in house prices (see Rey 2015 and Chapter 3 of the April 2017 *Global Financial Stability Report* [GFSR]).[1] Recent increases in house prices have been occurring in an environment of easy financial conditions in major advanced economies characterized by low policy rates, compressed spreads, and low volatility that has spread globally (Figure 3.2). Moreover, in some housing markets, the motives of global and institutional investors searching for yield in a low-interest-rate environment have emerged as a potential explanation for the brisk and synchronized increases in house prices. In the past several years, real estate investments—including in residential real estate—by private equity firms, real estate investment trusts (REITs), and institutional investors appear to have grown (Figure 3.3), and anecdotes point to increasing investor participation in select housing markets, such as Amsterdam, Melbourne, Sydney, Toronto,

Figure 3.1. House Price Gains in Selected Cities and Countries Have Been Widespread
(Average annual real house price growth, 2013–17, percent)



Sources: Bank for International Settlements; CEIC Data Co. Ltd; Emerging Markets Economic Data Ltd; Global Financial Data Solutions; Haver Analytics; IMF, Research Department house price data set; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Data used in this figure comes from the sources listed above, and therefore they could differ from data published by national authorities. Nominal house prices are deflated by consumer price inflation, when real house prices are not readily available in the sources above. Cities selected are the largest cities in each economy in the sample based on population owing to data availability, and overlap with the top 50 cities for global investors identified by Cushman & Wakefield (2017). Labels in the figure use International Organization for Standardization (ISO) codes. Latest available data as of 2017:Q2 for most economies; fewer than 15 economies have data through 2017:Q3.

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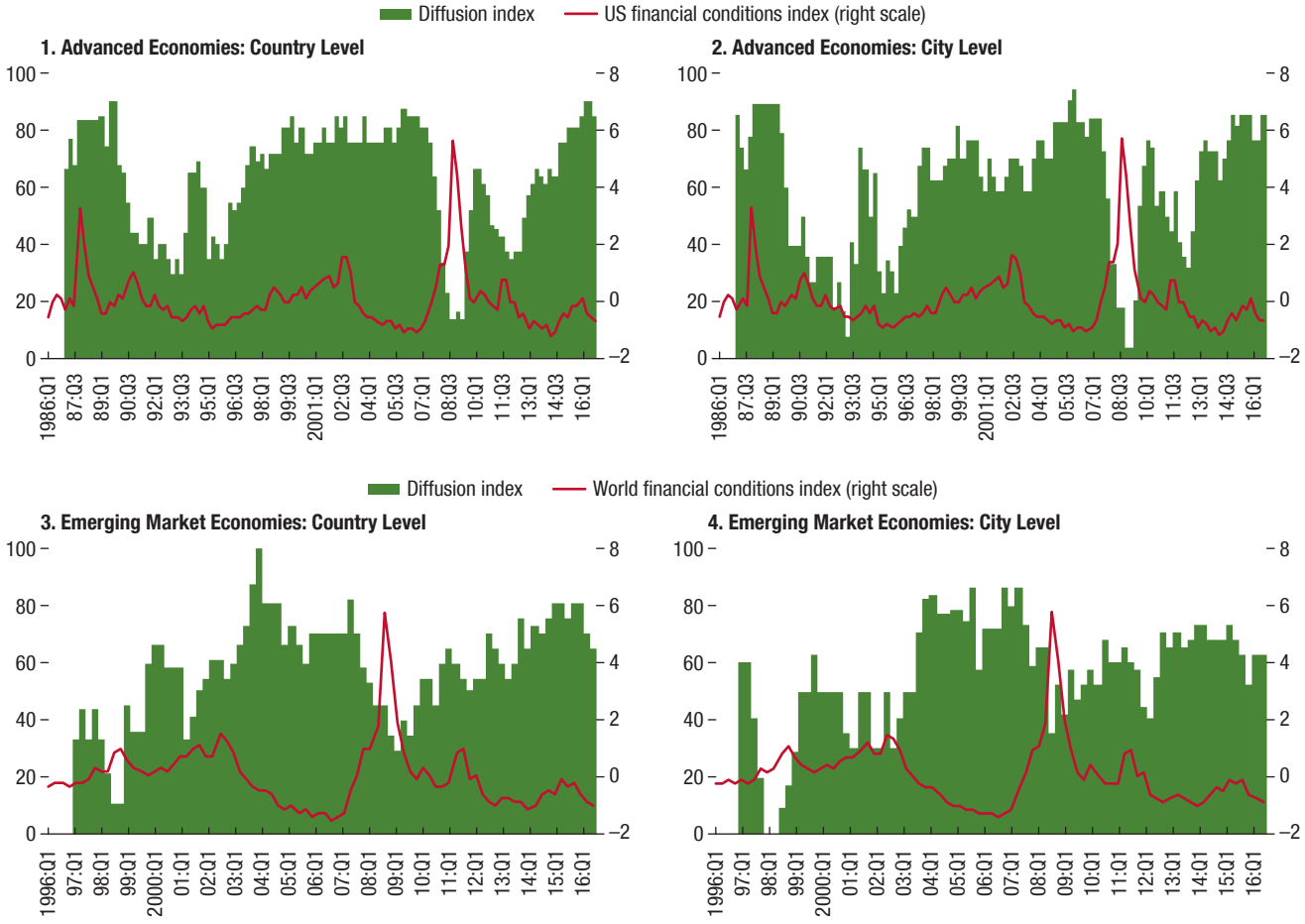
[1]Moreover, global financial conditions may affect the comovement in commercial real estate prices, but the chapter does not analyze the synchronicity in commercial real estate prices because high-quality, cross-country comparable data are limited to fewer than 10 countries.

Figure 3.2. Widespread House Price Gains Have Accompanied Accommodative Financial Conditions (Diffusion Index of House Price Growth and Global Financial Conditions)
(Left scale = percent; right scale = standard deviations)



Source: IMF staff calculations.
Note: Diffusion index is based on year-over-year growth rates of real house prices. This index measures the share of positive house price growth observations in each quarter.

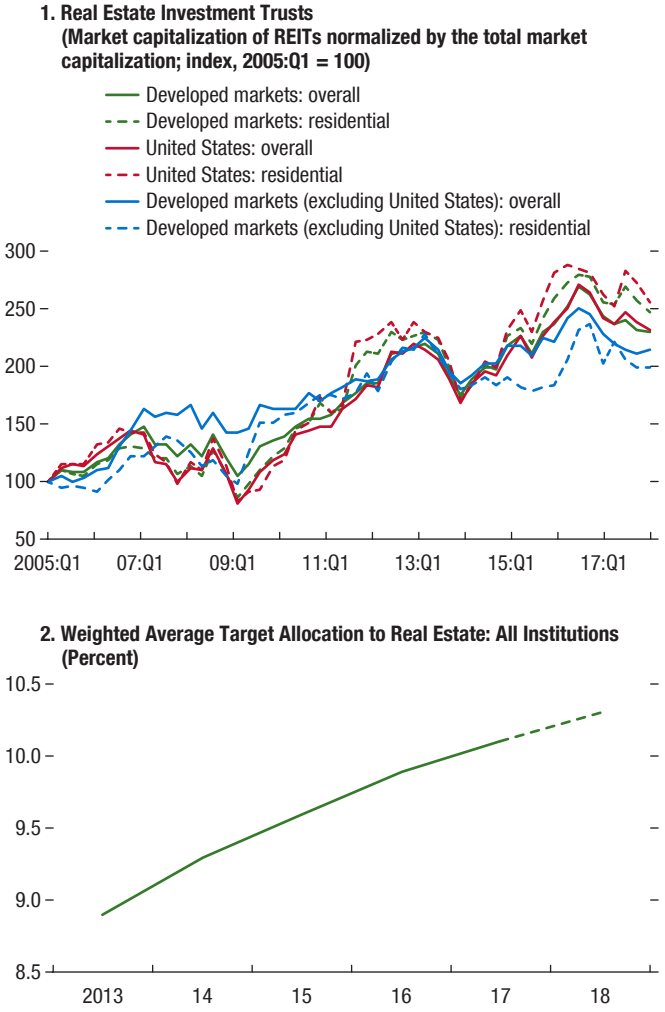
and Vancouver (Zillow Research 2017; Bloomberg News 2018).[2]

Synchronicity, or the correlation, in house prices should concern policymakers because it may signal stronger transmission of external shocks to local housing markets. The global integration of housing markets may contribute to house price synchronization, as well as to more liquidity in housing and mortgage markets, higher capital flows from abroad, and enhanced risk-sharing opportunities for households and lenders.

[2]Other factors, such as illicit capital flows, motives for tax evasion, or the legal environment, may contribute to cross-border real estate purchases, but analyzing these issues is beyond the scope of this chapter.

At the same time, however, the links across housing markets may transmit or amplify financial and macroeconomic shocks, increasing the exposure of local housing markets to global financial conditions or to shocks affecting foreign investors active in local markets. As a result, policymakers' ability to address imbalances in the housing market through national or local policies may be constrained, particularly if house prices across many countries decline at once. In this case, a decline in external demand may exacerbate the challenges of stabilizing household balance sheets, financial markets, and economic activity. In this sense, a sharp reversal of the prevailing accommodative global financial conditions could challenge how policymakers

Figure 3.3. Institutional Investor Participation Has Been on the Rise



Sources: Jones and Weill (2017); Thomson Reuters Datastream; and IMF staff calculations.
Note: Developed markets correspond to the aggregate REITs series compiled by Thomson Reuters Datastream for developed markets in line with the country classifications from Morgan Stanley Capital International and Dow Jones.
REITs = real estate investment trusts.

address financial and macroeconomic instability should a simultaneous decline in house prices occur.

This chapter analyzes whether and how house prices move in tandem across countries and major global cities; that is, the synchronicity in global house prices and its determinants. Using quarterly data on house prices for countries and major cities (see Annex 3.1), the chapter addresses the following questions:

- What are the trends in the synchronization of house prices across countries and across major cities? Has synchronization increased in recent years? Did it increase before the global financial crisis?
- What factors contribute to or dampen synchronicity? Is there a role for financial factors, or is house price synchronization related mainly to the comovement in economic activity? Do bilateral or two-way links between country or city pairs matter for synchronicity or do only global factors matter?
- Should policymakers pay attention to house price synchronicity to gain a better understanding of financial vulnerabilities and risks?

The chapter's focus on house price synchronization should not detract from the important task of monitoring house prices in individual markets. In fact, the analysis in the chapter seeks to complement bilateral surveillance efforts and country-level analysis that can explore house price valuation and dynamics using sophisticated models and rich data.

The main findings are as follows:

- On balance, synchronization in house prices across countries and major cities has increased over the past several decades in advanced and emerging market economies. This trend follows the rise in the comovement of financial asset prices documented elsewhere (see Chapter 2 of the April 2016 GFSR).
- The short-term comovement in house prices sharply increases around the time of global recessions in advanced economies. These spikes are much larger among major cities than at the country level, suggesting that the ramifications of the global financial cycle for cities may be particularly notable.
- Global financial conditions contribute to synchronization in house prices across pairs of countries and cities even after accounting for the comovement in economic activity and other fixed and time-varying fundamentals. Their contribution is particularly strong in major cities in advanced economies that are usually more integrated with global financial markets but also where local supply constraints may be more binding. The presence of global investors searching for yield or safe assets in major cities may also be an explanation.
- The dynamics of house prices are similar to those of other financial assets. For example, the expected return to investing in housing varies over time and is predictable in the long term. In the financial literature, this pattern is usually associated with variations in the risk premium demanded by investors,

indicating that the demand for housing may also be influenced by investors.
- Higher house price synchronization corresponds to increased downside risks to growth at horizons of up to one year, controlling for other financial and macroeconomic conditions. This finding suggests that the comovement in house prices can help predict the tail risk of an economic downturn.

The policy discussion for this chapter centers around the following sets of issues:
- Policymakers may wish to monitor the synchronization of house prices with respect to other countries, in addition to the over- or undervaluation of house prices within a country. To that end, increasing the granularity, timeliness, and coverage of data on house prices within countries would help provide richer indicators for bilateral and multilateral surveillance. In addition, more comprehensive data on the participation of global and institutional investors in housing markets would strengthen surveillance efforts.
- Macroprudential policies seem to retain some ability to influence local house price developments in countries with highly synchronized housing markets, albeit to a lesser extent than in those that are less synchronized. Consistently, macroprudential policy measures put in place to tame rising vulnerabilities in a country's financial sector are followed by a decline in a country's house price synchronization, suggesting that some of the drivers of synchronization operate through local financial intermediaries. Fiscal-based policies, such as ad valorem and buyers' stamp duty taxes, may also lower house price synchronization, but less so than other measures, such as limits on loan-to-value ratios. These unintended effects are an aspect to consider when evaluating the trade-offs of implementing macroprudential and other policies (IMF 2013).
- Other policies that enhance resilience to global financial shocks may also dampen house price synchronicity. This chapter presents evidence that exchange rate flexibility plays a role, but policies that deepen domestic real estate markets—or consumer financial protections that discourage excessive or predatory lending to households—may also help.

The rest of this chapter covers four areas. First, the next section provides a conceptual framework for analyzing house price synchronization. Second, stylized facts are presented to document trends and heterogeneity in house price synchronization across advanced and emerging market economies. Third, potential contributors to house price synchronization are analyzed, as is the importance of this measure for economic growth. The final section concludes with a policy discussion.

House Price Synchronicity: A Conceptual Framework

House prices may move in tandem across countries and major cities because of synchronous supply and demand factors (Figure 3.4).[3] Supply-side considerations include the costs of construction and land acquisition. On the demand side, demographics, tax and other policy considerations, and depreciation and maintenance play a role. Financial factors, such as the mortgage interest rate, the risk premium on assets with similar risk characteristics as housing, household leverage, and the expected nominal house price appreciation rate, also matter.[4]

The comovement in economic fundamentals may be a source of house price synchronization. Several of these factors, such as construction costs, taxes, and demographics, tend to be slow moving and may lead to synchronization only over long horizons. However, other economic fundamentals, such as rent, income, and inflation, may lead to comovement in housing prices at shorter terms.[5] Indeed, the coincidence of recessions and housing downturns is well-documented, with trade and financial links between countries possibly playing a contributing role (Claessens, Kose, and Terrones 2011; Kose, Otrok, and Prasad 2012; Kalemli-Özcan, Papaioannou, and Peydró 2013; Leamer 2015).

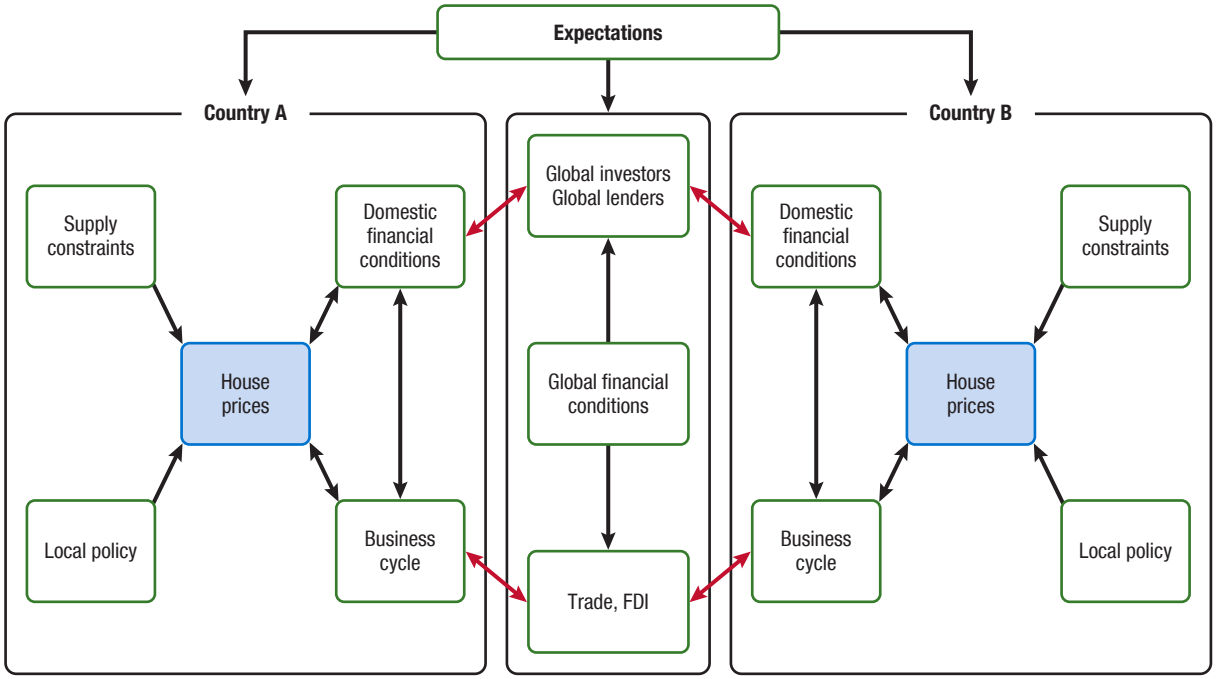
Simultaneous changes to financial factors can also lead to greater house price synchronization. Changing interest rates, risk premiums, or expected capital gains

[3]For an example of an asset pricing model that decomposes supply and demand factors for housing, see Poterba (1984) and Poterba, Weil, and Shiller (1991).

