

DOES HOUSING REALLY LEAD THE BUSINESS CYCLE?

2010

Luis J. Álvarez and Alberto Cabrero

Documentos de Trabajo
N.º 1024

BANCO DE ESPAÑA
Eurosistema



DOES HOUSING REALLY LEAD THE BUSINESS CYCLE?

DOES HOUSING REALLY LEAD THE BUSINESS CYCLE?

Luis J. Álvarez and Alberto Cabrero

BANCO DE ESPAÑA

The Working Paper Series seeks to disseminate original research in economics and finance. All papers have been anonymously refereed. By publishing these papers, the Banco de España aims to contribute to economic analysis and, in particular, to knowledge of the Spanish economy and its international environment.

The opinions and analyses in the Working Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the INTERNET at the following website: <http://www.bde.es>.

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

© BANCO DE ESPAÑA, Madrid, 2010

ISSN: 0213-2710 (print)

ISSN: 1579-8666 (on line)

Depósito legal: M. 33461-2010

Unidad de Publicaciones, Banco de España

Abstract

The aim of this paper is to characterize the cyclical properties of Spanish real and nominal housing related variables. Our three main results are: First, housing appears to lead the business cycle. Second, fluctuation in home prices are positively related to those of residential investment, suggesting the dominant role of demand factors over supply ones. Third, there are interesting asymmetries in cyclical fluctuations: contractions in GDP appear to be briefer than expansions.

Keywords: Housing, business cycles, filtering.

JEL classification: E32, R21, R32.

1 Introduction

The protracted period of sharp house price increases and booming investment in residential construction in most advanced economies has motivated an explosion of papers analysing the housing market. This interest is even stronger at present, as the boom has come to an end: house prices have rapidly decreased in a number of countries and residential investment is dragging down GDP.

Housing markets have multiple interactions with the rest of the economy, so a number of different issues have been addressed in the literature. For instance, a strand of research has analysed to which extent price levels are consistent with economic fundamentals [Ayuso and Restoy (2006), Mikhed and Zemcik (2009)]. Others authors have stressed the role of home wealth as a driver of household consumption on the basis of aggregate [Poterba (2000), L'Hotellerie and Sastre (2006)] and microeconomic data [Case *et al.* (2005), Bover (2005)]. The role of housing in the monetary transmission mechanism has also received a lot of attention, as reviewed in Mishkin (2007). Finally, there is growing work using estimated Dynamic Stochastic General Equilibrium models in which housing serves as a collateral asset [Iacoviello (2005), Iacoviello and Neri (2008), Aspachs-Bracons and Rabanal (2009), Rubio(2009)].

Evidence on volume cycles and the earlier warning signal nature of real housing developments is considerably scater than for price cycles.¹ Recently, Leamer (2007, 2009) has stressed the substantial effects on United States activity of volume changes in home building. Indeed, 8 out of the last 10 recessions in the US have been preceded by contractions in residential investment. For European countries, evidence for France, Germany, Italy and Spain has been recently made available in a joint project on housing to which this paper belongs- by the 4 major euro area central banks.²

The analysis of housing volume cycles in Spain is particularly relevant, given the strong investment in residential construction in the decade prior to 2006, against a background of low interest rates and sizable migration inflows. Real average annual growth of housing investment in this period exceeded 8% and its share in GDP reached record high levels in 2007 (9.3%), almost 5 pp. above 1996 and substantially above that in the euro area or the United States. The marked expansion of housing supply did not prevent a period of soaring house prices, but had a highly beneficial impact on employment in the construction sector: its share in total employment reached 13.8% in 2007, almost 5 pp. above 1996.

¹ The leading role of residential construction in the United States with respect to GDP has been stressed in Greene (1997), Stock and Watson (1999) and Coulson and Kim (2000)

² Besides this paper, see Álvarez *et al.* (2009), Bulligan (2009), Ferrara and Koopman (2009), Ferrara and Vigna (2009) and Knetsch (2009)

The aim of this paper is twofold. First, we analyse whether residential investment fluctuations in Spain lead those of GDP (section 2). With respect to other literature, we consider a much wider set of real and nominal construction variables. Robustness of results is analysed using several different estimation procedures. Second, asymmetries in the behaviour of housing related variables in expansions and contractions are analysed (section 3). Concluding remarks are presented in section 4.

2 The leading nature of housing

The aim of this section is to determine whether residential investment cycles in Spain tend to precede those in GDP, as in the United States, as well as to characterize the cyclical features of housing related variables in Spain. Where possible we make a comparison with available international evidence.

We consider a sample period that starts in 1980:Q1 and ends in 2008:Q4, thus including the last minimum turning point. The choice of starting in 1980 tries to strike a balance between having the longest available time series and avoiding substantial changes in the definition of the variables. However, seasonally adjusted quarterly national account estimates prior to 1995 are too noisy, reflecting the fact that the National Institute of Statistics used to pay close attention to trend estimates, rather than to seasonally adjusted series. This has led us to pre-filter (the logs of) all data using the methodology in Gómez and Maravall (2001). This procedure has the advantage that it provides a clearer signal that helps improve the dating of turning points. Prior to the pre-filtering stage, we have also extended the series with forecasts to obtain an accurate assessment of the cyclical component at the end of the sample (and minimise revisions).

Data sources of series used appear in appendix 1, year-on-year growth rates of the variables are plotted in appendix 2.

2.1 Housing and other expenditure side GDP components

In this subsection, we focus on the cyclical behaviour of expenditure side GDP components. To that end, we estimate cyclical components mainly using Butterworth and kernel methodologies. We also analyse the robustness of our results by considering alternative estimates of cyclical components. The methodology used is presented in appendix 3.

Results using the Butterworth filter and the Epanichnekov kernel are reported in table 1 and estimates of the cyclical components are plotted in appendix 4. The first column refers to the volatility of the component, as measured by the ratio of the standard definition of a variable ³ to the standard deviation of GDP. The remaining columns report the cross correlation coefficient ⁴ (ρ_j) between each variable at time t and GDP at $t + j$. We say that a variable leads (lags) GDP if (absolute value) cross correlation is highest with respect to future (past) GDP. We say that a variable is pro-cyclical (counter-cyclical) if the maximum cross-correlation is positive (negative).

The table shows that residential investment leads GDP, is pro-cyclical and is considerably more variable than total output or consumption (standard errors of estimates

Table 1 Cross correlation of demand components with GDP

Variable	Butterworthfilter									
	Volatility	Variable leads GDP				Contemp.	Variable lags GDP			
		4	3	2	1		0	1	2	3
Private consumption	1.0	0.48	0.60	0.71	0.77	0.74	0.64	0.51	0.41	0.33
Public consumption	0.6	-0.49	-0.44	-0.36	-0.24	-0.08	0.04	0.12	0.17	0.19
Equipment investment	5.0	0.70	0.76	0.82	0.85	0.83	0.76	0.65	0.51	0.35
Residential investment	2.7	0.61	0.69	0.74	0.76	0.75	0.71	0.65	0.57	0.48
Non residential invest.	2.4	0.08	0.16	0.23	0.28	0.31	0.30	0.27	0.24	0.20
Other investment	1.6	0.57	0.64	0.67	0.67	0.61	0.53	0.46	0.39	0.33
Exports	1.9	0.36	0.52	0.65	0.74	0.74	0.69	0.61	0.52	0.42
Imports	3.8	0.70	0.78	0.84	0.87	0.85	0.78	0.68	0.55	0.40
Variable	Epanechnikov filter									
	Volatility	Variable leads GDP				Contemp.	Variable lags GDP			
		4	3	2	1		0	1	2	3
Private consumption	1.1	0.53	0.63	0.72	0.78	0.80	0.79	0.76	0.73	0.72
Public consumption	1.0	0.43	0.51	0.58	0.64	0.70	0.75	0.78	0.78	0.76
Equipment investment	5.2	0.79	0.82	0.85	0.86	0.84	0.79	0.71	0.62	0.51
Residential investment	3.8	0.86	0.87	0.87	0.86	0.83	0.79	0.74	0.68	0.61
Non residential invest.	3.4	0.51	0.59	0.66	0.71	0.74	0.75	0.75	0.74	0.72
Other investment	2.5	0.87	0.89	0.90	0.89	0.86	0.81	0.76	0.70	0.64
Exports	2.0	0.08	0.12	0.15	0.16	0.15	0.11	0.05	-0.01	-0.06
Imports	3.9	0.78	0.84	0.88	0.90	0.90	0.86	0.81	0.74	0.66

are reported in appendices 5 and 6). Residential investment is linked to a higher extent with future output than with contemporaneous output and thus serves as a leading indicator, in line with the results in Leamer (2007, 2009). The maximum correlation coefficient of residential investment with GDP is high, but not perfect (0.76 using the Butterworth filter and 0.87 with the Epanichnekov kernel). The esti-

³ For clarity of exposition, we refer to the cyclical component as variable X , simply as variable X .

⁴ Standard errors of correlation coefficients are reported in appendices 4 and 5.

mated lead varies from 1 to 3 quarters. Further robustness analysis is presented in table 2, in which cross correlations of residential investment and nominal prices with respect to GDP are reported using Hodrick Prescott, band pass Hodrick Prescott, Baxter and King and Christiano and Fitzgerald filters.⁵ Using these alternative filters, residential investment leads GDP by 2 or 3 quarters. Maximum correlations are also high (in the 0.59-0.80 range). Larger quantitative differences are observed in terms of volatility, but the robust finding is that residential investment fluctuates considerably more than GDP. Table 3 presents an international comparison using a butterworth filter: residential investment is also found to lead GDP in Germany, but not in France or Italy. However, Ferrara and Vigna (2009) using a band pass Hodrick Prescott filter find that French residential investment also leads GDP as Leamer (2007, 2009) for the US. For advanced economies, IMF (2008) considers deviations from a log-linear trend, finding that housing tends to lead the cycle, although with some exceptions in the Euro area (Germany, Italy and Finland) and the Nordic countries (Sweden and Norway).

