STAFF MEMO

Relationships between nominal GDP and financial variables in OECD countries

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Relationships between nominal GDP and financial variables in OECD countries*

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Abstract

I look at the short-term relationship between nominal GDP and credit and nominal GDP and house prices in 20 OECD countries. In the recent years central banks have become increasingly concerned with financial stability. These concerns sometimes lead to trade-offs for monetary policy. One important policy question is how the variables related to financial stability is related to different macroeconomic aggregates followed by the central bank. I find considerable similarities in the short-term relationship between the variables across the countries in the data set. The cross correlations are notably large, and there are relatively stable lead/lag structures across most countries. I also develop a synchronization indicator which shows that the variables tend to follow the same growth cycles.

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1 Introduction

Nominal GDP targeting has been proposed by some academics as an alternative to inflation targeting. It is an old idea, first introduced by Meade (1978), von Weizsäcker (1978) and Tobin et al. (1980). Nominal GDP consists of both a price component, i.e. the GDP deflator, and a real (volume) component. Due to this property, the main-rationale for nominal GDP targeting is that it introduces a balance between price stability and output stability. Recent research shows that nominal GDP targeting may also have positive effects with respect to financial stability, see Sheedy (2014). There seems to be a quite strong relationship between the development in nominal GDP and credit and house prices in Norway, see Røisland (2017), which indicates that stabilizing nominal GDP may be an indirect way of "leaning against the wind".

The aim of this paper is to investigate whether the strong relationships between nominal GDP and credit and house prices in Norway are robust, in the sense that they apply more generally internationally.

In the recent years financial stability concerns have become more present in the conduction of monetary policy in Norway. A central question is how the central bank should take financial stability concerns into account. In some situations there may be trade-offs between reaching the operational target and ensuring financial stability. E.g. inflation can be below target at the same time as growth in credit and house prices are high and thus financial stability concerns are present. In this case, increasing inflation back to target by lowering the interest rate may lead to financial instability by lowering the price on credit. Thus, an operational target that correlates with variables related to financial stability is desirable because it reduces these tradeoffs in the monetary policy decision.

I analyse the cross-correlations and develop what I call a synchronization indicator for the growth in nominal GDP and credit and house prices in 20 OECD countries, including Norway. I find that the cross correlations are substantial in magnitude, and the lead/lag structures tend to follow a common pattern across several of the countries in the data set. From the synchronization indicator I find that growth in nominal GDP tends to be higher (lower) than normal at the same time as growth in credit and house prices are higher (lower) than normal.

The structure of the paper is as follows. First, in section 2, I give a description of the data I have used. Next, in section 3.1, I present the results from the cross-correlation analysis. In section 3.2, I present the results from the synchronization indicator. I refer to the appendix at the end for technical explanations, graphs of all the variables in all countries and results where I have repeated the analysis for CPI.

2 Data

I use quarterly data on nominal GDP, CPI, private credit, credit to households and NPISHs and house prices for 20 OECD countries over the period 1991:Q1 - 2014:Q4, see table 1.

Table 1. Extracted data.

Variable	**Source**	**Frequency**	**Comments**
Gross domestic product, value, market prices	OECD EO99 June 2016	Quarterly	Norway is mainland GDP.
4-quarter-change	Data extracted 13.06.2016	1991Q1 - 2014Q4	A gap is constructed for all countries, see appendix A Seasonally adjusted
Consumer prices	OECD MEI	Quarterly	A gap is constructed for all countries, see appendix A
4-quarter-change	Data extracted 13.06.2016	1991Q1 - 2014Q4	Not seasonally adjusted
Private credit	BIS	Quarterly	A gap is constructed for all countries, see appendix A
4-quarter-change	Long series on total credit	1991Q1-2014Q4	Adjusted for breaks, all sectors
Credit to households and NPISHs	BIS	Quarterly	A gap is constructed for all countries, see appendix A
4-quarter-change	Long series on total credit	1991Q1 – 2014Q4	Adjusted for breaks, all sectors Austria starts 1995Q4 Switzerland starts 1999Q4 Denmark starts 1994Q4 Ireland removed due to short sample
House prices	Dallas FED	Quarterly	A gap is constructed for all countries, see appendix A
4-quarter-change		1991Q1 - 2014Q4	Seasonally adjusted Austria removed due to short sample Portugal ends 2014Q1

* The 20 countries included in the data set are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK and USA.
* Appendix B shows the results from an ADF-test that verifies that the variables are stationary.
* This paper does not utilize real time data. Some of the variables undergo revisions.

3 Results

3.1 Cross correlations

I apply simple cross correlation methods to explore the relationship between nominal GDP and credit and house prices, see table 2, 3 and 4, and figure 1, 2 and 3, respectively. The evidence suggests that there are some systematic patterns across the countries.

Table 2 shows the cross correlations between nominal GDP and private credit, both measured as the gap of the four-quarter-change. The head of the table divides the cross correlations into three groups: leading, contemporaneous and lagging. These characteristics refer to private credit. E.g. the column named -2 (+2) refers to the cross correlation between nominal GDP in period t and private credit in period $t-2$ ($t+2$). The bold numbers indicate the three largest cross correlations for each country. This also applies to table 3 and 4. The results indicate substantial cross correlations and nominal GDP seems to be leading private credit in a majority of the countries. This implies that a nominal GDP growth rate above (below) its trend is associated with a growth rate in private credit above (below) its trend in the forthcoming quarters. Such a pattern could imply that stabilizing nominal GDP growth would contribute to stabilizing growth in private credit. The largest cross correlations for Norway are larger than the median of the largest correlations among the other countries, which is 0.46. There are no notable signs of Norway being an outlier, both in terms of magnitude and lead/lag structure. The variables tend to be highly correlated in countries like the US, France and Spain, while they tend to be poorly correlated in countries like Canada and Germany.