[4]Together, these nonfinancial and financial demand-side factors determine the annual cost of homeownership, which is a function of the user cost of housing. See US Department of Housing and Urban Development (2000) for the precise details of how user costs are calculated in the United States, and Poterba (1984) and Poterba, Weil, and Shiller (1991) for a more general discussion.

[5]See the October 2013 *World Economic Outlook* (WEO) for a discussion of the factors contributing to the synchronization in business cycles.

Figure 3.4. Global Financial Conditions, Portfolio Channels, and Expectations Contribute to House Price Synchronization, as Do Supply Constraints and Local Policy



Source: IMF staff.
Note: FDI = foreign direct investment.

may increase the comovement in house prices through the following mechanisms (Figure 3.4):[6]

- *Changes in global financial conditions:* The international transmission of financial conditions, such as those occurring because of a change in monetary policy in one large country, usually occurs through capital flows (Chapter 3 of the April 2017 GFSR).[7] These flows do not need to go directly into housing investments as long as they affect credit availability and mortgage rates in the receiving country. In addition, an increase in the global demand for safe assets may compress the rates of sovereign bonds considered as low risk, thereby holding down mortgage rates and supporting booming house prices across many countries at once (Bernanke and others 2011).
- *Portfolio channels:* The presence of common lenders or investors allows for the interdependence in house prices in both crisis and normal times for reasons potentially unrelated to economic fundamentals.[8] For example, a shock in one country may lead global financial institutions to pull back on mortgage lending in many countries, perhaps to maintain capital requirements (Allen and Gale 2000; Cetorelli and Goldberg 2011). Alternatively, investors experiencing distress in one market may liquidate leveraged housing investments in other countries, possibly to meet margin calls or in anticipation of future redemptions, or may rebalance their portfolios to follow predetermined investment mandates (Kodres and Pritsker 2002). Or shocks in one country can result in changes to investors' risk appetite and lead them to increase or withdraw their housing investments from many countries at once (Acharya and Pedersen 2005). In the housing market, recent

[6]The user cost may also shift simultaneously across countries if there is a coordinated tax reform that similarly changes tax rates or aligns the tax deductibility of mortgage interest, but this chapter does not focus on these issues.

[7]Hirata and others (2012) find a role for a broader range of global shocks, such as those to interest rates, productivity, credit, and uncertainty.

[8]See Chapter 2 of the April 2016 GFSR for a discussion of the sources of financial market spillovers.

developments point to the growing contribution of global and institutional investors to house price dynamics in select major cities (Hekwolter of Hekhuis, Nijskens, and Heeringa 2017). Though they are limited in number in the aggregate, the geographic concentration of investors in certain cities may make house price synchronization more apparent among cities than among countries. These channels may also contribute to house price synchronization in normal times through arbitrage and mortgage rates.

- *Changes in expected capital gains:* A coordinated change in households' or investors' views of future house prices across many countries can also result in synchronicity. These changes in expectations can be driven by rational views regarding future fundamentals (Himmelberg, Mayer, and Sinai 2005), but also by bouts of overoptimism, psychological factors, and speculation (Shiller 2015). Rational or irrational beliefs about house prices can propagate through social networks, word of mouth, and other interpersonal links (Bailey and others 2016). If a wake-up call leads to reassessment of these beliefs, perhaps in response to a shock in one country, a widespread realignment of house prices with fundamentals could occur (Goldstein 1998). There could even be a systematic overcorrection if house prices exhibit momentum and excess variance relative to fundamentals (Case and Shiller 1990; Glaeser, Ponzetto, and Shleifer 2016).

As with many financial assets, institutional characteristics may influence whether financial factors lead to simultaneous changes in house prices across countries. For example, financial integration can expose mortgage markets to global financial conditions and expose local financial markets to sudden stops in capital flows (Chapter 3 of the April 2017 GFSR). Moreover, a country's financial integration may create a favorable environment for global investors to purchase housing directly, allowing global factors to influence local house prices and local shocks to spread more widely through a variety of mechanisms (see earlier discussion).[9] In contrast, greater exchange rate flexibility may dampen the impact of global financial conditions because monetary policies may have more bite under such circumstances.

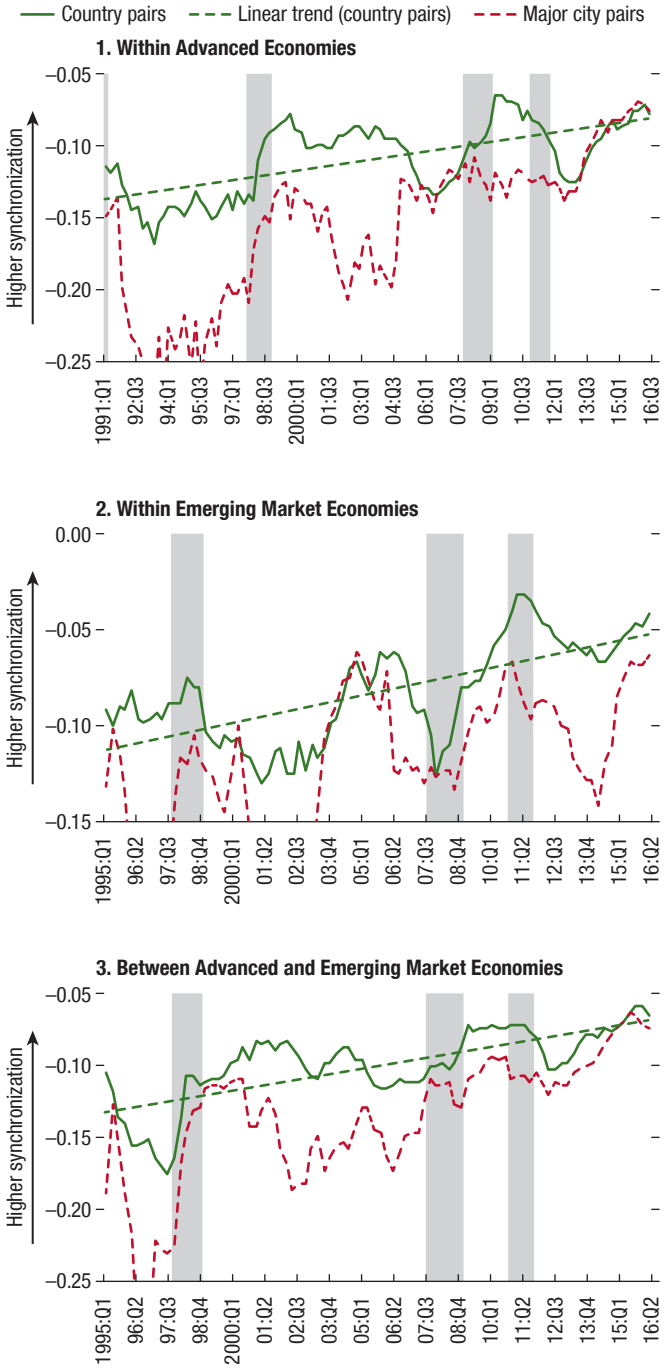
Fluctuations in home values pose risks to households and financial institutions even if they occur in only one country at a time. In a booming house price environment, households may engage in excessive risk taking (Mian and Sufi 2009; Bhutta and Keys 2016), financial institutions may relax lending standards (Demyanyk and Van Hemert 2009; Dell'Ariccia, Igan, and Laeven 2012; Chapter 2 of the April 2018 GFSR), and there may be overbuilding (Haughwout and others 2011). Thus, once the boom ends, a decline in house prices may result in risks to macroeconomic and financial stability. Consumption may fall given that housing is often the largest component of household wealth in many countries, and household deleveraging may be a further drag on growth (Chapter 2 of the October 2017 GFSR; Mian and Sufi 2009). Furthermore, banks' exposures to house prices can cause them financial difficulties and may lead them to curtail many forms of lending, which, in turn, can lower employment (Berrospide, Black, and Keeton 2016; Glancy 2017). Moreover, housing is a physical asset that requires maintenance and cannot be moved, so fire sales are often associated with blight and crime, which are destabilizing at the local level, because distressed homes often sit vacant before they are sold (Campbell, Giglio, and Pathak 2011; Anenberg and Kung 2014). These costs are borne not just by the households living in neighborhoods with distressed sales but also by financial institutions if the legal system is such that the ownership of foreclosed properties is transferred to them.

The challenges to macro-financial stability posed by a house price decline in a given country can be larger if the decline is synchronized with declines in other countries. In this case, the pullback in consumption and investment driven by balance sheet deleveraging would coincide with a decline in external demand,

[9]See Forbes (2012); Bekaert, Lundblad, and Siegel (2011); Bekaert and Harvey (2000); Burger, Warnock, and Cacdac Warnock (2012); and Miyajima, Mohanty, and Chan (2015) on equity and bond market integration. Theoretically, greater financial integration may also correspond to less house price synchronization given that housing purchases are tied to business cycles. This relationship may arise through the specialization of production or because of how financially integrated banks differentially increase lending to countries experiencing productivity shocks and contribute to divergent output growth (Kalemli-Özcan, Papaioannou, and Peydró 2013). Finally, greater participation of foreign investors, especially those with long horizons, may be able to stabilize asset prices, including housing, if they behave countercyclically and take advantage of fire sale opportunities. This would lead to a dampening of other drivers of synchronicity, although evidence on this countercyclical behavior may be limited (Chapter 2 of the April 2014 GFSR).

Figure 3.5. Synchronization Has Steadily Increased across Countries and Cities

(Median synchronization; closer to zero denotes higher synchronization)



Source: IMF staff estimates.
Note: The Synch1 measure capturing the negative of the absolute difference between two countries' house price gaps is used. See Annex 3.2 for methodology. Shaded areas correspond to US recessions.

leaving little room for the current account to offset the contraction in domestic demand. Indeed, in the past, large and widespread house price swings have been associated with periods of financial instability across many countries at once (Claessens, Kose, and Terrones 2008, 2011; Reinhart and Rogoff 2008). These risks would be compounded if a pullback among global investors were to lead to fire sales across asset classes, capital flight, and tighter mortgage market conditions (Kaminsky and Reinhart 2000; Campbell, Giglio, and Pathak 2011; Bekaert and others 2014; Chinco and Mayer 2015).[10]

House Price Synchronization in Countries and Cities

Different measures of house price synchronization capture distinct dimensions of this phenomenon. Synchronization can be measured in different ways and at different frequencies. To capture these distinctions, this chapter uses a broad set of measures applied to the comovement in house prices across countries and cities. All measures focus on either the cyclical component of real house prices—henceforth, the house price gap—or the quarterly growth rate in real house prices. The former removes the medium-term trend in these prices and allows for comparisons of housing markets with different medium-term cycles. The latter provides a higher-frequency measure of house price growth that can be analyzed at long horizons. Annex 3.2 provides details of these measures.

Synchronicity in housing markets has markedly increased over time.

- On balance, the house price gap has become more synchronized in countries and cities in advanced and emerging market economies (Figure 3.5).[11] The synchronization in the house price gap reflects medium-term changes to how shocks propagate

[10]More specifically, such a pullback could directly cause or accompany instability. Previous GFSR research analyzing the financial stability implications of rising equity and bond price correlations has found that financial factors explain cross-country spillovers and investor retrenchment during crises (see Chapter 3 of the April 2014 GFSR and Chapter 2 of the April 2016 GFSR). Moreover, as with financial assets, at times of fire sales, global investors may base their decision to sell on how liquid a particular housing market is rather than on the fundamentals of the housing market.

[11]The period for which data are available for each group starts in 1973 for advanced economies and 1995 for emerging market economies.

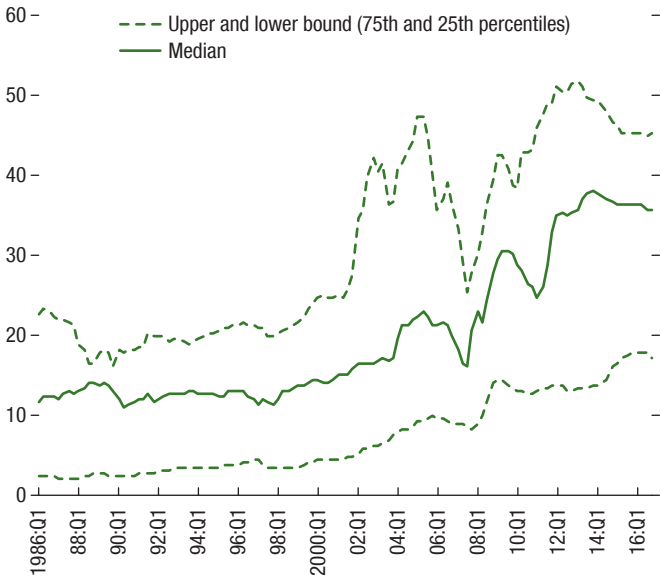
across countries or cities (see Annexes 3.2 and 3.3).[12] Between 1991 and 2016, synchronicity is lower among major cities in advanced economies than among the countries where they are located, but it has gradually moved closer to country-level synchronicity. This pattern is intriguing because synchronicity should be lower among cities that are affected by idiosyncratic shocks that average out at the country level, and it indicates that the factors driving house price synchronicity have become disproportionately more important for cities. This finding motivates a closer look at the house price dynamics of major cities. Among emerging markets, synchronicity between countries and between major cities is similar, perhaps for purely statistical reasons (the major city often represents the bulk of the national house price index) or because of more integrated internal housing markets.

- In many advanced economies, moreover, the increase in synchronization is evident in the rising share of the variation in house price growth explained by a common global factor (Figure 3.6). A dynamic factor model estimates that the share of the variance explained by the estimated global factor increases from about 10 percent to 30 percent over the period from 1971 to 2016.[13] This common global factor summarizes the long-term contribution of many sources of house price synchronicity, including the role of global financial developments and the tightening of financial links, among others (see Annex 3.3).

The short-term comovement in house prices increases sharply around the time of global recessions in advanced economies. This can be seen in Figure 3.7, which depicts the instantaneous quasi correlation, a measure of short-term comovement, in house price gaps. The sharp increases around global economic downturns are noticeable and may reflect common shocks affecting housing markets in many advanced economies.[14] For example, the housing boom of the 2000s extended to many advanced economies, and simultaneous declines in house prices triggered large financial sector losses worldwide during the global financial crisis. Common shocks appear to affect emerging market economies differently, as evidenced by the fact that the comovement in house prices is less likely to shoot up around the time of global recessions. Among advanced economies, the increase in short-term synchronicity before recessions is much larger between major cities than between countries. This again suggests that the factors driving this synchronous movement may particularly affect major cities in advanced economies.

Countries and cities differ in how synchronized they are. Their exposure to the common global factor varies, with a larger contribution of this factor to house prices in countries and cities in Europe than in other regions (Figure 3.8). In addition, advanced economies are more exposed than emerging market

Figure 3.6. The Relative Contribution of the Global Factor Has Grown
(Window = 15 years; percent)



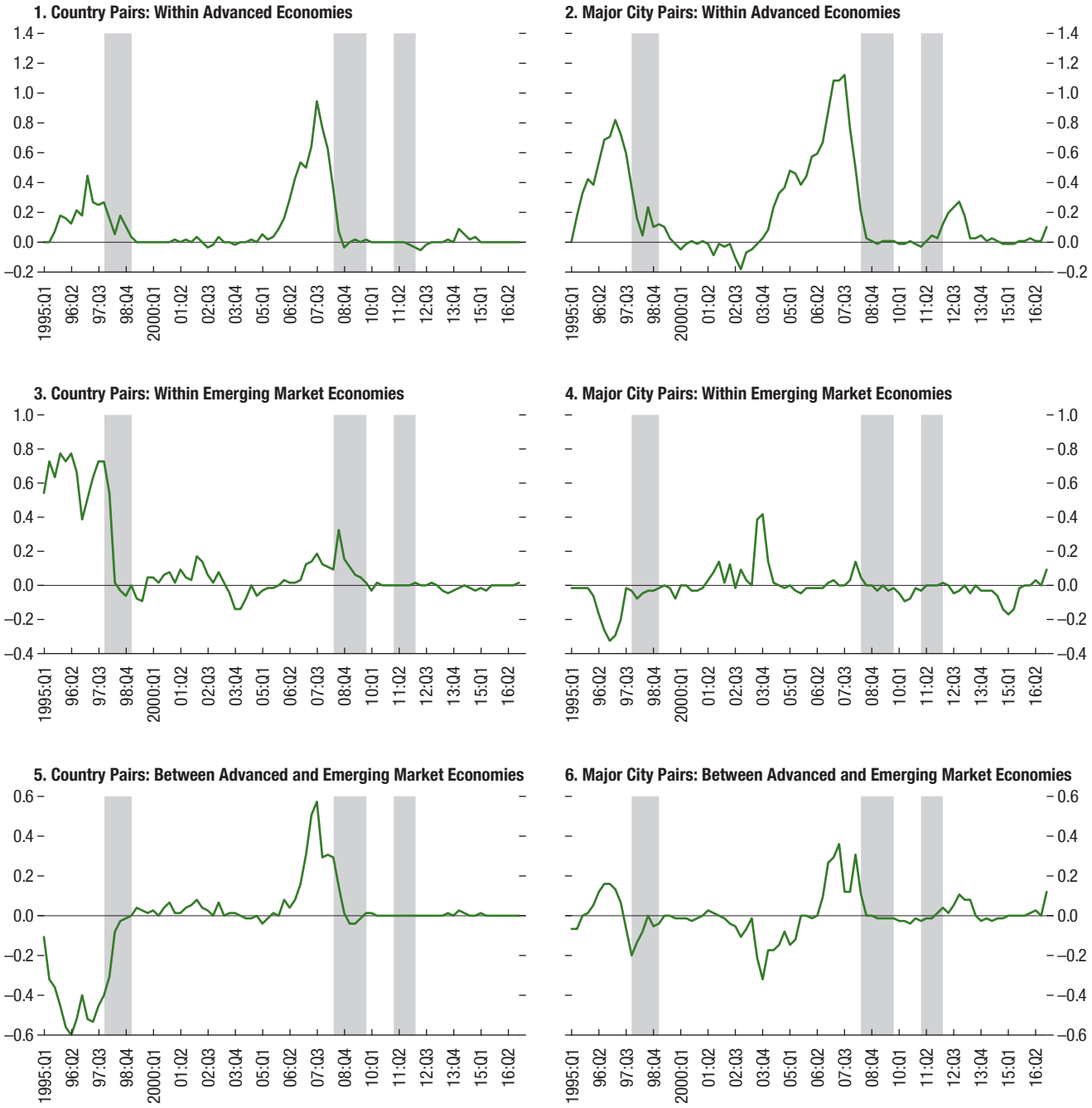
Source: IMF staff estimates.
Note: The figure shows the rolling estimation with a 15-year window for the share of the variation in house price growth explained by a common global factor in the dynamic factor model. See Annex 3.3.

