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What Broke First? Characterizing Sources of Structural Change Prior to the Great Recession

Isaiah Hull[†]

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No. 301

June 2015

Abstract

This paper identifies and characterizes episodes of structural change in the 27 years that preceded the Great Recession. This is done by performing Bai-Perron (2003a, 2003b) tests on 61,843 time series that span 34 countries, which collectively accounted for 81% of Gross World Product in 2013. Three major stylized facts are established. First, the rate of structural change increased throughout the early 1990s, stabilized in 2003, and then decreased slowly until 2007. Second, there were three large spikes in the pace of structural change after the 1990-1991 recession: 1993-1994, 2001-2003, and 2007-2009. The latter two overlap with recessions in the U.S. and many other major economies, but the first does not. This spike is associated with structural change in residential investment, consumption, exchange rates, and real estate. Across countries, the degree of structural change is highest in China during this episode. Third, the periods 1993-1994 and 1997-2000 contain heavy structural change in real estate and lending; however, the rate of structural change in house price and construction series was more pronounced in and after 2001.

JEL Classification: E30, E60, R20, C01, C59

Keywords: Great Recession, Macroeconomics, Econometrics, Break Tests, Structural Stability

The views expressed in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Executive Board of Sveriges Riksbank.

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1 Introduction

The Great Recession started in December of 2007 and ended in June of 2009. The events that that transpired immediately before and between those dates have been chronicled in detail in the literature. However, the sources of structural change that preceded 2007 and created the conditions for the Great Recession are still not well understood. Widespread disagreement remains about the cause of the cross-country rise in indebtedness and house prices that preceded the Great Recession.

Many points of contention involve the timing of discrete changes in structural relationships. For instance, when did household debt growth depart from its trend? Was it 1995, 2000, or 2004? Table 1, which shows debt as a percentage of disposable income in countries for which data was available in 1995, suggests that the answer is not obvious. Some countries witnessed fast debt growth in the 1990s; others did not. Furthermore, debt growth in the U.S., which is often identified as the epicenter of the crisis, does not seem unusually fast or unusually early relative to the average OECD country. Other points of contention are about causality, but involve the timing of structural change. For instance, did persistent current account deficits cause the run up in household indebtedness? And did increased access to credit push up house prices? Neither question can be answered without identifying the order of events.

Table 1: Debt as a Percentage of Disposable Income

Country	1995	2000	2007	2013
Australia	102	137	192	201
Austria	65	75	88	89
Belgium	59	67	86	105
Canada	98	110	143	165
Czech Republic	28	21	52	69
Denmark	192	232	324	310
Finland	69	68	113	122
France	66	74	96	104
Italy	38	54	80	90
Netherlands	144	196	257	281
Portugal	55	106	145	146
Slovak Republic	13	18	38	57
Sweden	89	108	157	169
United States	94	103	143	114

This paper contributes to the literature by identifying episodes of structural change that occurred in the years prior to the Great Recession. We concentrate on the 1990-2006

period to allow for change in the mid-1990s, but to exclude change prior to the 1990-1991 recession. This permits the origins of the Great Recession to predate the 2001 recession, but not the 1990-1991 recession. There are three reasons why we truncate our analysis at 1990. First, the most common argument for a pre-1991 origin focuses on current account deficits, which started in the U.S. in 1970, closed in 1991, and then began to grow again thereafter. Thus, the widening current account deficits may be seen as more of a post-1991 phenomenon. Second, if the structural change occurred prior to 1990, it does not appear to have made an impact on the variables of interest–real house prices and household indebtedness–until 1995. Prior to that, their growth rates were well-behaved and within historically normal ranges in the United States. And third, the U.S. other countries that experienced a rise in indebtedness and house prices prior to the Great Recession also encountered a smaller version of the same events during the 1990-1991 recession.

We analyze these episodes of structural change by performing Bai-Perron (2003a, 2003b) tests on 61,843 series from the St. Louis Federal Reserve's FRED database. We omit high frequency series and truncate the yearly, quarterly, and monthly series at 1985. We find that the rate of structural change–as measured by the proportion of total breaks that occurred in a given period–was low, but growing throughout the early 1990s. By 2003, the rate of structural change stabilized and then began to decline slowly until the start of the Great Recession. In addition to the trend movements in structural change, there were also three periods where structural change spiked, breaking dramatically from its previous rate: 1993-1994, 2001-2003, and 2007-2009. The 1993-1994 episode is the largest in terms of the absolute number of breaks; and is not associated with a major recession in the United States. The 2001-2003 and 2007-2009 episodes overlap with recessions. We focus primarily on the 1993-1994 and 2001-2003 episodes, since the purpose of this paper is to identify structural change that could have caused the Great Recession.

In addition to characterizing structural breaks in aggregate, we also divide breaks by country. Using this approach, we find further evidence for the importance of structural change that occurred during the 1993-1994 period. Restricting the sample to years prior to the Asian financial crisis (1997), 29 of 34 countries in the sample had a break-year mode of either 1993 or 1994. This includes China and the United States, both of which

had a mode of 1993. Together, these 34 countries accounted for 81% of Gross World Product in 2013.

We also look at the extent to which a country is "broken." We measure this as the proportion of a country's breaks that occur in a given period. We find that the China was experiencing the most structural change in the 1993-1994 period. After China, the United States, the United Kingdom, Australia, South Africa, Spain, France, Italy, and Germany were the most broken. With the exception of Germany, all of the aforementioned countries experienced a substantial increase in indebtedness from 1995 to 2007.

The structural change in both China and the U.S. coincides with changes in the growth rate of U.S. current account deficits; and may lend support to this channel for structural change. This position is articulated by Adam et al. (2012); Gete (2010); and Aizenmann and Jinjarak (2009), who argue that current account deficits–and, relatedly, financial inflows–may account for the surge in household indebtedness and house prices prior to the Great Recession. Reinhart and Rogoff (2008) make a more general observation: the Great Recession looks similar to the 18 financial crises that preceded it, except that house prices increased more than usual and current account deficits were larger.

We also divide the sample according to series type and examine breaks in exchange rates and interest rates. Prior to 2000, we find two major spikes in structural change with respect to exchange rates: one in 1993 and another in 1997, around the time of the Asian financial crisis. With respect to interest rates, we see a small spike in structural change in 1994, but then the rate of change declines until 2001, where the largest spike in the sample occurs; and is presumably related to the cross-country monetary easing that followed the 2001 recession. This lends further support to the current account deficit argument. It also conditionally strengthens Dokko et al. (2011), Glaeser et al. (2013), and Gelain et al. (2015), who argue that low interest rates were not the primary driver of the increase in household indebtedness. If, for instance, one claims that the departure from fundamentals began in the mid-1990s, then the degree of structural change in interest rates seems too mild to be the primary explanation; however, if one instead assumes that the debt surge started after the 2001 recession, then the structural change in interest rates could provide a possible explanation.

In addition to identifying the year, geographic distribution, and possible transmission channels for structural change, we also look at the nature of episodes of structural

change. We do this by identifying all series that can clearly be associated with an expenditure component of GDP: consumption, government spending, investment, or net exports. We find that, after the 1990-1991 recession, the two largest spikes in structural change occurred in 1993-1994 and 2001. The changes in both 1993-1994 and 2001 appear to be broad and affect all expenditure categories. Relative to surrounding periods, the structural change in consumption and investment components appears to be particularly pronounced.

