# Leveraged Bubbles*

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**PRELIMINARY. PLEASE DO NOT CITE/CIRCULATE.**

**Abstract**

What risks do asset price bubbles pose for the economy? This paper studies bubbles in housing and equity markets in 17 countries over the past 140 years. History shows that not all bubbles are alike. Some have enormous costs for the economy, while others blow over. We demonstrate that what makes some bubbles more dangerous than others is credit. When fueled by credit booms asset price bubbles increase financial crisis risks; upon collapse they tend to be followed by deeper recessions and slower recoveries. Credit-financed house price bubbles have emerged as a particularly dangerous phenomenon.

*Keywords:* boom, bust, bank lending, debt overhang, crises, local projections.

*JEL Codes:* C14, C52, E51, F32, F42, N10, N20.

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*All of us knew there was a bubble. But a bubble in and of itself doesn't give you a crisis.... It's turning out to be bubbles with leverage.*

*— Former Federal Reserve Chairman Alan Greenspan, CNBC Squawk Box, 2013*

What risk do asset price bubbles present to the economy? Naturally, in the wake of the largest financial crisis since the Great Depression, the causes and consequences of extended mispricing of financial assets have climbed to the top of the agenda for macroeconomists and policymakers. It has become harder to dismiss such bubble episodes as rare aberrations and exclude them from macroeconomic thinking on axiomatic grounds.

In the pre-crisis consensus, to a large extent, policymakers and economists preferred to ignore bubbles, arguing that they couldn't exist, or couldn't be detected, or not reliably, or that nothing could or should be done, or there might be unintended consequences, and so on. Researchers and central bankers imagined that the problem of depressions had been solved and that the financial sector would be self-stabilizing. The financial stability role of central banks was mostly regarded as secondary, if not quaintly vestigial. The crisis exploded these and other myths which had taken hold based on very little firm empirical evidence, and with scant regard for the lessons of history. The Former Fed Chairman very publicly resiled from old beliefs: he stepped away from a benign neglect approach to markets' irrational exuberance, admitted the "flaw" in his worldview, and began to entertain, as above, the possibility that central banks might need to pay heed to bubbles, or at least some of them, rather more seriously than before.[1]

Where are we now? Among policymakers and economists a post-crisis consensus seems to be emerging, and this new view worries a lot about *leveraged bubbles*. Yet, the skeptic might well ask: Isn't this new consensus just as detached from evidence-based macroeconomics as the last one? Isn't more empirical work needed before we rush to embrace another approach? Sadly, as of now, if one seeks statistically powerful inference based on data from large samples, then one can find little empirical evidence about varieties of asset price bubbles and the damage they might wreak on the economy.

This paper aims to close this gap by studying the nexus between credit, asset prices, and economic outcomes in advanced economies since 1870. We use a dataset that spans the near universe of advanced economies in the era of modern economic growth and finance capitalism over the last 150 years. Financial crises and asset price boom-busts are relatively rare events. Thus, any empirical study requires very long time series and the

[1]For the CNBC interview see Matthew J. Belvedere, "Bubbles and leverage cause crises: Alan Greenspan," October 23, 2013 (`http://www.cnbc.com/id/101135835`). For more depth see the interview with Gillian Tett ("An interview with Alan Greenspan," *FT Magazine*, October 25, 2013).

experience of more than one country to conduct any reasonable statistical analysis, as our prior work has shown.

Our key result is that some bubbles matter more than others. What makes bubbles dangerous is the role of credit, as was belatedly suspected by Greenspan. This finding also fits with conjectures put forward by Mishkin (2008, 2009) and other policymakers after the crisis: the idea that there are two categories of bubbles. Pure, unleveraged "irrational exuberance" bubbles may pose a limited threat to financial stability or the macroeconomic outlook. "Credit boom bubbles," on the other hand, may be a dangerous combination. In such bubbles, a positive feedback develops that involves credit growth, asset prices, and increasing leverage. When such credit boom bubbles go bust, in Mishkin's words, "the resulting deleveraging depresses business and household spending, which weakens economic activity and increases macroeconomic risk in credit markets." Arguably, these deleveraging pressures have been a key reason for the slow recovery from the financial crisis (Mian and Sufi 2014; Jorda, Schularick, and Taylor 2013).

The plan of the paper is as follows. First, we introduce the two historical datasets underlying this study. In the second part, we study the role of credit and asset price bubbles in the generation of financial crises. Using a comprehensive dataset, covering a wide range of macroeconomic and financial variables, we demonstrate that it is the interaction of asset price bubbles and credit growth that poses the gravest risk to financial stability. These results, based on long-rung historical data, offer the first sound statistical support based on large samples for the widely held view that the financial stability risks stemming from of an unleveraged equity market boom gone bust (such as the U.S. dotcom bubble) can differ substantially from a credit-financed housing boom gone bust (such as the U.S. 2000s housing market). Third, analyzing the consequences of bursting asset price bubbles for the macroeconomy, we show that the output costs in the depth of the financial crisis recession, and the speed of the subsequent recovery, are shaped by the interaction of asset price run-ups and the pace of credit growth in the prior boom phase.

Our conclusions align with the emerging post-crisis consensus, but add some actual evidentiary basis for that view: asset price bubbles are harmful when accompanied by credit booms. We find that the interaction of the two sows the seeds of severe economic distress. The risk of a financial crisis rises substantially and subsequent recessions are considerably more painful.

Our new discoveries also place a renewed and nuanced emphasis on our earlier work on the causes of financial instability (Schularick and Taylor 2012; Jordà, Schularick, and Taylor forthcoming). It is not only credit growth, but the interaction of credit and asset prices that matters for financial stability risks and the economic costs of financial crises.

# 1. Data

Our study relies on the combination and extension of two new long-run macro-finance datasets that have recently become available. In Jordà, Schularick, and Taylor (2014) we presented the latest vintage of our long-run credit and macroeconomic dataset in the form of an annual panel of 17 countries since 1870. To study asset price booms we have then added equity price data from stock price index time-series data, as detailed below. The second dataset underlying the study by Knoll (2014) and Knoll, Schularick, and Steger (2014) covers house prices since 1870 on an annual basis for a panel of 16 countries. All these datasets were then merged for the present study. Table 1 gives an overview of the underlying data for house prices, equity prices and bank credit.

The credit dataset covers credit aggregates, interest rates, equity prices as well as a large number of real economic variables for 17 countries since 1870 on an annual basis. We updated the dataset to include data up to 2012, which puts us in a position to include the global financial crisis and its aftermath in our analysis. We have also widened the coverage of equity prices to 17 countries, with data typically beginning in the late 19th or early 20th century. At the core of this dataset are credit-aggregates (bank lending) for 17 countries, both for total and disaggregated credit. Data on macroeconomic control variables come from our previous work, where we relied on the efforts of other economic and financial historians and the secondary data collections by Maddison (2005), Barro and Ursúa (2008), and Mitchell (2008abc). Data on financial crisis dates come from the now standard sources such as Bordo et al. (2001), Laeven and Valencia (2008, 2012), and Reinhart and Rogoff (2009).

The current dataset builds on and extends the long-run credit data compiled by Schularick and Taylor (2012), and the updated series in Jordà, Schularick, and Taylor (2014). Compared to the older vintage, the coverage of financial institutions is broader. In addition to commercial banks' balance sheets, the data now include credit extended by savings banks, credit unions, and building societies. We have compiled a new series of total bank lending to the private sector that replaces the older series from Schularick and Taylor (2012). As before, data constraints mean that we cannot include direct borrowing in capital markets and private credit contracts.[2]

The data come from a broad range of sources, including economic and financial history books, journal articles, publications of statistical offices and central banks. We also

[2]Historical research has shown that those have been sizable in some countries in the early 19th century (see, e.g. Hoffman, Postel-Vinay, and Rosenthal 2000 for France). Yet a comparison with Goldsmith's (1969) seminal estimates shows that our series capture the largest part of total private credit for most countries over the entire period.

**Table 1:** *Data sources, period, and coverage details of the house price and equity price data*

For each country, we show the period covered by the equitymarket index, the period covered by the house price index, and the period covered by the bank loans series.

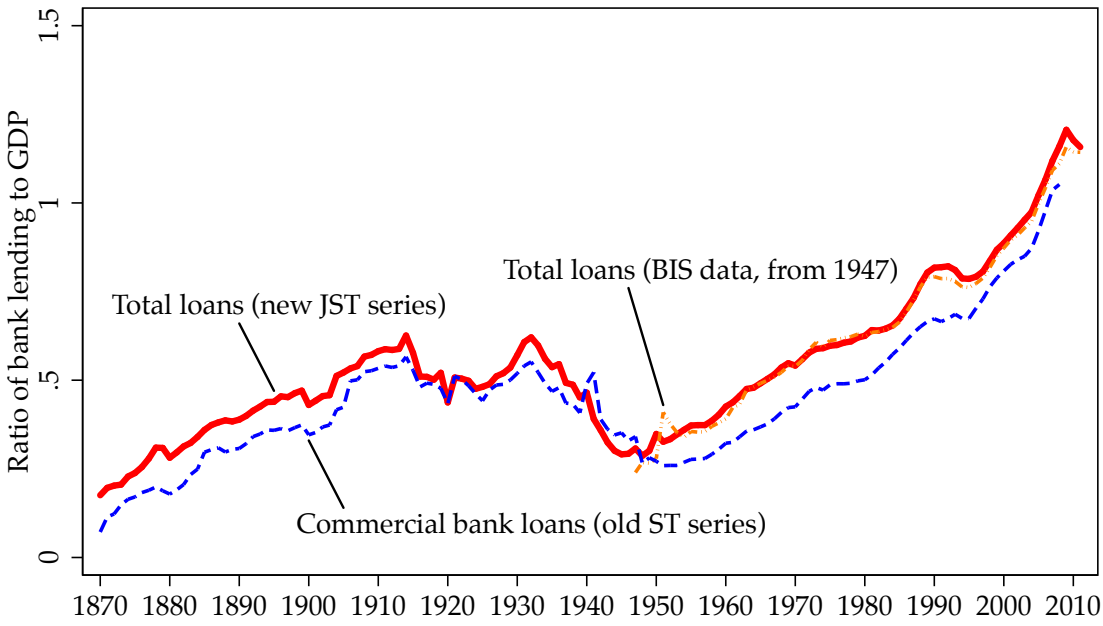
| Country | Equity prices | House prices | Bank loans |
|---|---|---|---|
| Australia | 1875–2012 | 1870–2012 | 1870–2012 |
| Belgium | 1897–2012 | 1878–2012 | 1885–2012 |
| Canada | 1915–2012 | 1921–2012 | 1870–2012 |
| Switzerland | 1910–2012 | 1900–2012 | 1870–2012 |
| Germany | 1870–2012 | 1870–2012 | 1883–2012 |
| Denmark | 1915–2012 | 1875–2012 | 1870–2012 |
| Spain | 1874–2012 | 1970–2012 | 1900–2012 |
| Finland | 1922–2012 | 1905–2012 | 1870–2012 |
| France | 1870–2012 | 1870–2012 | 1900–2012 |
| U.K. | 1870–2012 | 1899–2012 | 1880–2012 |
| Italy | 1906–2012 | 1970–2012 | 1870–2012 |
| Japan | 1913–2012 | 1913–2012 | 1888–2012 |
| Netherlands | 1890–2012 | 1870–2012 | 1900–2012 |
| Norway | 1914–2012 | 1870–2012 | 1870–2012 |
| Portugal | 1931–2012 | —— | 1870–1903 / 1920–2012 |
| Sweden | 1870–2012 | 1870–2012 | 1871–2012 |
| U.S. | 1870–2012 | 1890–2012 | 1880–2012 |

*Notes*: Equity prices are broad indices. House prices are quality adjusted where possible. For bank loans, the financial institutions covered include commercial banks (CB) and other financial institutions (OFI) such as savings banks, credit unions, and building societies. Data generally cover all monetary financial institutions.
*Sources*: Jordà, Schularick, and Taylor (2014) and Knoll, Schularick, and Steger (2014). See text.

consulted archival sources at central and private banks. The success of the data collection effort owes much to generous support of many colleagues at various research institutions, archives, central banks, and statistical offices. Details of the data construction can be found in Jordà, Schularick, and Taylor (2014).