[12]A similar pattern is found when using seven-year rolling correlations in house price gaps.

[13]The factor loadings and vector autoregression parameters are simultaneously estimated by the two-step procedure proposed in Koop and Korobilis (2013) using data for 19 advanced economies from the second quarter of 1971 to the fourth quarter of 2016. This procedure requires long time series, so it cannot be adequately applied to most emerging market economies.

[14]The instantaneous quasi correlation is constructed not to have a trend (see Annexes 3.2 and 3.3).

Figure 3.7. Instantaneous Quasi Correlation of House Price Gaps Shows Financial Cycle Properties (Median Shown)



Source: IMF staff estimates.
Note: Higher quasi correlation values imply that the house price gaps of both countries (cities) are simultaneously above or below their respective historical averages. See Annex 3.2 for methodology for quasi-correlation computation. Shaded areas correspond to US recessions.

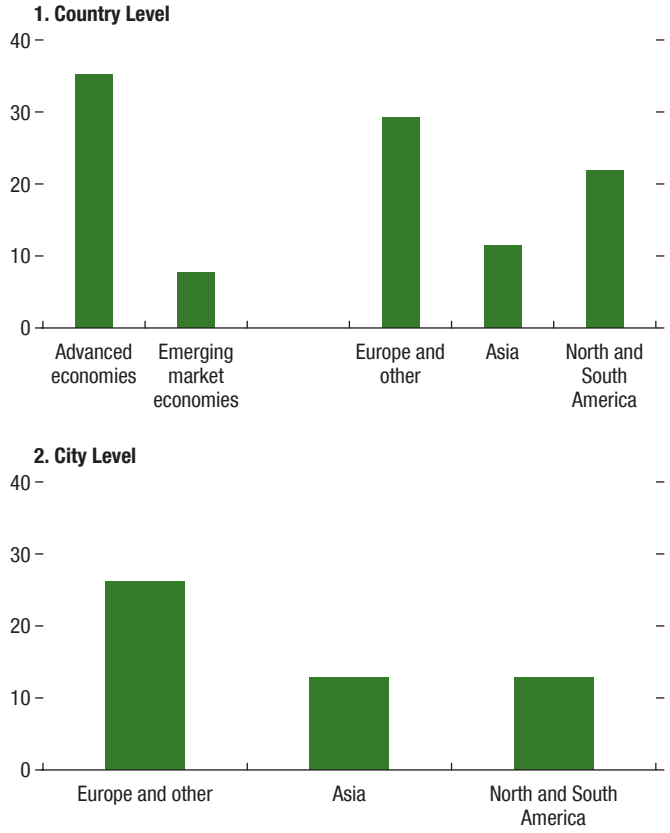
economies to global factors. Over time, the relative importance of the global factor has increased, but not uniformly across advanced economies.[15]

Countries and cities also differ in how interconnected they are. The approach in Diebold and Yilmaz (2014) offers one way to measure the interconnectedness in housing markets via an examination of quarterly house price growth correlations.[16] This approach shows that, after controlling for various global factors, countries' housing markets account differentially for house price developments in other countries. Moreover, countries differ in the degree to which their house prices can be attributed to other countries' house prices. For example, many large advanced economies' housing markets are closely interconnected, as suggested by their central location and proximity to other economies in a network map representing the links in housing markets (Figure 3.9). In contrast, many emerging market economies show weaker connectivity with other countries.

Cities may have housing markets that are highly interconnected even if their countries do not have strong connectivity (Figure 3.10). Some cities lie more at the core of the network, possibly reflecting the deviation of house price dynamics in these cities from the rest of their respective countries' experiences. For instance, while at the country level Japan is on the periphery of the network, at the city level, Tokyo is more centrally located, closer to cities such as London and Stockholm, perhaps reflecting the relative attractiveness of Tokyo to global investors over other cities in Japan. Moreover, looking at cities, it is apparent that many financial centers are more centrally positioned and influential, suggesting that city-level house price dynamics may also be transmitted across borders.

The interconnectedness of housing markets has also increased over time (Figure 3.11). Consistent with the rising trend in synchronicity discussed earlier, the network analysis shows that, on average, the share of the house price variance in a country that can be accounted for by changes in another *single* country—henceforth, "spillovers"—increased from 1.4 percent in 1990–2006 to 2.1 percent in 2007–16, which is a notable increase and comparable to that seen for equities (see Chapter 2 of the April 2016 GFSR).[17] Spillovers are particularly strong among advanced economies, but the proportional increase is the largest for spillovers from advanced economies to emerging market economies and then from emerging market economies to advanced economies, with average interconnectedness increasing by about 60 percent and 40 percent, respectively.

Figure 3.8. Relative Contribution of the Global Factor Varies across Regions
(Percent)



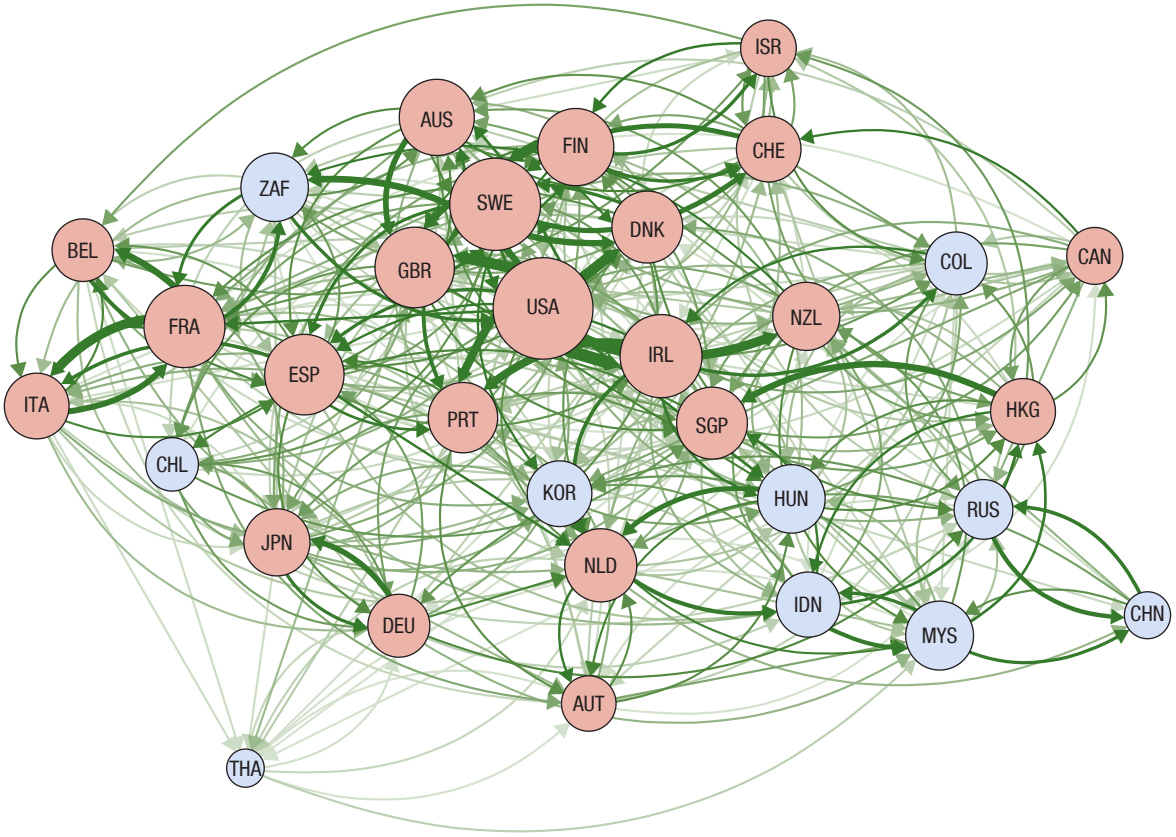
Source: IMF staff estimates.
Note: The figure shows the share of the variation in house price growth from 2002 to 2016 explained by a common global factor in the dynamic factor model. "Europe and other" category comprises European countries, South Africa, and Israel. See Annexes 3.2 and 3.3 for methodology.

[15]These results are available on request.

[16]Chapter 2 of the April 2016 GFSR explains the Diebold and Yilmaz (2014) methodology that is applied here.

[17]Data limitations preclude omitting the global financial crisis period in this comparison.

Figure 3.9. Economies Differ in Their House Price Interconnectedness



Source: IMF staff estimates.
Note: The figure is based on a vector autoregression of house price growth rates (quarter over quarter), controlling for global factors, from a sample covering 1990:Q1 to 2016:Q4. For methodology details, see Chapter 2 of the April 2016 *Global Financial Stability Report*. Node size is based on an economy's total outward spillovers. Pink nodes represent advanced economies, and blue nodes represent emerging market economies. Arrow thickness is based on link distribution. Only links above the 50th percentile are considered. The figure layout is based on the algorithm by Fruchterman and Reingold (1991) and plotted using the "qgraph" R package. Node labels used in the figure are International Organization for Standardization (ISO) codes. Following Morgan Stanley Capital International markets classification criteria and the IMF's *World Economic Outlook* country classification in 1990, the beginning of our sample, Korea is classified as an emerging market economy.

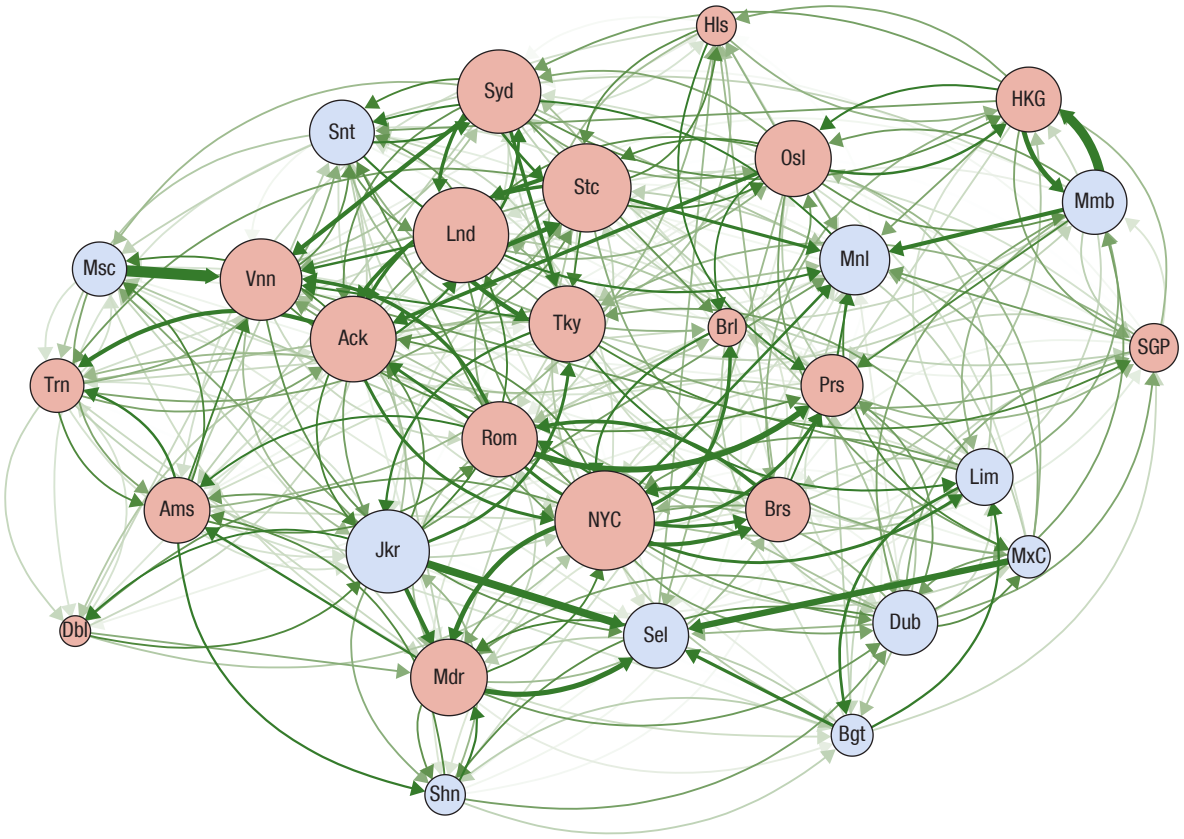
Analyzing Contributors to House Price Synchronization

What are the factors behind house price synchronization? What is the role of financial factors? As discussed earlier, the comovement in house prices may arise from synchronous business cycles or other nonfinancial economic fundamentals. To distinguish among potential factors, the econometric framework analyzes house price synchronization within country and city pairs over time.[18]

Countries with deeper financial links, as captured by their bilateral banking linkages, exhibit more synchronization (Figure 3.12). This result, which is independent of the comovement in output and other economic fundamentals, is consistent with financial factors propagating local economic or financial developments between

[18]The bilateral panel data approach removes hard-to-observe country characteristics influencing synchronicity in house prices across countries or cities, such as strong cultural ties, similar mortgage market design, or similar tax treatment of housing capital gains. Thus, the results discussed in this section are less likely to be confounded by these issues. The analyses are performed at the country-pair level using quarterly data from 1990 through 2016 for 40 countries (as well as for major city pairs) using two synchronicity measures: (1) negative value of the absolute difference in house price gaps (synch1), in which a value closer to zero suggests that the differences in house price gaps between two countries have declined; and (2) instantaneous quasi correlation of house price gaps (QCORR), in which a higher value implies that the house price gaps of both countries are simultaneously above or below their respective historical averages. See Annex 3.2 for a technical discussion of the econometric model.

Figure 3.10. Interconnectedness among Cities' House Prices Varies



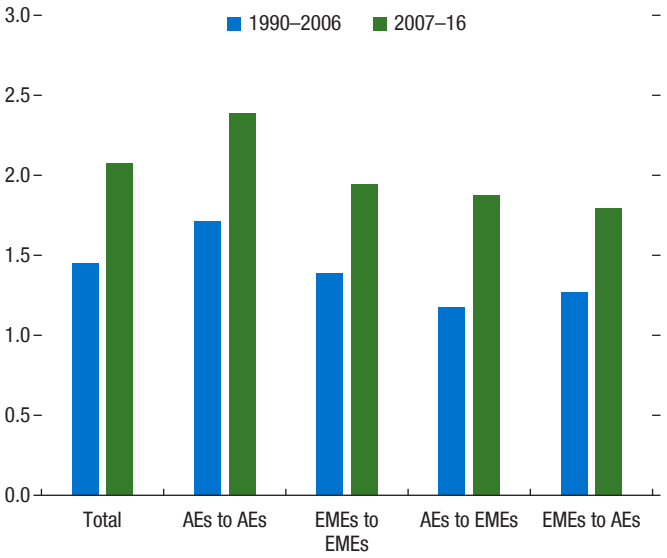
Source: IMF staff estimates.
Note: The figure is based on a vector autoregression of city-level house price growth rates (quarter over quarter), controlling for global factors, spanning 2004:Q1 to 2017:Q2. For methodology details, see Chapter 2 of the April 2016 *Global Financial Stability Report*. See Annex Table 3.1.2, note 1, for city selection criteria, conditional on data availability. Node size is based on the city's total outward spillovers. Pink nodes represent advanced economies, and blue nodes represent emerging market economies. Arrow thickness is based on link distribution. Only links above the 66th percentile are considered. The figure layout is based on the algorithm by Fruchterman and Reingold (1991) and plotted using the "qgraph" R package. Ack = Auckland; Ams = Amsterdam; Bgt = Bogotá; Brl = Berlin; Brs = Brussels; Dbl = Dublin; Dub = Dubai; HKG = Hong Kong SAR; Hls = Helsinki; Jkr = Jakarta; Lim = Lima; Lnd = London; Mdr = Madrid; Mmb = Mumbai; Mnl = Manila; Msc = Moscow; MxC = Mexico City; NYC = New York City; Osl = Oslo; Prs = Paris; Rom = Rome; Sel = Seoul; SGP = Singapore; Shn = Shanghai; Snt = Santiago; Stc = Stockholm; Syd = Sydney; Tky = Tokyo; Trn = Toronto; Vnn = Vienna. Following Morgan Stanley Capital International markets classification criteria and the IMF's *World Economic Outlook* country classification in 1990, the beginning of our sample, Korea (and thus Seoul) is classified as an emerging market economy.

two countries.[19] Moreover, the magnitude of the relationship is nearly as large as that between business cycle synchronization and house price synchronization, suggesting that financial frictions, such as contagion and sudden capital flow stops, may play an important role in transmitting shocks across countries (for example, see Allen and Gale 2000; Calvo and Mendoza 2000; Perri and Quadrini 2011). For instance, when a negative shock affects a country (or a set of countries), banks may retrench from activity abroad, triggering a credit crunch in other countries, which might lead to deeper recessions and lower asset prices.[20]

[19]These conclusions are robust to the inclusion of monetary policy synchronization and bilateral trade linkages as controls. While a causal link from bilateral banking linkages to house price synchronicity cannot be directly established from this analysis, the inclusion of country-pair fixed effects and multiple time-varying bilateral determinants reduces the possibility of confounding factors. Also, reverse causality, in which house price synchronicity increases bilateral banking linkages, is difficult since diversification motives should lead to a negative correlation between these two variables.