Table 3 shows the cross correlations between nominal GDP and credit to households and NPISHs, both measured as the gap of the four-quarter-change. The results indicate that the variables are highly correlated, but the lead/lag structure varies more than for nominal GDP and private credit. The contermporaneous correlation is among the largest among a majority of the countries. The largest cross correlations for Norway are lower than the median of the largest correlations among the other countries, which is 0.44. The results indicate that Norway is not an outlier, both in terms of magnitude and lead/lag structure. The variables tend to be highly correlated in countries like Spain and Korea, while they tend to be poorly correlated in countries like Canada and Germany again, as well as in Switzerland and Denmark.[1]

Table 4 shows the cross correlations between nominal GDP and house prices, both measured as the gap of the four-quarter-change. The results indicate that the variables are highly correlated, and the correlations are higher than for the measures of credit. The

[1]Note that Switzerland and Denmark have shorter samples.

lead/lag structure varies between the countries, but the contemporaneous correlation is among the highest in a large share. The largest correlations for Norway are larger than the median of the largest correlations among the other countries, which is about 0.58. There are no notable signs of Norway being an outlier, both in terms of magnitude and lead/lag structure. The variables tend to be highly correlated in several of the countries, especially Spain and Sweden. Switzerland seems to be the only outlier in the data set with poorly correlated variables.

Table 2. Cross correlations. Nominal GDP and private credit.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	-0.034	0.087	0.237	0.311	0.444	**0.505**	**0.543**	**0.547**	0.486
Australia	0.083	0.111	0.202	0.341	**0.451**	**0.487**	**0.461**	0.356	0.259
Austria	-0.155	0.044	0.254	0.431	**0.527**	**0.541**	**0.507**	0.443	0.360
Belgium	-0.192	-0.172	-0.178	-0.162	-0.067	0.048	**0.199**	**0.332**	**0.416**
Canada	-0.118	-0.040	0.031	0.095	0.127	0.158	**0.188**	**0.225**	**0.288**
Switzerland	0.133	0.267	**0.346**	**0.390**	**0.382**	0.320	0.301	0.316	0.343
Germany	-0.059	-0.070	-0.041	0.017	0.027	0.034	**0.091**	**0.127**	**0.174**
Denmark	0.005	0.160	0.275	0.403	**0.459**	**0.443**	**0.404**	0.325	0.291
Spain	0.530	0.601	0.659	0.711	0.744	**0.765**	**0.769**	**0.745**	0.697
Finland	-0.335	-0.229	-0.111	0.027	0.128	0.195	**0.262**	**0.291**	**0.319**
France	-0.109	-0.043	0.065	0.214	0.367	0.537	**0.663**	**0.725**	**0.717**
UK	-0.021	-0.008	0.027	0.116	0.201	0.282	**0.346**	**0.377**	**0.422**
Ireland	0.018	0.081	0.215	0.318	**0.383**	**0.435**	**0.345**	0.321	0.292
Italy	-0.272	-0.151	0.020	0.187	0.301	0.394	**0.442**	**0.465**	**0.452**
Japan	-0.044	-0.056	-0.019	0.004	0.061	0.162	**0.293**	**0.389**	**0.435**
Korea	-0.226	-0.204	-0.137	0.003	0.196	0.307	**0.400**	**0.426**	**0.425**
Netherlands	0.302	0.416	0.514	**0.566**	**0.563**	**0.524**	0.466	0.412	0.357
Portugal	-0.107	-0.088	-0.033	0.012	0.072	0.155	**0.263**	**0.376**	**0.474**
Sweden	-0.145	-0.122	-0.063	0.004	0.099	0.187	**0.283**	**0.374**	**0.490**
USA	-0.085	0.070	0.234	0.394	0.529	0.626	**0.689**	**0.718**	**0.712**

Nominal GDP is locked at period 0. The leads/lags refers to private credit.

Bold numbers indicate the three largest correlations for each country.

Table 3. Cross correlations. Nominal GDP and credit to households and NPISHs. Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	0.133	0.226	0.300	0.328	**0.370**	**0.373**	**0.367**	0.358	0.298
Australia	0.234	0.322	**0.397**	**0.443**	**0.411**	0.315	0.203	0.103	0.035
Austria[1)]	0.411	0.482	**0.502**	**0.536**	**0.506**	0.473	0.376	0.234	0.067
Belgium	0.160	0.099	0.016	0.016	0.091	0.209	**0.359**	**0.446**	**0.448**
Canada	-0.095	0.007	0.129	**0.221**	**0.253**	**0.201**	0.118	0.055	0.041
Switzerland[2)]	0.256	**0.264**	**0.269**	**0.274**	0.219	0.070	-0.068	-0.218	-0.359
Germany	0.130	**0.154**	**0.161**	**0.142**	0.091	0.006	-0.061	-0.122	-0.130
Denmark[3)]	-0.044	0.006	0.032	0.089	0.151	0.186	**0.210**	**0.208**	**0.228**
Spain	0.681	0.728	0.767	**0.796**	**0.783**	**0.770**	0.732	0.673	0.611
Finland	-0.034	0.045	0.144	0.239	0.321	**0.359**	**0.368**	**0.344**	0.304
France	0.189	0.283	0.371	**0.415**	**0.443**	**0.430**	0.394	0.330	0.285
UK	0.109	0.192	0.289	0.372	0.444	**0.477**	**0.490**	**0.489**	0.467
Ireland[4)]	-	-	-	-	-	-	-	-	-
Italy	0.063	0.123	0.224	0.297	**0.335**	**0.363**	**0.355**	0.333	0.307
Japan	0.367	**0.432**	**0.443**	**0.417**	0.365	0.328	0.355	0.327	0.315
Korea	-0.190	-0.065	0.136	0.372	**0.581**	**0.657**	**0.598**	0.436	0.239
Netherlands	0.390	0.453	**0.511**	**0.528**	**0.462**	0.395	0.319	0.236	0.166
Portugal	0.150	0.143	0.147	0.147	0.170	0.235	**0.288**	**0.340**	**0.357**
Sweden	0.212	0.293	0.380	**0.427**	**0.448**	**0.423**	0.388	0.355	0.333
USA	0.191	0.337	0.464	**0.553**	**0.595**	**0.584**	0.547	0.503	0.454

Nominal GDP is locked at period 0. The leads/lags refers to credit to households.