Segmenting the data further, we look at residential and nonresidential components of investment; and find large departures from surrounding periods in 1993-1994 and 2001-2003. Importantly, both components see substantial structural change, but the structural change for residential investment is particularly pronounced. An examination of permits and construction series reinforces this finding, but suggests that the structural change in this area was more pronounced in the post-2000 period than in the 1993-1994 period.

Next, we examine all residential property price series. We find slow, but growing structural change from 1990 to 2000 with a small spike at 1994. The largest breaks, however, arrive in 2001 and 2004; and all periods after 2001 contain an elevated level of structural change. These findings align well with the Great Recession description in Davis and Van Nieuwerburgh (2014), which provides a broad overview of the stylized facts and literature and dates the start of the boom period as 2000. It also suggests that something smaller, but related, was building throughout the early 1990s, even prior to the 2001 recession. A prolonged period of structural change in the financial and housing markets could have primed households and banks to expect continued expansion in the future. This is channel is supported empirically by Case, Shiller, and Thompson (2012); Jurgilas and Lansing (2013); Williams (2013); Coibon and Gorodnichencko (2012); and Dell'Arriccia, Igan, and Laeven (2012).

Finally, we use textual analysis to identify important phrases in the titles of broken series. Of all series with the tag "building," only five years contained unique phrases that were not contained in the corpus for the entire 1990-2007 period: 1993, 1999, 2003, 2006, and 2007. The 1993 phrases were related to fixed investment in structures. The 1999 phrases were related to construction and permits; and the 2006 and 2007 series were related to permits and construction. Similarly, series tagged with "bank" and "loan" returned "real estate" as a significant, unique phrase that that most frequently showed

up in 1994 structural breaks. Phrases for 1997-2004 primarily related to lending at commercial banks; and phrases for 2005 centered around loan commitment terms.

Overall, our findings suggest that structural change in the 1990s may have contributed to the rise in indebtedness and house prices that preceded the Great Recession. Furthermore, those structural changes were present across countries as early as 1993; and may have been transmitted bilaterally between the China and the United States.

2 Methods

We apply break tests to many series in this paper to identify episodes of broad structural change. Since we do not have a prior about any of the break dates and cannot inspect all series visually, we will use a test that does not require a known date. This would allow us to identify a break in the growth of bank lending in the late 1990s, for instance, even if we did not suspect that such a break existed.

In addition to this, we want to permit each series to contain multiple breaks. Limiting tests to a single break at an unknown date will force structural breaks to compete, leaving critical periods of change undetected. If, for instance, the structural change takes the form of a long–but temporary–above average rate of growth, then the start and end dates may constitute separate "structural breaks," but only one will be selected by the test.

We use the Bai-Perron (2003a, 2003b) test–as implemented by Hornik et al. (2003)–which satisfies all of the aforementioned criteria. We de-seasonalize each series and then apply the test to two different specifications. The first attempts to capture level and growth rate shifts:

$$log(y_t) = \alpha + \beta t + \epsilon_t \tag{1}$$

This specification may misidentify a permanent shock as an intercept shift if the series follows a random walk in logs:

$$log(y_t) = \alpha + log(y_{t-1}) + \epsilon_t \tag{2}$$

$$\rightarrow log(y_t) = log(y_0) + \sum_{s=1}^{t-1} \epsilon_s + \alpha t + \epsilon_t \tag{3}$$

In equation (3), $log(y_0) + \sum_{s=1}^{t-1} e_s$ is the intercept. Thus, if equation (1) is estimated, then permanent shocks will be identified as structural breaks. We remain neutral about this type of misidentification: that is, we are more concerned with identifying that an event happened–and had an apparent impact on the level or growth rate of the series–than correctly labelling it as a parameter shift or a shock.

We will, however, briefly consider a second specification, which will be stationary in differences under a random walk:

$$log(y_t) - log(y_{t-1}) = \alpha + \beta t + \epsilon_t \tag{4}$$

If the true process follows a random walk, then the underlying differenced series will be as follows:

$$log(y_t) - log(y_{t-1}) = \alpha t + \epsilon_t \tag{5}$$

Under the latter specification, we will not be able to identify level shifts. For this reason, most of the paper will use results from the first specification.

Finally, some series contain nonpositive observations. For these, we perform the same tests, but in levels and level differences, rather than logged levels and logged level differences.

3 Data

The complete dataset consists of 240,000 time series, drawn from the St. Louis Fed's FRED database. These series are broken down into eight broad categories and many smaller sub-categories. Table 2 lists the eight broad categories, along with the number of series in each.

The series also differ with respect to their observation frequencies. Since applying Bai-Perron (2003a, 2003b) tests to high frequency time series has a prohibitive time cost, we limit testing to yearly, quarterly, and monthly series, omitting weekly, daily, and intra-daily series. We also discard series that are not amenable to break tests, such as categorical series.

Table 2: Series Count by Category

Category	Count
U.S. Regional Data	105,373
International Data	91,440
Population, Employment, & Labor Markets	19,385
National Accounts	15,291
Academic Data	13,490
Production & Business Activity	9,376
Money, Banking, & Finance	6,502
Prices	2,950

The original data is drawn from 76 different providers. A large majority of series, however, are taken from only a handful of agencies. Table 3 lists the largest contributors (100+ series), as well as the number each source contributed.

In addition to separating time series by frequency and source, the FRED database also uses a tagging system to label series. Figure 1 shows the usage frequency of the 40 most commonly-used tags. In total, there are 5222 tags; and multiple tags may be associated with each series.

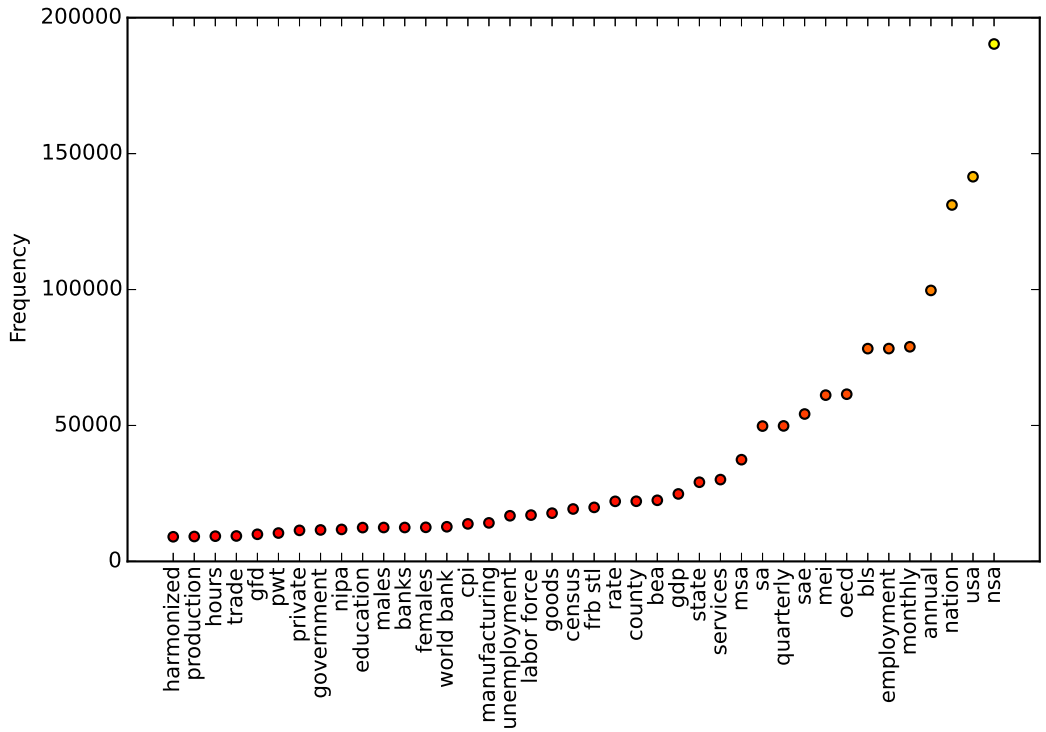
Table 3: Series Contributions by Organization