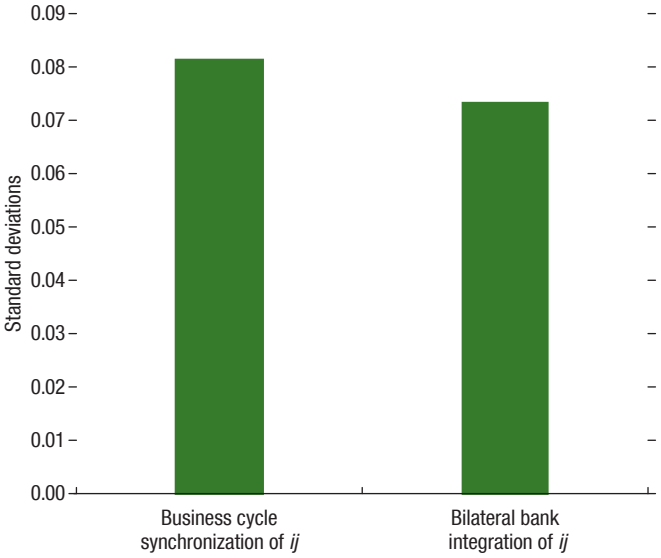
[20]For example, during the global financial crisis, subsidiaries of foreign banks had to reduce their operations in eastern Europe because of the subprime crisis and the new regulatory environment (Chapter 2 of the April 2015 GFSR). However, the results discussed here and in the literature are limited in identifying the mechanisms by which bank retrenchment may occur, as data on bilateral banking flows do not differentiate by their intended use.

Figure 3.11. Average Country-Level Housing Market Spillovers Have Increased
(Percentage points)



Source: IMF staff estimates.
Note: The figure is based on a vector autoregression of country-level house price growth rates (quarter over quarter), controlling for global factors, for two sample periods (1990–2006 and 2007–16). Spillovers are defined as the share of the house price variance in a country that can be accounted for by changes in another single country. For methodology, see Chapter 2 of the April 2016 *Global Financial Stability Report*. AEs = advanced economies; EMEs = emerging market economies.

Figure 3.12. Bilateral Links between Countries Are Associated with House Price Synchronization



Source: IMF staff estimates.
Note: Synchronicity is measured by the synch1 of gaps measure; see Annex 3.2 for computation methodology. Figure shows statistically significant standardized coefficients that are calculated using the coefficients in specification 4 in Annex Table 3.2.1 and their respective standard deviations, and presented in terms of standard deviations of the dependent variable; this specification also controls for global financial conditions (proxied through global liquidity) in addition to country-pair fixed effects and quadratic and linear time trends (standard errors are clustered at multiway at time, country *i*, and country *j*). The standard deviation for business cycle synchronization is 0.0124 and 1.040 for bilateral bank integration. See Country-Pair Analysis section of Annex 3.2 for further details. *i* = country 1 and *j* = country 2 in the country pair.

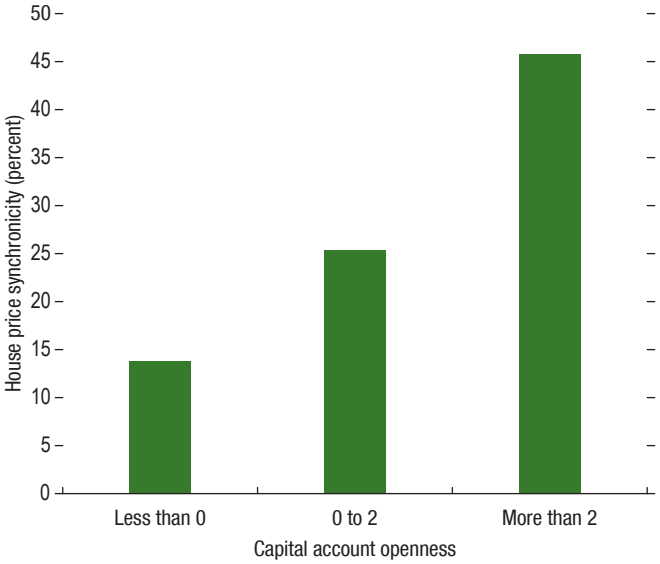
A country's financial openness contributes to house price synchronicity. Among advanced and emerging market economies, countries with greater capital account openness, as proxied by the Chinn-Ito index, are more exposed to global factors (Figure 3.13). Moreover, among the advanced economies that can be observed for a longer period, the rise in exposure to the global factor is observed in parallel with the increase in the comovement in equities documented here, in previous GFSRs, and elsewhere (Figure 3.14; Jordà and others 2017). Taken together, these results suggest that house price synchronization can be understood in the broad context of the asset price synchronization spurred by the evolution of financial openness.

Past increases in global liquidity, as well as good market sentiment and loose global financial conditions, are strongly associated with a higher short-term comovement in house prices. These relationships apply to the instantaneous quasi correlation in house price gaps when looking within country pairs in advanced and emerging market economies (Figure 3.15). Moreover, global financial factors play a role even after accounting for the comovement in business cycles, which points to an independent role for global factors in accounting for house price synchronization.

Greater exchange rate flexibility appears to dampen the importance of global financial conditions (Figure 3.15). The impact of global liquidity is lower in countries with high exchange rate flexibility, perhaps because countries with this feature may have tools for dealing with imbalances resulting from exposure to global financial conditions (Obstfeld, Ostry, and Qureshi 2017).[21] For instance, in countries where local currency loans prevail and exchange rates are flexible, central banks may have a stronger

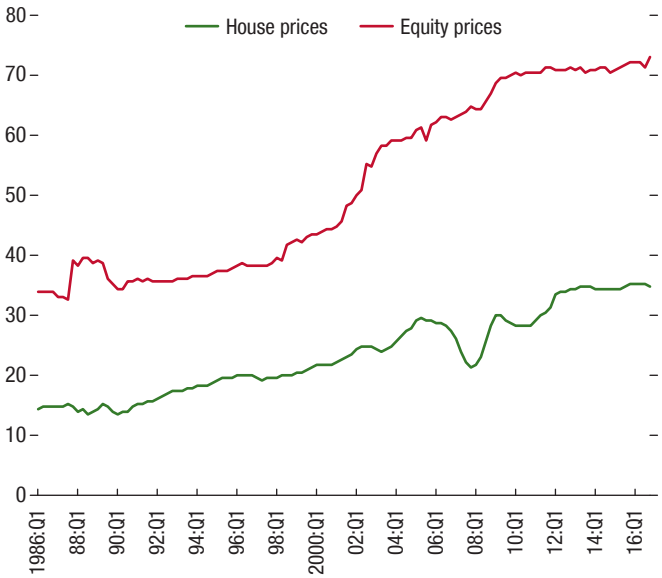
[21]Nominal rigidities may be less relevant in countries with exchange rate flexibility, dampening the role for global financial conditions.

Figure 3.13. Greater Financial Openness Is Associated with Higher House Price Synchronization



Sources: Chinn and Ito (2006); and IMF staff estimates.
Note: Synchronicity is measured by the share of the variation in house price growth from 2002 to 2016 explained by a common global factor in the dynamic factor model. See Annexes 3.2 and 3.3 for more details on methodologies.

Figure 3.14. On Average, the Global Factor for House Prices Has Increased along with That for Equities
(Window = 15 years; percent)



Source: IMF staff estimates.
Note: The figure shows the rolling estimation with a 15-year window for the share of the variation in house and equity price growth explained by a common global factor in the dynamic factor model. See Annexes 3.2 and 3.3 for methodology.

influence on short-term interest rates and thus on financing conditions.[22]

The contribution of global financial conditions to house price synchronization in cities is somewhat larger than for countries (Figure 3.15). If large cities attract global investors, house price comovement in cities may be particularly responsive to global financial conditions. This seems to be the case. Notably, cities in advanced economies show greater responsiveness to global financial conditions, using global liquidity as a proxy. These cities are, on average, more exposed to the global factor (Figure 3.8), but also may face constrained housing supply such that changes in housing demand driven by global liquidity conditions may have a more pronounced and coordinated impact.

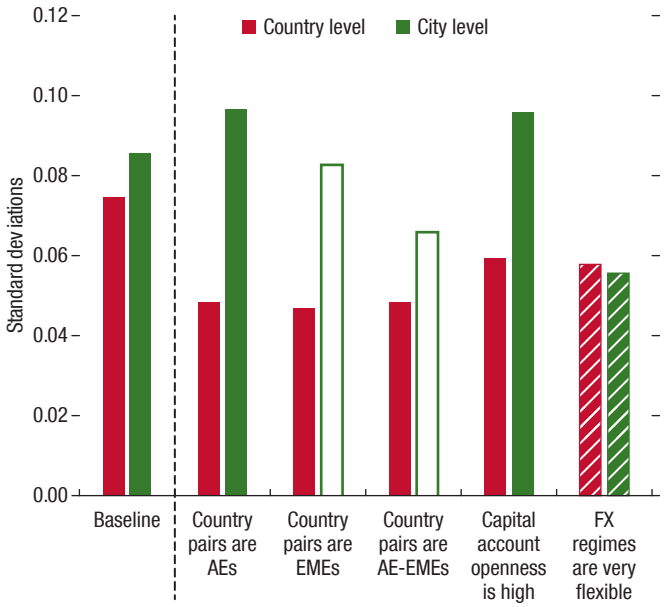
Indeed, city-level house price dynamics may reflect demand from global investors searching for yield or safe assets in residential real estate (Box 3.1). Granular analysis of housing market segments within the United States suggests that higher-priced homes are more responsive to changes in house prices of non-US cities. In particular, house prices in non-US cities characterized as destinations for global investors (such as London) exert more influence on higher-priced homes in the largest US cities, as would be the case if demand from global investors were exerting upward pressure on house prices in US and non-US markets.

The participation of global investors in local real estate markets may contribute to the behavior of housing returns, in addition to contributing to synchronized house prices across countries. As Box 3.2 discusses, as with many other financial assets, the expected return on housing assets varies over the investment horizon and is predictable in the long term. Moreover, this predictability is greater in countries with high capital account openness, suggesting that the risk sentiment of global investors is more likely to contribute to house price dynamics when capital account openness is high.

Global investors may also participate in the widespread acquisition of farmland, exposing remote devel-

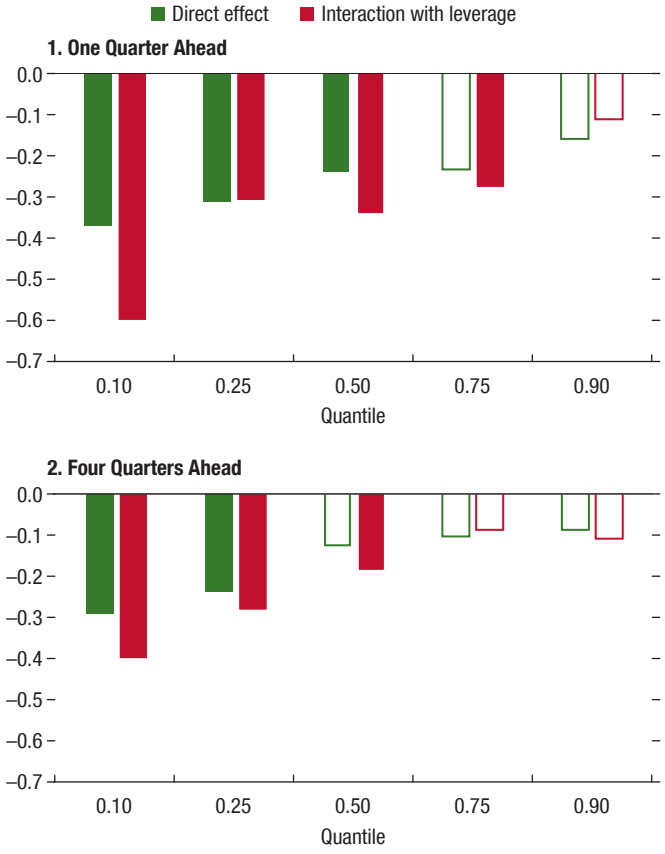
[22]However, recent literature has also found that long-term rates tend to be strongly influenced by global factors (Goodhart and Turner 2014; Obstfeld 2015), which might have a more important role in domestic real outcomes and asset prices. In addition, flexible exchange rates can amplify boom-bust cycles instead of acting as a shock absorber, because of leverage effects (especially when liabilities are mainly in foreign currency).

Figure 3.15. Global Financial Conditions, as Proxied by Global Liquidity, Have Different Associations with House Price Synchronization across Countries and Cities



Source: IMF staff estimates.
Note: Synchronicity is measured by the quasi correlation of gaps. Solid bars denote joint significance of the *F*-test at or above 90 percent. Patterned bars denote interaction terms that are statistically significant. Coefficients are standardized. For city level, 4th, 6th, and 8th bars correspond to city pairs that reside either in country pairs that are AEs, country pairs that are EMEs, or country pairs that are AE-EMEs, respectively. Standard deviation of the country-level dependent variable is approximately 0.85, and standard deviation of the city-level dependent variable is approximately 0.97. See Annex 3.2 for methodology and Annex Table 3.2.2 for detailed results. AEs = advanced economies; EMEs = emerging market economies; FX = foreign exchange rate.

Figure 3.16. House Price Synchronization Predicts a Downside Risk to Economic Growth at Short Horizons
(Quantile regression coefficients, percentage points of GDP)



Source: IMF staff estimates.
Note: Solid bars denote statistically significant quantile regression coefficients at a 10 percent confidence interval.

oping economies to global financial conditions. As explained in Box 3.3, private investors and food corporations turned to farmland as a new source of profit in the aftermath of the global financial crisis, motivated by low interest rates and diminished risk appetite.

House Price Synchronization and Risks to Growth

Higher house price synchronization corresponds to increased downside risks to growth at horizons of up to one year (Figure 3.16). In a standard growth-at-risk model, house price synchronization—as measured by the instantaneous quasi correlation between a country's house price growth and the global factor—appears to negatively affect the lower tail of the growth distribution, over and above the risks associated with the price of risk, leverage, and external conditions (Chapter 3 of the October 2017 GFSR). This means that a decline in one country's house prices, coinciding with those taking place in other countries, signals additional risks to growth.

In addition, at short horizons, the relationship between house price synchronization and risks to future growth is amplified when leverage is high (Figure 3.16). The negative impact of house price synchronicity is about twice as large when leverage is higher. The potential for a synchronized decline in house prices heightens the vulnerabilities associated with a highly leveraged economy.[23] When leverage

[23]While the relationship between downside risks to growth and house price synchronization may capture the influence of underlying financial and nonfinancial drivers of synchronization, these results are qualitatively unchanged when controlling for the role of business cycle synchronization.

is high, the magnitude of the relationship between house price synchronization and future growth is about two-thirds that of financial conditions, which measure the price of risk.

Policy Discussion

Increasingly, house prices have become determined at the global level. Local factors, such as land-use regulations, tax policy, and demographics, still account for most of the variation in house prices, but during the past three decades, house prices have become increasingly synchronized across countries, especially among major cities. Thus, policymakers cannot ignore the possibility that shocks to house prices elsewhere may affect domestic markets. The evidence presented in this chapter suggests that this trend is associated with the process of global financial integration, which, despite the many benefits, may have contributed to the "financialization" of housing (Box 3.2). The behavior of housing as a financial asset is particularly notable in light of housing's physical immobility. If synchronization leads to contagion during crises, the ramifications for housing markets may be more damaging for the real economy than in the case of financial assets (Dornbusch, Park, and Claessens 2000). This is because households hold most of their assets and liabilities in housing and mortgages, respectively, and because of financial institutions' outsized exposure to house prices.

Monitoring synchronization in addition to the over- or undervaluation of house prices may help policymakers understand the trade-offs associated with greater global links in housing markets. House prices may comove because business cycles are synchronized or because of financial factors such as global financial conditions, portfolio channels, or expected capital gains. While house price synchronization in and of itself may not warrant policy intervention, it points to the scope for global financial conditions and global investors to influence local house price dynamics. Moreover, the evidence presented in this chapter suggests that heightened synchronicity of house prices can signal a downside tail risk to real economic activity, especially in an environment with buoyant credit and high leverage. Thus, increasing the granularity, timeliness, and coverage of data on house prices may help provide richer indicators for bilateral and multilateral surveillance. Also, more comprehensive data on the participation of global investors in housing markets would strengthen surveillance efforts.