Despite the anticipatory nature of residential investment fluctuations with respect to those in GDP found in the data, attempts in the existing theoretical literature have had limited success [Gangopadhyay and Hatchondo (2009)]. In a standard general equilibrium model with homogeneous agents [Greenwood and Hercowitz (1991)] representative agents react to a positive technology shock by increasing business investment at the expense of residential investment, thus generating a negative co-

Table 2 Cross correlation. sensitivity to the filter used. Sample period (1980:Q1-2008:Q4)

Housing invest. vs GDP	Vol. *	Residential invest. leads GDP					Residential invest. lags GDP				
		4	3	2	1	0	1	2	3	4	
HP	3.7	0.74	0.76	0.77	0.76	0.72	0.66	0.58	0.50	0.41	
Band pass HP	3.6	0.77	0.80	0.80	0.79	0.76	0.70	0.62	0.53	0.42	
Baxter and King	4.9	0.68	0.69	0.68	0.64	0.61	0.52	0.43	0.35	0.27	
Christiano and Fitzgerald	3.9	0.57	0.59	0.58	0.56	0.54	0.45	0.37	0.29	0.23	
Butterworth	2.7	0.61	0.69	0.74	0.76	0.75	0.71	0.65	0.57	0.48	
Epanechnikov	3.8	0.86	0.87	0.87	0.86	0.83	0.79	0.74	0.68	0.61	
H. prices vs housing invest.	Vol. **	H. prices leads housing invest.					H. prices lags housing invest.				
		4	3	2	1	0	1	2	3	4	
HP	0.8	0.38	0.46	0.51	0.55	0.58	0.60	0.62	0.62	0.62	
Band pass HP	0.9	0.40	0.47	0.53	0.57	0.60	0.63	0.65	0.65	0.64	
Baxter and King	0.9	0.35	0.43	0.49	0.54	0.58	0.61	0.65	0.68	0.69	
Christiano and Fitzgerald	0.8	0.26	0.33	0.38	0.44	0.49	0.52	0.55	0.58	0.57	
Butterworth	0.6	0.38	0.50	0.59	0.65	0.70	0.72	0.72	0.70	0.64	
Epanechnikov	1.0	0.45	0.51	0.57	0.61	0.64	0.68	0.70	0.72	0.74	

*Standard deviation of housing investment relative to standard deviation of GDP

** Standard deviation of house prices relative to standard deviation of residential investment

⁵ The leading nature of housing is also found using year on year growth rates. From a historical perspective, annual data for the 1850-2009 period, also confirm this result.

movement between residential and business investment, at odds with the data. David and Heathcote (2005) obtain a positive comovement between both variables in a model with multiple sectors. In their model, positive technology shocks drive down house prices, allowing consumers to buy more houses. This view of supply driven residential cycles is inconsistent with the positive comovement of house prices and residential investment, typically found in the data. Fisher (2007) succeeds in explaining the leadership of residential over business investment, but not with respect to GDP. The idea is that by increasing the size of the house families increase their labour productivity. As a response to a positive productivity shock in the market sector, households first increase their residential investment at the expense of business investment, which allows them to increase their productivity in periods following the shock. Recently, Yuan (2009) has developed a model in which residential investment leads GDP. In his model, agents face collateral constraints and receive a signal about future productivity one period in advance. A good signal about future productivity makes household spend more to intertemporally smooth consumption. Increased expenditures are financed up to a fraction of the value of the house by borrowing at mortgage interest rates, which are lower than for unsecured consumer loans. As a result, agents buy more housing relative to other goods. Though the model is able to account for the leading nature of housing, the way the financial market is modelled is not completely satisfactory. In particular, households typically do not continuously vary the size of mortgages, according to fluctuations in total spending.

Table 3 Leading nature of housing. International comparison *

	Lead of variable with respect to GDP (quarters)				Maximum cross correlation			
	France	Germany	Italy	Spain	France	Germany	Italy	Spain
Residential investment	0	2	0	1	0.53	0.71	0.53	0.76
Building permits	5	5	na	4	0.75	0.59	na	0.75
Housing starts	4	na	na	4	0.58	na	na	0.75

*Sample: 1980:Q1-2008:Q4. Butterworth filter

2.2 Additional real and nominal construction variables

The leading nature of housing is considerably clearer when using some indicators, such as housing starts and building permits, instead of residential investment. Indeed, Butterworth and Epanichnekov kernel procedures show that both variables lead GDP by 4 quarters (see table 4). This is explained by the fact that residential investment in the national accounts refers to the value of the work of houses in progress. There is, thus, a time lag between the start of a house (or the time a building is authorised to start) and the national account magnitude. As expected, indicators constructed on the basis of housing starts or building permits and a time to build hypothesis lead to a smaller lead with respect to GDP. Building permits and housing starts in France and Germany are also found to lead GDP (Table 3), a result also found for France by Ferrara and Vigna (2009).

The leading nature of residential investment with respect to GDP is not shared by Gross Value Added in construction. This variable also includes non-residential construction, which is either synchronous or lags GDP. The maximum GVA-GDP correlation is considerably lower than the maximum residential investment GDP correlation, probably reflecting the discretionary nature of public construction. Even though at present public construction is being used to stabilize the economy through a fiscal stimulus package, this has not been always the case within the sample period. In Spain, public construction by regional governments and city councils typically is more closely linked to the electoral cycle rather than to the business cycle.

Labour input in the construction sector, both in terms of number of workers and full time equivalent workers, is pro-cyclical and lags residential investment using both filters: the Butterworth filter shows a lead of 1 quarter and Epanechnikov kernel of three quarters. The lag of the labour input probably reflects the fact that firms face costs in adjusting the size of their workforce. Material input indicators, such as concrete consumption and production, are pro-cyclical and coincident with GDP.

Nominal house prices and residential investment are pro-cyclical. The examination of the maximum cross correlation coefficient between residential investment and house prices (0.72 with the Butterworth filter and 0.74 with the Epanechnikov kernel) shows positive comovement. This result is also robust to the use of other filters (Table 2). This suggests that demand factors (e.g. demographics or interest rates) appear to have been more important than supply considerations (e.g. technological progress). This is in line with González and Ortega (2009) who find that immigration has played a major role in the recent housing market boom in Spain. Our evidence (table 4) also points out that price cycles lag volume cycles (1 quarter with the Butterworth filter and 4 quarters with the Epanechnikov kernel), reflecting price

Table 4 Cross correlation of several building indicators with GDP

Variable	Butterworth filter										
	Volatility	Variable leads GDP					Contemp.	Variable lags GDP			
		4	3	2	1	0		1	2	3	4
Residential investment	2.7	0.61	0.69	0.74	0.76	0.75	0.71	0.65	0.57	0.48	
Investment in non residential construction	2.4	0.08	0.16	0.23	0.28	0.31	0.30	0.27	0.24	0.20	
Gross value added in construction	2.0	0.25	0.31	0.37	0.41	0.41	0.39	0.35	0.31	0.27	
Building permits	11.3	0.75	0.73	0.69	0.60	0.47	0.35	0.22	0.09	-0.05	
Housing starts	10.4	0.75	0.74	0.72	0.68	0.60	0.50	0.40	0.29	0.15	
Housing in progress index (building permits)	10.6	0.68	0.74	0.77	0.77	0.74	0.69	0.62	0.53	0.42	
Housing in progress index (housing starts)	9.0	0.59	0.65	0.69	0.71	0.71	0.70	0.65	0.59	0.51	
Concrete production	4.7	0.45	0.58	0.68	0.74	0.74	0.70	0.62	0.53	0.42	
Concrete consumption	4.0	0.52	0.65	0.76	0.82	0.84	0.81	0.75	0.66	0.56	
Employment in construction (persons)	3.4	0.64	0.76	0.84	0.88	0.84	0.77	0.68	0.58	0.47	
Employment in construction sector (FTE)	9.2	0.78	0.82	0.81	0.72	0.57	0.44	0.30	0.15	0.00	
Nominal house prices(*)	0.6	0.38	0.50	0.59	0.65	0.70	0.72	0.72	0.70	0.64	
Real house prices(*)	0.6	0.50	0.61	0.68	0.72	0.73	0.72	0.68	0.62	0.54	
Residential investment deflator	1.1	0.17	0.16	0.13	0.10	0.06	0.02	-0.04	-0.10	-0.16	
Investment in construction deflator	0.8	0.29	0.40	0.49	0.56	0.57	0.55	0.51	0.46	0.39	
Mortgage credit	2.4	0.64	0.71	0.75	0.77	0.76	0.73	0.68	0.61	0.52	
Variable	Epanechnikov filter										
	Volatility	Variable leads GDP					Contemp.	Variable lags GDP			
		4	3	2	1	0		1	2	3	4
Residential investment	3.8	0.86	0.87	0.87	0.86	0.83	0.79	0.74	0.68	0.61	
Investment in non residential construction	3.4	0.51	0.59	0.66	0.71	0.74	0.75	0.75	0.74	0.72	
Gross value added in construction	2.7	0.70	0.76	0.81	0.83	0.84	0.83	0.80	0.77	0.73	
Building permits	11.1	0.73	0.70	0.66	0.60	0.52	0.44	0.35	0.26	0.17	
Housing starts	9.1	0.64	0.63	0.62	0.59	0.55	0.50	0.44	0.37	0.29	
Housing in progress index (building permits)	10.4	0.76	0.76	0.75	0.73	0.70	0.65	0.59	0.52	0.44	
Housing in progress index (housing starts)	8.5	0.64	0.65	0.65	0.64	0.61	0.59	0.55	0.50	0.43	
Concrete production	5.8	0.59	0.65	0.70	0.74	0.75	0.72	0.68	0.63	0.56	
Concrete consumption	6.1	0.77	0.82	0.87	0.89	0.90	0.88	0.84	0.79	0.73	
Employment in construction (persons)	4.1	0.68	0.76	0.83	0.88	0.89	0.88	0.86	0.83	0.78	
Employment in construction sector (FTE)	11.6	0.91	0.93	0.92	0.88	0.81	0.73	0.63	0.53	0.43	
Nominal house prices(*)	1.0	0.45	0.51	0.57	0.61	0.64	0.68	0.70	0.72	0.74	
Real house prices(*)	1.1	0.52	0.58	0.63	0.67	0.69	0.72	0.73	0.74	0.75	
Residential investment deflator	2.0	-0.07	-0.04	0.00	0.03	0.06	0.09	0.11	0.13	0.15	
Investment in construction deflator	1.6	-0.11	-0.05	0.00	0.06	0.10	0.12	0.14	0.15	0.17	
Mortgage credit	3.4	0.19	0.28	0.36	0.43	0.49	0.54	0.57	0.59	0.60	

*Cross correlation computed with housing investment

stickiness or investment decisions anticipating future prices changes. Results on real house prices are less clear. Real prices are coincident with residential investment using the Butterworth filter, but lag 4 quarters with the Epanechnikov kernel. For advanced economies, IMF (2008) finds the real house prices tend to lag the business cycle. For Italy, Bulligan (2009), finds that house prices lag residential investment. In contrast, Ferrara and Vigna (2009) find that French real house prices lead GDP. Finally, mortgage credit evidence is inconclusive.