Source	Count
Organisation for Economic Co-operation and Development	61,218
Federal Reserve Bank of St. Louis	58,436
Board of Governors of the Federal Reserve System	7,745
Bank for International Settlements	6,388
National Bureau of Economic Research	3,036
Federal Financial Institutions Examination Council	2,837
Federal Reserve Bank of Dallas	1,643
International Monetary Fund	538
Federal Reserve Bank of New York	232
BofA Merrill Lynch	192
ICE Benchmark Administration Limited (IBA)	150
CredAbility Nonprofit Credit Counseling & Education	134
Haver Analytics	124
Federal Reserve Bank of Philadelphia	102

To avoid sending many queries to the FRED system, we opted to download all 240,000 series at once. Since this prevents us from using the tagging system directly, we instead used textual analysis to identify whether a tag was present in the title of a series and limited this to the 1000 most frequently used tags.

Finally, the series can also be divided geographically. When the data was obtained, 216 different countries had at least one series in the database. Within the U.S., states and counties also had many time series. We performed geographic segmentation primarily at the country-level; and concentrated on the 34 countries with the most series, which collectively accounted for 81% of Gross World Product (GWP).

Figure 1: Frequency Plot of FRED Tags



4 Results

We started by dropping all series with a weekly, daily, or intra-daily frequency. Only yearly, quarterly, and monthly series were retained. This substantially reduced the program runtime by eliminating the longest series. It also reduced the redundancy of break tests, since many high frequency series also had a corresponding low frequency series.

Next, we dropped observations prior to 1985 in all remaining series. Both formal work and informal inspection suggest that indebtedness and house prices started to increase in several OECD countries around 1995, 2000, or 2004. We use 1985 as a start date to ensure that tests are able to identify breaks in the early 1990s. Finally, we dropped any series that was unsuitable for structural break testing, including series that contained strings or categorical variables; and then de-seasonalized all series. We do not, however, attempt to identify and remove cyclical components from the series.

Table 4 provides summary statistics for the start dates, end dates, and break dates for all remaining series. In total, there were 61,843 series that fit all of the aforementioned criteria. The mean start date was in 1990.91 and 75% of series started before 1994. The latest start date was 2010. Additionally, most series ended after the Great Recession, with only 25% ending on or prior to 2012. The mean end date was 2011.74.

Table 4: Summary Statistics of Start and End Dates

	Start Dates	End Dates
N	164811.0	164811.0
Mean	1990.92	2011.74
Std	5.68	1.61
Min	1985.0	1993.0
25%	1985.0	2012.0
50%	1990.0	2012.0
75%	1994.0	2012.0
Max	2010.0	2012.0

Table 5 provides summary statistics for the break dates. Each column evaluates a different set of breaks. Column I is the full set of breaks from the undifferenced data. Column II restricts that set to series that have a start date prior to 1990 and an end date after 2009. Column III describes only series that had a break in the differenced data. And Column IV describes series that have a start date prior to 1990, an end date after 2009, and have a break in the differenced series.

Since Column I contains all series that passed the initial set of restrictions, it also includes incomplete series. Series are much more likely to be introduced later than to be discontinued during the sample period, which creates a bias towards later break episodes.

When this bias is corrected, the mean break date drops from 2001.81 to 1998.74. Similarly, the mean break date for differenced series–given in Column III–drops from 2001.86 to 1998.37 (Column IV) when series that start late or end early are dropped.

Table 5: Summary Statistics of Break Dates

	I	II	III	IV
N	164713	45844	25305	10735
Mean	2001.81	1998.74	2001.86	1998.37
Std	5.95	5.92	6.16	5.56
Min	1986.25	1987.75	1985.5	1985.5
25%	1997.0	1993.75	1997.0	1994.0
50%	2002.25	1998.83	2002.0	1998.0
75%	2007.08	2003.0	2007.58	2002.0
Max	2013.5	2010.25	2012.58	2010.75

Examining the full distribution of breaks over time gives a more complete picture. Figure 2 shows the proportion of all level breaks that happened in each period between 1990 and 2010. There are local modes in 1993-1994, 2001, and 2007-2009. Additionally, the rate of structural change is trending upward throughout the 1990s, but declines slowly from 2001 to 2007.

Figure 2: All Breaks in Levels

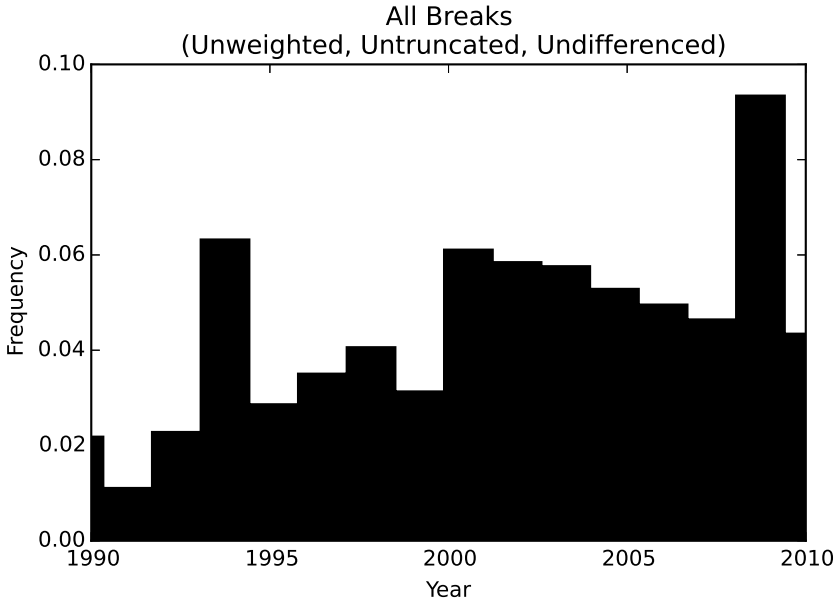
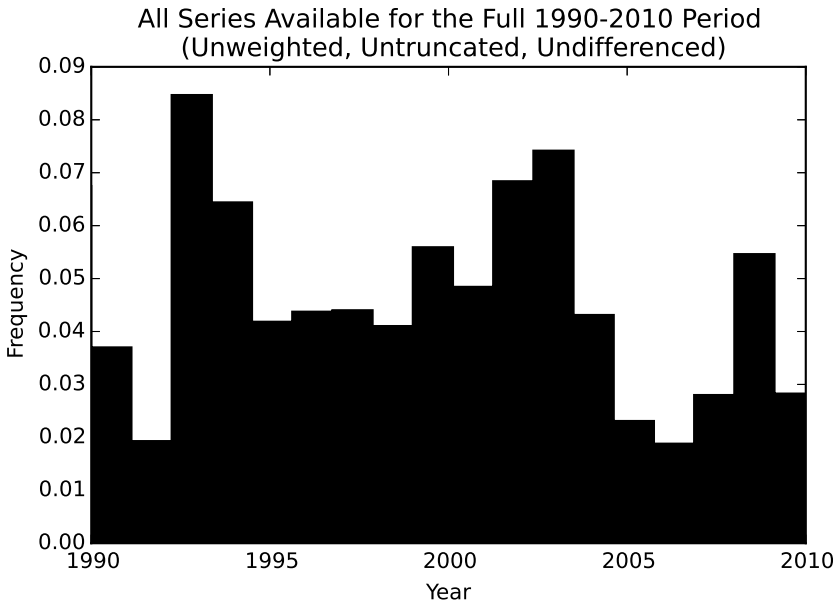