The effectiveness of demand-side macroprudential policy measures may vary with the degree of house price synchronicity (Box 3.4). For instance, the introduction of demand-side macroprudential policy measures, such as loan-to-value limits, is typically followed by a decline in house price growth, but this decline is larger and more persistent in countries with low house price synchronicity. Policymakers may thus have additional control over house price dynamics in countries where house price synchronicity is low and global investors may have a less prominent role. Nonetheless, the decline in house prices observed after the introduction of macroprudential policy measures in high-synchronicity countries suggests that the drivers of synchronicity operate at least partially through the local financial intermediaries that are usually targeted by these measures. Macroprudential policy measures aimed at dampening the accumulation of domestic financial vulnerabilities may have the additional consequence of reducing a country's house price synchronization (Box 3.4). Fiscal-based measures, such as ad valorem and buyers' stamp duty taxes, may also lower house price synchronization, but to a lesser extent than demand-based measures, such as loan-to-value limits. This does not mean that such policy tools should target the reduction of synchronicity. Rather, to the extent that they are able to tame excesses in domestic housing markets, macroprudential policy measures can also reduce the comovement between domestic and foreign house prices and potentially mitigate the influence of global financial conditions. This unintended effect is an aspect to consider when evaluating the consequences of macroprudential policy measures (IMF 2013).

Policymakers wishing to deter foreign buyers of real estate for the purpose of alleviating valuation pressures will likely face a number of challenges. For one, systematically identifying the impact of foreign buyers on housing affordability is difficult because of data limitations. And without a conclusive evidence base on their impact, there may be uncertainty in the appropriate timing and method of intervention in the housing market (Bank of Canada 2017).[24] A range of policy instruments, including tax policy, land-use regulation,

[24]For example, in Hong Kong SAR, a buyers' stamp duty tax affecting foreign buyers has faced limited success in taming house price appreciation, though other housing market policies have had a moderating effect on prices (IMF 2018b). In Canada, foreign buyer taxes in Vancouver and Toronto are expected to mitigate housing market imbalances, but authorities are aware of the uncertainty and scope for spillovers to other areas (Bank of Canada 2017).

and macroprudential policy measures, may be contemplated to address affordability concerns in residential real estate markets, but the effectiveness of these tools is far from certain. Moreover, some policies may be circumvented, leading to implementation challenges. Last, limiting house purchases in one city or country may steer foreign buyers elsewhere, leaving a role for national or international policy coordination.

More generally, policies that enhance resilience to global financial shocks may also dampen house price synchronicity. In the context of housing markets, exchange rate flexibility seems to play an important role, likely by giving more flexibility to monetary authorities to influence their domestic conditions (Chapter 3 of the April 2017 GFSR). Others may include policies that deepen domestic real estate markets or consumer financial protections to limit excessive or predatory lending to households. While this chapter does not explore the impact of these policies, existing research suggests that such abuses can accelerate during and reinforce housing booms (Bond, Musto, and Yilmaz 2009), and when financial shocks occur, consumer protections may help both insulate households' balance sheets and limit the fallout from household deleveraging, particularly among households with high marginal propensities to consume (Campbell and others 2011; Mian, Rao, and Sufi 2013; Chapter 2 of the October 2017 GFSR).

Box 3.1. Global Investors, House Price Dispersion, and Synchronicity

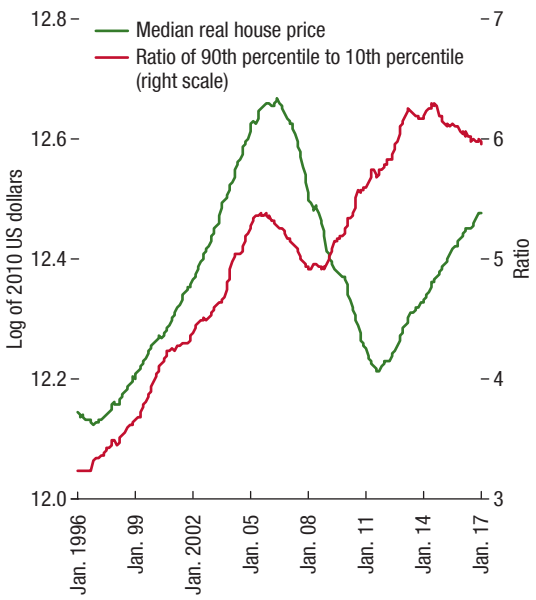
House price dispersion can be used as a proxy for demand from high-net-worth foreign investors with a preference for luxury housing. Using granular data from the US housing market, this box finds that house price dispersion in the United States has increased sharply over recent decades, and it increases when house prices in alternative investment destinations outside the United States rise. Both findings point to global investors contributing to house price synchronicity across cities and countries.

Housing serves a dual purpose: it is a residential good for the local population and an investment good for investors across the globe (Bernanke 2005, 2010; Sá, Wieladek, and Towbin 2014; Badarinza and Ramadorai 2016; Sá 2016). In its capacity as an asset for investment, housing is substitutable geographically and may attract significant amounts of funds from global investors. If this is the case, shocks to demand from global investors may be a source of synchronicity in house prices across cities and countries.

This possibility can be tested by looking at the behavior of house price dispersion, which can capture global investor demand. Global investors may prefer high-end properties in major cities for several reasons. First, information asymmetries may be less severe for high-end properties situated in recognizable areas. Second, investors with anonymity concerns may wish to minimize the number of properties they own. Third, the possibility of future migration may lead them to prefer these markets. To the extent that global investors prefer high-end houses, their prices will rise disproportionately in response to an increase in global investor demand. In other words, an increase in house prices in a global city like London should lead to a larger increase in high-end US house prices than in the median house price, bringing about a rise in house price dispersion.

A measure of house price dispersion in the 40 largest US cities can be constructed by taking the ratio of the top and bottom deciles of house prices.[1] Consistent with rising demand from global investors, house price dispersion has increased sharply in recent decades (Figure 3.1.1).[2] Moreover, there is substantial

Figure 3.1.1. Real House Prices in 40 Largest US Cities by Population



Sources: US Census Bureau; Zillow Group; and IMF staff calculations.

This box was prepared by Anil Ari.

[1]This is equivalent to the interpercentile range at log scale. The percentiles are determined by pooling house price estimates from Zillow at the granularity of individual ZIP codes. Cities are ranked according to 2015 population estimates from the US Census Bureau.

[2]An alternative interpretation is that luxury houses are located in areas with tighter constraints on housing supply and therefore experience greater price rises in response to a common rise in demand. However, this interpretation cannot account for the positive significant relationship between house price dispersion and house prices in foreign cities despite controlling for domestic determinants of housing demand (see Annex Table 3.3.2).

Box 3.1 *(continued)*

comovement between real house prices and house price dispersion.

Beyond these trends, regression analysis confirms the presence of a statistically significant relationship between US house price dispersion and house prices in alternative investment destinations outside the United States. House prices in major cities outside the United States—Beijing, Dublin, Hong Kong SAR, London, Seoul, Shanghai, Singapore, Tokyo, Toronto, and Vancouver—are positively associated with US house price dispersion. The coefficient associated with the foreign city index is positive and significant in all specifications considered, including those that control for potential domestic determinants of house prices. These findings indicate that common shocks to global investor demand may contribute to house price synchronicity.[3]

[3]An advantage of this approach is that using a measure of house price dispersion eliminates any confounding factors that have a uniform impact across the distribution of US house prices. Regression results are reported in Annex Table 3.3.2. These cities were selected based on the criteria of Cushman & Wakefield (2017) and data availability. The control variables include the unemployment rate as a proxy for economic fundamentals; the Chicago Board Options Exchange Volatility Index (VIX) as a proxy for risk appetite; and the effective federal funds rate, 30-year fixed-rate average mortgage interest rates, and the mortgage-backed security holdings of large domestically chartered commercial banks (excluding mortgage-backed securities with government guarantees) as proxies for ease of access to financing. Specifications with a time trend and a dummy variable for the global financial crisis are also considered.

Box 3.2. Housing as a Financial Asset

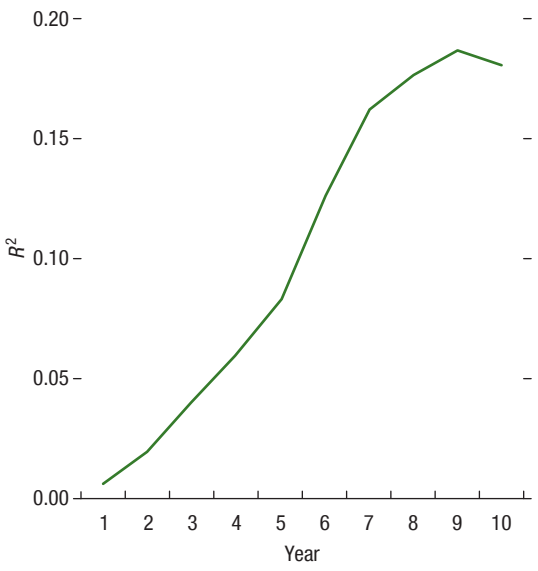
Housing is an important asset class for households and investors. In a typical economy, housing wealth, on average, accounts for roughly one-half of total national wealth and can fluctuate considerably over time (Piketty 2014). Real estate investors often borrow to purchase housing assets, making mortgage payments and receiving rental income and potential capital gains. Publicly traded real estate investment trusts have become available in many countries, allowing investors to invest indirectly in the real estate market. In addition, institutional investors have been increasing their direct exposure to residential real estate in recent years (see Figure 3.3 in the main text).

Investing in housing assets can yield considerable returns in the long term, but is subject to significant variation over time. In many advanced economies, the average annual real return on housing assets between 1950 and 2015 lies between 5 percent and 8 percent, comparable in magnitude to that of equity investment but with a lower standard deviation (Jordà and others 2017). In the shorter term, however, the expected returns on housing assets can vary significantly over time and are affected by the risk appetite of financial market investors as well as other behavioral factors (for example, Cheng, Raina, and Xiong 2014; Brunnermeier and Julliard 2008).

Time-Varying Expected Returns on Housing Assets

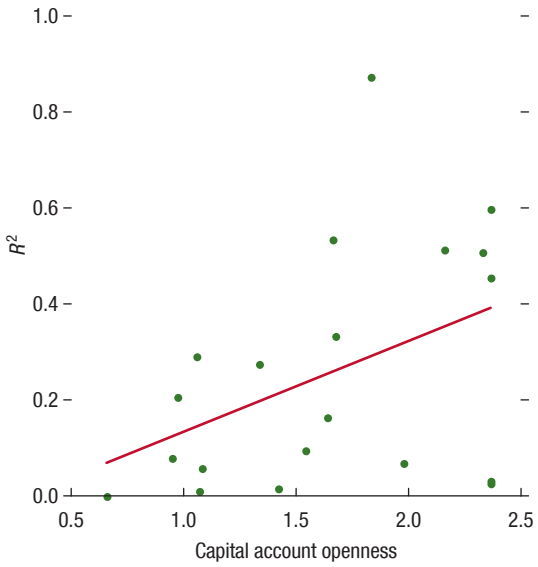
The expected return on housing assets varies over time and is predictable in the medium and long term, a typical feature of financial assets. A high current house-price-to-rent ratio strongly predicts low housing return in the future and vice versa. Moreover, the predictive power increases with the forecasting horizon (Figure 3.2.1), a property similar to many other financial assets, such as stocks (Fama and French

Figure 3.2.1. Housing Return Predictability



Source: IMF staff estimates.
Note: The forecasting equation uses the current price-to-rent ratio to predict future capital gains in housing assets. The *y*-axis in this figure shows the R^2 from the forecasting equation, that is, the proportion of variance in the future housing return explained by the current price-to-rent ratio. The forecasting horizon ranges from 1 year to 10 years. The median R^2 among countries in the sample is plotted in this figure.

Figure 3.2.2. Predictability of Returns on Housing and Capital Account Openness



Sources: Chinn and Ito (2006); and IMF staff estimates.
Note: The *y*-axis shows the R^2 from the housing return forecasting equation, which measures the proportion of variance in the future housing return nine years ahead explained by the current price-to-rent ratio.

This box was prepared by Alan Xiaochen Feng.

Box 3.2 *(continued)*

1988), bonds (Fama and Bliss 1987; Campbell and Shiller 1991), and foreign exchange rates (Hansen and Hodrick 1980). Such a high degree of housing return predictability indicates that house price variation is driven mostly by time-varying risk premiums on housing assets as opposed to shocks to rental income growth. As a result, volatility of house prices is generally much higher than suggested by the volatility of rent growth.

Empirical evidence suggests that housing return predictability is particularly strong in countries with high capital account openness (Figure 3.2.2). In an integrated global financial system, global financial conditions can significantly affect domestic house price variation because domestic prices are more likely to be affected by the risk sentiment of global investors. Consequently, house prices in these countries are more prone to temporary deviations from their domestic rental market fundamentals and are likely to exhibit excess volatility.[1]

[1]The analysis is based on a sample of 20 advanced economies that have long time series for the price-to-rent ratio. The estimated relationships may or may not be the same when emerging market economies are also considered.

Box 3.3. The Globalization of Farmland

What Is Farmland Globalization?

Over the past decade there has been an unprecedented increase in the amount of farmland, primarily in low- and middle-income countries, that has been sold or leased through large-scale land acquisitions to international commercial investors. These acquisitions imply the potential conversion of land from, for example, smallholder production or local community use to commercial use. In other words, farmland has become increasingly commodity-like.

Between 2000 and 2016 commercial investors negotiated more than 2,100 large-scale land acquisitions in 88 countries worldwide, with a cumulative size of almost 59 million hectares, roughly equal to 15 percent of the remaining global stock of unused and unforested arable land.[1] Sub-Saharan Africa (about 900 deals) and east Asia (about 600 deals) have been the most important target regions, followed by Latin America (about 350 deals).

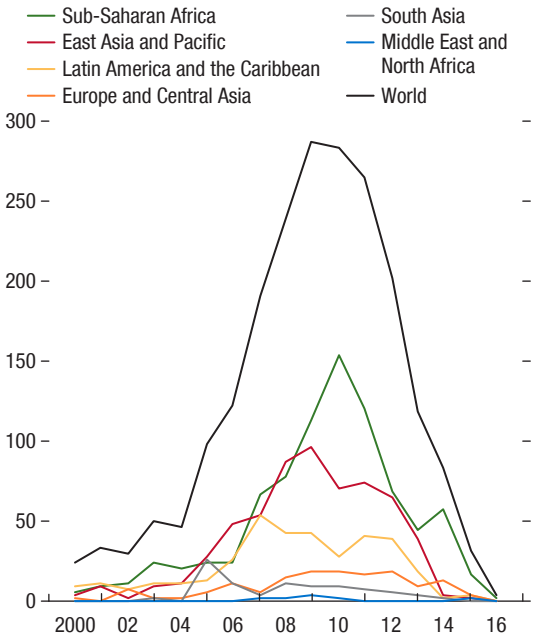
What Are the Implications for Farmland Prices?

Until recently, foreign interest in land in developing economies has been relatively limited. Not surprisingly, agricultural land rent in developing economies has been low compared with that in developed economies. For example, rent on land in Africa has been in the range of $3–$12 a hectare, compared with €100–€240 in the European Union and $200 in the United States (see Collier and Venables 2012). With most land deals now taking place in regions where land rent is currently relatively low, rent on farmland across different regions of the world could converge. To date, however, only 49 percent of the land deals has been cultivated to some extent. These and other facts suggest the convergence process is likely to be very slow.

What Drives the Globalization of Farmland?

Figure 3.3.1 depicts the evolution of the number of land deals over time by target region.[2] It shows how demand for farmland increased in tandem in sub-Saharan Africa and east Asia and the Pacific in the run-up to the 2007–08 global financial crisis and peaked shortly thereafter.

Figure 3.3.1. Large-Scale Land Acquisitions over Time by Target Region
(Number of deals)



Sources: The Land Matrix Global Observatory; and IMF staff calculations.

What Explains the Synchronization of Farmland Demand across Different Regions in the World?

In the aftermath of the global financial crisis, conventional stocks and assets became riskier, interest rates fell, and biofuel subsidies and prices of agricultural commodities soared. Private investors and food corporations turned to farmland as a new source of profit. In addition to these business cycle factors, the long-term demand for food and hence for farmland has been steadily increasing because of growing populations and rising incomes around the world.

What Is the Role of Global Investors?

Recent research indicates that much of the investment in land by international investors has been directed at remote developing economies that until recently participated little in global agricultural trade

This box was prepared by Christian Bogmans.

[1]See the Land Matrix (www.landmatrix.org), an online database of large-scale land acquisitions that are verified by nongovernmental organizations. The Land Matrix incorporates those deals that lead to a transfer of land rights from one party to another by means of sale, concession, or lease with a size of 200 hectares or more.

[2]The fact that investment has fallen sharply in recent years should not be interpreted as evidence that the interest in farmland has disappeared, because there is a lag in data collection. In addition, many investors may have become less transparent about their operations in developing economies.