Bold numbers indicate the three largest correlations for each country.

1) Credit to households from 1996Q4.

2) Credit to households from 2000Q4.

3) Credit to households from 1995Q4.

4) Removed due to short sample.

Table 4. Cross correlations. Nominal GDP and house prices.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	0.395	0.500	**0.658**	**0.685**	**0.601**	0.451	0.258	0.102	-0.010
Australia	**0.317**	**0.448**	**0.438**	0.289	0.044	-0.197	-0.327	-0.336	-0.217
Austria[1)]	-	-	-	-	-	-	-	-	-
Belgium	0.143	0.238	0.360	0.476	**0.556**	**0.564**	**0.513**	0.419	0.313
Canada	0.048	0.224	**0.416**	**0.547**	**0.524**	0.337	0.074	-0.150	-0.232
Switzerland	-0.015	-0.016	0.001	0.029	0.061	0.085	**0.101**	**0.099**	**0.088**
Germany	-0.003	0.094	0.202	0.279	**0.356**	**0.369**	**0.348**	0.303	0.210
Denmark	0.168	0.342	0.539	**0.675**	**0.678**	**0.542**	0.306	0.074	-0.088
Spain	0.662	0.733	**0.790**	**0.811**	**0.767**	0.680	0.599	0.520	0.473
Finland	0.484	**0.587**	**0.631**	**0.602**	0.517	0.363	0.201	0.071	-0.008
France	0.398	0.518	**0.630**	**0.700**	**0.690**	0.599	0.441	0.246	0.063
UK	0.123	0.327	0.531	**0.656**	**0.683**	**0.581**	0.392	0.184	0.006
Ireland	0.362	0.437	0.496	0.545	**0.580**	**0.578**	**0.571**	0.538	0.485
Italy	0.042	0.121	0.225	0.329	**0.407**	**0.442**	**0.431**	0.382	0.311
Japan	-0.102	-0.029	0.052	0.132	0.199	0.242	**0.276**	**0.299**	**0.314**
Korea	-0.206	-0.009	0.212	**0.391**	**0.469**	**0.413**	0.295	0.165	0.072
Netherlands	0.239	0.355	0.452	**0.535**	**0.583**	**0.541**	0.484	0.378	0.264
Portugal[2)]	0.039	0.136	0.271	0.412	**0.529**	**0.585**	**0.581**	0.525	0.450
Sweden	0.362	0.558	**0.691**	**0.752**	**0.721**	0.606	0.447	0.275	0.111
USA	0.427	0.488	0.530	**0.556**	**0.562**	**0.557**	0.541	0.500	0.442

Nominal GDP is locked at period 0. The leads/lags refers to house prices.

Bold numbers indicate the three largest correlations for each country.

1) Removed due to short sample.

2) House prices until 2014Q1.

Figure 1. Nominal GDP (solid) and private credit (dotted).
Gap of four-quarter-change. 1992Q1 - 2014Q4.

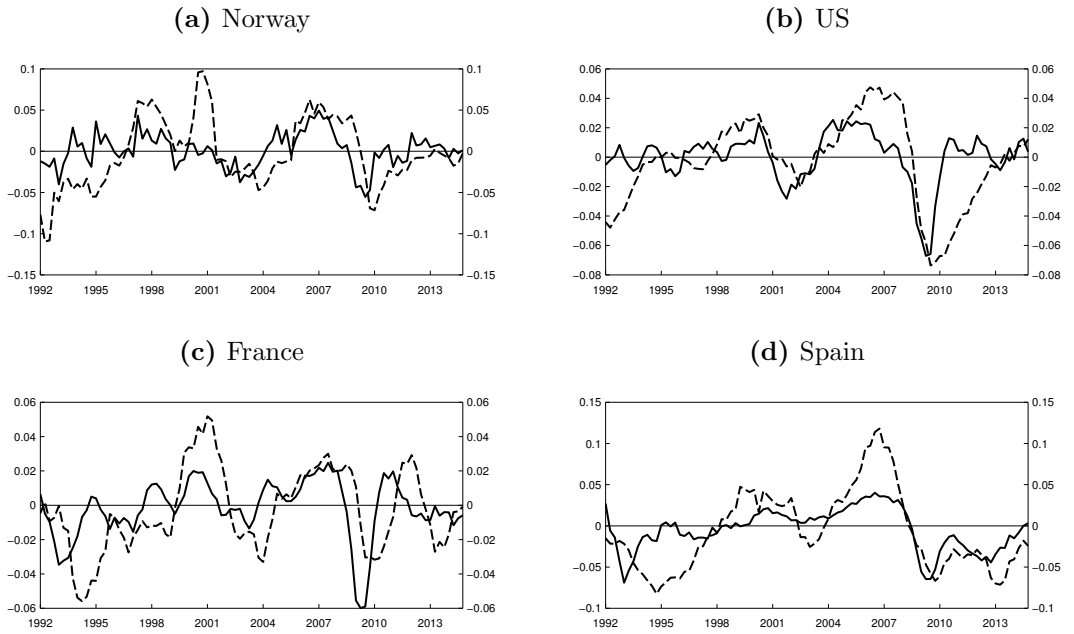


Figure 2. Nominal GDP (solid) and credit to households and NPISHs (dotted).
Gap of four-quarter-change. 1992Q1 - 2014Q4.