Figure 1 shows the total bank credit series from the new database compared with the older series taken from our previous dataset relying mainly on credit by commercial banks. For the post-WW2 period, the data can be compared to the credit database maintained by the Bank for International Settlements (2013). Both series track each other closely. The trends in long-run bank lending are well known by now: after an initial period of financial deepening in the late 19th century the average level of the credit-to-GDP ratio in advanced economies reached a plateau of about 50%–60% around 1900. Subsequently, with the notable exception of the deep contraction seen in bank lending in the Great Depression and World War II, the ratio broadly remained in this range until the 1970s. The trend then

**Figure 1:** *Bank credit to the domestic economy, 1870–2011, with a comparison of data from three different sources: Average ratio to GDP by year for 17 countries*




*Notes*: *Total Loans (new JST series)* refers to new data on total loans to the non-financial private sector (businesses and households) from the banking sector (broadly defined as explained in the text) and compiled by us for this paper; *Commercial bank loans (old ST series)* refers data on total loans to the non-financial private sector by commercial banks compiled by Schularick and Taylor (2012); *Total loans (BIS data)* refers to data on total loans by the banking sector compiled by the BIS (2013). All three series reported as a fraction to GDP and then averaged across all 17 countries in the sample. See text.

broke: the three decades that followed were marked by a sharp increase in the volume of bank credit relative to GDP. Bank lending on average roughly doubled relative to GDP between 1980 and 2009 as average bank credit to GDP increased from 62% in 1980 to 118% in 2010. Put differently, the data dramatically underscore the size of the credit boom prior to the global financial crisis of 2008. This is only a lower bound estimate as it excludes credit creation by the shadow banking system, which was significant in some countries, such as in the U.S. and the U.K.

We merge this historical macro dataset with panel data covering long-run house prices. Combining data from more than 60 different sources, Knoll, Schularick and Steger (2014) construct house price indices reaching back to the early 1920s in the case of Canada, the early 1900s (Finland, Germany, Switzerland), the 1890s (Japan, U.K., U.S.), and the 1870s (Australia, Belgium, Denmark, France, Netherlands, Norway). Compared to existing

studies such as Bordo and Landon-Lane (2013), the dataset extends the series for the United Kingdom and Switzerland by more than 30 years, for Belgium by more than 40 years, and for Japan by more than 50 years. Overall, the new dataset doubles the number of country-year observations, allowing a more detailed study of long-run house price dynamics.

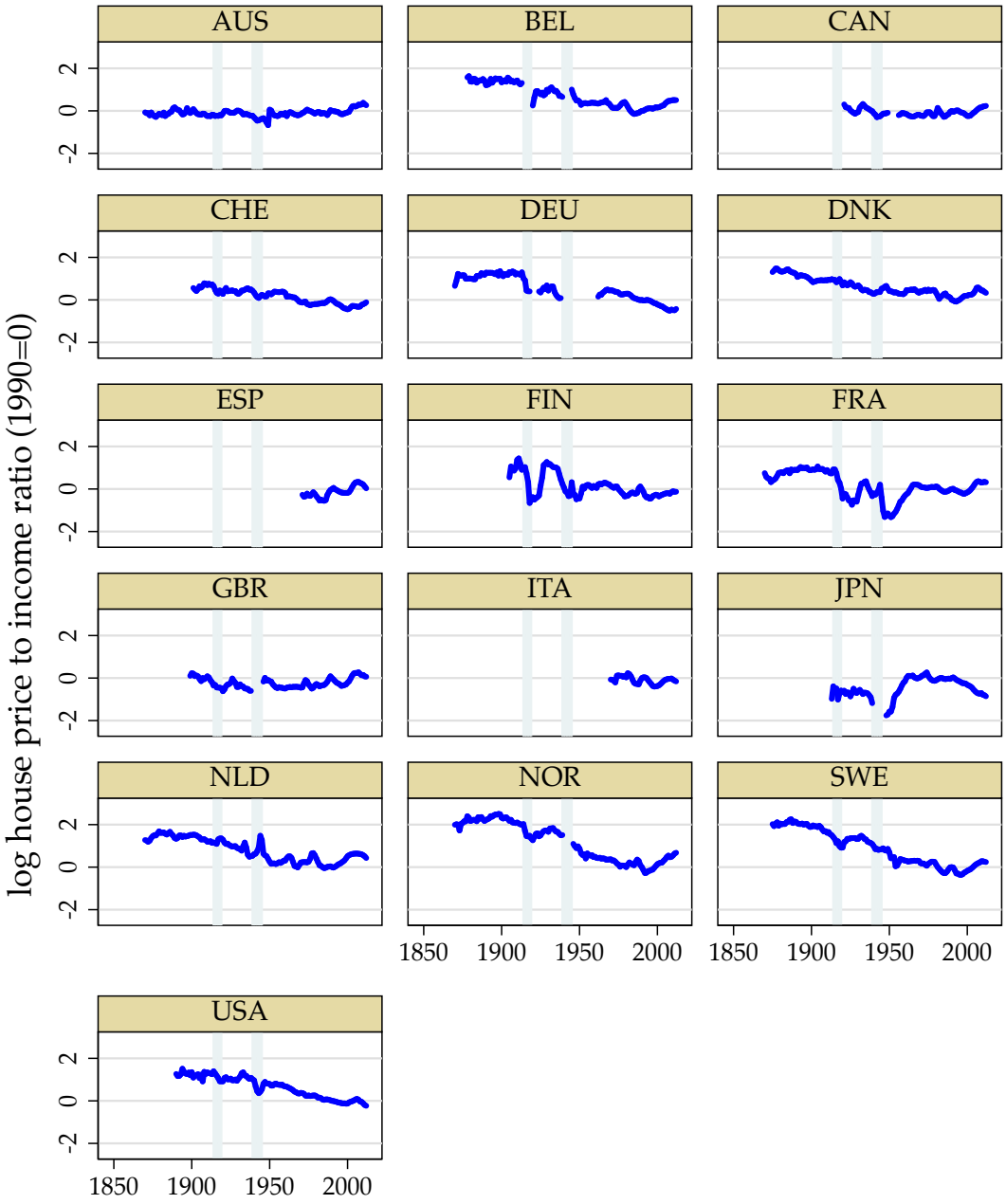
Constructing long-run house price data requires pragmatic choices between the ideal and the available data. A house is a bundle of the structure and the underlying land. The price of the structure corresponds to its replacement value which is a function of construction costs. The best possible index would measure, for each country, the appreciation of the price of a standard, unchanging house. But houses are heterogeneous assets posing particular challenges for the construction of price indices that are comparable across countries. Typically, house price data exist for shorter periods and have to be spliced to construct at a long-run index. With these caveats in mind, the series reconstructed by provide the best available basis for empirical analysis.

The house price data collected and analyzed by Knoll, Schularick and Steger (2014) show that the path of global house prices in the 20th century has not been continuous. Real house prices, deflated with the consumer price index (CPI), remained stable from 1870 until the middle of the 20th century after which they rose substantially, as Figure 2 shows. Figure 2 also demonstrates that there are large swings in real house prices. Periods of pronounced increases are often followed by abrupt corrections, as Knoll (2014) discusses. In addition, Figure 2 demonstrates that there is considerable heterogeneity in house price trends across economies that otherwise have similar characteristics and comparable long-run growth performance.

Complementing Figure 2, Figure 3 displays the equity market data underlying our empirical analysis. Just like house prices, real equity prices exhibit considerable cross-country heterogeneity and volatility in the course of the 20th century. It is also noteworthy that, just as house prices, equity prices seem to share a general tendency to increase faster than CPI in recent decades.

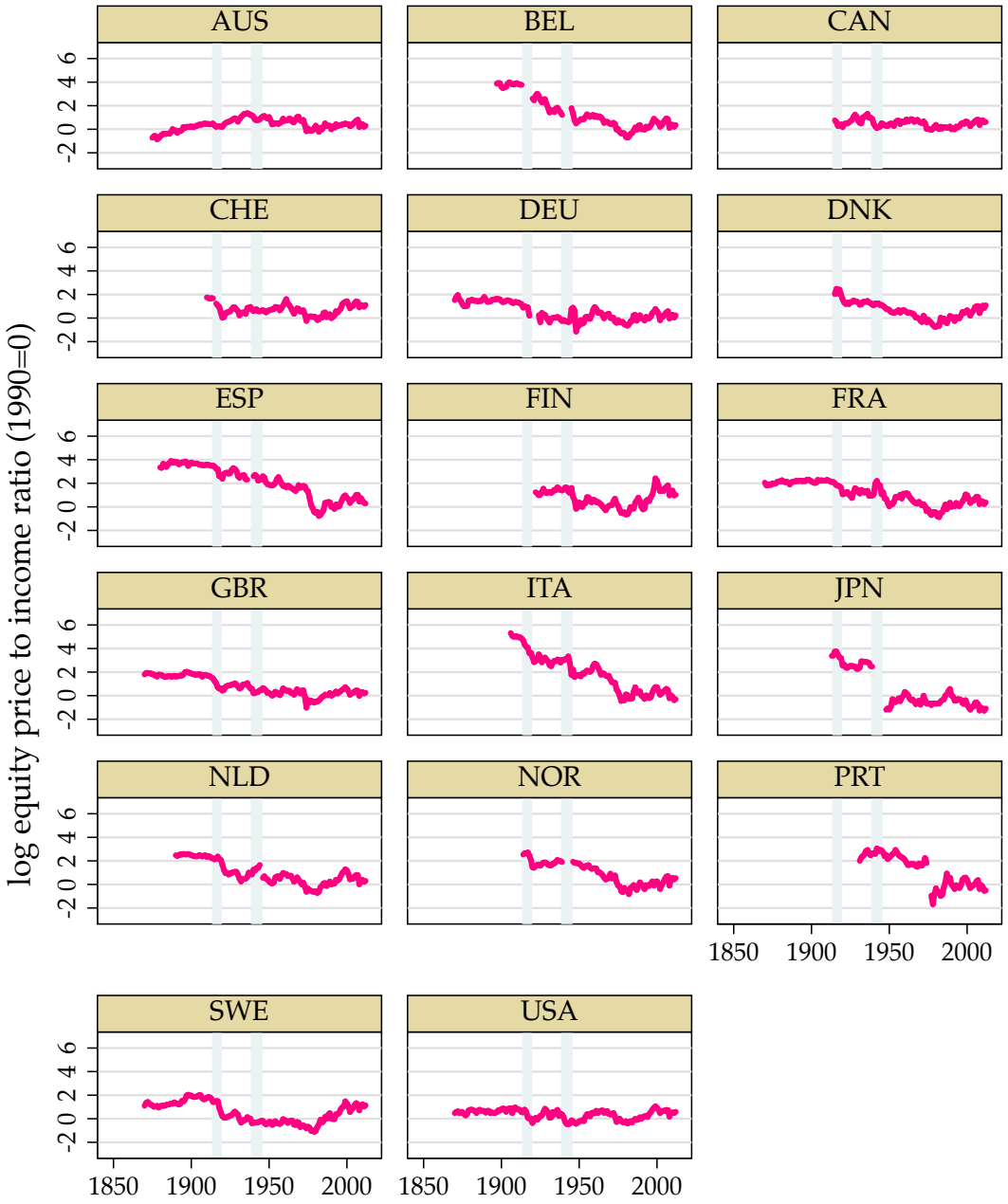
In total, the asset price dataset assembled for this study rests on 1998 country-year equity price and 1818 house price observations. On average, we have per country 117 years of equity price information and 113 years of house price data. With sample size comes statistical power: using this large historical dataset, we can perform more formal benchmarking and statistical analysis for the near-universe of advanced-country macroeconomic and asset price trends, covering over 90% of advanced economy output. In the next section, we will briefly present how we identify asset price bubbles in the data before formally studying their economic consequences.

**Figure 2:** *Real house prices in the 20th century*




*Notes*: Nominal house price index divided by consumer price index. See text. The years of the two world wars are shown with shading.