Figure 3: Complete Series Breaks in Levels



One possible problem with the interpretation of Figure 2 is that new series tend to be added faster than old series are discontinued. This skews the mass of breaks towards later dates. If we restrict the sample to series that are complete–that is, were neither added nor removed during the sample period–then the bias is removed, shifting the mass of breaks from the 2000s to the 1990s, as in Figure 3. After the adjustment, all three of the largest clusters of breaks fall prior to 2007; and two of the three clusters are not associated with any recession at all. Figure 4 shows the set of series that was removed, which has a clear bias in favor of later years.

For the differenced data, we skip directly to the complete series breaks.[1] Here, again, 1993 contains a large spike in the mass of structural breaks. Additionally, the pace of structural change grows until the 2001 recession, but then drops sharply, continuing to climb again in 2004, as shown in Figure 5. The 2007-2009 recession is also large and clearly pronounced in the differences.

Next, we divide level breaks by country, focusing on the period prior to the Asian financial crisis in 1997. We do this by performing a set of substring comparisons to determine whether the name of the country appears in the name of a given series. We then compute the modes of the breaks for each country, which are shown in Table 6.

[1]The distribution of breaks for all differenced series shows the same bias towards later years. To save space, I omit the distribution for all differenced series and the incomplete series.

Figure 4: Incomplete Series Breaks in Levels

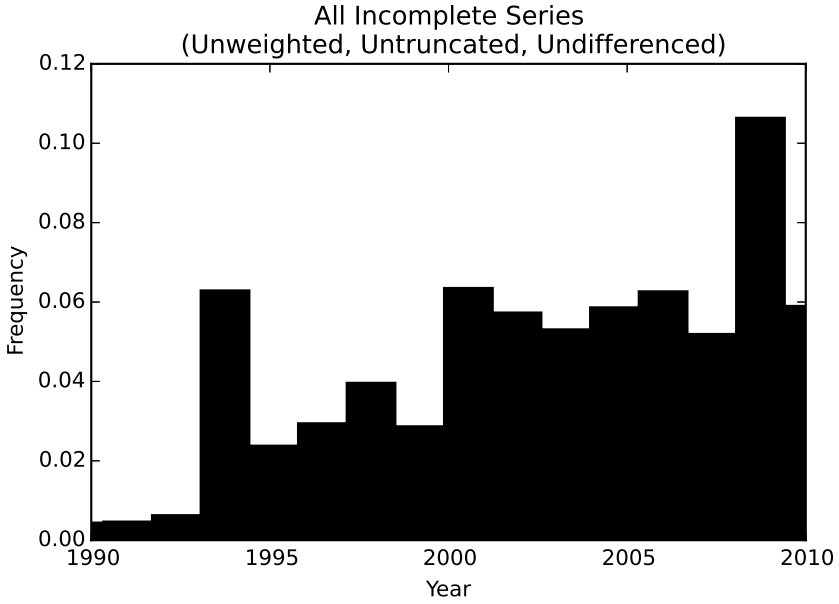


Figure 5: Complete Series Breaks in Differences

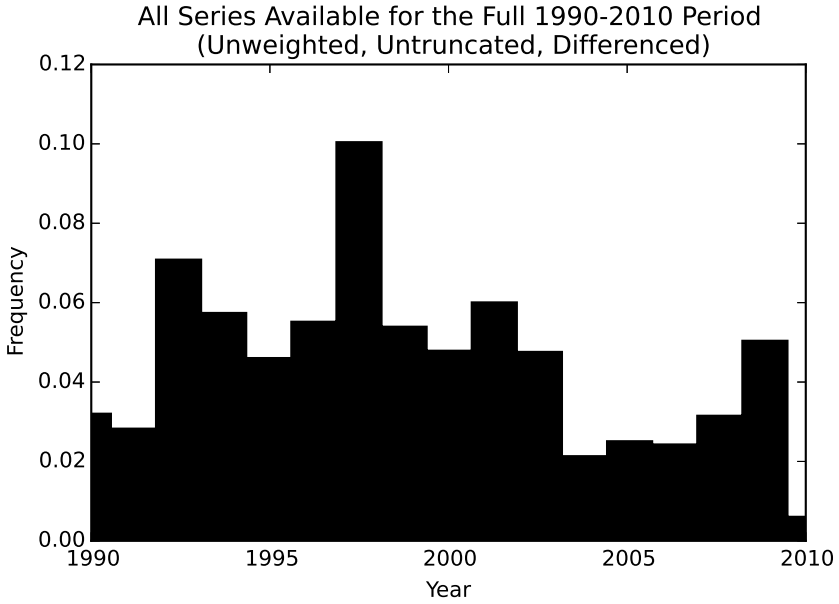


Table 6: Mode of Breaks Prior to 1997 by Country

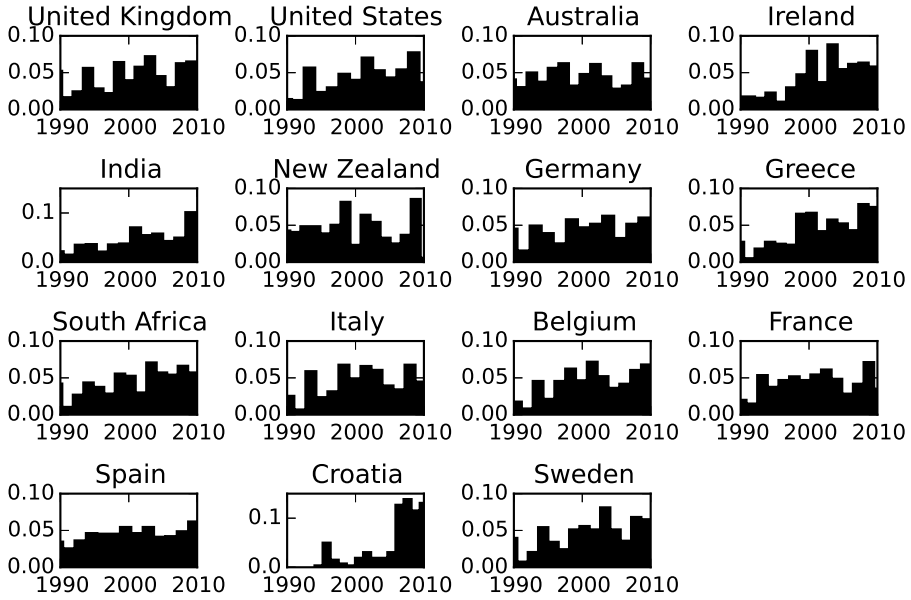
Country	Year	Country	Year
India	1993.0	Canada	1994.0
New Zealand	1993.0	Germany	1994.0
Australia	1993.0	Greece	1994.0
United States	1993.0	Italy	1994.0
Finland	1993.0	Sweden	1994.0
Mexico	1993.0	Turkey	1994.0
China	1993.0	Poland	1994.0
Denmark	1993.0	Portugal	1994.0
Japan	1993.0	Hungary	1994.0
South Africa	1993.0	Austria	1994.0
Ireland	1993.0	South Korea	1994.0
Belgium	1993.0	United Kingdom	1994.0
France	1993.0	Brazil	1995.0
Spain	1993.0	Slovenia	1996.0
Israel	1993.0	Estonia	1996.0
Norway	1993.0	Switzerland	1996.0
Iceland	1994.0	Croatia	1996.0