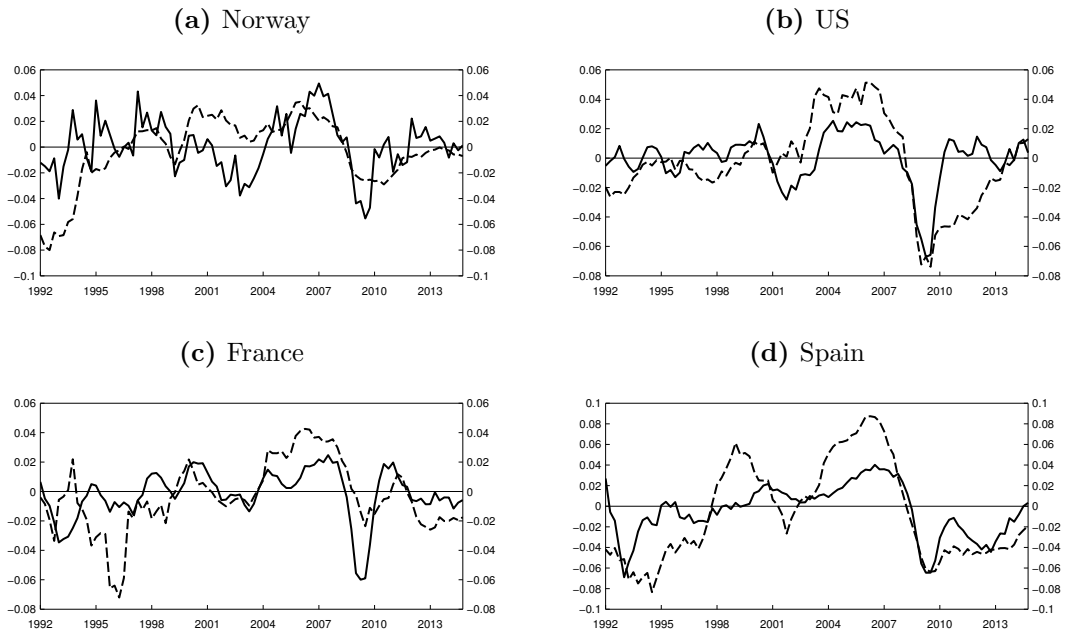
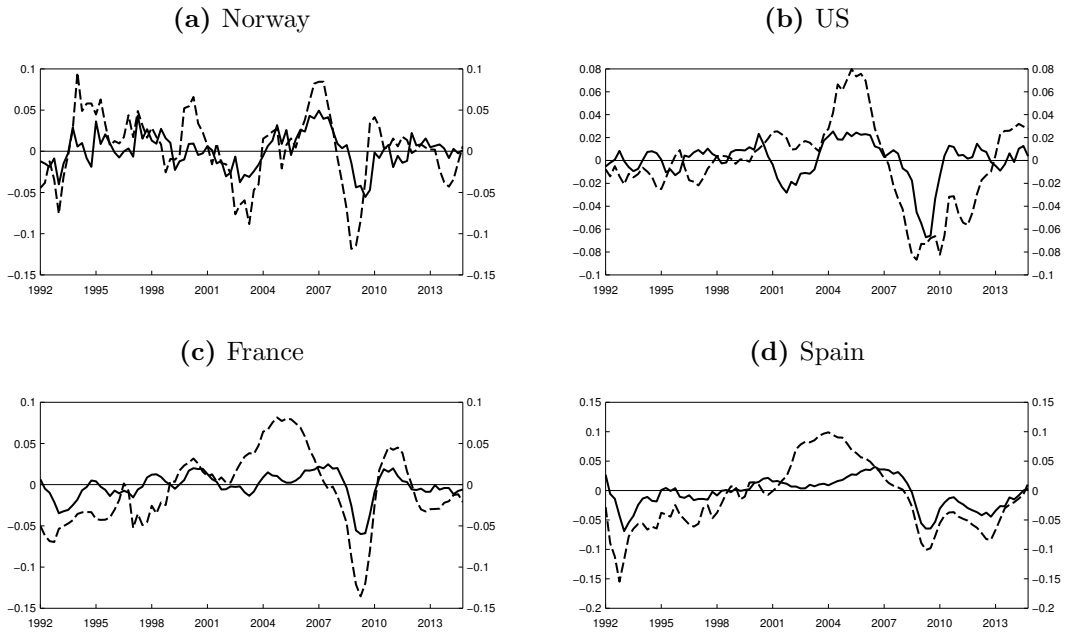


Figure 3. Nominal GDP (solid) and house prices (dotted).
Gap of four-quarter-change. 1992Q1 - 2014Q4.



3.2 Variable synchronization

In addition to the cross correlations between the variables of interest, an interesting approach is to investigate the synchronization of the growth cycles of the variables. I.e. how often do we observe both nominal GDP growth and growth in credit or house prices being above or below normal at the same time? A high degree of synchronization might suggest that if the central bank pays attention to nominal GDP, it will indirectly pay attention to credit and house prices as well.