3 Brevity and violence of expansions and contractions

A recurring theme in discussions about business cycle fluctuations is their asymmetric nature: are contractions of economic activity briefer than expansions? Are contractions more violent than expansions? A number of authors have developed theoretical models that allow for such asymmetries. For instance, in Hansen and Prescott (2005) asymmetries are due to capacity constraints: production takes place at individual plants that may or may not be operated in a given period. In recessions, some plants simply are not used, whereas in booms firms hit capacity constraints. In Kocherlakota (2000) asymmetric business cycles are the results of credit constraints. In contractions, agents would like to borrow, but are unable to obtain the amount they would like, as they have credit constraints. As a result, they have to cut down production. Other authors, such as McKay and Reis (2008), put the emphasis on the labour market: In contractions, firms can quickly dismiss workers, but in booms they need time to find and train workers.

In our empirical analysis, we first determine the turning points of the different variables, so as to segment the sample into periods of expansions and contractions. Specifically, we identify these periods with a binary random variable (S_t) that takes the value unity in expansions and zero in contractions. Then, we consider a number of statistics to characterise the brevity and violence of the cycles.

Turning points are dated non-parametrically, using a variant of the Bry and Boschan (1971) methodology proposed by Harding and Pagan (2002). The method first determines peaks (troughs) as the local maxima (minima) in the series. Second, it eliminates some of these preliminary turning points, so as to ensure that expansion (trough to peak) and contraction (peak to trough) phases exceed a pre-specified number of quarters, while completed cycles have a duration of at least a given number of quarters. We consider durations of 5 quarters for expansions and contractions and 10 quarters for full cycles. Third, it ensures that peaks and troughs alternate.

Table 5 presents statistics on the number of peaks, troughs, as well as mean durations and amplitudes of full cycles. In our sample period, we detect around 5 peaks and 4 troughs for the majority of variables. The mean duration of a full cycle (*i.e.* the time from peak to the next peak) is around 6 years, with a quite homogeneous distribution across variables. There are very marked differences, though, in terms of the amplitude of fluctuations. As expected, fluctuations in GDP are less marked than in residential investment, reflecting the smoothness of household consumption. Moreover, fluctuations in short-term indicators, such as housing starts and building permits, are considerably larger than for other variables. Fluctuations in real variables are generally larger than for prices.

To focus on asymmetries, we compute measures of brevity, violence and steepness of variables. Brevity is measured in terms of average duration of expansions (D^E) and contractions (D^C)

Table 5 Cyclical characterisation and classification of GDP and construction variables. Butterworth and Epanechnikov filters

Sample period: 1980-Q1 - 2008-Q4	Butterworth filter												
	Turning points		Mean duration		Mean ampl.		Steepness		Asymmetry		Coincidence Index	Median Lead	
	Peaks	Troughs	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Duration	Amplitude		Exp.	Cont.
GDP	5	4	14.3	9.5	2.8	3.0	0.2	0.3	1.5	1.0
Residential investment	5	5	11.7	13.8	10.2	10.0	0.9	0.7	0.8	1.0	0.8	3	-2
Investment in non residential construction	5	6	9.3	9.6	10.4	10.1	1.1	1.0	1.0	1.0	0.7	3	-1
Gross value added in construction	4	4	7.5	13.0	7.4	6.9	1.0	0.5	0.6	1.1	0.6	4	1
Building permits	5	5	14.3	11.0	48.1	35.9	3.4	3.3	1.3	1.3	0.6	2.5	1
Housing starts	5	4	14.0	11.3	39.0	30.8	2.8	2.7	1.2	1.3	0.6	3	7
Housing in progress index (building permits)	6	5	12.2	11.0	37.2	32.6	3.1	3.0	1.1	1.1	0.7	0.5	4
Housing in progress index (housing starts)	5	4	12.0	12.5	26.1	31.1	2.2	2.5	1.0	0.8	0.6	0.5	5
Concrete production	5	5	12.3	11.8	16.0	18.7	1.3	1.6	1.0	0.9	0.7	1	0
Concrete consumption	5	5	13.7	11.3	12.9	14.3	0.9	1.3	1.2	0.9	0.7	2	-2
Employment in construction (persons)	4	4	22.5	12.3	13.4	14.1	0.6	1.1	1.8	1.0	0.7	3	0
Employment in construction sector (FTE)	5	5	12.0	11.5	9.0	10.7	0.8	0.9	1.0	0.8	0.7	1	0
Nominal house prices	5	5	13.3	10.0	5.7	5.2	0.4	0.5	1.3	1.1	0.8	-0.5	0
Real house prices	5	4	12.7	12.0	5.6	5.8	0.4	0.5	1.1	1.0	0.8	0.5	0
Residential investment deflator	6	6	9.4	9.5	3.2	2.9	0.3	0.3	1.0	1.1	0.6	2	1
Investment in construction deflator	5	4	13.7	11.3	3.3	3.7	0.2	0.3	1.2	0.9	0.6	1.5	1
Mortgage credit	5	4	11.3	14.5	7.8	7.7	0.7	0.5	0.8	1.0	0.7	0.5	-2
	Epanechnikov kernel												
	Turning points		Mean duration		Mean ampl.		Steepness		Asymmetry		Concordance Index	Median Lead	
	Peaks	Troughs	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Duration	Amplitude		Exp.	Cont.
GDP	4	4	15.5	8.3	4.0	2.8	0.3	0.3	1.86	1.41
Residential investment	3	3	24.3	11.0	19.7	12.1	0.8	1.1	2.21	1.63	0.6	6	2.5
Investment in non residential construction	5	5	13.6	9.0	13.0	13.7	1	1.5	1.51	0.95	0.7	2	0
Gross value added in construction	2	2	40.0	13.0	20.2	22.1	0.5	1.7	3.08	0.92	0.7	3	2
Building permits	5	5	16.0	9.3	52.6	33.1	3.3	3.6	1.73	1.59	0.6	2	7
Housing starts	4	3	13.8	11.3	39.8	29.2	2.9	2.6	1.21	1.36	0.5	3	3
Housing in progress index (building permits)	6	5	13.2	9.5	40.8	31.8	3.1	3.3	1.39	1.28	0.7	-1	4
Housing in progress index (housing starts)	5	4	14.0	12.3	35.6	29.7	2.5	2.4	1.14	1.20	0.6	2	5
Concrete production	5	5	14.3	10.5	24.3	18.7	1.7	1.8	1.36	1.30	0.6	0	5
Concrete consumption	5	5	14.4	8.8	21.7	16.5	1.5	1.9	1.65	1.31	0.6	0	4
Employment in construction (persons)	4	4	19.0	10.0	18.6	17.1	1.0	1.7	1.90	1.09	0.7	3	5
Employment in construction sector (FTE)	4	4	19.0	10.0	18.6	17.2	1.0	1.7	1.90	1.08	0.7	1	1
Nominal house prices	2	2	28.0	28.0	24.9	26.9	0.9	1.0	1.00	0.92	0.6	3.5	12.5
Real house prices	2	2	29.0	28.0	25.4	24.8	0.9	0.9	1.04	1.02	0.6	3.5	-8.5
Residential investment deflator	3	2	27.5	31.0	8.3	9.1	0.3	0.3	0.89	0.91	0.5	4.5	13
Investment in construction deflator	5	4	11.0	10.7	4.1	3.3	0.4	0.3	1.03	1.25	0.7	2	1
Mortgage credit	4	3	14.7	19.3	14.8	15.1	1.0	0.8	0.76	0.98	0.7	3	3

Duration: Number of quarters in expansion (exp.)/contraction (cont.)
Amplitude: Change in the cyclical component between beginning and end of the expansion/contraction
Asymmetry: Ratio of median duration (amplitude) of expansions and contractions.
Steepness: Ratio between the duration and amplitude. Shows the intensity of the expansions and contractions
Concordance Index: Computed according to Harding and Pagan (2002)
Median lead: Number of quarters of median lead(+)/lag(-)

$$D^E = \frac{\sum_{t=1}^T S_t}{n_e} \quad D^C = \frac{\sum_{t=1}^T (1 - S_t)}{n_c} \quad (1)$$

where n_e and n_c refer, respectively, to the number of expansions and contractions and T is the sample size.

We find that GDP contractions are substantially briefer than GDP expansions. Depending on the filter, contractions tend to last slightly above 2 years, whereas expansions last close to 4 years.⁶ Asymmetry is less clear for residential investment: using the Epanechnikov kernel contractions are briefer, but the opposite result is found with the Butterworth filter. In contrast, other real indicators, such as housing starts or building permits share the asymmetric pattern. Employment in construction tends

⁶ The difference is economically significant. However, given the sample length, point estimates are fairly imprecise. The null hypothesis that the duration of expansions equals that of contractions is not rejected by the data.

to show higher asymmetry than GDP, as in McKay and Reis (2008): contractions last between 2 or 3 years, but expansions typically last close to 5 years. Asymmetry in terms of nominal and real house prices is found to be much less relevant.

Asymmetry may also refer to the violence of the change. Violence of expansions (A^e) is measured in terms of the change in the series (Δy_t) from a trough to the next peak and violence of contractions (A^c) as the change of the series from the peak to the following trough. Formally,

$$A^E = \frac{\sum_{t=1}^T S_t \Delta y_t}{n_e} \quad A^C = \frac{-\sum_{t=1}^T (1 - S_t) \Delta y_t}{n_c} \quad (2)$$

Having estimated the cycles for the different variables, a question that arises is whether booms or busts in two series go in tandem. Harding and Pagan (2002) define a coincidence indicator (CI) that measures the fraction of time that two series are in the same (expansionary or contractionary) phase. Formally,

$$CI = \frac{\sum_{t=1}^T S_{1t} S_{2t} + (1 - S_{1t})(1 - S_{2t})}{T} \quad (3)$$

where S_{1t} and S_{2t} are binary variables, defined analogously to S_t , that capture if series 1 and 2 are either in expansion or contraction. This measure provides additional information to the standard linear correlation coefficient.