There are two clusters of break year modes prior to the Asian financial crisis: 1993-1994 and 1996. These clusters are even more distinct in Figure 6, which plots the distribution of break modes over time. The earliest group (1993) includes both the United States and China.

Figures 6(a) and (b) provide plots of the complete time distribution of breaks by country. We can see that China's local mode in 1993 is distinct from all years prior to 2001, where structural breaks are much less frequent and where local modes are substantially smaller. The United States also shares a similarly large spike in 1993.

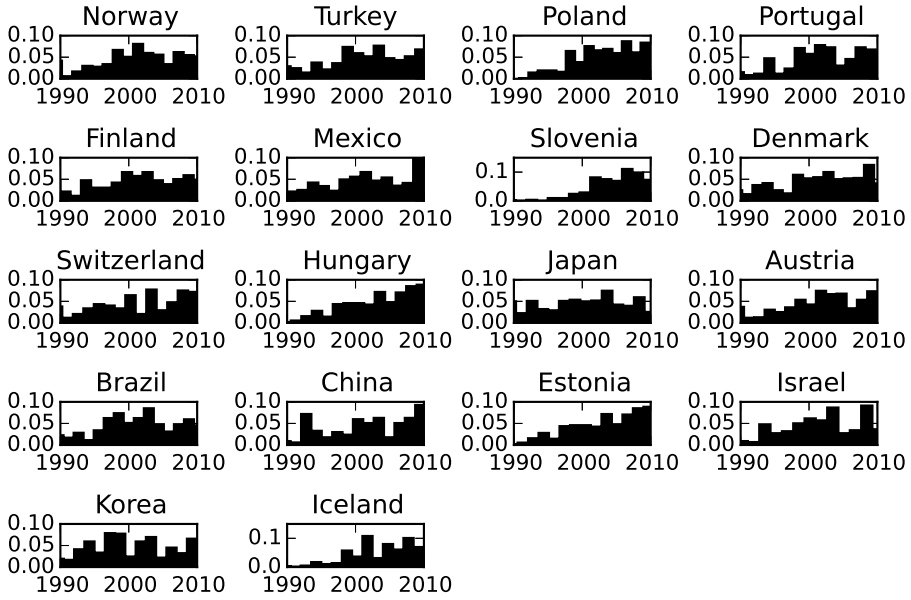
In addition to China and the United States, other countries have large, local break modes during the 1993-1994 period, including the United Kingdom, France, Italy, South Africa, Sweden, Portugal, Denmark, Belgium, and South Korea. Figure 7 shows the geographic distribution of structural "brokenness" in 1993. Here, the degree of "brokenness" is measured by the proportion of a country's breaks that occurred in 1993. The more "broken" a country is in 1993, the darker its color is on the map.

Figure 6(a): Breaks by Country



The degree of "brokenness" is highest for China in 1993, but is also high for the United States, Spain, Germany, France, Italy, Australia, and the United Kingdom. Brokenness is lower and varies in degree throughout the rest of Europe, as well as Japan and India. It is not immediately clear, however, whether this structural change is related; and, if it was, whether it was transmitted from one country to the others.

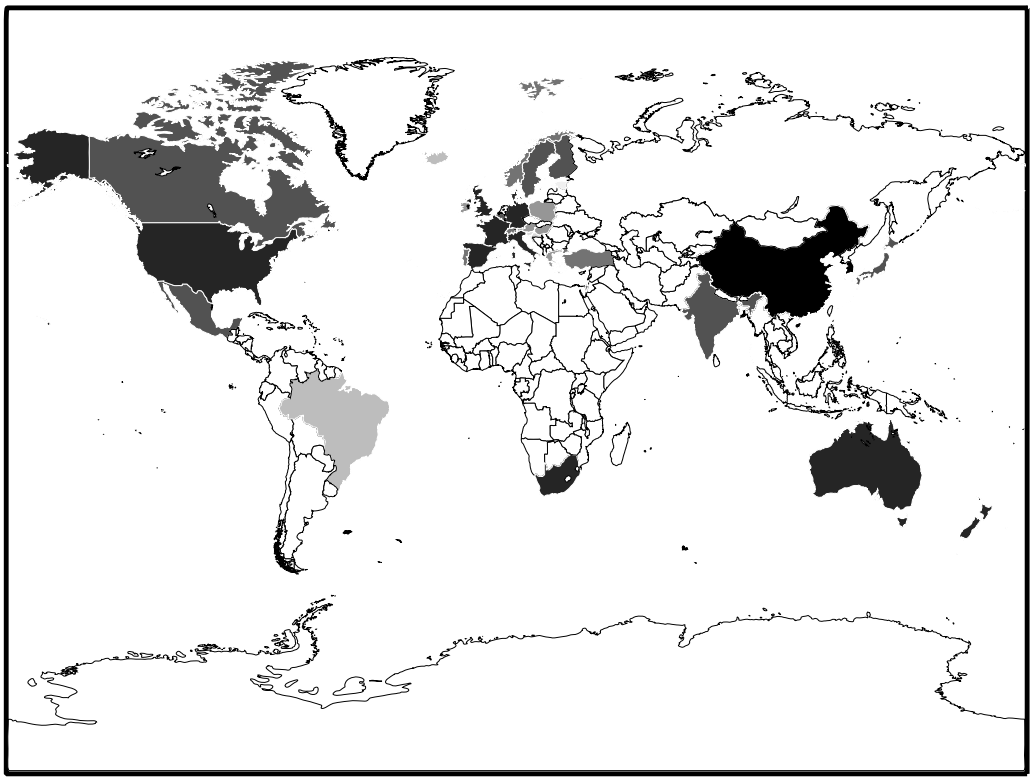
Figure 6(b): Breaks by Country



Beyond identifying the existence of structural change, its origin, and its possible transmission from across countries, we also try to describe the nature of the structural change. To get a broad picture, we segment series according to their association with the expenditure components of GDP: consumption, government spending, investment, and net exports. We do this by checking all series title substrings to determine whether they contain words or phrases related to a GDP expenditure component. Figure 8 shows the proportion of broken series across time and across expenditure components of GDP.

Again, 1993, 2001, and 2007-2009 emerge as large clusters. Structural change was present in all categories, but was especially pronounced in consumption, government spending, and investment. The biggest structural changes associated with investment occurred in 1993 and 2001. This is also the same for consumption and government spending; however, the difference in magnitudes is smaller. The biggest structural changes to net exports were concentrated in 2001 and 2007; however, there were also smaller spikes in 1993 and before and after the 2001 recession.