I construct an indicator that measures the fraction of time two time series have the same sign on the gap of the four-quarter-change, see table 5. The synchronization indicator describes the similarity of the growth cycles of the two variables. When both variables have a positive gap, they both inhabit growth above the trend, and vice versa. This implies that if the indicator returns a high number, the variables tend to be in the same part of the growth cycle over time. As an example, the synchronization indicator for Norway for nominal GDP and house prices is constructed in the following way:

Let $\widetilde{\text{gdp}}_t$ and $\widetilde{\text{hp}}_t$ be the gap of the four-quarter-change of nominal gdp and house prices in period t, respectively. Define two new variables in the following way

$$\text{gdp}_t^* = \begin{cases} 1 & \text{if } \widetilde{\text{gdp}}_t \geq 0 \\ 0 & \text{if } \widetilde{\text{gdp}}_t < 0 \end{cases} \qquad \text{hp}_t^* = \begin{cases} 1 & \text{if } \widetilde{\text{hp}}_t \geq 0 \\ 0 & \text{if } \widetilde{\text{hp}}_t < 0 \end{cases}$$

Take the sum of these two variables within each quarter, which will equal either 0, 1 or 2. Then, take the number of observations where the sum is equal to 0 or 2 and divide it by the number of observations where the sum is equal to 1. This number will be the synchronization indicator.

Interestingly, the results indicate that there is substantial synchronization between nominal GDP and credit and house prices.[2] There seems to be a relatively common pattern among the countries, and there are no signs of Norway being an outlier. The indicator suggests that nominal GDP and credit and house prices are more often in the same part of the growth cycle than not among all the countries.[3]

[2] Again, the variables are measured as gaps of the four-quarter-change.

[3] Nominal GDP and house prices in the US is the only exception.

Table 5. Synchronization indicator.* Nominal GDP. 1992Q1 - 2014Q4.

	Private credit	Credit to households	House prices
Norway	0.663	0.576	0.674
Australia	0.685	0.717	0.609
Austria[1)]	0.674	0.753	-
Belgium	0.554	0.598	0.772
Canada	0.576	0.598	0.620
Switzerland[2)]	0.554	0.632	0.478
Germany	0.543	0.500	0.652
Denmark[3)]	0.707	0.571	0.598
Spain	0.837	0.826	0.870
Finland	0.652	0.630	0.522
France	0.717	0.793	0.750
UK	0.522	0.620	0.696
Ireland[4)]	0.674	-	0.696
Italy	0.641	0.696	0.728
Japan	0.620	0.717	0.598
Korea	0.598	0.696	0.533
Netherlands	0.804	0.707	0.761
Portugal[5)]	0.533	0.630	0.674
Sweden	0.543	0.663	0.717
USA	0.630	0.587	0.489
Average	0.636	0.659	0.655

* The fraction of time two series have the same sign on the gap of the four-quarter-change.

1) Credit to households from 1996Q4. House prices removed due to short sample.

2) Credit to households from 2000Q4.

3) Credit to households from 1995Q4.

4) Credit to households removed due to short sample.

5) House prices until 2014Q1.

4 Conclusion

The results indicate a common pattern in the short-term relationship between nominal GDP and credit and house prices among several OECD countries. I find considerable cross correlations and the growth cycles of the variables seem to be somewhat synchronized over time. The findings indicate that Norway is not an outlier in the OECD with respect to the short-term relationship between nominal GDP and credit and house prices.

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Appendix A. The gap

First, the series with the four-quarter-change are expanded to 1987Q1 - 2019Q4, due to poor estimation of the end points. For the variables that do not have observations for the whole period I use the average of the 4 nearest observations to extrapolate. Then, I apply a HP-filter ($\lambda = 40\ 000$) to the series to obtain the deviation from the trend, the so-called gap of the four-quarter-change. Finally, I reduce the sample length back to 1992Q1 - 2014Q4.

Appendix B. Stationarity

Stationarity is an important concept in time series analysis. Non-stationarity may lead us to make false conclusions about the actual relation between the processes of two variables. I test for a unit root in the variables by applying the Augmented Dickey Fuller (ADF) test to the sample. Table 6 shows the order of integration of the variables.

Table 6. ADF test. Order of integration.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Nominal GDP	CPI	Private credit	Credit to households	House prices
Norway	I(0)***	I(0)***	I(0)***	I(0)*	I(0)***
Australia	I(0)**	I(0)***	I(0)**	I(0)*	I(0)***
Austria[1)]	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
Belgium	I(0)***	I(0)***	I(0)***	I(0)***	I(0)**
Canada	I(0)***	I(0)***	I(0)***	I(0)**	I(0)**
Switzerland[2)]	I(0)***	I(0)***	I(0)***	I(1)**	I(1)***
Germany	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
Denmark[3)]	I(0)***	I(0)***	I(0)***	I(1)***	I(0)***
Spain	I(0)**	I(0)***	I(0)**	I(0)**	I(0)*
Finland	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
France	I(0)***	I(0)**	I(0)***	I(0)*	I(0)**
UK	I(0)***	I(0)*	I(0)***	I(0)*	I(0)**
Ireland[4)]	I(0)**	I(0)***	I(0)***	-	I(0)***
Italy	I(0)***	I(0)***	I(0)**	I(0)**	I(0)**
Japan	I(0)***	I(0)**	I(0)**	I(0)***	I(0)***
Korea	I(0)***	I(0)***	I(0)***	I(0)***	I(0)***
Netherlands	I(0)***	I(0)***	I(0)**	I(1)***	I(0)**
Portugal[5)]	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
Sweden	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
USA	I(0)***	I(0)***	I(0)***	I(0)**	I(0)***
I(0)	100 %	100 %	100 %	84 %	95 %
I(1)	0 %	0 %	0 %	16 %	5 %

* p-value < 0.1. ** p-value < 0.05. *** p-value < 0.01.

If a variable is I(0), the gap of the four-quarter-change is stationary.

If a variable is I(1), the first difference in the gap of the four-quarter-change is stationary.

1) Credit to households from 1996Q4. House prices from 2001Q1 - 2014Q1.

2) Credit to households from 2000Q4.

3) Credit to households from 1995Q4.

4) Credit to households removed due to short sample.

5) House prices until 2014Q1.