GDP does not show a clear asymmetry in terms of violence: troughs do not appear to be deeper than peaks are tall and the main two filters we use give conflicting signals. Residential investment also does not present a clear pattern: the Epanechnikov kernel shows asymmetry, but this is not shared by the Butterworth filter. There is no consistent evidence of asymmetry for the rest of variables. Statistics of steepness of expansions and contractions which measure the average gain (loss) per unit of time in an expansion (contraction)- also do not show interesting asymmetric patterns for the different variables.

Regarding cyclical classification, table 5 reports the coincidence index for the different construction variables. It is seen that there is substantial comovement of these variables with GDP. Around 70% of the time each variable is in the same expansionary or contractionary phase as GDP. The table also reports the median lead of the turning points in each variable with respect to those in GDP. Results of mean lags confirm those of the previous cross-correlation analysis: housing leads GDP. This is particularly true for housing starts and building permits indicators and somewhat less clear for residential investment. Results for nominal and real prices are not conclusive: the Butterworth filter suggests a coincident role with respect to GDP, but linear kernels show some lead.

In section 2 we have emphasized the leading nature of housing with respect to GDP: housing related variables show a higher correlation with future output than with current or past output. An alternative approach is to analyse whether the turning point in a given variable precedes or not that of GDP. Table 5 also reports median lead for all turning points, peaks and troughs. This allows us to check for asymmetries in the lead-lag relationship. We find that the lead of residential investment with respect to GDP in expansions is larger than in contractions.

4 Concluding remarks

This paper analyses housing volume and price cycles in Spain. We find that residential investment is linked to a higher extent with future output than with contemporaneous or past output and thus serves as a leading indicator of GDP, as found with US data. Earlier signals of future changes in GDP are given by housing starts or building permits. These empirical regularities deserve close attention and more theoretical work is needed to further understand them.

The recent experience of the Spanish economy has shown a marked expansion of housing supply that has not prevented a protracted period of sharp house price rises. It is, therefore, not surprising that we find that fluctuations in home prices have been positively linked to those of residential construction. This supports a view of mainly demand driven housing volume cycles, in line with the observed increase in immigrants and the number of single person households, as well as the drop in interest rates. Among supply factors, technological progress in home building is likely to have played a minor role, but land use constraints probably less so. Moreover, price cycles tend to lag volume cycles, reflecting price stickiness or the fact that building firms may anticipate future prices changes.

Third, there are interesting asymmetries in cyclical fluctuations: contractions in GDP and housing real variables appear to be briefer than expansions. Further, we find that the lead of residential investment with respect to GDP in expansions is larger than the lead in contractions.

References

1. Álvarez, L. J., Bulligan, G., Cabrero, A., Ferrara, L. and Stahl, H. (2009) Housing cycles in the major euro area countries, Banque de France, *Working Paper*, No. 269
2. Álvarez, L. J and Cabrero, A. (2009) Pitfalls in business cycle estimation with local polynomial regression, Banco de España, *mimeo*
3. Artis, M.J.; M. Marcellino and T. Proietti (2003) Dating the euro area business cycle. CEPR. *Discussion Paper*, n° 3696
4. Aspachs-Bracons, O. and P. Rabanal (2009) The Drivers of Housing Cycles in Spain, IMF, *Working Paper*, 09/203
5. Ayuso, J. and F. Restoy (2006) House prices and rents: An equilibrium asset pricing approach, *Journal of Empirical Finance*, 13(3): 371–388.
6. Baxter, M. and R. G. King (1999) Measuring Business Cycles. Approximate Band-Pass Filters for Economic Time Series, *The Review of Economics and Statistics*, 81(4): 575–593
7. Bry, Gerhard and Charlotte Boschan (1971), Cyclical Analysis of Economic Time Series: Selected Procedures and Computer Programs, NBER, *Technical Working Paper*, No. 20
8. Bulligan, G. (2009), Housing and the macroeconomy: The Italian case, Banca d'Italia, *mimeo*
9. Burns, A. M. and W. C. Mitchell (1946) Measuring Business Cycles, National Bureau of Economic Research
10. Butterworth, S. (1930) On the theory of filter amplifiers, *Experimental Wireless and the Wireless Engineer*, 7: 536–541
11. Canova, F. (1998) Detrending and business cycle facts, *Journal of Monetary Economics*, 41: 475-512
12. Caporello, G., And Maravall, A. (2004) Program TSW: Revised Manual, Banco de España, *Occasional Paper*, n° 0408
13. Case, K.; J. Quigley and R. Shiller (2005), Comparing Wealth Effects: the Stock Market versus the Housing Market, *Advances in Macroeconomics*, 5(1)
14. Christiano, L. J. and Fitzgerald, T. J. (2003) *The band pass filter*, International Economic Review. 44(2): 435–465
15. Coulson, N. E. and M-S. Kim (2000) Residential Investment, Non-residential Investment and GDP, *Real Estate Economics*, 28(2): 233–47
16. Ferrara, L. and O. Vigna (2009) Evidence of relationships between macroeconomic and housing cycles in France, Banque de France, *mimeo*
17. Ferrara, L. and S. J. Koopman (2009) Common business and housing markets cycles in the euro area: A multivariate component approach, Banque de France, *mimeo*
18. Gómez. V. (2001) The use of Butterworth filters for trend and cycle estimation in economic time series, *Journal of Business and Economic Statistics*, 19(3): 365–373
19. Gómez, V. and A. Maravall (2001) Seasonal adjustment and signal extraction time series in *A Course in Time Series Analysis*. Peña, D.; G. C. Tiao and R. S. Tsay (eds.) John Wiley and Sons.
20. González, L. and F. Ortega (2009) Immigration and Housing Booms: Evidence from Spain, Universitat Pompeu Fabra, Department of Economics and Business, *Economics Working Papers* n° 1167
21. Green, R. K (1999) Follow the Leader: How Changes in Residential and Non-residential Investment Predict Changes in GDP, *Real Estate Economics*, 25 (2): 253 - 270
22. Hansen, G. D. and E. C. Prescott (2005) Capacity constraints, asymmetries, and the business cycle, *Review of Economic Dynamics*, 8(4): 850–865
23. Harding, D. and A. Pagan (2001a) Dissecting the Cycle: A Methodological Investigation, *Journal of Monetary Economics*, 49 (2), 365–381
24. Hodrick, R. J. and E. C. Prescott (1997) Postwar U.S. Business Cycles: An Empirical Investigation, *Journal of Money, Credit and Banking*, 29(1): 1-16
25. Iacobucci, A. and A. Noullez (2005) A Frequency Selective Filter for Short-Length Time Series, *Computational Economics*, 25(1):75-102

26. Iacoviello, M. (2005) House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle, *American Economic Review*, 95(3): 739-764
27. Iacoviello, M. and S. Neri (2008) Housing market spillovers: Evidence from an estimated DSGE model, *Temi di discussione*, 659, Banca d'Italia.
28. International Monetary Fund (2008) World Economic Outlook: Housing and the business cycle, April.
29. Knetsch, T. (2009) Trend and cycle features in German residential investment before and after unification, Deutsche Bundesbank, *mimeo*
30. Kocherlakota, N. R. (2000) Creating business cycles through credit constraints, *Quarterly Review*, Federal Reserve Bank of Minneapolis, Summer, 2-10
31. Leamer, E. E. (2007) Housing is the business cycle, Proceedings, Federal Reserve Bank of Kansas City, 149-233
32. Leamer, E. E. (2009) Homes and Cars: Why are the Cycles in Homes and Consumer Durables so Similar?, *Advances in Economic Analysis & Policy*, Berkeley Electronic Press, 9(3), article 5
33. L'Hotellerie, P. and T. Sastre (2006) Demand decisions by households and firms in Servicio de Estudios del Banco de España (ed.) *The analysis of the Spanish economy*. Banco de España
34. McKay, A. and R. Reis (2008) The brevity and violence of contractions and expansions, *Journal of Monetary Economics*, 55(4): 738-751
35. Mikhed, V. and P. Zemcik (2009) Do house prices reflect fundamentals? Aggregate and panel data evidence, *Journal of Housing Economics*, 18 (2): 140-149
36. Mills, T. C. (2003) *Modelling Trends and Cycles in Economic Time Series*, Palgrave Macmillan
37. Mishkin, F. S (2007). Housing and the Monetary Transmission Mechanism, *NBER Working Papers* # 13518, National Bureau of Economic Research
38. Poterba, J. M. (2000). Stock Market Wealth and Consumption, *Journal of Economic Perspectives*, 14
39. Prescott, E. C. (1986) Theory Ahead of Business Cycle Measurement, *Quarterly Review*, Federal Reserve of Minneapolis, Fall, 9-22
40. Rubio, M. (2009) Fixed and variable mortgages, business cycles and monetary cycle. *Working Paper*, 0903, Banco de España.
41. Stock, J. and Watson, M. (1999) Business cycle fluctuations in US macroeconomic time series in J. B. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics* 1. Elsevier.

Acknowledgements We wish to thank participants at the Conference "The macroeconomics of housing markets", particularly our discussants Ralph Brüggemann (Konstanz University) and Gilles Dufrénot (Aix-Marseille University and Banque de France). We are also grateful to seminar participants at Banco de España, Banque de France, José Manuel González, Luis Ángel Maza and Juan Peñalosa for their comments and suggestions. We are specially indebted with Víctor Gómez for providing his Butterworth filter software (TRACE).