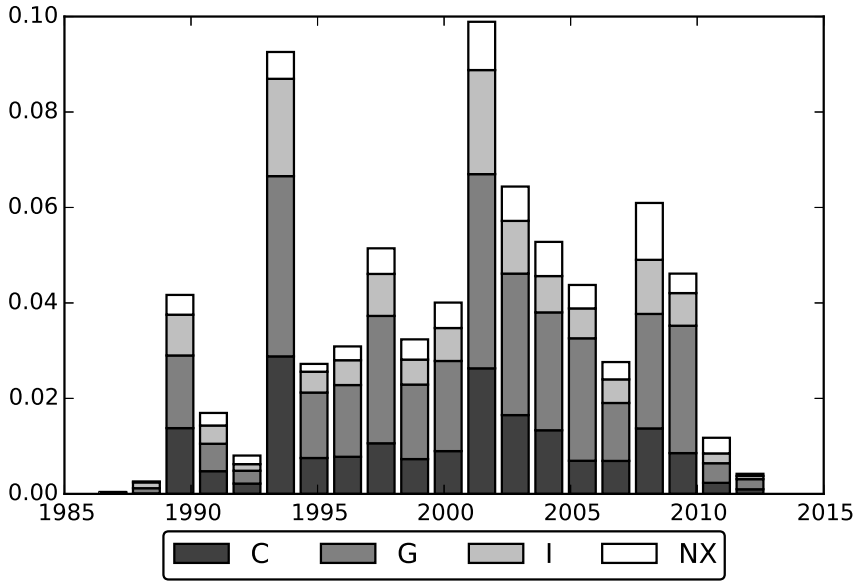
Figure 7: Geographic Distribution of Structural Brokenness, 1993-1994



In Figure 9, we narrow down the nature of the structural change further by only examining series that contain the terms "residential" and "nonresidential." These series

typically describe investment, construction, and lending. The first large spike in breaks occurred for residential series in 1993 and 1994; and was accompanied by a break in the nonresidential series. Both the residential and nonresidential series contain large spikes in 2001, 2002, and 2003. They also contain spikes during the Great Recession; however, both the average level and the size of spikes tends to be substantially larger for residential series.

Figure 8: Time Distribution of Breaks by GDP Component



In Figure 10, we focus exclusively on residential series and divide them into three additional groups: investment, permits, and construction series. Again, we plot the distribution over time and across groups. This yields a spike in 1993, which comes primarily from investment and construction. Structural change then slows through the mid-1990s, spikes again after 2000, and remains high until 2005. The latter changes come primarily from construction and permits.

Figure 9: Time Distribution of Breaks for Residential and Nonresidential Investment

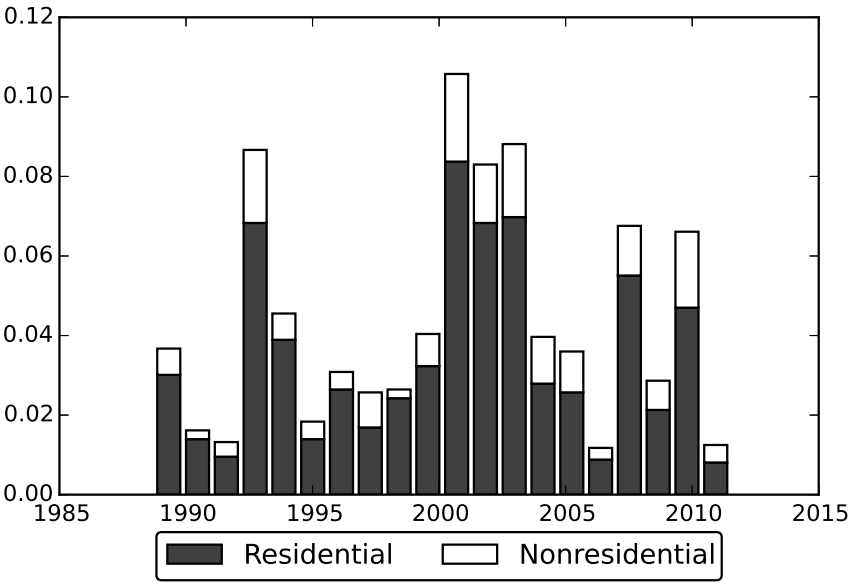


Figure 10: Time Distribution of Breaks for Residential Permits, Investment, and Construction

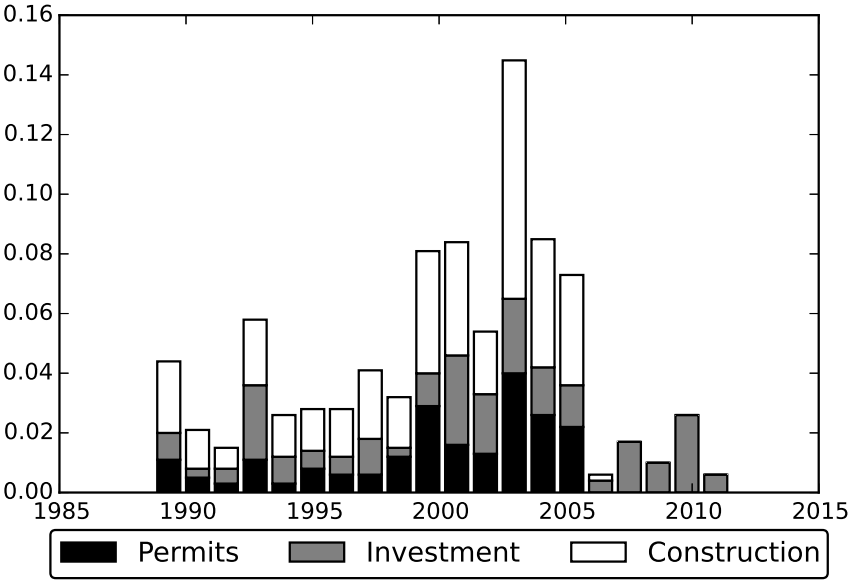


Figure 11 shows the distribution of breaks in residential price series over time. The rate of structural change is low throughout the 1990s, but increasing prior to the Great

Recession. The largest jumps arrive in 2001 and 2004. This provides weak support for the role of the post-2001 credit expansion as a driver for structural change in house prices; however, it also suggests that structural change was already occurring slowly in the 1990s.