Box 3.3 *(continued)*

(Arezki, Bogmans, and Selod, forthcoming). Hence, all else equal, more distant locations are preferred to more central locations. As such, these investments signal that capital, technology, and agronomic knowledge in the agricultural sector is flowing to countries that need them the most. By promoting these flows, global investors could be instrumental in driving convergence of global farmland prices.

What Are the Policy Implications?

Attracted by the potential for large future capital gains (from increasing land value), much of the land that has been acquired by financial investors has been held idle for speculative purposes. Depending on whether the land was initially used for small-scale farming or something else, the domestic opportunity costs of these investor strategies are potentially high. This problem has parallels to housing: purchases of housing assets by private and institutional investors in major cities around the world may limit the affordability and availability of housing for the local population. In addition, much land has been acquired in countries where the land rights of existing land users are weak (Arezki, Deininger, and Selod 2013), supposedly because investors can obtain land at a lower cost. Host-country governments can remedy the risks by investing in monitoring capacity to ensure that land is leased to responsible investors and by setting strict rules for compensation to displaced land users (Glaeser, Ponzetto, and Shleifer 2016).

Box 3.4. House Price Gap Synchronicity and Macroprudential Policies

This box analyzes the relationship between macroprudential policies and house price synchronicity. Macroprudential policies targeted at dampening the accumulation of domestic vulnerabilities in the financial and housing sectors may have the indirect effect of reducing the correlation of house price cycles, thereby leaving room for policymakers to regain control over local house price dynamics. Tighter macroprudential tools targeting bank capital and credit conditions are found to be associated with lower house price synchronicity.

Macroprudential tools, which have been used more actively since the global financial crisis (Alam and others, forthcoming), aim to curb leverage and reduce financial vulnerabilities for the purpose of decreasing the likelihood of domestic asset bubbles and financial crises. Macroprudential policies are usually domestically targeted, with a large share of measures focused on domestic credit and housing market conditions. However, in countries experiencing deeper financial integration, where business cycles are more intertwined at the regional and global levels, house prices are, in part, driven by other factors, such as capital flows from global investors and by global financial conditions.[1] Thus, the relationship between macroprudential tools and house price synchronicity might be ambiguous because it may be offset by other factors.[2]

House price growth seems to evolve differently after the adoption of demand-side macroprudential policies, such as loan-to-value limits, depending on the level of synchronicity (Figure 3.4.1, panel 1). Before the adoption of these policies, house prices grow similarly in countries with high or low house price synchronicity. After they are adopted, house price growth declines in both groups of countries, but the decline is stronger and more sustained in low-synchronicity countries. These simple patterns suggest that policymakers may have more control over the dynamics of the housing market in these countries. At the same time, they suggest that a high degree of synchronicity does not render macroprudential policies ineffective. This could be the case if the financial factors behind house price synchronization operate at least partially through local financial intermediaries.

Macroprudential tools are also associated with a reduction in house price synchronicity (Figure 3.4.1, panel 2).[3] Since these tools mostly affect local financial intermediaries and domestic demand, this finding also suggests that factors driving house price comovement operate, at least partially, through these channels. The relationship between capital-based measures, which include countercyclical capital buffers, and house price synchronicity seems the most negative. Likewise, loan-targeted measures, including loan-to-value limits, and supply-side loan-targeted tools, such as limits on foreign currency loans, are found to lessen correlations with the global house price cycle.[4] The adoption of fiscal-based measures, such as ad valorem and buyers' stamp duty taxes, that could potentially deter global investors from engaging in speculative real estate purchases is also associated with a decline in synchronicity, but to a lesser extent than other macroprudential policies.[5]

This box was prepared by Adrian Alter and Dulani Seneviratne.

[1]House price synchronicity with the global cycle is heterogeneous across regions, potentially reflecting deeper intraregional financial and trade integration.

[2]Recent empirical literature (Cerutti, Claessens, and Laeven 2015; Cerutti, Dagher, and Dell'Ariccia 2017; Vandenbussche, Vogel, and Detragiache 2015) suggests that the role of macroprudential policies in mitigating house price imbalances is less consistent than when household credit is considered. For instance, loan-targeted measures (Akinci and Olmstead-Rumsey 2017) and those that complement monetary policy (Bruno, Shim, and Shin 2017) seem to be most effective in mitigating house price growth. In contrast, there is no robust evidence for the effectiveness of policies such as risk weighting and provisioning requirements (Kuttner and Shim 2016).

[3]The relative magnitude of the effect of macroprudential measures averages about one-half of the effect of global factors and about one-third of the effect of bilateral financial integration. Consistent with Figure 3.15, both global factors and financial integration are positively associated with house price synchronicity.

[4]When only periods with credit booms are considered, the results are both qualitatively and quantitatively similar, although the relationships are slightly less significant.

[5]In some instances, fiscal-based measures target speculative investments, including by foreign buyers (see IMF 2018b).

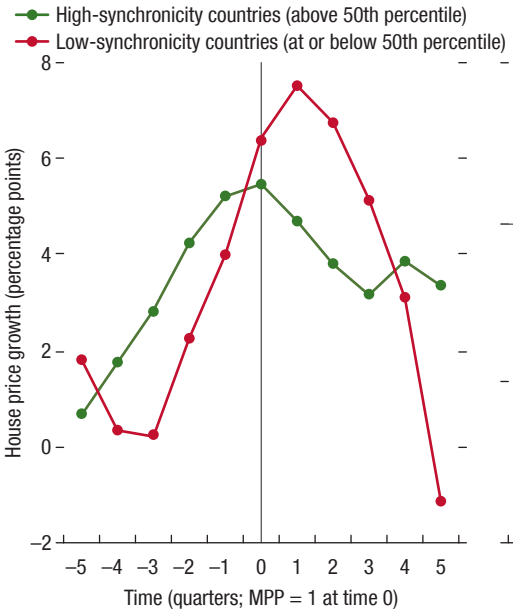
Box 3.4 *(continued)*

Figure 3.4.1. Macroprudential Tools Indirectly Reduce House Price Synchronicity

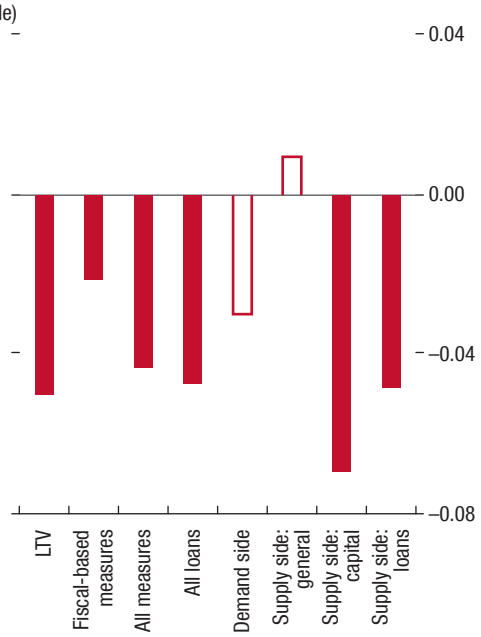
On average, house prices are affected more by demand-side macroprudential policies in low-synchronicity countries.

Supply-side measures targeting bank capital and loan-specific measures, including loan-to-value limits, seem effective in reducing synchronicity with the global cycle.

1. Average House Price Growth and Demand-Side Macroprudential Policies



2. Impact of Macroprudential Measures on House Price Synchronicity (Standard deviations)



Source: IMF staff estimates.

Note: Panel 1 depicts the average year-over-year house price growth for high-synchronicity and low-synchronicity countries within a period of plus or minus five quarters around the tightening of demand-side macroprudential policies (MPPs). Demand-side MPPs include limits on debt-service-to-income and loan-to-value (LTV) ratios. The total number of demand-side events is 47, and $t = 0$ is identified as the first quarter in which demand-side MPPs were implemented within the plus-or-minus-five-quarter window. Synchronicity is based on the quasi correlation of house price gaps with the global cycle. A country is classified in the high-synchronicity group when its average synchronicity (over the sample period) with the global cycle is above the 50th percentile in the sample, and vice versa. Panel 2 depicts estimated average effects of macroprudential tools on house price synchronicity with the global cycle (refers to through-the-cycle regressions). Solid bars in panel 2 show statistically significant standardized coefficients at the 10 percent confidence level. Estimated panel regressions use data for 41 countries spanning the period 1990:Q2–2016:Q4. Regressions control for business cycle synchronicity, financial integration, and global financial conditions. All regressors are lagged one quarter. Supply side (loans) consists of limits on credit growth, loan loss provisions, loan restrictions, and limits on foreign currency loans. Supply side (capital) consists of capital requirements, conservation buffers, the leverage ratio, and the countercyclical capital buffer. Supply side (general) consists of reserve requirements, liquidity requirements, and limits on foreign exchange positions. Demand side consists of limits to debt-service-to-income and LTV ratios. All loan measures include demand side and supply side (loans). Fiscal-based measures include taxes such as ad valorem, sellers' and buyers' stamp duty, or other taxes. For more details about the macroprudential tools database and estimation details, see Annex 3.3 on the methodology for Box 3.4.

Annex 3.1. Data Sources and Country Coverage

Annex Table 3.1.1. Data Sources

Variable	Description	Source
Country-Level Variables		
Real House Price Indices	Residential real property prices (seasonally adjusted) at country level (also at city level)	Bank for International Settlements; CEIC Data Co. Ltd; Emerging Markets Economic Data Ltd; Global Financial Data Solutions; Global Property Guide; Haver Analytics; IMF, Research Department house price data set; Organisation for Economic Co-operation and Development; Thomson Reuters Datastream; IMF staff calculations
Real House Price Indices (long historical)	Annual nominal house prices starting 1870 for 17 advanced economies, adjusted for inflation	Jordà-Schularick-Taylor Macrohistory database; IMF staff calculations
Real GDP	GDP at constant prices, seasonally adjusted	Haver Analytics; Organisation for Economic Co-operation and Development; IMF, Global Data Source database; IMF, World Economic Outlook database
Real GDP (long historical)	Annual real GDP starting 1870 for 17 advanced economies	Jordà-Schularick-Taylor Macrohistory database
Nominal GDP	GDP at current prices, seasonally adjusted (in both national currency and US dollars)	Haver Analytics; Organisation for Economic Co-operation and Development; IMF, Global Data Source database; IMF, World Economic Outlook database
Claims on Private Sector	Depository corporations' claims on private sector, in nominal and real terms (adjusted for inflation), both as nonseasonally adjusted and seasonally adjusted series	Bank for International Settlements; Haver Analytics; IMF, Global Data Source database; IMF staff calculations
Equity Returns	Log difference of the equity indices	Bloomberg Finance L.P.; Thomson Reuters Datastream; IMF staff calculations
Real Estate Investment Trust Index	Market capitalization of overall and residential real estate trust indices, normalized by the total market capitalization and rebased to 2005:Q1 = 100	Thomson Reuters Datastream; IMF staff calculations
Weighted Average Target Allocations to Real Estate	Based on all institutions, as reported	Jones and Weill (2017)
Short-Term Nominal Interest Rate	Three-month Treasury bill or interbank rate	Bloomberg Finance L.P.; Haver Analytics; Thomson Reuters Datastream; IMF staff calculations
Real Effective Exchange Rate	Trade-weighted exchange rate vis-à-vis trade partners (adjusted for inflation)	IMF, International Financial Statistics database
Bilateral Exchange Rate	National currency per US dollar	IMF, International Financial Statistics database
Inflation	Percent change in the consumer price index	Haver Analytics; IMF, Global Data Source database; IMF staff calculations
Inflation (long historical)	Percent change in the consumer price index for 17 advanced economies starting 1870	Jordà-Schularick-Taylor Macrohistory database
Trade Openness	Exports plus imports vis-à-vis the world, in percent of GDP	IMF, Direction of Trade database; IMF staff calculations
Total Bank Claims and Liabilities	Total locational assets and liabilities vis-à-vis the world in percent of GDP	Bank for International Settlements; IMF staff calculations
Financial Openness	Foreign assets plus foreign liabilities in percent of GDP	Lane and Milesi-Ferretti (2007) data set (updated)
Financial Development	Domestic credit to private sector in percent of GDP	Bank for International Settlements; Haver Analytics; IMF staff calculations
Capital Account Openness	Chinn-Ito index, measuring a country's degree of capital account openness	Chinn and Ito (2006) data set (updated)
Exchange Rate Regime	De facto exchange rate regime of a country (variables based on 15 categories and 6 categories are used)	Ilzetzki, Reinhart, and Rogoff (2017) data set
Macroprudential Policies	Macroprudential policy tools at quarterly frequency	Alam and others (forthcoming)
Large-Scale Land Acquisitions	Number of deals	The Land Matrix Global Observatory
Term Spreads	Yield on 10-year government bonds minus yield on three-month Treasury bills	Bloomberg Finance L.P.; Haver Analytics; IMF staff calculations
Interbank Spreads	Interbank interest rate minus yield on three-month Treasury bills	Bloomberg Finance L.P.; Haver Analytics; IMF staff calculations

(continued)

Annex Table 3.1.1. Data Sources *(continued)*

Variable	Description	Source
Change in Long-Term Real Interest Rate	Percentage point change in the 10-year government bond yield, adjusted for inflation	Bloomberg Finance L.P.; Haver Analytics; IMF staff
Corporate Spreads	Corporate yield of the country minus yield of the benchmark country. JPMorgan CEMBI Broad is used for emerging market economies where available.	Bloomberg Finance L.P.; Thomson Reuters Datastream
Equity Return Volatility	Exponential weighted moving average of equity price returns	Bloomberg Finance L.P.; IMF staff
Change in Financial Sector Share	Log difference of the market capitalization of the financial sector to total market capitalization	Bloomberg Finance L.P.
Credit Growth	Percent change in the depository corporations' claims on private sector	Bank for International Settlements; Haver Analytics; IMF, International Financial Statistics database
Change in Credit to GDP	Change in credit provided by domestic banks, all other sectors of the economy, and nonresidents (in percent of GDP)	Bank for International Settlements; Haver Analytics; IMF staff
Sovereign Spreads	Yield on 10-year government bonds minus the benchmark country's yield on 10-year government bonds	Bloomberg Finance L.P.; Haver Analytics; IMF staff
Banking Sector Vulnerability	Expected default frequency of the banking sector	Moody's Analytics, CreditEdge; IMF staff
Domestic Commodity Price Inflation	A country-specific commodity export price index constructed following Gruss 2014, which combines international commodity prices and country-level data on exports and imports for individual commodities. Change in the estimated country-specific commodity export price index is used.	Bloomberg Finance L.P.; IMF, Global Data Source database; United Nations, COMTRADE database; IMF staff
Trading Volume (equities)	Equity markets' trading volume, calculated as level to 12-month moving average	Bloomberg Finance L.P.
Market Capitalization (equities)	Market capitalization of the equity markets, calculated as level to 12-month moving average	Bloomberg Finance L.P.; Thomson Reuters Datastream
Market Capitalization (bonds)	Bonds outstanding, calculated as level to 12-month moving average	Dealogic; IMF staff
Bilateral-Level Variables		
Bilateral Bank Claims vis-à-vis Counterparty Economies	Bilateral locational cross-border claims on residency basis	Bank for International Settlements, International Banking Statistics confidential databases
Bilateral Gross Trade vis-à-vis Counterparty Economies	Gross exports vis-à-vis counterparty economies	IMF, Direction of Trade database; IMF staff calculations
Global-Level Variables		
Global Liquidity	Total claims of all Bank for International Settlements reporters vis-à-vis the world, in percent of world GDP	Bank for International Settlements; Haver Analytics
US Financial Conditions Index	Positive values of the FCI indicate tighter-than-average financial conditions. For methodology and variables included in the FCI, refer to Annex 3.2 of the October 2017 *Global Financial Stability Report*.	IMF, October 2017 *Global Financial Stability Report* (Chapter 3)
Global Financial Conditions Index	Based on a PCA of all FCIs estimated; positive values of the FCI indicate tighter-than-average financial conditions. For methodology and variables included in the FCI, refer to Annex 3.2 of the October 2017 *Global Financial Stability Report*.	IMF, October 2017 *Global Financial Stability Report* (Chapter 3)
VIX	Chicago Board Options Exchange Volatility Index	Haver Analytics
MOVE	Merrill Lynch Option Volatility Estimate Index	Bloomberg Finance L.P.
US Shadow Interest Rates	Wu-Xia and Krippner shadow federal funds rates	Bloomberg Finance L.P.; Haver Analytics
Global Oil Prices	Petroleum prices, US dollar a barrel	Bloomberg Finance L.P.; IMF, Global Data Source database
Global Commodity Prices	Commodity prices: all primary commodities	IMF, Global Data Source database

Source: IMF staff.
Note: CEMBI = Corporate Emerging Markets Bond Index; FCI = financial conditions index; MOVE = Merrill Lynch Option Volatility Estimate Index; PCA = principal component analysis; VIX = Chicago Board Options Exchange Volatility Index.