**Figure 3:** *Real equity prices in the 20th century*




*Notes*: Nominal equity price index divided by consumer price index. See text. The years of the two world wars are shown with shading.

## 2. Empirical identification of asset price bubbles

The term "bubble" is typically used when asset prices deviate from their fundamental value in an asymmetric and explosive way, often in conjunction with a subsequent crash. Bubbles can occur even if investors have rational expectations and have identical information—so called rational bubbles—but also under asymmetric information, in the presence of limits to arbitrage and when investors hold heterogeneous beliefs (e.g., Brunnermeier 2008).

Determining the presence of bubbles empirically, however, is no easy task. One option is to follow Borio and Lowe (2002), as well as Detken and Smets (2004) and Goodhart and Hofmann (2008), who have defined house price booms as deviations of real house prices above some some specified threshold relative to an HP filtered trend with a high smoothing parameter. We build upon this kind of definition, but it is not the only approach. Bordo and Jeanne (2002), by contrast, focus on the explosive growth dynamics instead of the level deviation from long-run assumed fair value. In their work, an asset price boom episode is detected when the 3-year moving average growth rate exceeds the series average by more than 1.3 times the series standard deviation. Other definitions of bubbles based on sustained peak-trough or trough-peak changes appear in works by Helbling (2005), Helbling and Terrones (2003), and Claessens et al. (2008) for the IMF.

As this brief survey makes clear, there is no accepted standard definition of bubble phenomena. Research has used both large deviations of price levels from some reference level and also large rates (or amplitudes) of increase/decrease as indicative of the rise and fall of bubble events. In the following, we propose a combination of both approaches and apply two criteria for the detection of an asset price bubble episode. In essence, we require that log real asset prices must not only diverge significantly from their trend—by more than one standard deviation from a Hodrick-Prescott filtered trend ($\lambda$=100, annual data)—but they must also involve large price corrections when the bubble bursts, by more than 15% (a change of –0.15 log points) within a 3-year window looking forwards at some point during the years in which prices are elevated. The precise signals we use in each country-year observation are as follows, where $z_{it}$ is the HP detrended log real asset price, whether equity or housing, and $I$ is the indicator function:

$$\text{Price Elevation Signal}_{it} = I(z_{it} > \text{standard deviation of } z \text{ in country } i)$$

$$\text{Price Correction Signal}_{it} = I(z_{i,t+3} - z_{it} < -0.15 \text{ for some year } t \text{ within the episode})$$

$$\text{Bubble Signal}_{it} = \text{Price Elevation Signal}_{it} \times \text{Price Correction Signal}_{it}$$

**Table 2:** *Largest equity and housing price bubbles during business cycle expansions as measured by price elevation, by country*

| | | | Equity price | | | | | Housing price | |
|---|---|---|---|---|---|---|---|---|---|
| Recession/type | | | Elevation, max. s.d | Correction, max. drop | Recession/type | | | Elevation, max. s.d. | Correction, max. drop |
| AUS | 1973 | N | 2.6 | .82 | AUS | 1889 | N | 3 | .32 |
| BEL | 2008 | F | 2.1 | .59 | BEL | 1980 | N | 2.6 | .34 |
| CHE | 1974 | N | 2.7 | .76 | CHE | 1990 | F | 2.3 | .22 |
| DEU | 1966 | N | 2.4 | 1.08 | DEU | 1913 | N | 4.7 | .1.09 |
| DNK | 1987 | F | 2.4 | .25 | DNK | 2007 | F | 2.6 | .21 |
| ESP | 1974 | N | 2.4 | 1.24 | ESP | 1978 | F | 1.6 | .30 |
| FIN | 2008 | N | 3.2 | 1.00 | FIN | 1929 | F | 2.9 | .23 |
| FRA | 2007 | F | 2.5 | .66 | FRA | 1937 | N | 2.8 | .51 |
| GBR | 1973 | F | 3.1 | 1.37 | GBR | 1990 | F | 2.8 | .25 |
| ITA | 1992 | F | 2.7 | .61 | ITA | 1992 | F | 1.8 | .32 |
| JPN | 1973 | N | 2.8 | .61 | JPN | 1973 | N | 2.5 | .20 |
| NLD | 2001 | N | 2.6 | .81 | NLD | 1980 | N | 3.5 | .49 |
| NOR | 1981 | N | 2.6 | .79 | NOR | 1987 | F | 3.4 | .34 |
| PRT | 1992 | N | 3.2 | .86 | PRT | | | | |
| SWE | 2007 | F | 2.8 | .84 | SWE | 1990 | F | 2.6 | .36 |
| USA | 1929 | F | 3.2 | .92 | USA | 2007 | F | 2.4 | .19 |

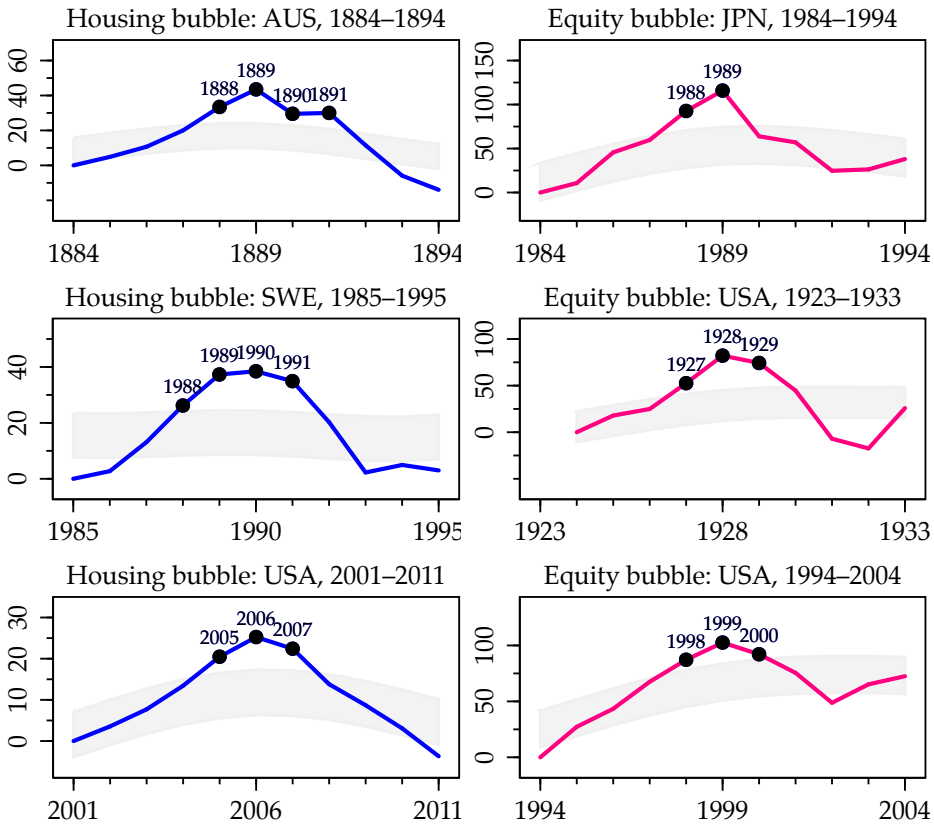
*Notes*: Country-years for recessions for which there are also data on bubbles in equity and house prices. N/F refers to whether the recession is normal or financial; *Max. SD* indicates the maximum price elevation deviation from log real asset price HP trend in country-specific standard deviation units; and *Max. Drop* refers to the maximum price correction drop in log real asset prices (in log times 100) in a 3-year forward-looking window. For each county, only the episodes with the maximum price elevation are shown. No historical house price data for Portugal. See text.

As a first cut of the data, Table 2 shows the most significant asset price boom episodes in real housing and equity prices in the past 140 years of macroeconomic history for each country in our sample when we look at asset price booms coincident with business cycle expansions. The year of the episode's expansion peak is listed, along with information on the maximum degree of price elevation (the deviation from HP trend, as described above, measured here in country-specific units of standard deviation) where the expansion episode with the largest such deviation is the one listed for each country; we also list in each case the corresponding magnitude of the associated asset price correction (100 times 3-year log change, as described above).

In every case, the most dramatic run ups in equity prices led to deviations from trend of +2.1 to +3.2 in standard deviation units, with subsequent corrections exceeding 0.59 log points in all but one case, and over 1.00 log points in 4 out of 17 cases. The largest run ups in housing prices are also dramatic, with deviations from trend of between +1.8 and

**Figure 4:** *Examples of the bubble indicator for six illustrative episodes*

The figures show, for each 10-year window, the log real asset price (rebased to the start year), a band of ±1 standard deviation (for that country's detrended log real asset price), and the years for which the bubble signal is turned on using our algorithm.




*Notes*: See text.

+4.7 in standard deviation units. Subsequent corrections are in the .19 to .51 range, with one exception. The data show the wide range of historical episodes in extreme bubbles of each kind, and also illuminate how heterogeneous country experiences are: not every country has its most dramatic equity boom in the 1920s, and not every big housing boom was in the 2000s, according to our metrics.

To provide a more granular view of our bubble signal algorithm, Figure 4 zooms in on several 10-year windows surrounding well known asset price boom and bust cycles for several countries in our dataset. The line in each chart plots the log real asset price for that country in the specified period, with the ±1 s.d. reference band centered on the HP trend, and the markers on the line with year labels pick out those years which our algorithm selects as "bubble" episodes. To the naked eye the algorithm seems to produce

**Table 3:** *Amplitude, rate, and duration of bubbles*

| | | *Full sample* | | *Pre-WW2* | | *Post-WW2* | |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| | | Equity | House | Equity | House | Equity | House |
| *Amplitude* | Mean | 31.12 | 15.29 | 24.41 | 14.00 | 32.97 | 16.28 |
| | | (21.15) | (13.04) | (16.15) | (16.96) | (22.06) | (9.285) |
| | Minimum | -15.22 | 2.30 | 4.52 | 2.30 | -15.22 | 3.65 |
| | Maximum | 99.93 | 72.19 | 75.33 | 72.19 | 99.93 | 40.38 |
| *Rate* | Mean | 17.05 | 5.20 | 12.99 | 4.73 | 18.18 | 5.56 |
| | | (11.26) | (3.47) | (7.92) | (4.24) | (11.82) | (2.80) |
| | Minimum | -3.81 | 0.58 | 1.51 | 0.58 | -3.81 | 0.91 |
| | Maximum | 71.83 | 18.05 | 34.04 | 18.05 | 71.83 | 10.30 |
| *Duration* | Mean | 2.00 | 3.08 | 2.14 | 3.06 | 1.96 | 3.09 |
| | | (0.88) | (1.24) | (0.91) | (1.56) | (0.87) | (0.97) |
| | Minimum | 1 | 1 | 1 | 1 | 1 | 1 |
| | Maximum | 4 | 6 | 4 | 6 | 5 | 5 |
| Observations | | 97 | 39 | 21 | 17 | 76 | 22 |

*Notes*: *Amplitude* refers to the percentage change in the price from the point in time where the asset price breaks the one standard deviation barrier with respect to the Hodrick-Prescott trend, and the collapse of the bubble. *Rate* refers to the annual rate of change in the price of the asset identified by the *amplitude* variable. *Duration* refers to the number of periods that the bubble lasts so that *amplitude* divided by *duration* equals *rate*. Standard errors in parenthesis. See text.

reasonable signals for all these cases.

Finally, Table 3 provides a bird's-eye view on the main features of equity and housing bubbles from the point they start until they collapse. Start is defined as the moment when the price elevation signal switches on at +1 s.d. Comparing columns (1) and (2) based on the full sample, it is clear that fluctuations in equity prices are far more volatile, and on average, about twice the size of those in house prices. As a result, the average duration of equity bubbles is one third shorter on average (2 versus 3 years). These differences are similar across eras, as the subsample analysis in columns (3)-(6) reveals.

Some of the most-well known historical episodes that our algorithm picks up include the Australian real estate boom of the 1880s that came to an abrupt end in the early 1890s leading to a prolonged period of economic adjustment. We also pick up a major speculative real estate boom that took hold in Copenhagen and spread to other Danish cities in the early 1900s as well as the 1920s real estate boom in the U.S. The parallels to the boom and bust of the 2000s have recently been analyzed by White (2014): housing starts surged and, with large regional variation, prices rose strongly, fueled by easy credit and financial innovations. The crash occurred in the mid-1920, well in advance of the

Great Depression. Yet it led to a surge in foreclosures that weakened the financial system.