Appendix C. Cross correlations for CPI

Table 7. Cross correlations. CPI and private credit.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	0.360	0.385	0.433	**0.465**	**0.483**	**0.440**	0.323	0.176	0.033
Australia	0.192	0.309	**0.388**	**0.440**	**0.419**	0.368	0.274	0.161	0.087
Austria	0.095	**0.232**	**0.285**	**0.264**	0.179	0.051	-0.088	-0.244	-0.381
Belgium	-0.054	0.021	0.097	0.192	**0.270**	**0.300**	**0.299**	0.219	0.096
Canada	0.093	0.115	0.149	0.184	0.201	**0.214**	0.211	**0.225**	**0.289**
Switzerland	**0.322**	**0.370**	**0.336**	0.261	0.108	-0.046	-0.115	-0.143	-0.135
Germany	0.207	0.202	0.244	0.314	**0.419**	**0.399**	**0.336**	0.257	0.181
Denmark	0.154	0.195	**0.230**	**0.260**	**0.251**	0.196	0.088	-0.037	-0.136
Spain	**0.255**	**0.241**	**0.195**	0.141	0.091	0.042	0.005	-0.040	-0.098
Finland	0.218	0.338	0.443	**0.532**	**0.551**	**0.508**	0.427	0.296	0.151
France	0.097	0.148	0.198	**0.270**	**0.308**	**0.287**	0.222	0.093	-0.052
UK	-0.022	**0.024**	**0.076**	**0.074**	-0.023	-0.056	-0.094	-0.116	-0.134
Ireland	**0.213**	**0.221**	**0.196**	0.163	0.114	0.058	0.030	0.012	0.002
Italy	0.059	0.168	**0.251**	**0.271**	**0.213**	0.079	-0.078	-0.214	-0.318
Japan	0.254	0.235	0.275	0.329	**0.334**	**0.370**	**0.351**	0.209	0.124
Korea	0.385	**0.430**	**0.466**	**0.496**	0.374	0.259	0.114	-0.033	-0.110
Netherlands	**0.405**	**0.300**	**0.203**	0.079	-0.051	-0.162	-0.286	-0.400	-0.476
Portugal	0.018	0.029	0.064	0.116	0.120	**0.158**	**0.159**	**0.140**	0.122
Sweden	0.231	0.319	**0.376**	**0.379**	**0.348**	0.287	0.216	0.150	0.085
USA	0.134	0.230	0.318	**0.378**	**0.411**	**0.382**	0.314	0.230	0.130

CPI is locked at period 0. The leads/lags refers to private credit.

Bold numbers indicate the three largest correlations for each country.

Table 8. Cross correlations. CPI and credit to households.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	**0.360**	**0.375**	**0.361**	0.312	0.282	0.219	0.196	0.178	0.162
Australia	0.340	**0.400**	**0.405**	**0.363**	0.278	0.183	0.114	0.113	0.127
Austria[1)]	0.165	**0.198**	**0.184**	**0.176**	0.138	0.050	-0.057	-0.158	-0.251
Belgium	-0.027	0.009	0.031	0.112	**0.158**	**0.131**	**0.140**	0.100	-0.033
Canada	0.197	0.262	**0.313**	**0.310**	**0.286**	0.211	0.174	0.181	0.231
Switzerland[2)]	-0.077	-0.155	-0.193	-0.047	**0.024**	**-0.021**	**-0.023**	-0.093	-0.185
Germany	**0.127**	0.084	0.067	0.081	**0.117**	0.100	0.082	0.089	**0.140**
Denmark[3)]	-0.136	-0.126	**-0.106**	**-0.092**	**-0.122**	-0.162	-0.228	-0.278	-0.305
Spain	**0.162**	**0.152**	**0.126**	0.092	0.029	-0.038	-0.114	-0.177	-0.218
Finland	**0.385**	**0.375**	**0.354**	0.310	0.248	0.187	0.126	0.065	0.009
France	0.174	**0.207**	**0.213**	**0.207**	0.185	0.109	0.041	-0.006	-0.046
UK	**-0.076**	**-0.093**	**-0.101**	-0.130	-0.207	-0.246	-0.266	-0.282	-0.272
Ireland[4)]	-	-	-	-	-	-	-	-	-
Italy	**0.078**	**0.040**	**-0.028**	-0.108	-0.189	-0.293	-0.367	-0.406	-0.422
Japan	**0.367**	**0.362**	**0.327**	0.215	0.130	0.074	0.038	-0.002	-0.002
Korea	**0.429**	**0.393**	**0.318**	0.145	-0.059	-0.246	-0.393	-0.415	-0.390
Netherlands	**-0.027**	**-0.061**	**-0.093**	-0.164	-0.229	-0.279	-0.354	-0.412	-0.455
Portugal	**-0.080**	**-0.116**	**-0.171**	-0.242	-0.287	-0.320	-0.305	-0.272	-0.286
Sweden	**0.335**	**0.326**	**0.308**	0.274	0.211	0.117	0.025	-0.046	-0.088
USA	0.241	0.299	**0.349**	**0.362**	**0.354**	0.268	0.160	0.074	-0.008

CPI is locked at period 0. The leads/lags refers to credit to households.

Bold numbers indicate the three largest correlations for each country.

1) Credit to households from 1996Q4.

2) Credit to households from 2000Q4.

3) Credit to households from 1995Q4.

4) Removed due to short sample.

Table 9. Cross correlations. CPI and house prices.
Gap of four-quarter-change. 1992Q1 - 2014Q4.