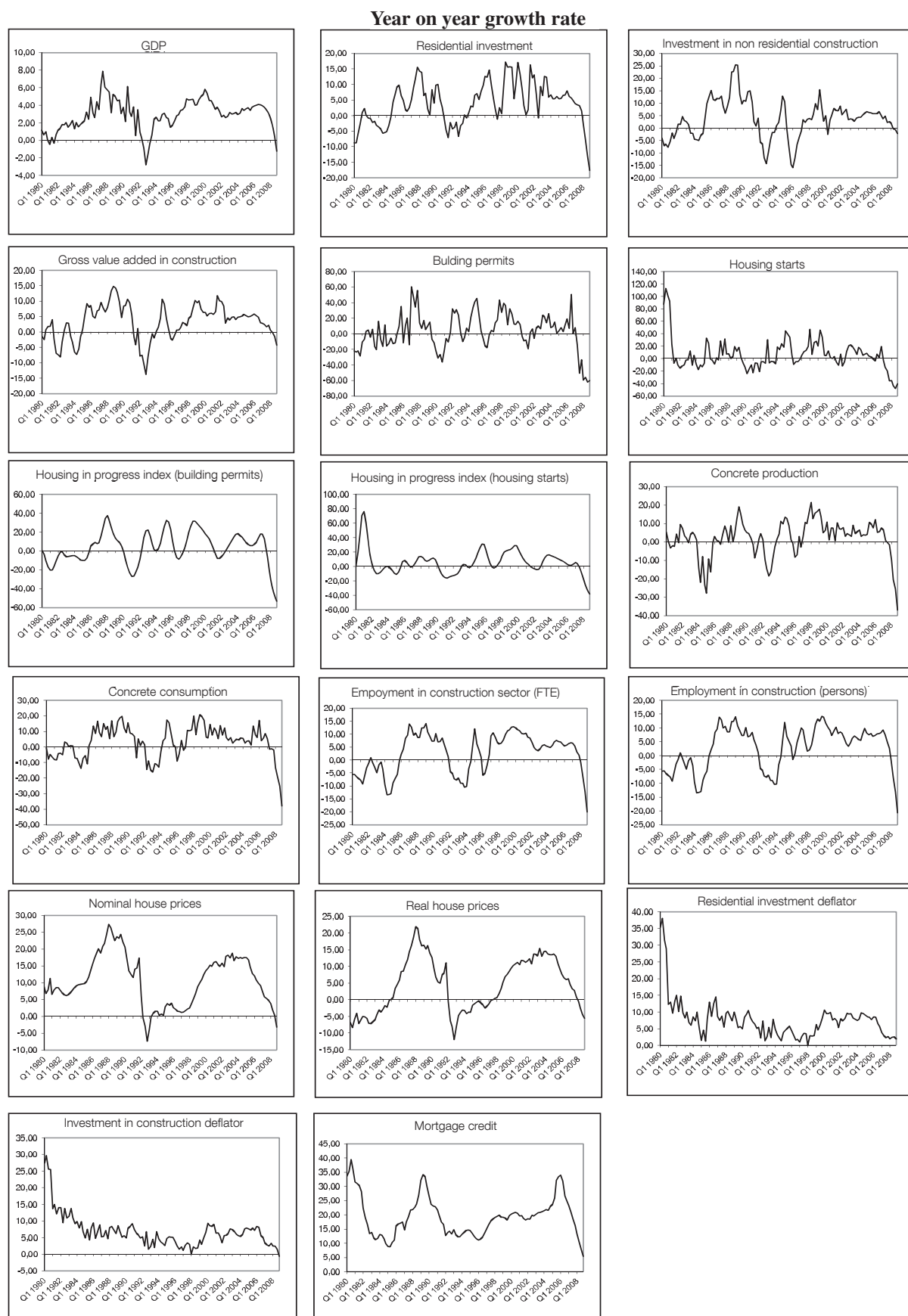
Appendix 1: Database description

Variables	Source	Comments
1 GDP	QNA. INE and own elaboration (*)	
2 Private consumption	QNA. INE and own elaboration	
3 Public consumption	QNA. INE and own elaboration	
4 Investment in equipment	QNA. INE and own elaboration	
5 Residential investment	QNA. INE and own elaboration	Linkage of national accounts bases 1995 since 1980 to 1994:Q4) and 2000 using q-o-q growth rates Index 2000=100
6 Non residential investment	QNA. INE and own elaboration	
7 Investment in other products	QNA. INE and own elaboration	
8 Exports of goods and services	QNA. INE and own elaboration	
9 Imports of goods and services	QNA. INE and own elaboration	
10 Gross value added in construction	QNA. INE and own elaboration	
11 Building permits	Architects and own elaboration (**)	Number of buildings
12 Housing starts	Ministry of Housing	Number of houses. Includes both subsidized and unsubsidized houses.
13 Housing in progress index (building permits)	Architects and own elaboration	Index calculated with building permits and an estimated calendar of construction
14 Housing in progress index (housing starts)	Ministry of Housing and own elab.	Index elaborated on housing starts and an estimated calendar of construction
15 Concrete production		
16 Concrete consumption		
17 Employment in construction (persons)	Labour Force Survey (INE)	Thousand of people
18 Employment in construction sector (FTE)	QNA and own elaboration	Full time equivalent
19 Nominal house prices	Ministry of Housing and own elab.	
20 Real house prices	INE and own elaboration	
21 Residential investment deflator	QNA	
22 Investment in construction deflator	QNA	
23 Mortgage credit	Bank of Spain	

(*) INE. National Institute of Statistics INE

(**) Architects: Architects and Technical Architects Associations

Appendix 2: Seasonally adjusted (or original) series (1980:1 2008:4)



Appendix 3: Estimating cycles: methodological considerations

Decomposing aggregate output into a trend which accounts for long term growth-, a cyclical component which measures deviations from this trend corresponding to business cycle frequencies- and an irregular component -which accounts for very short-term fluctuations- have been made using a large number of procedures, each with different properties [Canova (1998) or Mills (2003)]. In this context, it is crucial to define beforehand the business cycle concept the researcher is interested in, so as to avoid conceptual confusions.

We consider procedures that eliminate trend and irregular components, while retaining intermediate (business cycles) components. Our desired filter is what is known in the literature as an ideal band-pass filter. This definition is conceptually different from the one used in other approaches, such as DSGE models, production function approaches or Markov switching models.

1 The ideal band-pass filter

The aim of an ideal band-pass filter is to pass through components of a time series belonging to a pre-specified band of frequencies (*pass band*), while removing components at higher and lower frequencies. The gain function $G(p)$ of a filter determines how the different cyclical fluctuations contribute to the signal. If $G(p_0) = 1$ cyclical fluctuations with period p_0 are fully passed by the filter, whereas if $G(p_0) = 0$ they are fully suppressed. In formal terms, the ideal band-pass filter $G_i^{BP}(p)$ has a gain function (Figure 1) given by

$$G_i^{BP}(p) = \begin{cases} 0 & \text{if } |p| < p_1 \\ 1 & \text{if } p_1 \leq |p| \leq p_2 \\ 0 & \text{if } |p| > p_2 \end{cases} \quad (1)$$

which means that cyclical fluctuations belonging to the interval $[p_1, p_2]$ pass through the filter untouched, but all other fluctuations are completely removed.

1.1 Butterworth filters

Butterworth filters [Butterworth (1930)] are low-pass or band-pass filters widely used in electrical engineering in their one-sided form. In business cycle analysis, two-sided versions are to be preferred, to avoid phase shifts that would distort the timing of turning points. There are two families of Butterworth filters, which are

based on the sine function (BFS) and the tangent function (BFT), respectively. Interestingly, the Hodrick Prescott filter is a particular low pass BFS [Gómez (2001)], so that Butterworth filters are more flexible than the HP filter, suggesting that there may be gains from their use. BFT filters fully suppress high frequency fluctuations, in contrast with BFS, so they are more appropriate for cycle estimation.

Butterworth band-pass filters in the time domain are symmetric, two sided filters in the lag and forward operator given by

$$BPL(L, F) = \frac{(1 - L^2)^d (1 - F^2)^d}{(1 - L^2)^d (1 - F^2)^d + \lambda (1 - \alpha L + L^2)^d (1 - \alpha F + F^2)^d} \quad (2)$$

where d is an integer parameter, $\alpha = \cos((\omega_{p2} + \omega_{p1})/2) / \cos((\omega_{p2} - \omega_{p1})/2)$, ω_{p1} , and ω_{p2} are the lower and upper limits of the band-pass, respectively, and λ is a parameter to ensure that the gain of the filter at a pre-specified period equals one-half. Note that larger values of d produce sharper filters, so there is better approximation to the ideal filter (Figure 1). Approximations to the ideal filter are quite good for moderate values of d .

Gómez (2001) suggests a model-based two-stage procedure to obtain the cyclical component based on Butterworth filters, which can be shown to be identical to joint estimation of all components. In the first stage, the series is extended with ARIMA forecasts and backcasts to minimise the size of revisions and then a model-based trend-cycle component is obtained following the methodology in Gómez and Maravall (2001). Second, the band-pass BFT is applied. This method presents several advantages. First, the identification of a model for the first stage decreases the risk of inducing spurious results. For instance, if one tries to obtain a trend from a white noise series, the first stage will lead to the conclusion that no such a trend exists. Second, since optimal forecasts are used, revisions in preliminary estimates are re-

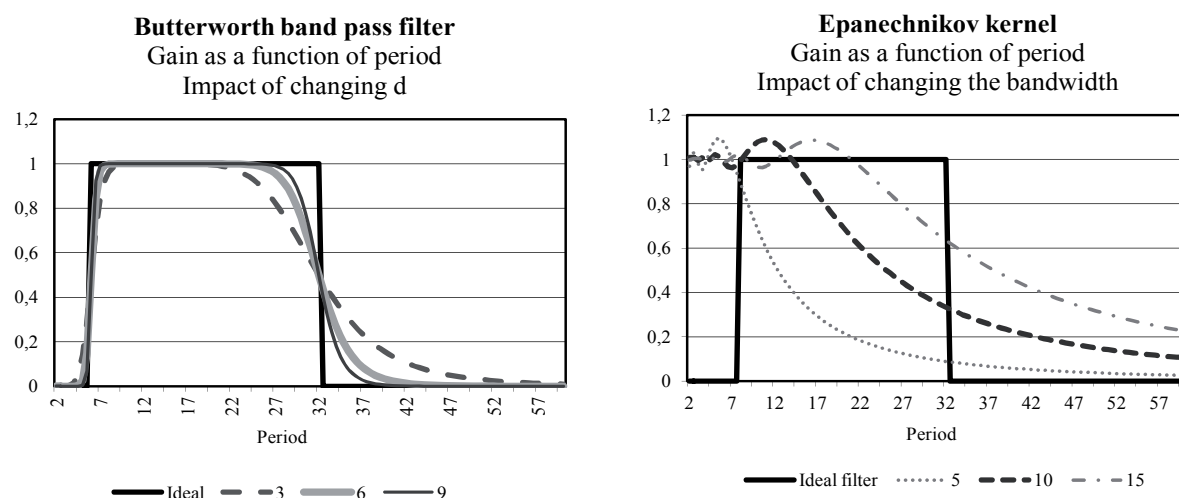


Fig. 1 Butterworth and Epanechnikov filters

duced and an earlier detection of turning points is allowed for. Third, use of trends instead of seasonally-adjusted series or raw data leads to less noisy cycles, so the detection of turning points is easier.