The boom and bust of equity markets in the late 1920s is arguably the most famous asset price boom and bust episode in modern economic history. From their trough in 1921, U.S. equity prices increased 6-fold in the course of the 1920s. Yet the Roaring Twenties ended for good on October 24, 1929, on Black Thursday. The market lost 11 percent of its value within a few minutes of trading. In the following week, Black Thursday was followed by Black Monday and Black Tuesday. On both days, shares posted double-digit losses. The Wall Street of October 1929 crash has ever since played a central role in historical accounts of the Great Depression.

Turning to the second half of the 20th century, we include the Swiss housing boom in the 1980s as well as the Scandinavian boom and bust episodes of the late 1980s and early 1990s, often linked to the process of financial deregulation that swept the region at the beginning of the decade. The Japanese asset price bubble accelerated strongly after 1985 (Okina et al. 2001). Initially, equity prices posted the strongest gains. Land prices only followed the Nikkei index with a lag of a few years. Japanese urban land prices doubled over a few years, while the price of listed equities tripled. Equity prices peaked in 1989, while real estate peaked in 1991. While stock prices had fallen by 60 percent in 1992 already, land prices deflated more slowly and remained on a downward trajectory for almost two decades after their peak. By 2012, the nominal value of real estate was about half its 1991 value.

## 3. Bubbles and the business cycle

The Global Financial Crisis, the gravest crisis to engulf advanced economies since the Great Depression, is often linked to the bursting of a housing bubble in the U.S. Are financial crisis recessions typically preceded by asset price booms? Table 4 provides a simple tally of this association in the context of our historical dataset.

We split the sample before and after WW2 in addition to providing the full sample results. Furthermore, we separate recessions into financial crisis recessions (those recessions where a financial crisis took place within a two year window) and normal recessions (for which we are unable to find a concomitant financial event). Recessions are dated using the Bry and Boschan (1971) algorithm. In annual data, this simply means that years in which output declines are years of recession. The recession dates that we use refer to the peak of the business cycle, that is, the first year of recession.

An important reason to split the sample with WW2 is to recognize the dramatic growth in mortgage lending that took place in many countries following this turning point,

sometimes facilitated by government programs designed to promote home ownership. Home ownership rates in the U.K. before WW2 stayed well below 30% and barely cracked 50% in the U.S., for example. In the eve of the Great Recession those numbers more than doubled for the U.K. and would top up at 65% in the U.S. The implication for the analysis is clear and well reflected in Table 4. As a larger portion of the population invested in real estate, fluctuations in the price of this asset class had more widespread economic implications.

The first noteworthy result in Table 4 is that financial crisis recessions in the pre-WW2 era were just as likely to take place in association with a bubble episode in equities and/or houses than not –10 out of 22 financial crisis recessions have this feature. In part this likely reflects the observation that speculation took place in other asset classes, primarily commodities. For example, the panic of 1907 in the U.S. is often associated with speculation in copper prices by United Copper Co. When copper prices collapsed, so did United Copper Co. and its main creditor, Knickerbocker Trust Co., at the time the third largest financial institution in the U.S. The fall of Knickerbocker set off massive consolidation of the financial system (and subsequently the creation of the Federal Reserve System), as well as one of the largest waves of bank failures in U.S. history.

After WW2, however, we find that all but one financial crisis recession (out of a total of 22) were associated with a collapse of equity and/or house prices. The differences do not stop there. Whereas equity price booms play a prominent role in those financial recessions associated with a bubble episode before WW2 (8 out of 12 bubble related financial crisis recessions involve equities alone), after WW2 it appears that most episodes involved bubbles in both equity and house prices—11 out of 21 episodes are linked to bubbles in both asset classes.

What about normal recessions? Is there a similar pattern pre- and post-WW2? Do bubbles always lead to recessions? The bottom part of Table 4 contains the frequency tally of bubble episodes in normal recessions. And just as with financial crisis recessions, there are marked differences between the pre- and post-WW2 eras. Before WW2, the vast majority of normal recessions have no links to bubbles in either equities or houses—45 out of 52 recessions fit this mold. After WW2 only about one third –22 out of 62 recessions– fall in this category. About half of the post-WW2 era recessions –29 out of 62– are linked to bubbles in equities, and a smaller number is linked with a bubble in house prices or both house prices and equities (5 and 6 episodes respectively out of 62 total normal recessions).

It is useful to keep in mind that equity prices are far more volatile that house prices. As a result, we find a larger proportion of equity price bubbles relative to house price

**Table 4:** *Relative frequency of asset price bubbles by type of recession*

| **Financial Recessions** | (1) Pre-WW2 | (2) Post-WW2 | (3) Full Sample |
|---|---|---|---|
| No Bubble | 10 | 1 | 11 |
| Bubble in equity prices only | 8 | 7 | 15 |
| Bubble in house prices only | 2 | 3 | 5 |
| Bubbles in both | 2 | 11 | 13 |
| *Total* | *22* | *22* | *44* |
| **Normal Recessions** | | | |
| No Bubble | 45 | 22 | 67 |
| Bubble in equity prices only | 3 | 29 | 32 |
| Bubble in house prices only | 2 | 5 | 7 |
| Bubbles in both | 2 | 6 | 8 |
| *Total* | *52* | *62* | *114* |

*Notes*: Recessions are the peaks of business cycles identified using Bry and Boschan (1971) algorithm. A recession is labeled *financial* if it is associated with a financial crisis within a 2 year window of the peak. Otherwise it is labeled *normal*. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. See text.

bubbles. For the full sample, there are 28 equity price bubble episodes out of 44 financial crisis recessions versus 18 for house price bubbles. The contrast is starker in normal recessions with 40 price bubble episodes relative to 15 house price bubbles out of 114 normal recessions.

Finally, financial crisis recessions happened regularly in the pre-WW2 era. Nearly one third of all recessions (22 out of 74) have to be classified as a financial crisis recession. After WW2 the incidence of these disruptive episodes wanes somewhat: 22 out of 84 post-WW2 recessions are classified as associated with a financial crisis.

Table 4 already reveals several important themes in the data that we will explore in more detail in the next few sections. Importantly, the post-WW2 era appears to have weathered numerous equity price bubbles that did not turn into financial crisis episodes. House price bubbles, although less frequent, are more disruptive and are more likely to be associated with a financial crisis episode.

In the next few sections we will elaborate further on this distinction. First, we will ask under what circumstances do bubbles lead to financial crises. Second, we will aim to quantify the economic consequences of asset price bubbles. We will show that credit growth plays a central role both for the likelihood that a bubble leads to a financial instability and for the costs of a bursting bubble on the economy as a whole.

## 4. Asset price bubbles and financial crises

Perhaps one of the most striking features of the era of modern finance has been the proliferation of bank lending (as a ratio to GDP) experienced in advanced economies following WW2 and first reported in Schularick and Taylor (2012). Subsequent research has further clarified the sources of this proliferation in bank lending. Building on the original data collected by Schularick and Taylor (2012), Jordà, Schularick and Taylor (2014) break-down bank lending into mortgage and non-mortgage lending. While both types of bank lending experienced rapid growth in the post-WW2 era, the share of mortgages relative to other types of lending grew from a low point of less than 20% in the 1920s to the nearly 60% in the Great Recession.

Rapid expansion of credit has subsequently been associated with a higher likelihood of experiencing a financial crisis recession (Jordà, Schularick and Taylor 2013; Drehmann and Juselius 2014). The goal of this section is to study the interaction of asset price bubbles and credit growth in generating financial crisis recessions.

In particular, we investigate how the pairing of credit and asset price bubbles affect the probability that a recession will be financial in nature. Define a binary variable $F_{i,t(p)} \in \{0,1\}$ for $p = 1, ..., P$ and $i = 1, ..., 17$, that is, for each country $i$ $F_{i,t(p)}$ is observed only when calendar time $t$ coincides with a peak $p$ in economic activity—the start of a recession. Therefore the sample size is $P$, the total number of peaks in the sample. $F_{i,t(p)}$ takes the value of one if the $p^{th}$ peak corresponds to a financial crisis recession (defined as a recession where a financial crisis is recorded to have happened at any time in a two year window of the peak), and is zero if the recession was normal instead.

The data on peaks spans 1870 to 2012 in 17 advanced economies, as we described earlier, and are therefore best thought of as a panel. In order to accommodate the observation that some countries experience more financial crisis recessions than others, we include a set of fixed effects and estimate a simple panel logit model. We call this the *benchmark* model and the summary statistics of fit are reported in column (1) in Table 5 for the full sample analysis, and column (4) for the post-WW2 subsample. This fixed-effects only specification captures the heterogeneity in a sample of 17 countries. The specification simply models the probability of financial crisis recession as:

$$Pr[F_{i,t(p)} = 1|\alpha_i] = \frac{exp(\alpha_i)}{1 + exp(\alpha_i)}. \tag{1}$$

Next we consider a credit control. This variable is defined in similar fashion to the credit variable in Jordà, Schularick and Taylor (2013). It measures the growth of credit

**Table 5:** *Logit models for financial recessions. Full and Post-WW2 samples*

| | Full sample | | | Post-WW2 sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Benchmark | Credit Only | Full model | Benchmark | Credit only | Full model |
| Credit | | 0.43*** | | | 0.52*** | |
| | | (0.11) | | | (0.17) | |
| Housing bubble | | | 0.58*** | | | 0.67** |
| × credit | | | (0.20) | | | (0.29) |
| Equity bubble | | | 0.41** | | | 0.24 |
| × credit | | | (0.20) | | | (0.27) |
| No bubble | | | 0.14 | | | 0.17 |
| × credit | | | (0.16) | | | (0.29) |
| Both bubbles | | | 0.76*** | | | 1.00** |
| × credit | | | (0.28) | | | (0.40) |
| Pseudo $R^2$ | 0.02 | 0.14 | 0.17 | 0.07 | 0.22 | 0.27 |
| AUC | 0.60 | 0.71 | 0.72 | 0.67 | 0.77 | 0.80 |
| | (0.05) | (0.05) | (0.05) | (0.07) | (0.06) | (0.06) |
| Observations | 144 | 144 | 144 | 85 | 85 | 85 |

*Notes*: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable based on peaks of business cycles identified using Bry and Boschan (1971) algorithm. The dependent variable is one if the recession is associated with a financial crisis within a 2 year window of the peak, 0 otherwise. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. See text.

over the expansion preceding the $p^{th}$ peak in deviations from a country mean (again, to soak up any cross-country variation that may unduly enhance the fit of the model). The results of extending the benchmark model are reported in Table 5 column (2) for the full sample, and column (5) for the post-WW2 subsample. The specification of the logit model now becomes

$$Pr[F_{i,t(p)} = 1|\alpha_i, (x_{i,t(p)} - \bar{x}_i)] = \frac{exp(\alpha_i + \beta(x_{i,t(p)} - \bar{x}_i))}{1 + exp(\alpha_i + \beta(x_{i,t(p)} - \bar{x}_i))}. \quad (2)$$

The final specification interacts the credit variable with our bubble indicators. The objective is to capture the interaction of having a bubble and credit expansion during the expansion that precedes the recession in question. Here we consider a collection of different scenarios: (a) recessions preceded by a house price bubble, $d^H_{i,t(p)} = 1$; (b) recessions preceded by a bubble in equities, $d^E_{i,t(p)} = 1$; (c) recessions preceded by normal asset price fluctuations, $d^N_{i,t(p)} = 1$; and (d) recessions preceded by both a bubble in

equities and a bubble in house prices, $d^B_{i,t(p)} = 1$. The variables $d^j_{i,t(p)}$ for $j = H, E, N, B$ are dummy variables. The results of this exercise are reported in column (3) and (6) in Table 5 for the full and post-WW2 samples respectively. The specification of the logit in this case becomes:

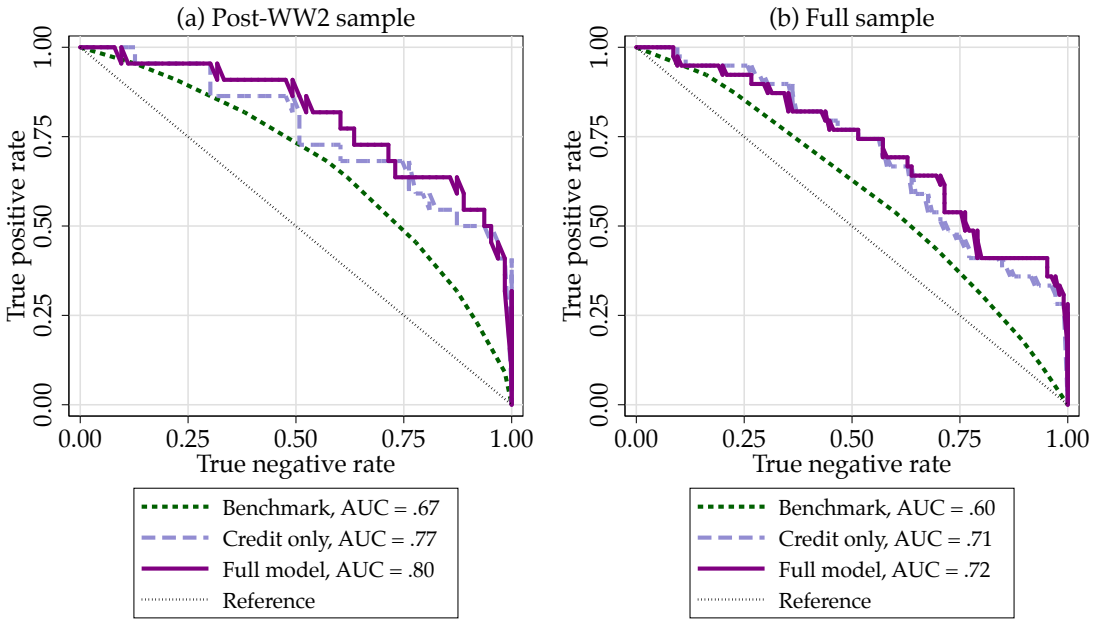
$$Pr[F_{i,t(p)} = 1|\alpha_i, (x_{i,t(p)} - \bar{x}_i), d^j_{i,t(p)}] = \frac{exp(\alpha_i + \beta(x_{i,t(p)} - \bar{x}_i) + \sum_j \gamma_j d^j_{i,t(p)}(x_{i,t(p)} - \bar{x}_i))}{1 + exp(\alpha_i + \beta(x_{i,t(p)} - \bar{x}_i) + \sum_j \gamma_j d^j_{i,t(p)}(x_{i,t(p)} - \bar{x}_i))}. \quad (3)$$

Before discussing the particulars of the estimation, we remark on how we measure the ability of the model to sort recessions into normal versus financial crisis recessions. We move away from metrics based on the likelihood (such as the reported pseudo-$R^2$) and focus instead on the AUC statistic, which stands for the *area under the curve*. This statistic takes on the value 0.5 in models where the covariates offer no ability to sort the data into each bin, and takes on the value of 1 in models with the ability to perfectly sort the data. The reason to use this type of statistic is that models with apparent low fit can nevertheless have considerable classification ability. The AUC statistic is a standard in biomedical research and is frequently reported when evaluating the properties of medical tests. It has the advantage that in large samples it is approximately distributed as a Gaussian random variable. In economics, Jordà and Taylor (2011) explain its properties and its applicability. We refer the interested reader to their paper.

Turning our attention to Table 5 first, consider the benchmark model reported in column (1). This model has an AUC = 0.60 indicating low sorting ability but different from the 0.50 null. The explanation is that knowing what country is under consideration is useful because some countries have experienced more financial crisis recessions than others in our sample. Next, column (2) extends the model with the credit variable. Here we are able to replicate the main result in Jordà, Schularick and Taylor (2013): credit growth is associated with a higher likelihood of experiencing a financial crisis recession (notice the coefficient estimate is positive). The AUC grows from 0.60 to 0.71 and is statistically difference from the benchmark null.

The more interesting set of results is reported in column (3). The interaction with the different bubble scenarios is quite revealing. The coefficient estimates all have the correct sign (they are positive). Moreover, all coefficients associated with the incidence of either type of bubble or both at the same time have a statistically significant coefficient whereas the coefficient on credit when there is no bubble in the preceding expansion is not significant and close in value to zero. The AUC for this model is 0.72, hardly an

**Figure 5:** *Correct classification frontiers for financial recessions: the interaction of credit and asset price bubbles*




*Notes*: The CCF for the post-WW2 corresponds to the estimates in columns (4)-(6) of Table 5 whereas the full sample CCF corresponds to the estimates reported in columns (1)-(3) of Table 5.

improvement on the simpler model in column (2) based on the credit variable alone. However, the more revealing part of this exercise is concentrated in the significance of the individual components of this coefficient, as reported in column (3).

In order to assess the properties of these estimates before and after WW2 and in light of the trends in mortgage credit discussed earlier, we turn or attention to the results reported in columns (4)-(6) for the post-WW2 sample. The benchmark model is reported in column (4) and attains an AUC of 0.67. Knowing the country is still informative, more so given the smaller size of the sample. Next, column (5) confirms the Jordà, Schularick and Taylor (2013) results reported in column (2). Credit remains an important factor in understanding financial crises. The AUC climbs to 0.77 in the post-WW2 sample, a very respectable value indicating high levels of sorting ability.

Finally, column (6) displays estimates for the full model in which the credit variable is interacted with each of the bubble scenarios. These results suffer from having a small sample but by and large support the findings reported in columns (1)-(3) using the full sample. However, over this period the equity bubble scenario has a coefficient that is not statistically significant. This is consistent with the summary statistics reported in Table 4.

In the post-WW2 era there are many instances of normal recessions preceded by equity bubbles that did not trigger a financial episode. The AUC climbs further from 0.77 to 0.80.

As a way to visualize the sorting ability of the different models we display in Figure 5 the *correct classification frontiers* (or CCFs) of the post-WW2 and the full sample models. The CCF plots the rate of true predictions of financial crisis recession on the vertical axis (true positive rate) against the rate of true predictions of normal recession (true negative rate). A perfect classification technology would generate a CCF that would hug the north-east corners of the unit square whereas a classifier no better than a coin toss would generate a classification technology on the diagonal of this same unit square. Jordà and Taylor (2011) provide a more careful and detailed explanation on how this curve can be constructed and its statistical properties.

Both figures clearly show that there are considerable gains in classification ability from using the panel logit estimates based on the covariates considered. More importantly, the results of this exercise support an important observation: credit fueled asset price booms in the expansion tend to be associated with a higher likelihood of a subsequent financial crisis recession. In the next section we explore the interaction between credit and asset bubbles over the business cycle in more detail.

## 5. The economic costs of bubbles

We have seen that credit fueled asset price bubbles, especially those in housing markets after WW2, are associated with a higher likelihood of financial crisis recession. Cerra and Saxena (2008) and Jordà, Schularick and Taylor (2013) show that financial crisis recessions tend to be deeper and more protracted. In this section, we ask whether the bursting of bubbles in housing or equity markets are associated with deeper recessions. To answer this question we turn to modern, semi-parametric time series methods.

The empirical approach is based on the local projections method pioneered by Jordà (2005). The particular set-up we use here closely mirrors that in Jordà, Schularick and Taylor (2013). Specifically, let $\Delta_h y_{i,t(p)+h} = y_{i,t(p)+h} - y_{i,t(p)}$ for $h = 1, ..., 5$ and where $y_{i,t(p)}$ refers to 100 times the log of output per capita in country $i$ at the time of the $p^{th}$ peak or recession. In other words, $\Delta_h y_{i,t(p)+h}$ measures the cumulative growth rate of output per capita from period $t(p)$ to period $t(p) + h$ measured in percent. This is the left-hand side variable whose fluctuations we are interested in characterizing.

Because of sample size limitations, we are unable to pursue as ambitious a specification as we used in the previous section. Moreover, since the pre-WW2 sample contains too few instances of housing bubbles, in the analysis that follows we focus solely on full

sample results and results based on the post-WW2 era only. Furthermore, we approach the problem more modestly by examining recessions and their recovery on average in the presence of bubbles in equities and house prices, but sorted depending on whether credit during the expansion grew above or below the historical mean rather than with an interaction term as we did in the previous section. Before we bring additional controls, we set up the benchmark specification.

Using similar definitions to those in the previous section, define the following bubble binary indicator variables, $d^j_{i,t(p)}$ for $j = (E)quities, (H)ouses$. Next, define the indicator variable $\delta_{i,t(p)} = \mathbf{1}[(x_{i,t(p)} - \bar{x}_i) > \overline{(x_{i,t(p)} - \bar{x}_i)}]$, which is meant to capture when credit grows above the historical mean ($\delta_{i,t(p)} = 1$) or below the mean ($(1 - \delta_{i,t(p)}) = 1$). In order to account for country fixed effects but still estimate an overall average constant path, we define the fixed effects to add up to one and implicitly define them in reference to the U.S. as follows. $D_{i,t(p)} = \mathbf{1}[i]/I$ for $i = 1, ..., I-1$ and $D_{i,t(p)} = \mathbf{1}[i](1 - 1/I)$ when $i = I$. Hence the benchmark local projection specification is

$$\Delta_h y_{i,t(p)} = \sum_{i=1}^{I} \alpha_{i,h} D_{i,t(p)} + \mu_h + \sum_j \gamma_h^{j,Hi} d^j_{i,t(p)} \times \delta_{i,t(p)} + \sum_j \gamma_h^{j,Lo} d^j_{i,t(p)} \times (1 - \delta_{i,t(p)}) + \epsilon_{i,t(p)} \quad \text{for } h = 1, ..., 5, \tag{4}$$

and the coefficients of interest are $\mu_h$, which captures the average path of output in a recession and subsequent recovery, and the coefficients $\gamma_h^{j,k}$ for $j = E, H$ and $k = Hi, Lo$ with *Hi* indicating when credit grew above the mean in the preceding expansion, and *Lo* when it grew below the mean. The coefficients $\gamma_h^{j,k}$ capture how much worse the path of the recession is whenever there is a bubble in either equities or house prices and credit in the expansion grows above or below the historical mean. That is, the sum of $\mu_h$ and $\gamma_h^{H,Hi}$, for example, refers to the average path of the recession and recovery when the preceding expansion is characterized by experiencing above average growth in lending and a housing bubble.

Table 6 reports the estimates of expression (4) for the full sample that we consider. That is, yearly data over the following periods, 1870–1909, 1920–1935, and 1948–2012—basically, we exclude a 5 year windows around the two World Wars. The entry labeled *Recession* corresponds to the average path when there are no bubble episodes. In the first year of recession output declines by about 2%. By year 2, the economy has bounced back into positive territory and it keeps on growing so that by year 5 the economy is nearly 7% above where it started. This pattern is consistent with Cerra and Saxena (2008) and Jordà, Schularick and Taylor (2013).

How does the presence of an asset price bubbles affect these paths? We start with bubbles in equity markets which, as we saw in Section 3, are more frequent events than bubbles in housing markets. On their own, i.e, without a parallel credit boom, equity bubbles appear to have virtually no effect on the depth of the recession and the speed of the recovery. This is true in a statistical sense since none of the coefficients estimates is significant, but also quantitatively as the coefficient estimates themselves are small. When the equity bubble coincides with a credit boom, the effect is stronger. In that case the recession lasts an extra year and the overall drag after five years is in the neighborhood of 3 percentage points GDP per capita levels relative to the peak of the cycle.

Turning to house bubbles, it is immediately obvious that they are considerably more damaging events. The drag on the economy is nearly twice as big when accompanied by higher than average credit growth. In terms of the path of the recession and recovery, we note that it can sink the economy for several years running so that even by year 5 the economy is still operating below the level at the start of the recession. These results can be more easily visualized in Figure 6. The left-hand side panel shows the average path of the recession along with the average path when there is an equity bubble and below/above average credit growth, and the right-hand side panel shows a similar chart using the housing bubble indicator instead. Each panel displays the average path of the economy with a 90% confidence region.