Annex Table 3.1.2. Economies and Cities Included in the Analyses

Economies Included in the Analyses			
Australia	Euro area	Italy	Singapore
Austria	Finland	Japan	Slovenia
Belgium	France	Korea	South Africa
Canada	Germany	Malaysia	Spain
Chile	Greece	Mexico	Sweden
China	Hong Kong SAR	Netherlands	Switzerland
Colombia	Hungary	New Zealand	Taiwan Province of China
Cyprus	India	Norway	Thailand
Czech Republic	Indonesia	Portugal	Turkey
Denmark	Ireland	Russia	United Kingdom
Estonia	Israel	Serbia	United States
Cities Included in the Analyses[1]			
Amsterdam	Dublin	Madrid	South Santiago
Athens	Finland metro area	Manila	Southern Seoul
Auckland	Greater Stockholm	Mexico City	Sydney
Bangkok	Hong Kong SAR (urban areas)	Moscow	Taipei City
Belgrade	Inner Paris	Mumbai	Tallinn
Berlin	Istanbul	New York City	Tokyo
Bogotá	Jakarta	Oslo	Toronto
Brussels	Kuala Lumpur	Prague	Vienna
Budapest	Lima	Rome	Zurich
Buenos Aires	Lisbon	São Paulo	
Copenhagen	Ljubljana	Singapore (core central region)	
Dubai	London	Shanghai	

Source: IMF staff.
[1]Cities selected are the largest cities based on population owing to data availability, and overlap with the top 50 cities for global investors identified by Cushman & Wakefield (2017). An additional sample comprising 76 cities based on the top 30 cities for global investors in Cushman & Wakefield's (2017) Global Capital Markets 2017 report's economic scale, financial center, technology hub, and innovation pillars is also used in robustness checks. In the latter data set, if none of the cities in an economy (where data are available) are chosen based on the four pillars stated above, the largest city by population owing to data availability is used.

Annex 3.2. Measuring Synchronization and Country-Pair Analysis

Measuring Synchronization

First, the instantaneous quasi correlation (Morgan, Rime, and Strahan 2004; Kalemli-Özcan, Papaioannou, and Perri 2013; Kalemli-Özcan, Papaioannou, and Peydró 2013; Duval and others 2016) in house price gaps[25] is defined as follows:

$$HPsynch_{ijt} = QCORR_{ijt} = \frac{\left(HPgap_{it} - \overline{HPgap_i}\right)\left(HPgap_{jt} - \overline{HPgap_j}\right)}{\sigma_i^{gap}\sigma_j^{gap}}, \quad \text{(A3.2.1)}$$

in which $HPgap_{it}$ and $HPgap_{jt}$ stand for house price gaps of countries i and j, respectively, at quarter t, and the gaps are measured as explained in note 25. $\overline{HPgap_i}$ and $\overline{HPgap_j}$ are the average house price gaps of countries i and j, respectively, and σ_i^{gap} and σ_j^{gap} are the standard deviations of house price gaps of countries i and j, respectively.

Second, the negative of the absolute difference of house price gaps in countries i and j at quarter t is calculated as follows:

$$HPsynch_{ijt} = Synch1_{ijt} = -\left|HPgap_{it} - HPgap_{jt}\right|. \quad \text{(A3.2.2)}$$

Third, based on a dynamic factor model (Kose, Otrok, and Prasad 2012; Kose, Prasad, and Terrones 2003; Del Negro and Otrok 2007), the synchronization measure for house prices for country i, $synch_{L,i,t}$, is defined as:

$$synch_{L,i,t} = \frac{var_L\left(\lambda_{i,t}g_t\right) + var_L\left(\lambda_{r,i}r_{k,t}\right)}{var_L\left(h_{i,t}\right)} \text{ or}$$

$$synch_{L,i,t} = \frac{var_L\left(\lambda_{i,t}g_t\right)}{var_L\left(h_{i,t}\right)}, \quad \text{(A3.2.3)}$$

[25]House price gaps are measured by extracting the cyclical component of real house prices using the band-pass filter of Christiano and Fitzgerald (2003), with a maximum length of 20 years to capture medium-term financial cycles. The cyclical components of house prices are then taken as a ratio of house price levels to obtain house price gaps. As a robustness check, house price gaps are also constructed using a Hodrick and Prescott (1997) filter with a lambda of 400,000, which is commonly used as the lambda relevant for financial cycles. House price gaps broadly consistent with those of the Christiano and Fitzgerald (CF) filter are obtained. The CF filter is chosen for the analysis because it computes the cyclical component for all observations without being prone to tail bias.

in which $var_L(\cdot)$ is the realized variance from period $t - L$ to t, $\lambda_{i,t}$, and $\lambda_{r,i}$ are the factor loadings to the global, g_t, and regional, $r_{k,t}$, factors. In the model, the quarterly growth rate of house prices for country i in period t, $h_{i,t}$ consists of the global factor, g_t, the regional factor for region k (k = *Europe, Asia,* and *the Americas*), $r_{k,t}$, and the country-specific idiosyncratic component, $c_{i,t}$. See Annex 3.3 for more details on the dynamic factor models and related analyses.

Country-Pair Analysis[26]

This analysis uses bilateral country-pair panel data to estimate the impact of business cycle synchronization, bilateral financial links, and global factors on house price synchronization. The baseline econometric specification presented below is estimated at quarterly frequency spanning the period 1990–2016, for 40 countries:[27]

$$\begin{aligned} HPsynch_{ijt} = {} & \alpha_{ij} + \beta_1 BCS_{ijt-1} + \beta_2 FININT_{ijt-1} \\ & + \beta_3 GLOBAL_{t-1} \\ & + \beta_4 INST_{ijt-1} \times GLOBAL_{t-1} \\ & + \beta_5 OTHER_{ijt-1} + tr + \varepsilon_{ijt}, \end{aligned} \qquad \text{(A3.2.4)}$$

in which $HPsynch_{ijt}$ is the synchronization of house price gaps between country-pairs i and j at quarter t. BCS_{ij} denotes business cycle synchronization between countries i and j.[28] $FININT_{ij}$ refers to bilateral financial integration between countries i and j.[29] $GLOBAL_t$ is the global factor proxied by changes in global liquidity (see Annex Table 3.1.1 for descriptions of variable).

$INST_{ij}$ denotes dummies that equal 1 if both countries have a high level of an institutional characteristic (that is, economic development level, capital account openness, exchange rate flexibility, or financial development).[30] $OTHER_{ij}$ includes other controls (for example, institutional factors). All regressors are lagged by one quarter. In addition, linear and quadratic time trends (tr) are included. The term α_{ij} is the country-pair fixed effects capturing unobservable time-invariant idiosyncratic factors common to country-pairs i and j, such as geographic proximity. The error term is ε_{ijt}.[31] Importantly, country-pair fixed effects capture how time-invariant supply-side and regulatory considerations influence house price synchronicity between two countries. Results are presented in Annex Tables 3.2.1 and 3.2.2.[32]

Robustness Checks

In addition to the results in Annex Tables 3.2.1 and 3.2.2, various robustness checks are performed, with the main findings broadly unchanged. For instance, alternative proxies for global liquidity include the US financial conditions index (FCI), global FCI, Chicago Board Options Exchange Volatility Index (VIX), US shadow interest rates (in the spirit of Wu and Xia 2016; and Krippner 2013).[33] The specifications above were also estimated by replacing business cycle synchronization with interest rate synchronization to investigate the contribution of synchronized monetary policies to house price synchronization. Interest rate synchronization is found to be a statistically significant driver of house price synchronization on its own when either synchronicity measure is used (either Synch1 or quasi correlation). However, the statistical significance of interest rate synchronicity above and beyond other financial factors, such as global liquidity and bilateral banking links, is robust only to a less stringent manner

[26]Prepared by Adrian Alter and Dulani Seneviratne.

[27]Although the house price time series in this analysis, particularly for advanced economies, start several decades before 1990, the econometric analysis is restricted to series beginning in 1990 because the availability of data on bilateral banking links significantly improves that year. Four emerging markets out of the sample of 44 countries in the econometric analysis are excluded because of the short length of their house price time series.

[28]Business cycle synchronization measures are calculated similarly to house price synchronicity.

[29]Financial integration is measured using bilateral locational banking statistics on residency basis obtained from Bank for International Settlements International Banking Statistics confidential databases. Bilateral banking integration is measured as the logarithm of the sum of bilateral claims of country i vis-à-vis country j and bilateral claims of country j vis-à-vis country i as a ratio of the sum of the GDPs of countries i and j. Additional forms of bilateral financial integration measures, such as bilateral portfolio links and bilateral direct investment links, are not used in the analysis because of their lower frequency and much shorter time span.

[30]High level is defined based on the top fifth of the distribution of institutional characteristics at any time. In addition, robustness checks were performed by defining the institutional factors as high if both countries are at or above the 75th or 66th percentiles instead of the 80th percentile.

[31]To account for serial correlation, following Cameron, Gelbach, and Miller (2011), standard errors are multiway clustered (at country i, country j, and time level, where appropriate).

[32]Similar analyses for city-level house prices were performed, in which the dependent variable is city-level house price gap synchronization, and the explanatory variables are the same as the variables presented in this annex (see Figure 3.15 for city-level results).

[33]Although results are robust to these alternative proxies for the global factor, when some proxies are combined with the most stringent manner of standard error clustering, the level of statistical significance declines.

Annex Table 3.2.1. House Price Gap Synchronization at Country Level and Bilateral Linkages

Dependent Variable: House Price Gap Synchronization of Country Pair *i* and *j* (Synch1)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Business Cycle Synchronization of *ij*	0.766***	0.675**	0.733***	0.657**	0.658**	0.746***	0.725***	0.725***	0.675**	0.706**
	(0.254)	(0.293)	(0.243)	(0.254)	(0.253)	(0.262)	(0.261)	(0.262)	(0.253)	(0.337)
Bilateral Bank Integration of *ij*			0.006*	0.007**	0.012	0.009*	0.007**	0.007*	0.007**	0.004
			(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)
Global Factor (global liquidity)				–0.001	–0.001	–0.001	–0.001	–0.001	–0.001	0.001
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Bilateral Bank Integration Interacted with:										
× EMEs-EMEs Dummy					–0.016*					
					(0.009)					
× EMEs-AEs Dummy					–0.009					
					(0.010)					
× High Capital Account Openness with the World						–0.005				
						(0.003)				
× High Exchange Rate Regime (*ij*) (15 categories; high = more flexible)							–0.005			
							(0.004)			
× High Exchange Rate Regime (*ij*) (6 categories; high = more flexible)								–0.001		
								(0.004)		
× High Financial Openness with the World (*ij*)									–0.019***	
									(0.004)	
GFC Period Dummy Interacted with:										
× Business Cycle Synchronization of *ij*										–0.080
										(0.516)
× Bilateral Bank Integration of *ij*										0.008**
										(0.004)
× Global Factor										0.001
										(0.001)
Post-GFC Period Dummy Interacted with:										
× Business Cycle Synchronization of *ij*										0.380
										(0.456)
× Bilateral Bank Integration of *ij*										0.007
										(0.005)
× Global Factor										0.004
										(0.003)
GFC Dummy										0.048***
										(0.011)
Post-GFC Dummy										0.042***
										(0.009)
Observations	65,450	65,343	49,384	49,384	49,384	43,871	46,708	46,708	47,353	49,384
R^2	0.353	0.498	0.386	0.356	0.356	0.361	0.356	0.356	0.360	0.360
Multiway Clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Two-way
Time FE and Country-Pair FE	Yes		Yes							
Time FE, Country-Pair FE, and country*time FE		Yes								
Quadratic Trend and Country-Pair FE				Yes	Yes	Yes	Yes	Yes	Yes	
Country-Pair FE										Yes

Source: IMF staff estimates.

Note: GFC Period Dummy = a dummy variable that equals 1 during 2008–09 and zero otherwise. Post-GFC Period Dummy = a dummy variable that equals 1 during 2010–16 and zero otherwise. All regressors are lagged by one quarter. Institutional characteristics dummies are included in specifications 5 through 9, but are not shown above (specifically, dummy variables for EMEs-EMEs, EMEs-AEs, high capital account openness, high exchange rate regime, and high financial openness are included in specifications 5 through 9, but not shown). High = a dummy variable that equals 1 when both countries are in the top fifth of the institutional characteristic. Standard errors (in parentheses) are three-way clustered (at country *i*, country *j*, and date), with the exception of regression 10, in which errors are two-way clustered (at country *i*, country *j*). The standard deviation for business cycle synchronization is 0.0124 and 1.040 for bilateral bank integration. AEs = advanced economies; EMEs = emerging market economies; FE = fixed effects; GFC = global financial crisis; Synch1 = synchronization measure introduced in the text of this annex.

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Annex Table 3.2.2. House Price Gap Synchronization at Country Level and Global Factors

Dependent Variable: House Price Gap Synchronization of Country Pair *i* and *j* (Quasi correlation)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Business Cycle Synchronization of *ij*	0.025*	0.030**	0.022	0.026*	0.026*	0.025*	0.026*	0.026*	0.026**	0.042
	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.015)	(0.014)	(0.014)	(0.013)	(0.033)
Bilateral Bank Integration of *ij*			–0.011	0.012	0.012	0.011	0.022	0.022	0.012	–0.016
			(0.033)	(0.031)	(0.031)	(0.036)	(0.036)	(0.035)	(0.032)	(0.034)
Global Factor (global liquidity)				0.016**	0.016**	0.020**	0.019***	0.019**	0.018**	0.022*
				(0.006)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.013)
Global Factor Interacted with:										
× EMEs-EMEs Dummy					–0.001					
					(0.009)					
× EMEs-AEs Dummy					0.000					
					(0.006)					
× High Capital Account Openness with the World						–0.002				
						(0.005)				
× High Exchange Rate Regime (*ij*)							–0.023***			
(15 categories; high = more flexible)							(0.008)			
× High Exchange Rate Regime (*ij*)								–0.009		
(6 categories; high = more flexible)								(0.007)		
× High Financial Openness with the World (*ij*)									0.003	
									(0.006)	
GFC Period Dummy Interacted with:										
× Business Cycle Synchronization of *ij*										–0.032
										(0.038)
× Bilateral Bank Integration of *ij*										–0.022
										(0.035)
× Global Factor										–0.025*
										(0.012)
Post-GFC Period Dummy Interacted with:										
× Business Cycle Synchronization of *ij*										–0.039
										(0.035)
× Bilateral Bank Integration of *ij*										0.010
										(0.033)
× Global Factor										–0.029
										(0.018)
GFC Dummy										–0.137**
										(0.060)
Post-GFC Dummy										–0.044
										(0.052)
Observations	65,450	65,343	49,384	49,384	49,384	43,871	46,708	46,708	47,353	49,384
R^2	0.227	0.354	0.251	0.230	0.230	0.233	0.224	0.223	0.241	0.232
Multiway Clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Two-way
Time FE and Country-Pair FE	Yes		Yes							
Time FE, Country-Pair FE, and country*time FE		Yes								
Quadratic Trend and Country-Pair FE				Yes	Yes	Yes	Yes	Yes	Yes	
Country-Pair FE										Yes

Source: IMF staff estimates.

Note: GFC Period Dummy = a dummy variable that equals 1 during 2008–09, and zero otherwise. Post-GFC Period Dummy = a dummy variable that equals 1 during 2010–16, and zero otherwise. All regressors are lagged by one quarter. Institutional characteristics dummies are included in specifications 5 through 9, but are not shown above (specifically, dummy variables for EMEs-EMEs, EMEs-AEs, high capital account openness, high exchange rate regime, and high financial openness are included in specifications 5 through 9, but not shown). High = a dummy variable that equals 1 when both countries are in the top fifth of the institutional characteristic. Standard errors (in parentheses) are three-way clustered (at country *i*, country *j*, and date), with the exception of regression 10, in which errors are two-way clustered (at country *i*, country *j*). AEs = advanced economies; EMEs = emerging market economies; FE = fixed effects; GFC = global financial crisis.

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

of standard error clustering (for instance, clustering at the country-pair and time dimension or computing robust standard errors instead of the multiway clustering of standard errors used in the main analyses). Moreover, trade integration was included as an additional control, but found not to be statistically significant. When equity price synchronization is included as an additional control, the results presented in Annex Tables 3.2.1 and 3.2.2 remain broadly unchanged. However, equity price synchronization itself does not consistently have a statistically significant relationship with house price synchronization.

Various clustering alternatives were used (clustering at country-pair level, two-way at country *i* and country *j*, two-way at country-pair and time levels, and without clustering, robust), and as expected, the level of significance improves under less restrictive clustering options. Additional time controls, such as year fixed effects and linear time trends, were also analyzed with little change to the main conclusions. Additional robustness checks were performed by dropping one country pair at a time.

In a separate exercise, regressions were run using a panel of three nonoverlapping seven-year periods in which house price and business cycle synchronization is captured by the bilateral Pearson correlation coefficients for the period. Explanatory variables apart from business cycle synchronization are the average values for the period. Further robustness checks in this exercise were explored by collapsing the other explanatory variables using the last value of the previous period instead. The interaction term of the global factor and foreign exchange regime is still found to be statistically significant, in addition to the global factor itself.

The relationship between house price gap synchronicity and business cycle synchronization is found to be positive and statistically significant when using the Jordà, Schularick, and Taylor (2017) data set, which starts in 1870 for 17 advanced economies at annual frequency. Additional analysis was limited by data availability.