Figure 11: Residential Price Breaks

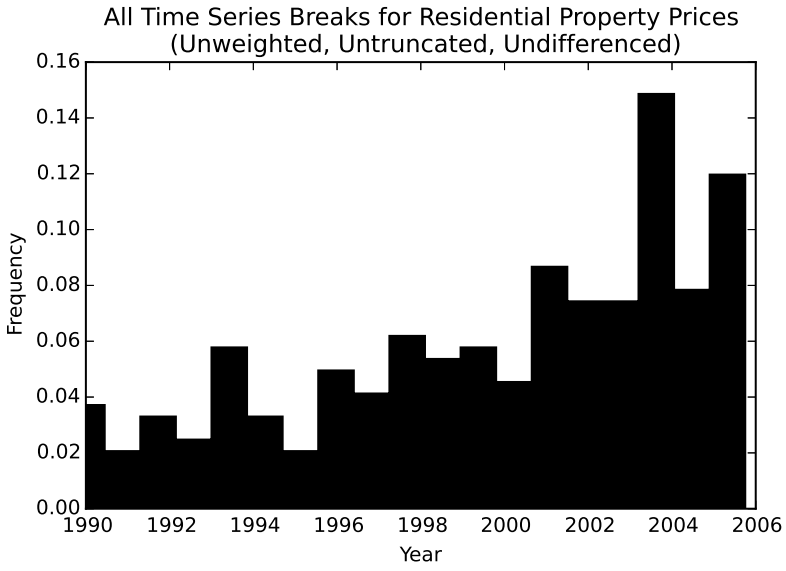
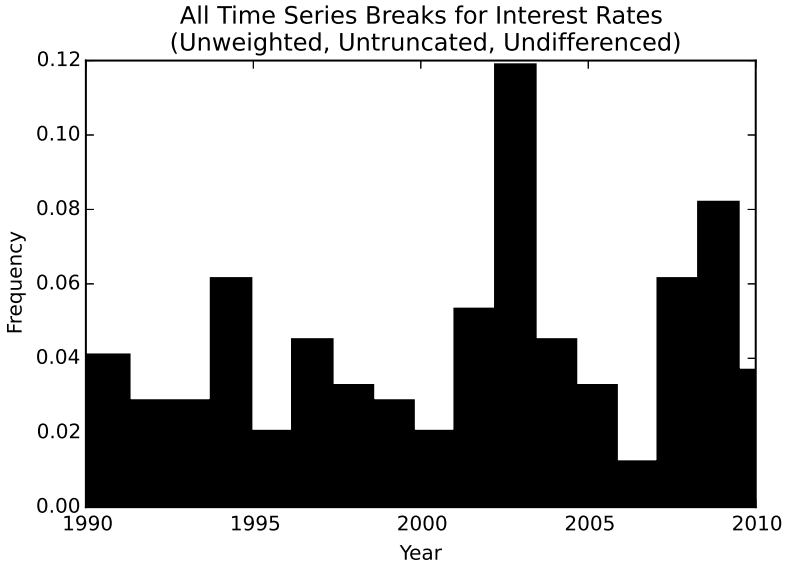


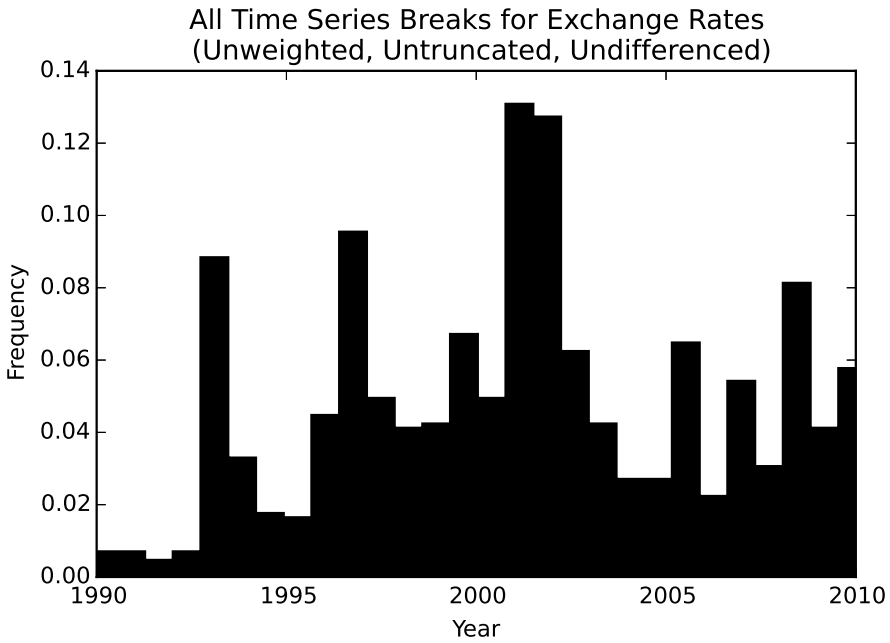
Figure 12: Interest Rate Breaks



Next, Figures 12 and 13 show the time distribution of breaks for interest rates and exchange rates, respectively. Both exhibit spikes in structural breaks in 1993-1994; however, the deviation is smaller for interest rates than for exchange rates. The spike for

interest rates in 1993-1994 is particularly small when compared to breaks in the early 2000s–during the cross-country monetary easing–and at the great recession. Furthermore, it is important to note that this spike may denote a higher–not lower–interest rate regime.

Figure 13: Exchange Rate Breaks



Next, we identify common words and phrases in series titles that are associated with each period. We do this using the following procedure:

1. Select a tag, such as "bank." Identify the series and year of each break associated with the tag.
2. Combine all of the series titles associated with the tag into a single corpus. Remove common words and phrases, such as articles.
3. Apply the bag-of-words technique to the entire corpus to recover the 100 most common 2-5 word phrases for the entire 1990-2010 period.
4. Divide the breaks by year and then create a separate corpus for each group of yearly titles.
5. Recover the most common 2-5 word phrases from each yearly corpus.
6. For each yearly set, drop phrases that are also in the corpus for the full 1990-2010 period.

The purpose of this procedure is to remove phrases associated with frequently broken series, leaving only the terms that are specific to the period under consideration. Table 7 shows the phrases for the tag "building" in the 1990-2006 period.

Table 7: Common Title Phrases for Tag "Building"

1993	1999	2003
1. fixed investment structures	1. dwellings residential buildings permits issued 2. residential buildings permits issued construction	1. total dwellings residential buildings stage 2. dwellings residential buildings permits issued 3. buildings stage construction started 4. buildings permits issued construction 5. dwellings residential buildings stage construction
2006	**2007**	
1. dwellings residential buildings permits issued 2. residential buildings permits issued construction	1. dwellings residential buildings permits issued 2. residential buildings permits issued construction	

For the term "building," only 1993, 1999, 2003, 2006, and 2007 had frequently used phrases that were not also common to the entire period. The phrase for 1993 is "fixed investment structures," which reinforces our earlier finding that the 1993-1994 period can be characterized by structural change in residential investment. The 1999, 2003, 2006, and 2007 phrases relate to residential building permits and construction. The 1999 phrases suggest that structural change in residential development may have started prior to the 2001 recession.

In Table 8, we consider phrases for the word "loan." In 1994 and 1995, the phrases were related to delinquencies, which may refer to structural changes associated with the tail end of the savings and loan crisis. We also see "real estate" in 1994; and both 1997 and 1998 concern structural change in commercial bankings, including total lending. In 2000-2002, phrases related to commitment status and lending at commercial and small domestic banks. We see further structural change in lending and commitment status in

2004-2006.

Table 8: Common Title Phrases for Tag "Loan"

1994	1995	1997
1. booked domestic offices	1. delinquencies loans leases	1. loans commercial banks assets 5b
2. real estate		2. total loans commercial banks assets
3. delinquency rate		
1998	**2000**	**2001**
1. total loans leases net	1. amount loans made commitment	1. banks total assets 300m
2. net unearned income commercial banks	2. commitment status percent amount loans	2. total value loans
3. leases net unearned income commercial	3. daily overnight interval	3. small domestic bank
4. loans leases net unearned income	4. percent value loans	4. real estate
	5. percent value loans	
	6. zero interval	
2002	**2005**	**2005**
1. branches agencies foreign banks	1. loan thousands	1. months since loan commitment terms
	2. small domestic banks	2. status average months since loan
	2. risk acceptable	3. commitment status average months since
	3. 365 days	4. commitment terms set
	4. since loan commitment terms set	5. total loans banks total assets
	5. commitment status average months since	6. loans banks total assets 300m
2006		
1. total loans banks total asset		
2. loans banks total assets 300m		

Finally, Table 9 provides results for the tag "bank." Again, real estate shows up in 1994; and delinquencies in 1994 and 1995. Total lending and lending at commercial

banks is important in 1997 and 1998; and both lending and commitment status become important from 2000-2006.