## 5.1. Adding controls

Table 6 and Figure 6 provide the first of several interesting findings, and they accord well with the results discussed in Section 4. Briefly, it appears that equity bubbles are less harmful to the economy than housing bubbles are. However, regardless of the type, asset bubbles associated with rapid credit growth are specially damaging. These results could be manifestations of other economic phenomena happening at the same time and driving the bubbles and credit creation themselves. Consequently, we expand the control set as much as possible to try to account for macroeconomic conditions existing at the start of the recession.

In order to do this, we expand the specification of the benchmark local projection in expression (4). First, in order to account for whether higher than average credit growth has a negative effect on output beyond its interaction with the bubble indicators, we include $\delta_{i,t(p)}$ directly as a regressor. Note we cannot enter $(1 - \delta_{i,t(p)})$ simultaneously as a regressor since then we would have perfect colinearity with the constant term.

Next, we include the value at the peak and one lag of the following controls: (1)

**Table 6:** *LP recession/recovery path, no controls. Full sample, 1870–2012*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -1.93 | 0.46 | 3.21 | 5.41 | 6.59 | 14.19 |
| | (0.21) | (0.48) | (0.69) | (0.94) | (1.02) | (3.43) |
| Equity bubble, low credit | 0.18 | -2.09** | -2.63* | -2.89* | -1.27 | -8.30 |
| | (0.46) | (0.87) | (1.38) | (1.40) | (1.79) | (5.47) |
| Housing bubble, low credit | -0.27 | -1.22 | -2.69 | -3.10 | -2.04 | -9.15 |
| | (0.71) | (0.92) | (1.64) | (2.35) | (2.17) | (7.33) |
| Equity bubble, high credit | 0.11 | -1.57 | -3.52** | -4.38*** | -4.05** | -12.82** |
| | (0.64) | (1.03) | (1.40) | (1.45) | (1.64) | (5.27) |
| Housing bubble, high credit | -0.77 | -5.03* | -6.79** | -7.95** | -8.20** | -29.80** |
| | (1.64) | (2.73) | (2.35) | (3.69) | (3.15) | (13.22) |
| Macroeconomic controls | no | no | no | no | no | no |
| $R^2$ | 0.14 | 0.18 | 0.22 | 0.21 | 0.24 | 0.23 |
| Observations | 139 | 132 | 131 | 131 | 123 | 123 |

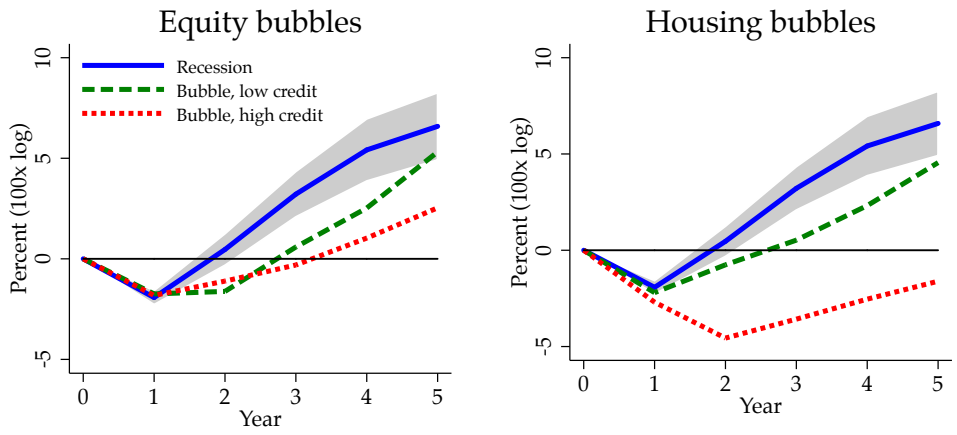
*Notes*: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

the growth rate of real GDP per capita; (2) the growth rate in investment per capita; (3) the CPI inflation rate; (4) real private loan growth per capita; (5) the short-term interest rate (usually measured as the 3-month rate on government securities); (6) the long-term interest rate (usually measured as the 5-year rate on government securities); and (7) the current account to GDP ratio. Notice that we include the loan growth variable to stack the odds against finding an independent channel through which credit matters when it comes to evaluating the effect of bubbles.

Let $X_{i,t(p)}$ denote the vector containing the seven controls observed at the peak and one lag, then extending expression (4) with the additional controls, we obtain the following specification:

$$\Delta_h y_{i,t(p)} = \sum_{i=1}^{I} \alpha_{i,h} D_{i,t(p)} + \mu_h + \beta_h \delta_{i,t(p)} + \sum_j \gamma_h^{j,Hi} d_{i,t(p)}^j \times \delta_{i,t(p)} + \sum_j \gamma_h^{j,Lo} d_{i,t(p)}^j \times (1 - \delta_{i,t(p)}) + X_{i,t(p)}\Phi + \epsilon_{i,t(p)} \quad \text{for } h = 1, ..., 5. \tag{5}$$

**Figure 6:** *Recession and recovery paths: the role of bubbles and credit, no controls. Full sample*




*Notes*: The figure displays the coefficients reported in Table 6. The solid blue line reports the average path. The grey area represents the 90% confidence region around the average path. The green dashed line is the sum of the average recession path and the bubble coefficient when credit is below the mean, whereas the dotted red line is the sum of the average recession and the bubble coefficient when credit is high. Full sample: 1870–2012, excludes de World Wars and a window of 5 years around them.

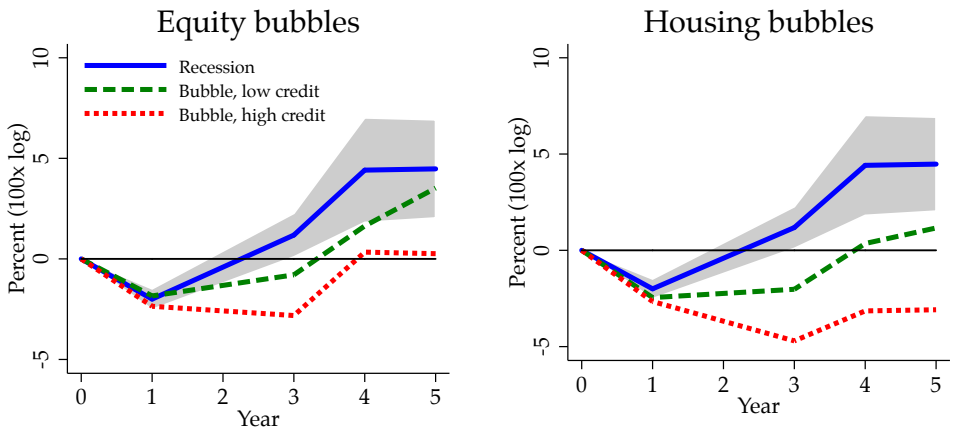
Selected coefficient estimates of expression (5) are reported in Table 7 for the 1870–2012 (excluding 5 year windows around the World Wars), whereas estimates based on shorter sample from the post-WW2 period (1948–2012) are reported in Table 8. Figure 7 presents in graphical form the estimates from both tables by appropriately combining the coefficients in expression (5).

The basic lessons from the naive analysis in expression (4) and Table 6 remain largely unchanged with the additional controls. Equity based bubbles are damaging (making the recession worse and the recovery slower), but by relatively small amounts so that the paths are largely indistinguishable from the typical path in recessions. Although equity bubbles have little effect overall, they are clearly more damaging if accompanied by above average growth in credit.

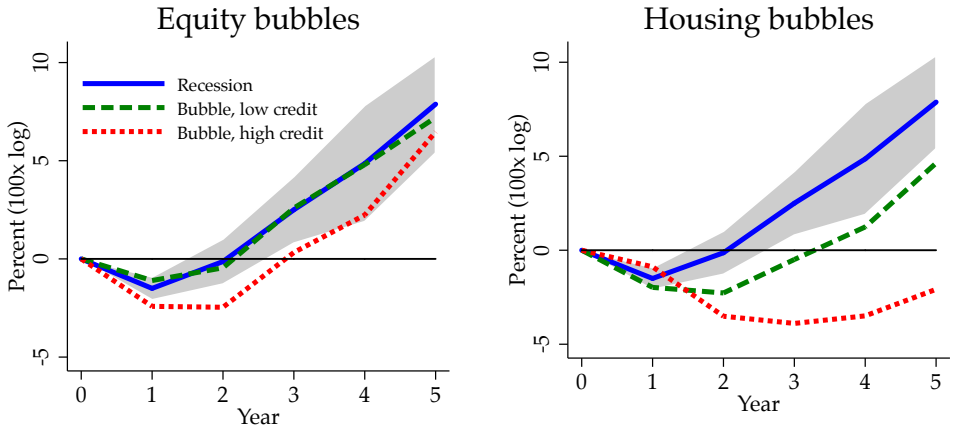
Meanwhile, bubbles in house prices have noticeably negative effects on the recession, more so, when credit expands above the historical mean during the preceding expansion. Panel (a) of Figure 7 makes this difference readily apparent. The coefficient estimates are negative and statistically significant. A useful cross-check is to consider the coefficient on

**Figure 7:** *Recession and recovery paths: the role of bubbles and credit, with controls*

**(a)** *Full sample: 1870–2012*




**(b)** *Post-WW2 sample: 1948–2012*




*Notes*: Panel (a) in the figure displays the coefficients reported in Table 7, whereas panel (b) corresponds to the coefficients in Table 8. The solid blue line reports the average path. The grey area represents the 90% confidence region around the average path. The green dashed line is the sum of the average recession path and the bubble coefficient when credit is below the mean, whereas the dotted red line is the sum of the average recession and the bubble coefficient when credit is high. The full sample, 1870–2012, excludes de World Wars and a window of 5 years around them.

**Table 7:** *LP recession/recovery path, with controls. Full sample, 1870–2012*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -2.00 | -0.72 | 1.18 | 4.41 | 4.48 | 6.63 |
| | (0.31) | (0.77) | (0.66) | (1.58) | (1.49) | (4.68) |
| Equity bubble, low credit | 0.16 | -1.40 | -1.98 | -2.78* | -0.96 | -6.26 |
| | (0.54) | (0.95) | (1.22) | (1.43) | (1.40) | (4.97) |
| Housing bubble, low credit | -0.45 | -1.79 | -3.21* | -4.06 | -3.32 | -12.55 |
| | (0.69) | (1.07) | (1.73) | (2.51) | (2.33) | (7.64) |
| Equity bubble, high credit | -0.36 | -1.52 | -4.00*** | -4.08** | -4.22* | -13.48** |
| | (0.50) | (1.56) | (1.30) | (1.67) | (2.12) | (5.71) |
| Housing bubble, high credit | -0.66 | -4.68 | -5.89** | -7.56* | -7.56** | -26.82** |
| | (1.91) | (2.80) | (2.37) | (3.80) | (2.78) | (12.53) |
| Macroeconomic controls | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.23 | 0.30 | 0.44 | 0.39 | 0.50 | 0.43 |
| Observations | 139 | 132 | 131 | 131 | 123 | 123 |

*Notes*: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

the $\delta_{i,t(p)}$ term, which in Table 7 is labeled as *Credit (high)*. Notice that all the coefficient estimates are relatively small and except for one, not significant. Therefore, the effect of rapid credit growth appears to be mediated by the presence of a bubble. Again, this effect endures despite having included in our control set the value of credit growth at the peak and one lag.