Annex 3.3. Technical Annex

Measuring Synchronicity: Conceptual Issues[34]

Measuring whether house prices move in tandem can take many approaches; this chapter focuses on three commonly used techniques to take advantage of each method's strengths (for example, see Hirata and others 2012; Del Negro and Otrok 2007; Jara and Romero 2016; and Landier, Sraer, and Thesmar 2017). For simplicity, assume the economy consists of two countries, *i* and *j*. Based on the framework in Doyle and Faust (2005), house prices in each country, h_i and h_j, can be decomposed into a common factor, ε_c, and an idiosyncratic factor for each country, ε_i and ε_j:

$$h_i = \varepsilon_c + \varepsilon_i + \gamma h_j, \text{ and } h_j = \varepsilon_c + \varepsilon_j + \gamma h_i . \quad \text{(A3.3.1)}$$

Here, $0 \le \gamma < 1$ represents the interconnectedness of house prices between the two countries. Simple arithmetic yields the following:

$$h_i = \frac{1}{1-\gamma^2}\left[\varepsilon_i + \gamma\varepsilon_j + (1+\gamma)\varepsilon_c\right], \text{ and}$$

$$h_j = \frac{1}{1-\gamma^2}\left[\varepsilon_j + \gamma\varepsilon_i + (1+\gamma)\varepsilon_c\right] . \quad \text{(A3.3.2)}$$

Without loss of generality, we assume that the size of the variance of the idiosyncratic shock is the same between the two countries (that is, $\sigma_i = \sigma_j$), all shocks are independent of each other (that is, $\sigma_{ij} = \sigma_{ic} = \sigma_{jc} = 0$), and house prices in each country have a mean of zero. In what follows, we define the three measures of synchronization used in the main text based on this framework and explain how we interpret those measures.

First, the instantaneous quasi correlation (qc_{ijt}) is defined in this framework as follows:

$$\begin{aligned} qc_{ijt} &= h_{it}h_{jt}/\sigma_{h_i}\sigma_{h_j} \\ &= \frac{1}{(1-\gamma^2)^2\sigma_{h_i}\sigma_{h_j}}\Big[\gamma\left(\varepsilon_{it}^2+\varepsilon_{jt}^2\right) + (1+\gamma)\varepsilon_{it}\varepsilon_{jt} \\ &\quad + (1+\gamma)\left(\varepsilon_{it}\varepsilon_{ct}+\varepsilon_{ct}\varepsilon_{jt}+\varepsilon_{ct}^2\right)\Big]. \end{aligned} \quad \text{(A3.3.3)}$$

When γ is not very large, the squared terms for idiosyncratic shocks, $\varepsilon_{it}^2 + \varepsilon_{jt}^2$, do not have large effects on this measure. In addition, since the interaction terms, $\varepsilon_i\varepsilon_j$, $\varepsilon_i\varepsilon_c$, and $\varepsilon_c\varepsilon_j$, fluctuate around zero, systematic movements of qc_{ijt} are driven by the square term of the common shock $(1+\gamma)\varepsilon_c^2$. Hence, this measure is suitable for identifying short-term comovement of house prices that is caused by the common shock and, indeed, as seen in Figure 3.7, sharp movements in the instantaneous quasi correlation are observed around global recessions in advanced economies, which, in this framework, points to a role for a common rather than an idiosyncratic shock driving the spike.

Second, the bilateral absolute difference in house prices between two countries (ad_{ijt}) is defined in this framework as follows:

[34]Prepared by Mitsuru Katagiri

$$ad_{ijt} = -\left|h_{it} - h_{jt}\right| = -\frac{1}{1+\gamma}\left|\varepsilon_{it} - \varepsilon_{jt}\right|. \quad \text{(A3.3.4)}$$

In contrast to the instantaneous quasi correlation, this measure is independent of the common shock because it cancels out. Given that idiosyncratic shocks are independent of one another and that their absolute difference moves almost randomly, this measure is suitable for assessing a long-term trend in synchronicity driven by changes in γ (the interconnectedness of house prices). Hence, the increasing trend in ad_{ijt}, as is observed in both advanced and emerging market economies, implies that the interconnectedness of housing markets across countries represented by γ has been increasing over the long term.

Third, the relative contribution of the global factor in country i (rc_i) is defined in this framework as follows:

$$rc_i = \frac{var\left(\frac{1+\gamma}{1-\gamma^2}\varepsilon_c\right)}{var(h_i)} = \frac{\sigma_c^2}{\frac{1+\gamma^2}{(1+\gamma)^2}\sigma_i^2 + \sigma_c^2}. \quad \text{(A3.3.5)}$$

As long as we estimate these variances using a relatively long-term window (for example, 15 years), this measure is suitable for identifying a long-term trend in synchronization. An observed increasing trend in rc_i, as is the case in advanced economies in the past two decades, could include any or all of three possibilities: (1) the size of common shocks has become larger (σ_c has risen); (2) the size of idiosyncratic shocks has become smaller (σ_i has declined); and (3) the interconnectedness has become tighter (γ has risen). Hence, this measure is a comprehensive measure for house price synchronicity, but it is empirically difficult to separately identify the above three cases using this measure.

Estimation of a Dynamic Factor Model[35]

House price dynamics are decomposed into the common and idiosyncratic factors by a dynamic factor model with time-varying parameters. In the model, the quarterly growth rate of house prices for country i in period t, $h_{i,t}$, consists of the global factor, g_t, the regional factor for region k (k =*Europe, Asia,* and *the Americas*), $r_{k,t}$, and the country-specific idiosyncratic component, $c_{i,t}$:

$$h_{i,t} = \lambda_{g,i} g_t + \lambda_{r,i} r_{k,t} + c_{i,t}, \quad \text{(A3.3.6)}$$

in which $\lambda_{g,i}$ and $\lambda_{r,i}$ are the factor loadings on the global and regional factors. The regional factor is extracted by region from the residuals after extracting the global factor. The global and regional factors are assumed to follow the vector autoregression jointly with global output, global inflation, and the global interest rate, which are the first principal components of each sequence across countries, and the time-varying factor loadings and the vector autoregression parameters are simultaneously estimated by the two-step procedure proposed in Koop and Korobilis (2013).

The relationship between house price synchronization and financial and trade openness is examined by the panel regression using the synchronization measured by estimating a dynamic factor model ($synch_{L,i,t}$):

$$synch_{L,i,t} = \alpha_i + \delta_t + \beta_1 kaopen_{i,t} + \beta_2 tr_{i,t} + \gamma Z_{i,t} + \varepsilon_{i,t}, \quad \text{(A3.3.7)}$$

in which α_i is a country fixed effect and δ_t is a time dummy. Here, financial openness is measured by capital account openness as represented by the Chinn-Ito index (Chinn and Ito 2006), $kaopen_{i,t}$, and trade openness is measured by the ratio of gross trade volume to GDP, $tr_{i,t}$. A vector of control variables, $Z_{i,t}$, includes the level of real GDP and consumer price index inflation. We use 15 years for the length of the fixed window for $synch_{L,i,t}$ for the baseline results and present results for 20 years as a robustness check. Also, for the measures of financial and trade openness, $kaopen_{i,t}$ and $tr_{i,t}$, the weighted average over the length of the window $\left(\text{that is, } \frac{1}{\sum_{l=0}^{L}(l+1)}\sum_{l=0}^{L-1}(l+1)x_{i,t-l}\right)$ is used. The weighted average assigns greater weight to the periods close to the beginning of the window because financial and trade openness may take some time to have effects on synchronization.

For house price synchronization, Annex Table 3.3.1 shows that β_1 and β_2 are positive and statistically significant. This result implies that, among 19 advanced economies that can be observed for a longer period, increases in financial and trade openness over time partly account for the rise in exposure to the global factor. Financial openness also explains the increase in the comovement in equities. Taken together, those results suggest that house price synchronization can be understood as part of asset price synchronization induced by the progress of financial openness more generally.

Growth at Risk[36]

Data Partitioning

To avoid parameter inflation and to reduce noise in financial time series, financial data are aggregated

[35]Prepared by Mitsuru Katagiri.

[36]Prepared by Romain Lafarguette.

Annex Table 3.3.1. Capital Account Openness and Synchronicity

	House Price Synchronicity		Equity Price Synchronicity	
	15 years	20 years	15 years	20 years
Chinn-Ito Index	0.06691**	0.06220***	0.13516**	0.12603***
	(0.02387)	(0.01585)	(0.04697)	(0.02585)
Exports plus Imports (over GDP)	0.00911**	0.01096***	–0.00160	–0.00715*
	(0.00394)	(0.00351)	(0.00416)	(0.00346)
Log of Output	0.22121	0.27416**	0.80820*	0.86895***
	(0.13475)	(0.11590)	(0.43479)	(0.21138)
Inflation	0.02439	0.00052	0.02031	0.01830**
	(0.02069)	(0.00643)	(0.02969)	(0.00775)
Observations	1,861	1,645	1,296	1,140
R^2	0.38823	0.47414	0.71709	0.88296
Number of Countries	19	19	12	12

Source: IMF staff estimates.
Note: 15 years and 20 years correspond to the window for variance decomposition. Robust standard errors are in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

between three ad hoc groups of variables representing, respectively, price of risk, leverage, and external factors.[37] The data-reduction technique used is linear discriminant analysis (LDA); the goal of LDA is to project a data set onto a lower-dimensional space while ensuring adequate separation of data into categories. LDA is similar to principal components analysis (PCA) in the sense that it maximizes the common variance among a set of variables, but it diverges from PCA in also ensuring that the linear combination of the variables discriminates across the classes of another categorical variable of interest. In the framework of the chapter, this categorical variable is a dummy variable, defined at the country level, equaling 1 when future GDP growth at a one-year horizon is below the 20th percentile of historical outcomes and equaling zero otherwise. Consequently, the loading on each individual financial indicator in the LDA is determined in a way that maximizes its contribution to discriminating between periods of low GDP growth and periods of normal GDP growth. This is convenient from the chapter's perspective because it allows for a link between financial indicators and GDP growth in the data-reduction process. By contrast, the PCA approach only aggregates information about the common trend among financial indicators.[38]

[37]The tables in Annex 3.2 in Chapter 3 of the October 2017 *Global Financial Stability Report* describe the specific financial indicators used.

[38]LDA assumes independence of normally distributed data and homoscedastic variance among each class, although LDA is considered robust when these assumptions are violated. See Duda, Hart, and Stork (2001). See Izenman (2009) for a thorough exposition of the LDA technique.

Quantile Regressions

The complex interplay between financial variables, house price synchronicity, and GDP growth is captured through a simple nonlinear framework using panel quantile regressions.[39] The model investigates the relative significance of asset prices, credit aggregates, foreign factors, and house price synchronicity in signaling risks to GDP growth (y), h quarters ahead.

The estimation is performed over different quantiles, spanning the full GDP growth distribution at different horizons (near, medium, and long term):

$$y_{t+h,q} = \alpha_q^h p_t + \beta_q^h Agg_t + \gamma_q^h y_t + \phi_q^h f_t + \theta_q^h HP_t + \epsilon_{t,q}^h, \quad \text{(A3.3.8)}$$

in which p, Agg, f, and HP correspond to the aggregated data of the price of risk (asset prices and risk spreads), credit aggregates (leverage), global and foreign variables (commodity prices, exchange rates, and global risk sentiment), and house price synchronicity.

[39]For an introduction to quantile regression, see Koenker (2005). As discussed in Komunjer (2013), quantile regressions rely on specific functional form assumptions and have some important advantages in forecasting the conditional distribution of the variable of interest. These advantages include the optimality of the conditional quantile estimator as a predictor of the true future quantile; robustness of the estimation to extreme outliers and violations of normality and homoscedasticity of the errors; flexibility, in terms of allowing for time-varying structural parameters and the optimal weighting of predictors depending on country, horizon, and the part of the distribution that is of interest; and the ability to avoid overfitting (compared with more complex models such as copulas and extreme value theory). Panel quantile regressions are estimated using the methodology proposed by Koenker (2004).

The role of house price synchronicity in signaling downside and upside risks to future growth can also function through amplification effects, particularly in conjunction with higher leverage or tighter financial conditions. To investigate this amplification mechanism, an augmented specification is considered:

$$y_{t+h,q} = \alpha_q^h p_t + \beta_q^h Agg_t + \gamma_q^h y_t + \phi_q^h f_t + \theta_q^h HP_t + \varsigma_q^h HP_t \times Agg_t(or\, p_t) + \epsilon_{t,q}^h. \quad \text{(A3.3.9)}$$

The coefficient ς_q^h represents the amplification effect of the impact of house price synchronicity when leverage increases or when financial conditions tighten. Overall, this approach disentangles the contribution of changes in house price synchronicity from the evolving price of risk, credit aggregates, and shocks to the external environment to forecasting risks to GDP growth. It thereby provides insights into which variables signal growth tail risks over different time horizons. This can help policymakers and others design a surveillance framework that seeks to embed information flowing in at different frequencies.

Methodology for Boxes

Methodology: Box 3.1

Four alternative regression specifications are considered to analyze the role of global investors. The main specification can be written parsimoniously as:

$$HPD_t = \beta_0 + \beta_1 FC_t + \beta_2 X_t + \beta_3 \gamma_t + \beta_4 GFC_t + \varepsilon_t, \quad \text{(A3.3.10)}$$

in which the dependent variable HPD_t is the ratio of the 90th percentile of house prices to the 10th percentile in the 40 largest US cities by population. The independent variable of interest, FC_t, is an unweighted real US$ average of house prices in non-US destinations for global investors. X_t is a vector of domestic control variables that includes the unemployment rate as a proxy for economic fundamentals, the Chicago Board Options Exchange Volatility Index (VIX) as a proxy for risk appetite, and the effective federal funds rate, 30-year fixed-rate average mortgage interest rates, and the mortgage-backed security holdings of large domestically chartered commercial banks (excluding mortgage-backed securities with government guarantees) as proxies for ease of access to financing. γ_t is a time trend, and GFC_t is a dummy variable for the global financial crisis.[40] Specification (1) regresses HPD_t on FC_t and a time trend; (2) includes the control variables. Specifications (3) and (4) use the first difference of the dependent variable to eliminate potential common trends. Specification (4) also includes the global financial crisis dummy GFC_t. See Annex Table 3.3.2.

Methodology: Box 3.4

The analysis in Box 3.4 gauges the effectiveness of macroprudential tools in reducing house price synchronicity across 41 countries from 1990:Q2–2016:Q4. More specifically, the following panel regression specification is estimated, with *i* denoting the country and *t* representing the quarter:

$$HPS_{i,t} = \rho BCS_{i,t-1} + \beta MPP_{i,t-1} + \gamma X_{i,t-1} + \alpha_i + \epsilon_{i,t}, \quad \text{(A3.3.11)}$$

in which α_i denotes country fixed effects. The dependent variable *HPS* refers to house price cycle synchronicity (instantaneous quasi correlation) with the global cycle. *BCS* is business cycle synchronicity with the rest of the world. *X* is a vector of controls (including a global factor, financial integration with the world, and institutional characteristics). *MPP* is a macroprudential tool (such as limits on loan-to-value ratios or debt-to-income ratios or fiscal-based measures that include sellers' and buyers' stamp duty taxes) or a macroprudential group index (such as loan-targeted, supply-side [capital, general, loans], or demand-side tools).[41]

[40] GFC_t equals 1 during 2008 and 2009.

[41] For more details regarding the macroprudential tools database, see Alam and others (forthcoming).

Annex Table 3.3.2. Global Investors, House Price Dispersion, and Synchronicity: Regression Results

Dependent Variable: Ratio of 90th Percentile of House Prices to the 10th Percentile in the 40 Largest US Cities by Population	(1)	(2)	(3)	(4)
	Levels		Differences	
Foreign City House Price Index (FC_t)	0.600***	0.339**	0.019**	0.019**
	(0.000)	(0.031)	(0.039)	(0.039)
VIX Index		–0.002**	0.000**	0.000**
		(0.041)	(0.021)	(0.022)
Federal Funds Rate (effective)		0.002	0.007***	0.007***
		(0.952)	(0.009)	(0.009)
Mortgage Interest Rates		–0.011	0.005**	0.005**
		(0.654)	(0.017)	(0.017)
Bank MBS Holdings		0.434*	–0.002	–0.002
		(0.053)	(0.883)	(0.881)
Unemployment Rate		0.012	–0.003	–0.003
		(0.652)	(0.145)	(0.148)
Time Trend	0.025***	0.024***		
	(0.000)	(0.000)		
Financial Crisis Dummy (GFC_t)				–0.000
				(0.528)
Constant	0.188*	0.287**	–0.001	–0.001
	(0.073)	(0.016)	(0.618)	(0.619)
Observations	256	250	250	250
Adjusted R^2	0.904	0.911	0.060	0.083

Sources: Board of Governors of the Federal Reserve; Haver Analytics; Zillow Group; and IMF staff calculations.
Note: Monthly data from 1996:Q4 to 2017:Q9. Robust (Newey-West, 12 lags) *p*-values in parentheses. Dependent variables are lagged one month. All variables other than the foreign city real house price index pertain to the United States. Bank MBS holdings refer to MBS without government guarantees held by large domestically chartered commercial banks, and mortgage interest rates reflect the 30-year fixed-rate average. The dependent variable, foreign city house prices, and bank MBS holdings are in log scale. All variables are in first differences except the VIX, bank MBS holdings, and the dependent variable in (1)–(3), which are stationary in levels according to unit root tests. FC = foreign city house price index; GFC = global financial crisis; MBS = mortgage-backed securities; VIX = Chicago Board Options Exchange Volatility Index.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

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