Table 9: Common Title Phrases for Tag "Bank"

1994	1995	1996
1. booked domestic offices 2. real estate 3. delinquency rate	1. delinquencies loans leases	
1997	**1998**	**2000**
1. total loans commercial banks assets 2. quarterly average total 3. securities commercial banks	1. average total assets commercial banks 2. quarterly weighted average total	1. commitment status 2. amount loans made commitment 3. status percent 4. percent value loans 5. risk acceptable 6. daily overnight interval 7. small domestic banks 8. weighted average maturity
2001	**2002**	**2004**
1. delinquency rate 2. total value 3, banks total assets 300m 4. real estate 5. small domestic banks 6. percent value loans 7. zero interval	1. branches agencies foreign banks 2. 365 days 3. large domestic banks	1. risk acceptable 2. 365 days
2005	**2006**	
1. since loan commitment terms set 2. commitment status average months since	1. total loans banks total assets 2. loans banks total assets 300m	

5 Conclusion

We performed Bai-Perron (2003a, 2003b) tests for multiple, unknown structural breaks on 61,843 time series that were drawn from the St. Louis Federal Reserve's FRED database. This is the full set of series that were suitable for structural break testing and had either a yearly, quarterly, or monthly frequency. We then recovered the full set of structural breaks for the 1990-2010 period; and segmented them according to time,

geography, and type.

Along the time dimension, we found that the rate of structural change grew throughout the 1990s, stabilized in 2003, and then shrank until the Great Recession. After the 1990-19991 recession, there were three spikes in the rate of structural change that departed from the broader trends: 1993-1994, 2001-2003, and 2007-2009. The 2001-2003 and 2007-2009 spikes aligned with recessions in major economies, but the 1993-1994 period of structural change did not. Along the geographic dimension, the 1993-1994 period was almost uniformly important: in the period prior to the 1997 Asian financial crisis, 29 of the 34 countries in the sample had the its modal break year in 1993 or 1994. This included both China and the United States.

Further segmentation identified the time distribution of breaks by broad series type, focusing on titles that could be associated with the expenditure-components of GDP: consumption, government spending, investment, and net exports. Series associated with all four components experienced substantial breaks in 1993-1994 and 2001-2003; however, the consumption and investment breaks were particularly large relative to the level of breaks in surrounding periods. Both the "residential" and "nonresidential" investment components of the structural change were large for both periods, but the residential changes were particularly pronounced. Furthermore, the 1993-1994 period appeared to be more closely associated with structural change in residential investment; whereas, the 2001-2003 period witnessed changes primarily in construction and permits. We also found a large spike in exchange rate structural breaks at 1993-1994, but only a small spike in residential house prices and interest rates. For the latter two, the larger breaks came after the 2001 recession.

Finally, we use textual analysis on the titles of broken series to identify phrases that are uniquely important during each period. For series with "building" in the title, only five years contained unique phrases that were not contained in the corpus for the entire 1990-2007 period: 1993, 1999, 2003, 2006, and 2007. The 1993 phrases were related to fixed investment in structures. The 1999 phrases were related to construction and permits; and the 2006 and 2007 series were related to permits and construction. This aligns with the earlier findings, but provides further evidence that the construction and permit boom may have preceded the 2001 recession. Additionally, for titles that contain "bank" or "loan," the phrase "real estate" was important in 1994. In 1997-2004, phrases

related to commercial bank lending were important. And in 2005, loan commitment terms were most important.

Overall, our findings suggest that structural change related to the Great Recession may have predated the 2001 recession and could date back to the early 1990s. Broadly, this paper lends weak support to the role of current account deficits–and, relatedly, financial inflows; de-emphasizes the role of interest rates prior to 2001; emphasizes the role of interest rates after 2001; and emphasizes structural change in housing investment and prices throughout the 1990s, but finds that the degree of change was much more pronounced after 2001.

6 References

Adam, K., P. Kuang, and A. Marcet (2012). "House Price Booms and the Current Account," NBER Macroeconomics Annual 2011. Chicago: University of Chicago Press, 77-122.

Aizenmann, J., and Y. Jinjarak (2009). "Current Account Patterns and National Real Estate Markets," Journal of Urban Economics, 66, 75-89.

Bai, J. and P. Perron (2003a). "Computation and Analysis of Multiple Structural Change Models," Journal of Applied Econometrics 18, 1-22.

Bai, J. and P. Perron (2003b). "Critical Values for Multiple Structural Change Tests," Econometrics Journal 6, 72-78.

Case, K.E., Shiller, R.J., Thompson. A. (2012). "What Have They Been Thinking? Home Buyer Behavior in Hot and Cold Markets," Brookings Papers on Economic Activity, 265-298.

Coibion, O. and Y. Gorodnichencko (2012). "What Can Survey Forecasts Tell Us About Informational Rigidities," Journal of Political Economy 120, 116-159.

Davis, M. and S. Van Neiuwerburgh (2014). "Housing, Finance, and the Macroeconomy," NBER Working Paper No. 20287, National Bureau of Economic Research.

Delli'Ariccia, G,. D. Igan, and L. Laeven (2012). "Credit Booms and Lending Standards: Evidence from the Subprime Mortgage Market," Journal of Money Credit and Banking 44, 367-384.

Dokko, J., B.M. Doyle, M.T. Kiley, J. Kim, S. Sherlund, J. Sim, and S. Van Den Heuvel (2011). "Monetary Policy and the Global Housing Bubble," Economic Policy 26 (66), 237-287.

Gelain, P., K.J. Lansing, G.J. Natvik (2015). "Explaining the Boom-Bust Cycle in the U.S. Housing Market: A Reverse-Engineering Approach," FRBSF Working Paper 2015-02, Federal Reserve Bank of San Francisco.

Gete, P. (2010). "Housing Markets and Current Account Dynamics." Georgetown University Working Paper.

Glaeser, E.L., J.D. Gottlieb, and J. Gyourko (2013). "Can Cheap Credit Explain the Housing Boom?" Housing and the Financial Crisis. Chicago: University of Chicago Press, 301-360.

Hornk, K., C. Kleiber, W. Kramer, and A. Zeileis (2003). "Testing and Dating Structural Changes in Practice." Computational Statistics & Data Analysis 44.

Jurgilas, M. and K.J. Lansing (2013). "Housing Bubbles and Expected Returns to Home Ownership: Lessons and Policy Implications," Property Prices and Real Estate Financing in a Turbulent World, 2013/4, 101-128.

Reinhart, C. and K. Rogoff (2008). "Is the 2007 US Sub-Prime Financial Crisis So Different? An International Historical Comparison," NBER Working Paper 13761, National Bureau of Economic Research.

Williams, J.C. (2013). "Bubbles Tomorrow, Yesterday, but Never Today? Federal Reserve Bank of San Francisco." Economic Letter 2013-27.

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