1.2 Kernel regressions

Kernel regression is a well known method in the statistical literature, which has recently been used by Leamer (2007) for business cycle analysis. The underlying idea of this nonparametric method is that, under suitable regularity conditions, any function can be well approximated by a Taylor series expansion in the neighbourhood of any point. The approach provides a method for obtaining pointwise estimates. That is, an arbitrary point is chosen and then a local polynomial regression provides an estimate of the trend at that point. The procedure is then repeated for all data points, so to obtain an estimate of the entire trend it is required to fit as many regressions as the number of observations.

Specifically, to estimate the trend for a given date (t_0) a linear regression is fit using only the data in an interval around t_0 . The width of the interval used the *bandwidth* is a fixed number (h) chosen by the analyst. As h gets large, the local polynomial fit approaches the polynomial fit using the whole sample. Specifically,

$$y_t = a(t_0) + b_1(t_0)(t - t_0) + \dots + b_k(t_0)(t - t_0)^k + \varepsilon_t \quad t \in [t_0 - h, t_0 + h] \quad t = 1 \dots n \quad (3)$$

Each of these regressions is fit using weighted least squares (WLS), solving the following minimization problem over a and b .

$$\sum_{t=1}^n K\left(\frac{t - t_0}{h}\right) (y_t - a(t_0) - b_1(t_0)(t - t_0) - \dots - b_k(t_0)(t - t_0)^k)^2 \quad (4)$$

The trend estimate is then obtained as the fitted value of the above regression. In our empirical application, we consider kernel regression using an Epanechnikov kernel.⁷

$$K(u) = \frac{3}{4}(1 - u^2)I(|u| \leq 1) \quad (5)$$

where u is the argument of the kernel function and $I(|u| \leq 1)$ is an indicator function that takes a value of one if its argument is true, and zero otherwise. The window width (h), which determines the number of points used in each regression. Increasing (decreasing) h involves using a wider (narrower) interval, which tends to

⁷ Use of alternative kernels, such as biweight, cosine or Gaussian produces very similar results.

increase (decrease) the smoothness of the trend. We have considered a bandwidth equal to 10.

Álvarez and Cabrero (2009) provide a frequency domain interpretation of kernel regressions. Figure 1 plots the gain function of a linear Epanechnikov kernel with different bandwidths. It is seen that the kernel method provides a reasonable approximation to the ideal filter, except for short-run fluctuations, where it performs quite badly. To avoid this problem and make comparisons with results of the Butterworth filter easier, we do not employ original series in our empirical application, but rather the trend-cycle component using Gómez and Maravall (2001) procedure. This method eliminates very short-run fluctuations, so kernel results that we present do not suffer from their general limitation.

1.3 Comparisons with other filters

In this section, we briefly review some widely used non-parametric procedures to obtain business cycles.

This is relevant since other cyclical analyses of the housing sector have employed different procedures. For instance, Ferrara and Vigna (2009) use a band pass Hodrick and Prescott filter and Bulligan (2009) the Baxter and King (1999) filter.

Hodrick and Prescott filter The underlying assumptions of the Hodrick and Prescott (1997) filter are that the trend is stochastic and it varies smoothly over time. The original motivation of the procedure is to obtain a trend balancing its smoothness and the fit to the original series. The parameter λ that characterises the filter determines to which extent fit is traded-off by smoothness. Interestingly, the HP estimator of the cycle may be considered as a high-pass filter [Prescott (1986)]. The cyclical HP filter damps cyclical fluctuations with high periods and leaves short-run cycles barely untouched. The higher the value of lambda the more attention is paid to long-term cycles (figure 2).

Hodrick and Prescott bandpass filter Given the frequency domain interpretation of the Hodrick-Prescott filter, it is natural to design a band pass filter as the difference of two HP filters [Artis et al. (2003)], the first working on short run fluctuations (e.g. less than six quarters) and the second one on long run movements (e.g. fluctuations with periods over 8 years). However, as stressed by Iacobucci and Noullez (2005), the bandpass version of the Hodrick Prescott filter cumulates the compression of two standard HP filters and is thus a poor approximation of the ideal bandpass filter (figure 2)