	Leading indicator (-)					Lagging indicator (+)			
	-4	-3	-2	-1	0	1	2	3	4
Norway	**0.191**	**0.112**	-0.034	-0.129	-0.245	-0.293	-0.266	-0.194	**-0.015**
Australia	**0.212**	**0.252**	**0.250**	0.203	0.107	0.021	-0.017	0.032	0.167
Austria[1)]	-	-	-	-	-	-	-	-	-
Belgium	0.179	**0.236**	**0.275**	**0.276**	0.232	0.144	0.027	-0.078	-0.152
Canada	0.237	**0.310**	**0.349**	**0.349**	0.287	0.170	0.085	0.042	0.082
Switzerland	**0.217**	**0.086**	-0.036	-0.134	-0.209	-0.219	-0.176	-0.093	**0.001**
Germany	0.470	**0.513**	**0.525**	**0.515**	0.492	0.453	0.413	0.381	0.346
Denmark	**-0.017**	**-0.012**	**-0.026**	-0.068	-0.152	-0.288	-0.426	-0.525	-0.556
Spain	0.174	**0.202**	**0.202**	**0.175**	0.102	0.012	-0.062	-0.131	-0.167
Finland	**0.359**	**0.306**	**0.205**	0.065	-0.089	-0.238	-0.338	-0.365	-0.327
France	0.349	**0.405**	**0.457**	**0.466**	0.388	0.247	0.056	-0.132	-0.241
UK	**0.000**	**-0.006**	**-0.054**	-0.141	-0.249	-0.338	-0.383	-0.352	-0.249
Ireland	0.260	**0.287**	**0.303**	**0.293**	0.252	0.182	0.087	0.000	-0.055
Italy	0.165	**0.209**	**0.233**	**0.215**	0.146	0.031	-0.104	-0.231	-0.327
Japan	0.105	0.168	**0.210**	**0.222**	**0.214**	0.189	0.156	0.122	0.100
Korea	**0.433**	**0.396**	**0.256**	0.068	-0.152	-0.292	-0.303	-0.241	-0.133
Netherlands	**0.294**	**0.218**	**0.124**	0.023	-0.091	-0.204	-0.294	-0.399	-0.442
Portugal[2)]	**0.374**	**0.359**	**0.355**	0.347	0.276	0.144	-0.007	-0.153	-0.263
Sweden	**0.291**	**0.262**	**0.190**	0.084	-0.028	-0.128	-0.185	-0.188	-0.179
USA	**0.293**	**0.320**	**0.304**	0.241	0.168	0.131	0.124	0.101	0.046

CPI is locked at period 0. The leads/lags refers to house prices.

Bold numbers indicate the three largest correlations for each country.

1) Removed due to short sample.

2) House prices until 2014Q1.

Appendix D. Synchronization indicator for CPI

Table 10. Synchronization indicator.* CPI. 1992Q1 - 2014Q4.

	Private credit	Credit to households	House prices
Norway	0.750	0.641	0.413
Australia	0.554	0.500	0.587
Austria[1)]	0.500	0.589	-
Belgium	0.565	0.543	0.609
Canada	0.554	0.598	0.598
Switzerland[2)]	0.391	0.544	0.424
Germany	0.630	0.522	0.652
Denmark[3)]	0.598	0.416	0.315
Spain	0.500	0.446	0.467
Finland	0.620	0.576	0.380
France	0.652	0.620	0.728
UK	0.489	0.391	0.380
Ireland[4)]	0.511	-	0.424
Italy	0.511	0.478	0.511
Japan	0.685	0.609	0.707
Korea	0.533	0.587	0.489
Netherlands	0.413	0.402	0.457
Portugal[5)]	0.565	0.446	0.607
Sweden	0.598	0.565	0.424
USA	0.641	0.641	0.565
Average	0.563	0.532	0.513

* The fraction of time two series have the same sign on the gap of the four-quarter-change.

1) Credit to households from 1996Q4. House prices removed due to short sample.

2) Credit to households from 2000Q4.

3) Credit to households from 1995Q4.

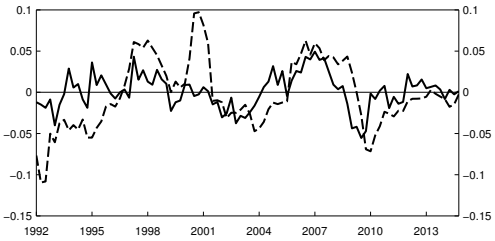
4) Credit to households removed due to short sample.

5) House prices until 2014Q1.

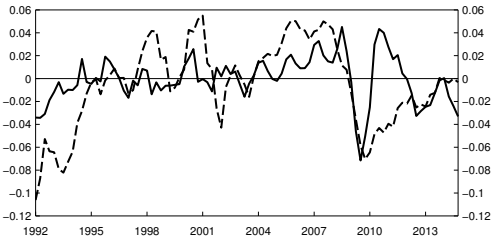
Appendix E. Graphs

Figure 4. Nominal GDP (solid) and private credit (dotted).
Gap of four-quarter-change. 1992Q1 - 2014Q4.