Table 8 repeats the estimation of expression (5) but restricting the sample to the post-WW2 period. As we discussed earlier, there are some differences in the incidence of bubble episodes before and after WW2. However, the pre-WW2 sample is too short to provide reliable estimates. Hence, the comparison between Tables 7 and 8 and panels (a) and (b) of Figure 7 provide the best way to assess the stability of our findings across samples. By and large the differences are small, although there is perhaps one noticeable difference. In the post-WW2 sample it makes a big difference whether the bubble, either in equities or in houses, is accompanied by higher than average growth in credit. And even more than in the full sample, the coefficient on the $\delta_{i,t(p)}$ term is not significant

**Table 8:** *LP recession/recovery path, with controls. Post-WW2 sample*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -1.50 | -0.13 | 2.50 | 4.86 | 7.88 | 12.86 |
| | (0.36) | (0.70) | (1.04) | (1.80) | (1.51) | (4.44) |
| Equity bubble, low credit | 0.40 | -0.32 | 0.09 | -0.05 | -0.67 | 0.58 |
| | (0.63) | (0.85) | (1.34) | (1.97) | (1.62) | (4.87) |
| Housing bubble, low credit | -0.47 | -2.14$^{*}$ | -2.99 | -3.62 | -3.25 | -11.74 |
| | (0.72) | (1.18) | (1.89) | (2.45) | (3.37) | (9.90) |
| Equity bubble, high credit | -0.91$^{*}$ | -2.33$^{**}$ | -2.17 | -2.62 | -1.41 | -8.92 |
| | (0.44) | (0.95) | (1.57) | (2.06) | (2.54) | (6.81) |
| Housing bubble, high credit | 0.62 | -3.38$^{**}$ | -6.39$^{***}$ | -8.35$^{***}$ | -9.96$^{**}$ | -27.37$^{**}$ |
| | (0.71) | (1.48) | (1.98) | (2.81) | (4.27) | (12.34) |
| Macroeconomic controls | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.40 | 0.61 | 0.64 | 0.67 | 0.70 | 0.67 |
| Observations | 84 | 77 | 76 | 76 | 68 | 68 |

*Notes*: Standard errors in parentheses. $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

except in year 5. It cannot be said that credit affects the path of the recession through an independent channel.

Before we examine the robustness of our results, we summarize the main findings so far. Recessions tend to last for one year and the average loss of output is about 2% in real per capita terms. The recovery starts in year 2 by which time most of the loss in the first year is made up, and the economy continues to grow at about the same yearly rate for the next three years. If the economy experiences an asset price boom during the preceding expansion, the recession tends to be deeper and the recovery slower. The detrimental effects of an asset price boom depend on two factors: whether the boom happens in equities or in houses, and whether the boom happens to coincide with a credit boom as well. The worst outcome is clearly when the boom is in asset prices and credit. In that case, even after five years, the economy may have not yet quite recovered from the recession.

Several factors could affect these preliminary conclusions and the next section conducts

a number of robustness checks. In Section 4 we saw that credit fueled bubbles have classification ability for whether the recession is normal or associated with a financial crisis. Therefore, the next section evaluates whether allowing for a different average path depending on whether the recession is normal or not will undo our main results. The second important robustness check has to do with the differences we have reported all along between the pre- and post-WW2 periods. The pre-WW2 period is characterized by the preponderance of equity bubbles over housing bubbles and to a great extent, this result could be driven by the volatile period between World Wars. Thus, we check how sensitive are our results when we exclude this particularly tumultuous decade. Finally, many of the conclusions from this section are an almost too perfect description of the Global Financial Crisis. Naturally, we ask to what extent the results on how the economy responds are driven by the recent experience. To that end, we cut-off the sample in 2008 to examine whether the main results survive when we omit this influential episode.

## 5.2. Robustness check 1: accounting for financial crises

The first of the robustness checks investigates whether the estimates we obtain for our bubble indicators may be proxying for the fact that financial crisis recessions are different than normal recessions and asset price bubbles are often associated with financial crises, as Section 4 showed. The simplest way to check for this effect is to expand the specification in expression (5) as follows. Let $F_{i,t(p)} = 1$ if the recession at time $t(p)$ is a financial crisis recession, 0 otherwise. Using this indicator, we expand the specification in (5) as follows:

$$\Delta_h y_{i,t(p)} = \sum_{i=1}^{I} \alpha_{i,h} D_{i,t(p)} + \mu_h + \beta_h \delta_{i,t(p)} + \theta_h^{Hi} F_{i,t(p)} \delta_{i,t(p)} + \sum_j \gamma_h^{j,Hi} d_{i,t(p)}^j \times \delta_{i,t(p)}$$
$$+\theta_h^{Lo} F_{i,t(p)} (1 - \delta_{i,t(p)}) + \sum_j \gamma_h^{j,Lo} d_{i,t(p)}^j \times (1 - \delta_{i,t(p)}) + X_{i,t(p)} \Phi + \epsilon_{i,t(p)} \quad \text{for } h = 1, ..., 5. \quad (6)$$

That is, we interact the financial crisis recession indicator $F_{i,t(p)}$ with the indicator that determines whether credit grew above or below the historical mean, $\delta_{i,t(p)}$. The results of this estimation are reported in Table 9. The financial crisis recession indicator picks up on the fact that this type of recession tends to be worse than normal recessions, a fact already documented in Cerra and Saxena (2008), for example. However, even though we are soaking up this source of variation from the data directly, estimates associated with the bubble indicators are largely unchanged with respect to the estimates reported in Table 7. The difference between equity versus housing bubbles remains. The latter are worse, more so when associated with a credit boom as well.

**Table 9:** *LP recession/recovery path, normal/financial, with controls. Full sample: 1870–2012*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -1.81 | -0.03 | 1.83 | 5.01 | 4.93 | 9.10 |
| | (0.38) | (0.97) | (0.86) | (1.62) | (1.48) | (5.11) |
| Equity bubble, low credit | 0.44 | -0.76 | -1.34 | -2.21 | -0.56 | -4.39 |
| | (0.47) | (0.70) | (0.95) | (1.58) | (1.37) | (4.32) |
| Housing bubble, low credit | -0.20 | -1.44 | -2.80 | -3.72 | -2.63 | -9.46 |
| | (0.85) | (1.11) | (1.66) | (2.64) | (2.31) | (7.83) |
| Equity bubble, high credit | -0.34 | -1.03 | -3.62*** | -3.69** | -4.17* | -12.70** |
| | (0.59) | (1.49) | (1.22) | (1.56) | (2.05) | (5.00) |
| Housing bubble, high credit | -0.44 | -2.21 | -3.88* | -5.59 | -6.65* | -20.02 |
| | (1.67) | (2.07) | (2.10) | (3.21) | (3.14) | (11.98) |
| Financial recession, low credit | -1.44 | -3.70** | -3.61* | -3.25 | -3.52 | -17.45* |
| | (0.82) | (1.66) | (1.90) | (2.62) | (2.28) | (9.67) |
| Financial recession, high credit | -0.53 | -4.46** | -3.70*** | -3.60** | -2.13 | -14.21** |
| | (1.03) | (1.67) | (1.20) | (1.56) | (2.33) | (5.90) |
| Macroeconomic controls | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.27 | 0.42 | 0.49 | 0.42 | 0.52 | 0.48 |
| Observations | 139 | 132 | 131 | 131 | 123 | 123 |

*Notes*: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

## 5.3. Robustness check 2: excluding the interwar period

The interwar period, which here we define to be between 1909 and 1948 so as to include 5-year windows around the beginning of WW1 and the end of WW2 is characterized by considerable turmoil in international financial markets. Naturally, this period includes the Great Depression, which could be skewing some of the results we have been reporting so far about the changing importance of equity bubbles and the overall results we have reported in Table 7. This experiment is reported in Table 10. The broad picture remains largely unchanged. Equity bubbles become somewhat less relevant (not surprisingly since we have eliminated the Great Depression), and the dramatic effects of credit and house price booms remain of about the same magnitude as our main results.

**Table 10:** *LP recession/recovery path, with controls. Sample: 1870–1909 and 1948–2012*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -1.46 | 0.47 | 1.75 | 6.25 | 6.79 | 12.66 |
| | (0.45) | (1.12) | (0.95) | (2.07) | (1.59) | (6.24) |
| Equity bubble, low credit | 0.25 | -1.12 | -0.29 | -2.33 | -0.99 | -1.56 |
| | (0.65) | (1.30) | (1.59) | (2.63) | (1.62) | (7.00) |
| Housing bubble, low credit | -0.94 | -2.73$^{*}$ | -4.58$^{*}$ | -5.77$^{*}$ | -5.68$^{*}$ | -18.62$^{*}$ |
| | (1.02) | (1.30) | (2.16) | (3.11) | (2.72) | (9.80) |
| Equity bubble, high credit | -0.34 | -0.46 | -2.79$^{**}$ | -2.36 | -3.05 | -9.77$^{*}$ |
| | (0.54) | (1.49) | (1.22) | (1.45) | (1.80) | (5.30) |
| Housing bubble, high credit | -1.48 | -5.00$^{*}$ | -6.09$^{**}$ | -7.05$^{*}$ | -7.23$^{***}$ | -25.64$^{**}$ |
| | (1.85) | (2.67) | (2.21) | (3.45) | (2.42) | (9.88) |
| Macroeconomic controls | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.36 | 0.37 | 0.49 | 0.47 | 0.58 | 0.54 |
| Observations | 123 | 116 | 115 | 115 | 107 | 107 |

*Notes*: Standard errors in parentheses. $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

## 5.4. Robustness check 3: excluding the Global Financial Crisis

The last of the robustness checks that we conduct examines whether some of the strong results we find are driven by the recent Global Financial Crisis. In many countries, notoriously the U.S., U.K. and Spain, many blamed the housing bubble as the trigger for rapid expansion of mortgage lending, shadow banking activities such as mortgage backed securities, and other housing related derivatives. The collapse of house prices then set off the fall of the economic dominoes in 2008. Table 11 re-estimates the main results by truncating the sample in 2007, before the Global Financial Crisis sets in. Again, the data indicate strongly that the findings reported in Table 7 are not the result of this one global episode but rather an enduring characteristic in the historical record.

**Table 11:** *LP average recession/recovery path, with controls. Sample: 1870–2008*

*Dependent variable:* cumulative percentage change in real GDP per capita ($100 \times \Delta \log$)

| | (1) Year 1 | (2) Year 2 | (3) Year 3 | (4) Year 4 | (5) Year 5 | (6) Sum |
|---|---|---|---|---|---|---|
| Recession | -2.26 | -0.27 | 1.65 | 5.17 | 5.55 | 9.85 |
| | (0.37) | (0.84) | (0.77) | (1.59) | (1.32) | (4.36) |
| Equity bubble, low credit | 0.44 | -1.64 | -2.25 | -3.13** | -1.47 | -8.05 |
| | (0.53) | (1.11) | (1.42) | (1.42) | (1.39) | (4.93) |
| Housing bubble, low credit | -0.35 | -1.57 | -3.02 | -4.00 | -3.18 | -12.12 |
| | (0.63) | (1.14) | (1.77) | (2.54) | (2.38) | (7.83) |
| Equity bubble, high credit | 0.06 | -1.01 | -3.89** | -3.62* | -3.87 | -12.34* |
| | (0.47) | (1.48) | (1.55) | (1.77) | (2.28) | (6.01) |
| Housing bubble, high credit | -0.73 | -4.57 | -5.80** | -7.40* | -7.25** | -25.74* |
| | (1.77) | (2.83) | (2.25) | (3.64) | (2.85) | (12.64) |
| Macroeconomic controls | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.29 | 0.30 | 0.44 | 0.40 | 0.49 | 0.42 |
| Observations | 123 | 123 | 123 | 123 | 123 | 123 |

*Notes*: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the cumulative change in real GDP per capita from the peak of the business cycle (the start of the recession). Peaks are identified using Bry and Boschan (1971) algorithm. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. The bubble indicators are binned depending on whether bank lending (credit in the table) grew above (high) or below (low) the historical mean. See text.

## 6. Conclusion

In recent years, central banks typically stayed on the sideline when asset price bubbles inflated. This hands-off approach has been criticized, among others, by institutions such as the BIS that took a more sanguine view of the self-equilibrating tendencies of financial markets and warned of the potentially grave consequences of asset price busts. The critical assumption was that central banks would be in a position to manage the macroeconomic fall-out. They could clean-up after the mess. While the aftermath of the dotcom bubble seemed to offer support for this rosy view of central bank capabilities, the 2008 global financial crisis dealt a severe blow to the assumption that the fall-out of asset price bubbles was always and everywhere a manageable phenomenon. This observation meshes well with the key finding of this paper: not all bubbles are created equal.