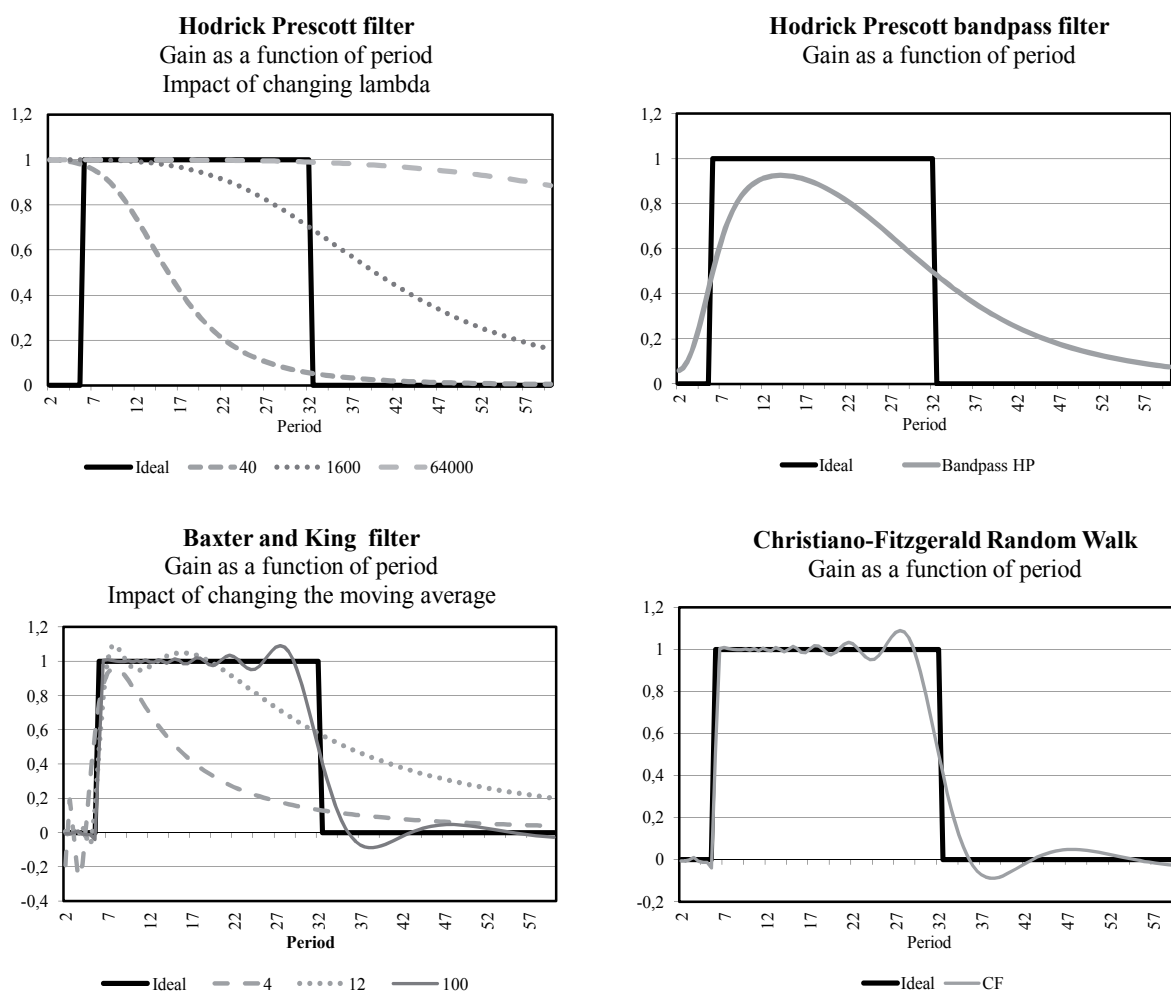


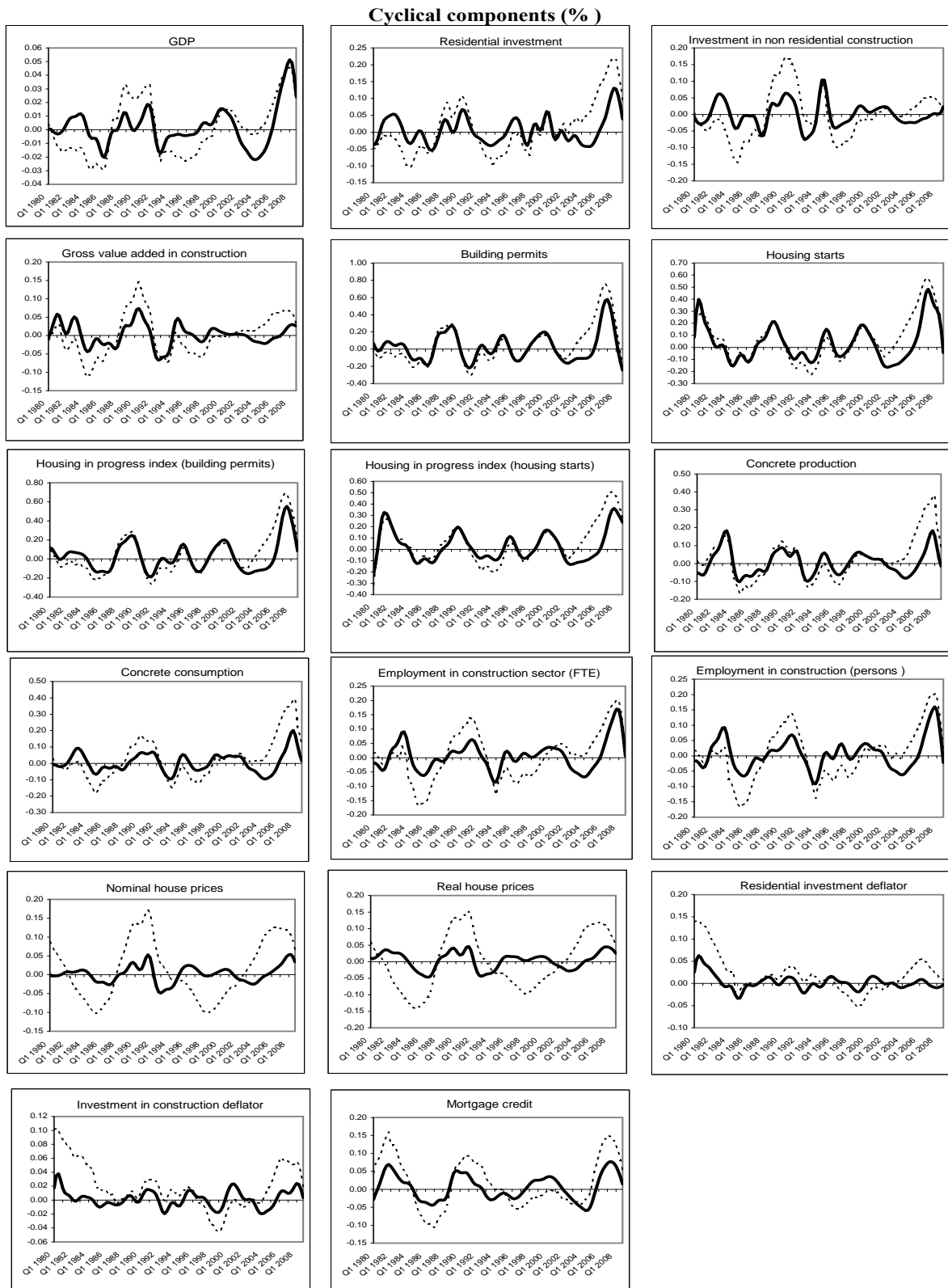
Fig. 2 Alternative filters

Baxter and King bandpass filter It is well known that the ideal band-pass filter requires an infinite-order moving average. Since series are of finite length in empirical applications, Baxter and King (1999) derive an approximation of the ideal band-pass filter with a symmetric moving average of $2k + 1$ terms. The approximation error (figure 2) diminishes by increasing k , but this leads to a loss of $2k$ observations (k leads and k lags). In practice, with quarterly data, k is equal to 12, which entails losing information for the first and last 12 quarters, a great loss for policymakers. Moreover, the gain of the BK filter oscillates around the gain of the ideal filter.

Christiano and Fitzgerald (2003) filter Christiano and Fitzgerald (2003) provide an alternative band pass filter. Their optimal filter depends on the data generating process, but they find that weights under the assumption that the series is a random walk provide a reasonable approximation. Weights are not symmetric in terms of past and future observations, except in the middle of the data set, so that for each date a different filter is used.

The asymmetry of the filter causes a nonzero phase, which distorts the timing of the different frequency components and the nonstationarity causes the gain and the phase to depend on time. Iacobucci and Noullez (2005) stress the spurious shifts induced in the signal by the Christiano and Fitzgerald filter and show that distortions can be large: some cyclical fluctuations can be shifted up to plus or minus 5 months. Another limitation of this procedure is that the gain can be negative, so peaks (troughs) associated with some cyclical fluctuations could be turned into troughs (peaks).

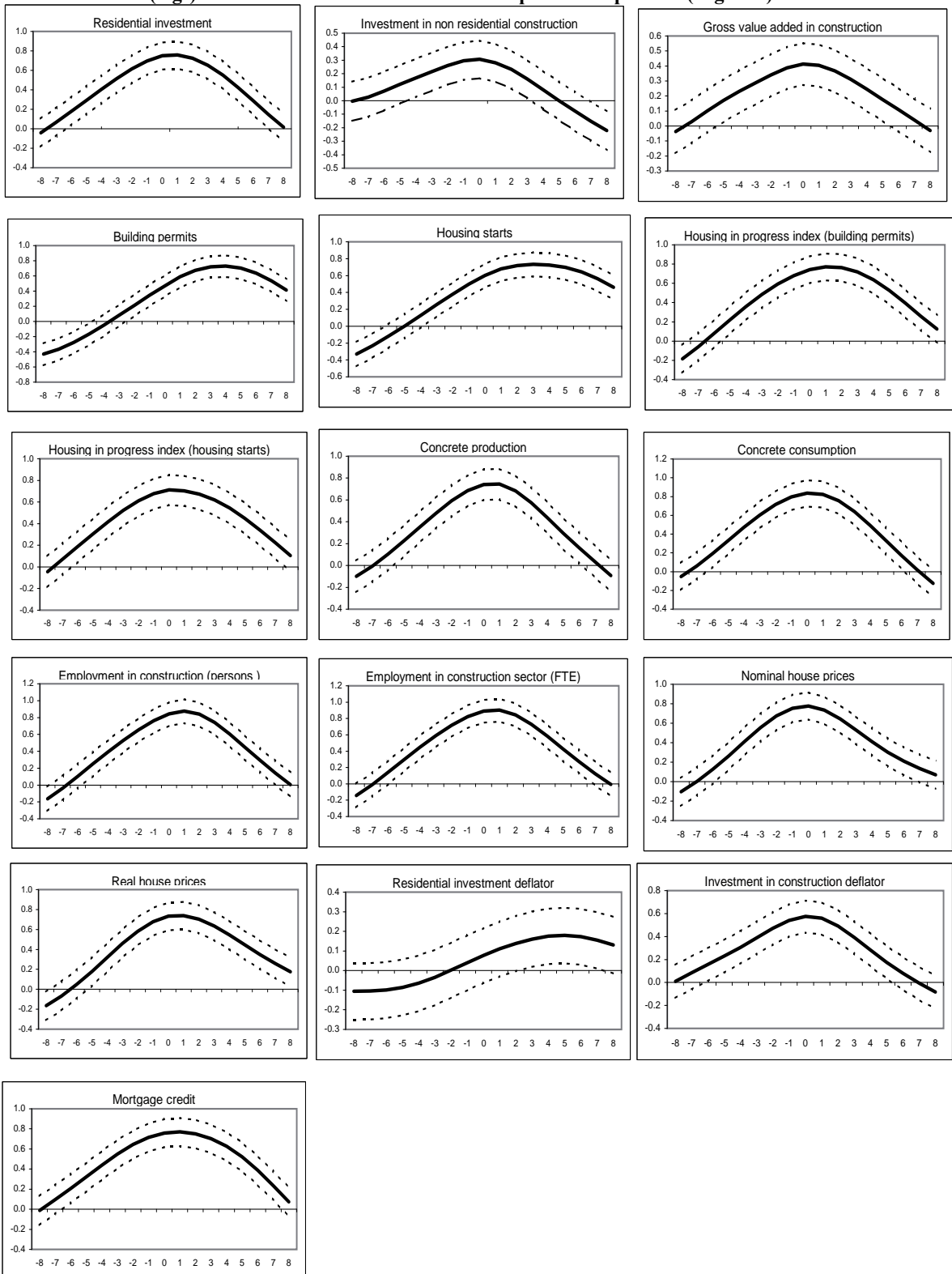
Appendix 4: Cyclical components (1980:1 2008:4)



Solid line: Butterworth filter (d=6)
Dotted line: Epanechnikov filter (Bw=10)

Appendix 5: Cross correlation of variables with GDP. Butterworth filter

Variable leads (lags) GDP if maximum correlation corresponds to a positive (negative) value in the X-axis

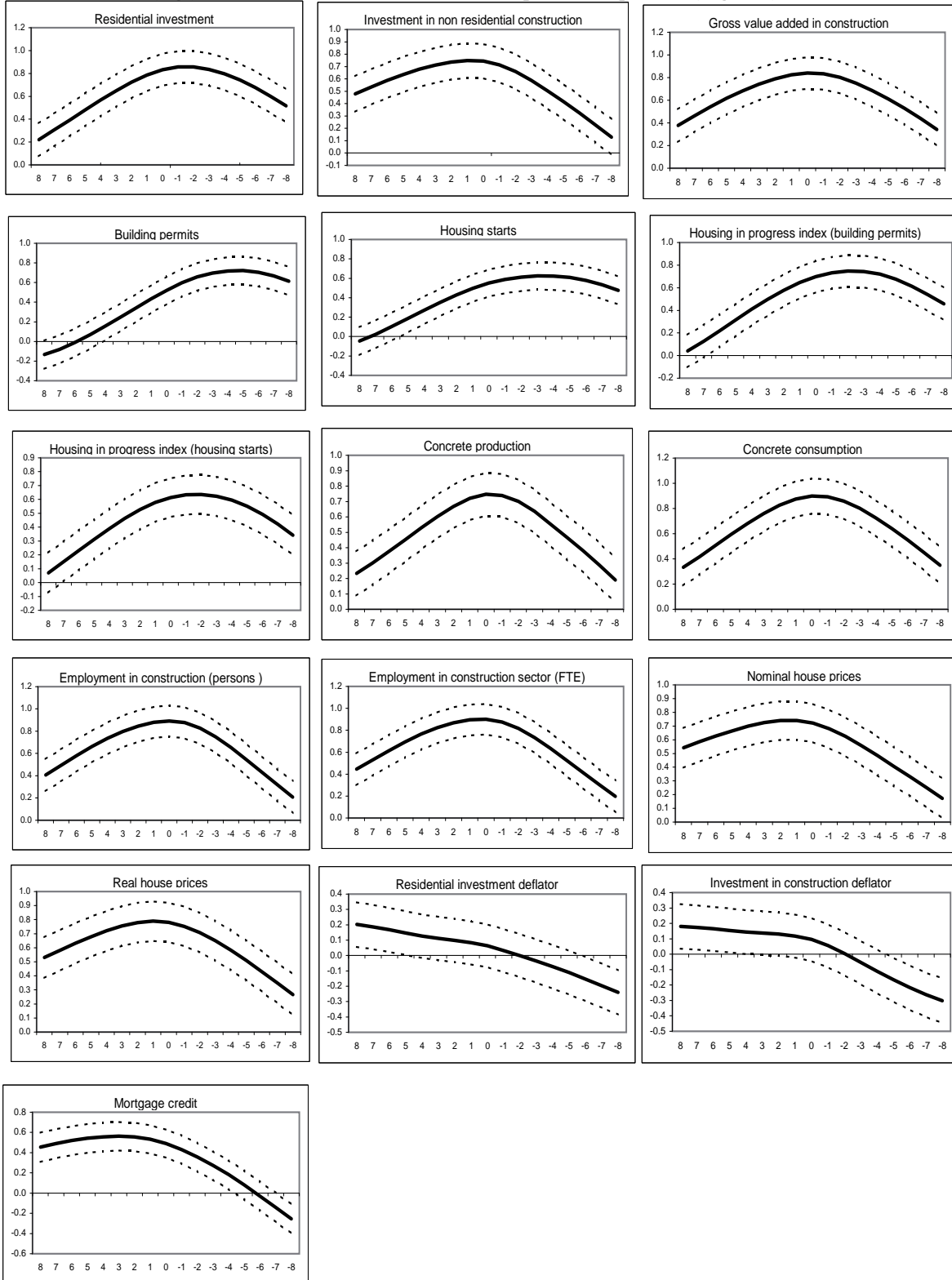


Solid lines: Point estimates

Dotted lines: Plus/minus 1.5 standard deviation bands

Appendix 6: Cross correlation of variables with GDP. Epanechnikov filter

Variable leads (lags) GDP if maximum correlation corresponds to a positive (negative) value in the X-axis



Solid lines: Point estimates

Dotted lines: Plus/minus 1.5 standard deviation bands

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS¹

- 0901 PRAVEEN KUJAL AND JUAN RUIZ: International trade policy towards monopoly and oligopoly.
- 0902 CATIA BATISTA, AITOR LACUESTA AND PEDRO VICENTE: Micro evidence of the brain gain hypothesis: The case of Cape Verde.
- 0903 MARGARITA RUBIO: Fixed and variable-rate mortgages, business cycles and monetary policy.
- 0904 MARIO IZQUIERDO, AITOR LACUESTA AND RAQUEL VEGAS: Assimilation of immigrants in Spain: A longitudinal analysis.
- 0905 ÁNGEL ESTRADA: The mark-ups in the Spanish economy: international comparison and recent evolution.
- 0906 RICARDO GIMENO AND JOSÉ MANUEL MARQUÉS: Extraction of financial market expectations about inflation and interest rates from a liquid market.
- 0907 LAURA HOSPIDO: Job changes and individual-job specific wage dynamics.
- 0908 M.ª DE LOS LLANOS MATEA AND JUAN S. MORA-SANGUINETTI: Developments in retail trade regulation in Spain and their macroeconomic implications. (The original Spanish version has the same number.)
- 0909 JAVIER MENCÍA AND ENRIQUE SENTANA: Multivariate location-scale mixtures of normals and mean-variance-skewness portfolio allocation.
- 0910 ALICIA GARCÍA-HERRERO, SERGIO GAVILÁ AND DANIEL SANTABÁRBARA: What explains the low profitability of Chinese banks?
- 0911 JAVIER MENCÍA: Assessing the risk-return trade-off in loans portfolios.
- 0912 MAXIMO CAMACHO AND GABRIEL PEREZ-QUIROS: Ñ-STING: España Short Term Indicator of Growth.
- 0913 RAQUEL VEGAS, ISABEL ARGIMÓN, MARTA BOTELLA AND CLARA I. GONZÁLEZ: Retirement behaviour and retirement incentives in Spain.
- 0914 FEDERICO CINGANO, MARCO LEONARDI, JULIÁN MESSINA AND GIOVANNI PICA: The effect of employment protection legislation and financial market imperfections on investment: Evidence from a firm-level panel of EU countries.
- 0915 JOSÉ MANUEL CAMPA AND IGNACIO HERNANDO: Cash, access to credit, and value creation in M&As.
- 0916 MARGARITA RUBIO: Housing market heterogeneity in a monetary union.
- 0917 MAXIMO CAMACHO, GABRIEL PEREZ-QUIROS AND HUGO RODRÍGUEZ MENDIZÁBAL: High-growth Recoveries, Inventories and the Great Moderation.
- 0918 KAI CHRISTOFFEL, JAMES COSTAIN, GREGORY DE WALQUE, KEITH KUESTER, TOBIAS LINZERT, STEPHEN MILLARD AND OLIVIER PIERRARD: Wage, inflation and employment dynamics with labour market matching.
- 0919 JESÚS VÁZQUEZ, RAMÓN MARÍA-DOLORES AND JUAN-MIGUEL LONDOÑO: On the informational role of term structure in the U.S. monetary policy rule.
- 0920 PALOMA LÓPEZ-GARCÍA AND SERGIO PUENTE: What makes a high-growth firm? A probit analysis using Spanish firm-level data.
- 0921 FABIO CANOVA, MATTEO CICCARELLI AND EVA ORTEGA: Do institutional changes affect business cycles? Evidence from Europe.
- 0922 GALO NUÑO: Technology, convergence and business cycles.
- 0923 FRANCISCO DE CASTRO AND JOSÉ LUIS FERNÁNDEZ: The relationship between public and private saving in Spain: does Ricardian equivalence hold?
- 0924 GONZALO FERNÁNDEZ-DE-CÓRDOBA, JAVIER J. PÉREZ AND JOSÉ L. TORRES: Public and private sector wages interactions in a general equilibrium model.
- 0925 ÁNGEL ESTRADA AND JOSÉ MANUEL MONTERO: R&D investment and endogenous growth: a SVAR approach.
- 0926 JUANA ALEDO, FERNANDO GARCÍA-MARTÍNEZ AND JUAN M. MARÍN DIAZARAQUE: Firm-specific factors influencing the selection of accounting options provided by the IFRS: Empirical evidence from Spanish market.
- 0927 JAVIER ANDRÉS, SAMUEL HURTADO, EVA ORTEGA AND CARLOS THOMAS: Spain in the euro: a general equilibrium analysis.
- 0928 MAX GILLMAN AND ANTON NAKOV: Monetary effects on nominal oil prices.
- 0929 JAVIER MENCÍA AND ENRIQUE SENTANA: Distributional tests in multivariate dynamic models with Normal and Student *t* innovations.
- 0930 JOAN PAREDES, PABLO BURRIEL, FRANCISCO DE CASTRO, DANIEL GARROTE, ESTHER GORDO AND JAVIER J. PÉREZ: Fiscal policy shocks in the euro area and the US: an empirical assessment.

1. Previously published Working Papers are listed in the Banco de España publications catalogue.

- 0931 TERESA LEAL, DIEGO J. PEDREGAL AND JAVIER J. PÉREZ: Short-term monitoring of the Spanish Government balance with mixed-frequencies models.
- 0932 ANTON NAKOV AND GALO NUÑO: *Oilgopoly*: a general equilibrium model of the oil-macroeconomy nexus.
- 0933 TERESA LEAL AND JAVIER J. PÉREZ: Análisis de las desviaciones presupuestarias aplicado al caso del presupuesto del Estado.
- 0934 JAVIER J. PÉREZ AND A. JESÚS SÁNCHEZ: Is there a signalling role for public wages? Evidence for the euro area based on macro data.
- 0935 JOAN PAREDES, DIEGO J. PEDREGAL AND JAVIER J. PÉREZ: A quarterly fiscal database for the euro area based on intra-annual fiscal information.
- 1001 JAVIER ANDRÉS, ÓSCAR ARCE AND CARLOS THOMAS: Banking competition, collateral constraints and optimal monetary policy.
- 1002 CRISTINA BARCELÓ AND ERNESTO VILLANUEVA: The response of household wealth to the risk of losing the job: evidence from differences in firing costs.
- 1003 ALEXANDER KARAVANOV, SONIA RUANO, JESÚS SAURINA AND ROBERT TOWNSEND: No bank, one bank, several banks: does it matter for investment?
- 1004 GABRIEL PEREZ-QUIROS AND HUGO RODRÍGUEZ MENDIZÁBAL: Asymmetric standing facilities: an unexploited monetary policy tool.
- 1005 GABRIEL JIMÉNEZ, JOSE A. LOPEZ AND JESÚS SAURINA: How does competition impact bank risk-taking?
- 1006 GIUSEPPE BERTOLA, AURELIJUS DABUSINSKAS, MARCO HOEBERICHTS, MARIO IZQUIERDO, CLAUDIA KWAPIL, JEREMI MONTORNÈS AND DANIEL RADOWSKI: Price, wage and employment response to shocks: evidence from the WDN Survey.
- 1007 JAVIER MENCÍA: Testing non-linear dependence in the Hedge Fund industry.
- 1008 ALFREDO MARTÍN-OLIVER: From proximity to distant banking: Spanish banks in the EMU.
- 1009 GALO NUÑO: Optimal research and development expenditure: a general equilibrium approach.
- 1010 LUIS J. ÁLVAREZ AND PABLO BURRIEL: Is a Calvo price setting model consistent with micro price data?
- 1011 JENS HAGENDORFF, IGNACIO HERNANDO, MARÍA J. NIETO AND LARRY D. WALL: What do premiums paid for bank M&As reflect? The case of the European Union.
- 1012 DAVID DE ANTONIO LIEDO: General equilibrium restrictions for dynamic factor models.
- 1013 JAMES COSTAIN, JUAN F. JIMENO AND CARLOS THOMAS: Employment fluctuations in a dual labor market.
- 1014 LUIS M. VICEIRA AND RICARDO GIMENO: The euro as a reserve currency for global investors.
- 1015 PALOMA LÓPEZ-GARCÍA AND JOSÉ MANUEL MONTERO: Understanding the Spanish business innovation gap: The role of spillovers and firms' absorptive capacity.
- 1016 AITOR LACUESTA AND SERGIO PUENTE: El efecto del ciclo económico en las entradas y salidas de inmigrantes en España.
- 1017 REBEKKA CHRISTOPOULOU, JUAN F. JIMENO AND ANA LAMO: Changes in the wage structure in EU countries.
- 1018 THOMAS BREUER, MARTIN JANDAČKA, JAVIER MENCÍA AND MARTIN SUMMER: A systematic approach to multi-period stress testing of portfolio credit risk.
- 1019 LUIS J. ÁLVAREZ AND PABLO BURRIEL: Micro-based estimates of heterogeneous pricing rules: The United States vs. the euro area.
- 1020 ALFREDO MARTÍN-OLIVER AND VICENTE SALAS-FUMÁS: I.T. investment and intangibles: Evidence from banks.
- 1021 LUISA LAMBERTINI, CATERINA MENDICINO AND MARIA TERESA PUNZI: Expectations-driven cycles in the housing market.
- 1022 JULIÁN MESSINA, PHILIP DU CAJU, CLÁUDIA FILIPA DUARTE, NIELS LYNGGÅRD HANSEN AND MARIO IZQUIERDO: The incidence of nominal and real wage rigidity: an individual-based sectoral approach.
- 1023 ALESSIO MORO: Development, growth and volatility.
- 1024 LUIS J. ÁLVAREZ AND ALBERTO CABRERO: Does housing really lead the business cycle?