In this paper, we turned to economic history for the first comprehensive assessment of the costs of asset price bubbles. We provide evidence on which types of bubbles matter and how their economic costs differ. From a monetary and macroprudential policy point

of view, our findings help understand the trade-offs involved in the "leaning against the wind" and "mopping up after" strategies. We show that when credit growth fuels asset price bubbles, the dangers for the financial sector and the real economy are much more substantial. The damage done to the economy by the bursting of credit-boom bubbles is significant and long-lasting. These findings can inform ongoing efforts to devise better guides to macro-financial policies at a time when policymakers are searching for new approaches in the aftermath of the Great Recession.

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# A. Appendix: House price data

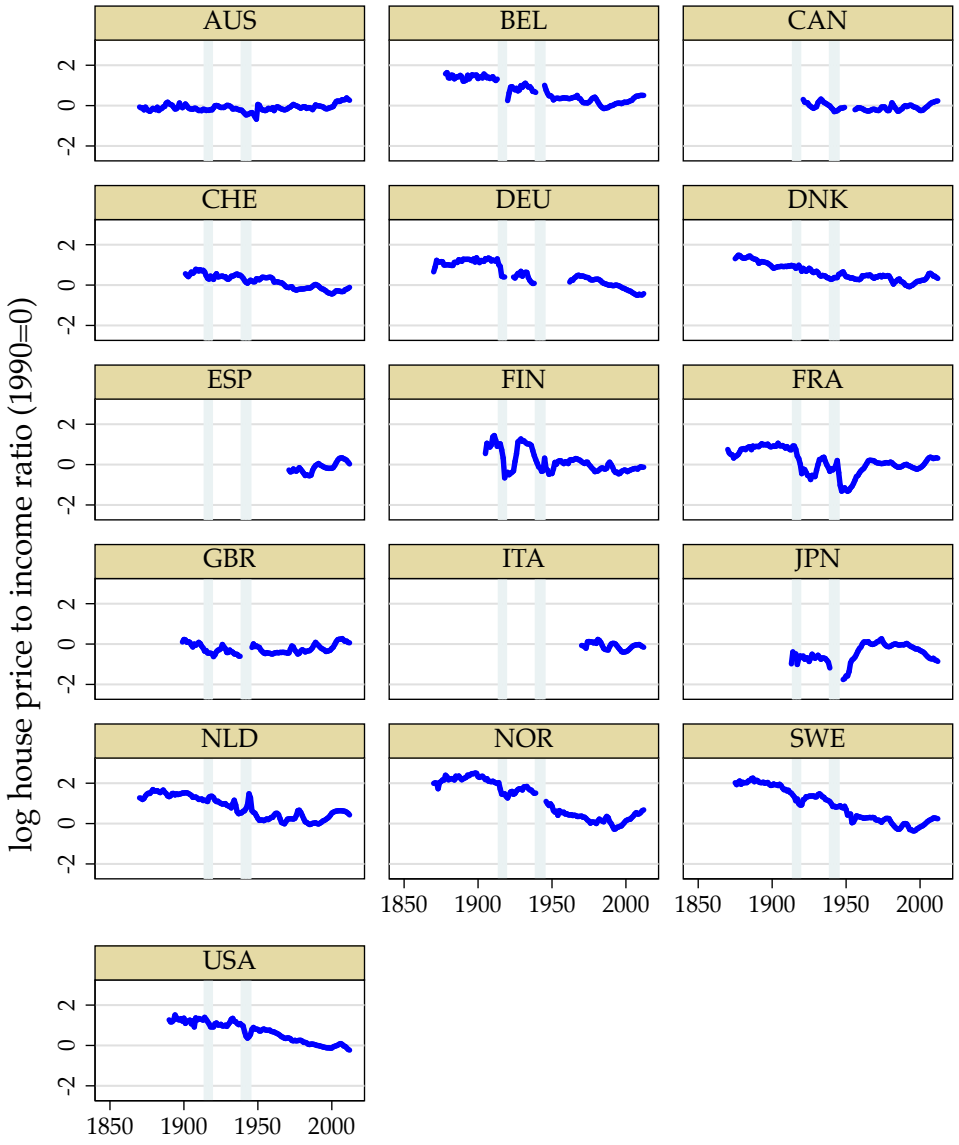
**Table 12:** *House Price Data*

| Country | Period | Geographic coverage | Type of real estate | Method |
|---|---|---|---|---|
| Australia | 1870-1889 | Urban (Melbourne) | Existing Dwellings | Median Price |
| | 1900-2002 | Urban (6 Capital Cities) | Existing Dwellings | Median Price |
| | 2003–2012 | Urban (8 Capital Cities) | New & Existing Dwellings | Mix-adjustment |
| Belgium | 1878-1950 | Urban (Brussels Area) | Existing Dwellings | Median Price |
| | 1951-2003 | Nationwide | Existing Dwellings | Mean Price |
| | 2004–2012 | Nationwide | Existing Dwellings | Mix-adjustment |
| Canada | 1921-1949 | Nationwide | Existing Dwellings | Replacement value |
| | 1956-1974 | Nationwide | New & Existing Dwellings | Average Prices |
| | 1975–2012 | Urban (5 Cities) | Existing Dwellings | Average Prices |
| Denmark | 1875-1937 | Rural | Existing Dwellings | Average Prices |
| | 1938-1970 | Countrywide | Existing Dwellings | Average Prices |
| | 1971–2012 | Countrywide | New & Existing Dwellings | SPAR method |
| Finland | 1905-1946 | Urban (Helsinki) | Building Sites | Average sqm prices |
| | 1947-1969 | Urban (Helsinki) | Existing Dwellings | Average prices |
| | 1970–2012 | Nationwide | Existing Dwellings | Mix adj. hedonic |
| France | 1870-1935 | Urban (Paris) | Existing Dwellings | Repeat sales |
| | 1936-1995 | Nationwide | Existing Dwellings | Repeat sales |
| | 1996–2012 | Nationwide | Existing Dwellings | Mix adj. hedonic |
| Germany | 1870-1902 | Urban (Berlin) | Developed & Undeveloped | Average Prices |
| | 1903-1922 | Urban (Hamburg) | Developed & Undeveloped | Average Prices |
| | 1923-1938 | Urban (10 Cities) | Developed & Undeveloped | Average prices |
| | 1962-1969 | Nationwide | Building Sites | Average prices |
| | 1970–2012 | Urban | New & Existing Dwellings | Mix adjustment |
| Japan | 1880-1913 | Rural | Residential Land | Average Prices |
| | 1913-1930 | Urban | Residential Land | |
| | 1930-1936 | Rural | Paddy Fields | |
| | 1936-1955 | Urban | Residential Land | |
| | 1955–2012 | Urban | Residential Land | Mix adjustment |
| Netherlands | 1870-1969 | Urban (Amsterdam) | Existing Dwellings | Repeat sales |
| | 1970-1996 | Nationwide | Existing Dwellings | Repeat sales |
| | 1997–2012 | Nationwide | Existing Dwellings | SPAR Method |
| Norway | 1870-2003 | Urban (4 cities) | Existing | Hedonic, Repeat Sales |
| | 2004–2012 | Urban (4 cities) | Existing | Hedonic |
| Switzerland | 1900-1929 | Urban (Zurich) | Developed & Undeveloped | Average price |
| | 1930-1969 | Nationwide | New & Existing | Hedonic |
| | 1970–2012 | Nationwide | New & Existing | Mix adjustment |
| Sweden | 1870–2012 | Stockholm, Gothenburg | Existing | Repeat sales |
| U.K. | 1899-1929 | Urban | Existing Dwellings | Average Prices |
| | 1930-1938 | Nationwide | New & Existing Dwellings | Average Price |
| | 1946–1952 | Nationwide | Existing Dwellings | Average Prices |
| | 1953–1967 | Nationwide | New Dwellings | Average Prices |
| | 1968–2012 | Nationwide | Existing | Mix adjustment |
| United States | 1890–1934 | Urban (22 Cities) | New & Existing Dwellings | Repeat sales |
| | 1935–1952 | Urban (5 Cities) | Existing Dwellings | Median Prices |
| | 1953–1974 | Nationwide | New & Existing Dwellings | Mix adjustment |
| | 1975–2012 | Nationwide | Existing Dwellings | Repeat sales |

Source: Knoll (2014) and Knoll, Schularick, and Steger (2014).

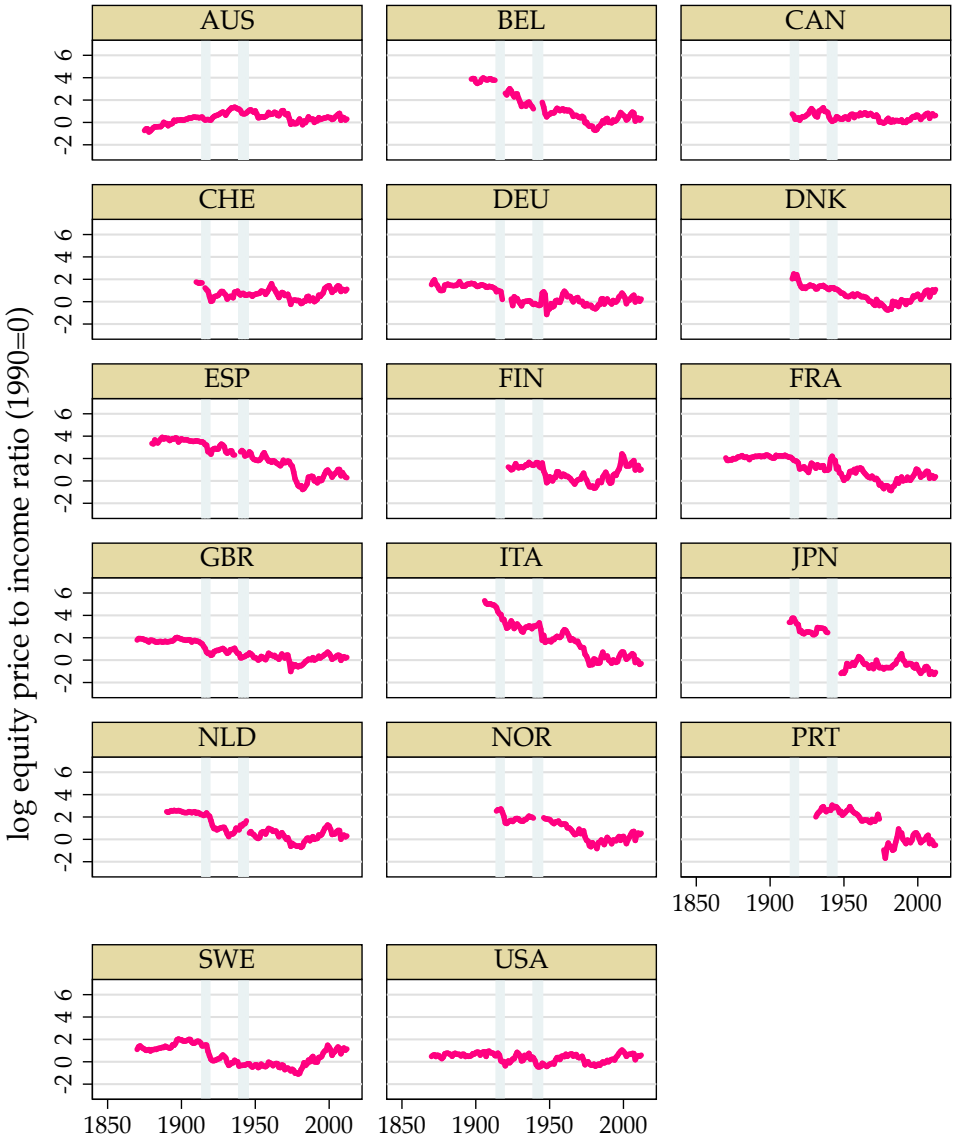
## B. Appendix: Equity and house prices by country

**Figure 8:** *House prices relative to income per capita in the 20th century*




*Notes*: Real CPI-based house price divided by real income per capita. See text. The years of the two world wars are shown with shading.

**Figure 9:** *Equity prices relative to income per capita in the 20th century*




*Notes*: Real CPI-based equity price divided by real income per capita. See text. The years of the two world wars are shown with shading.