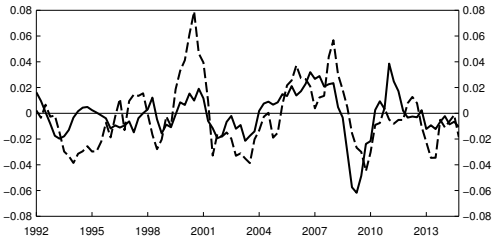
(a) Norway



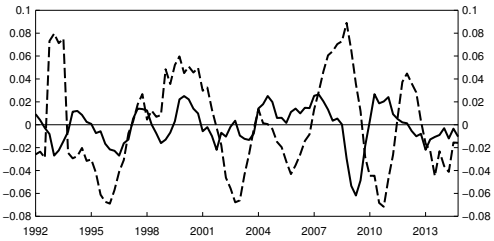
(b) Australia



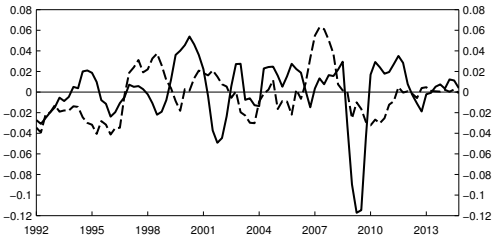
(c) Austria



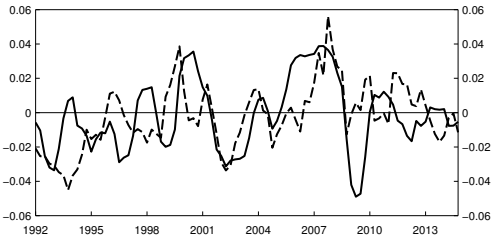
(d) Belgium



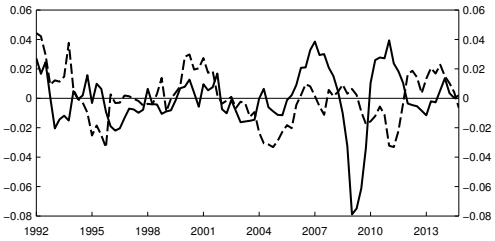
(e) Canada



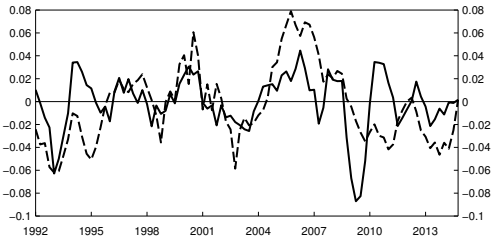
(f) Switzerland



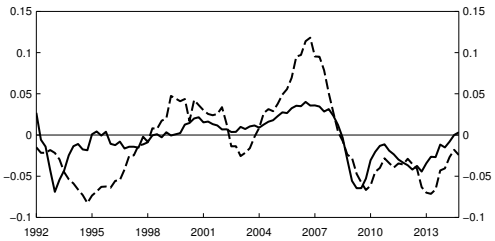
(g) Germany



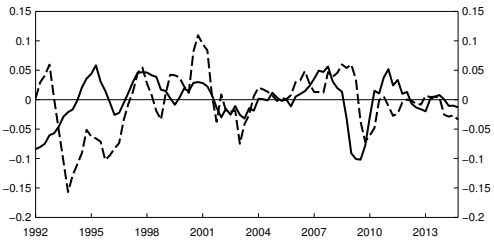
(h) Denmark

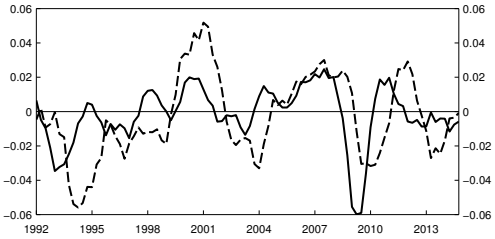


(i) Spain

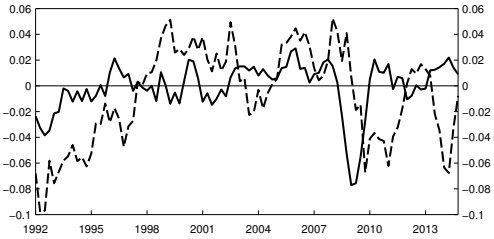


(j) Finland

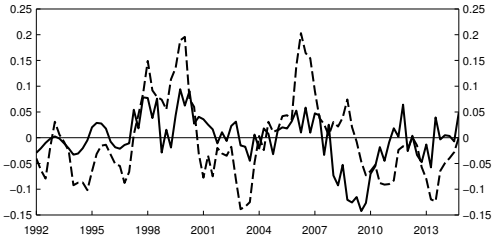




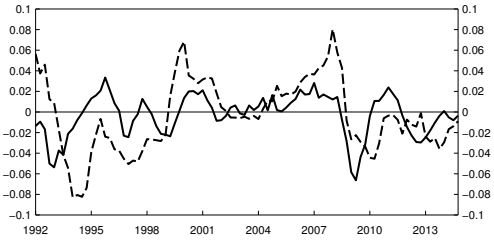
(k) France



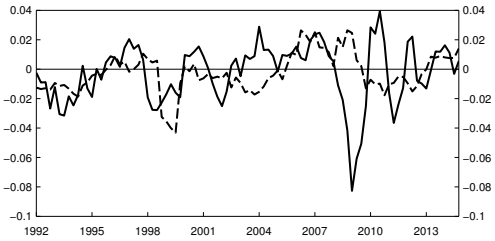
(l) UK



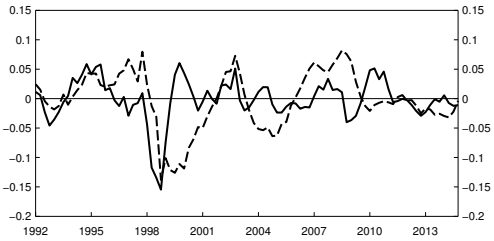
(m) Ireland



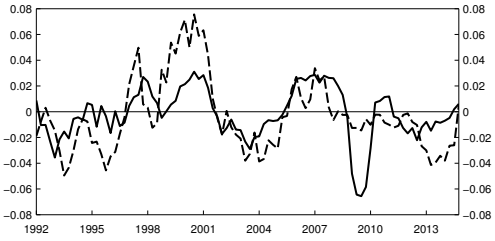
(n) Italy



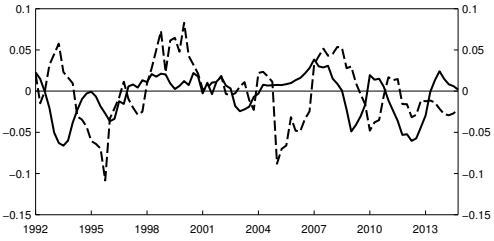
(o) Japan



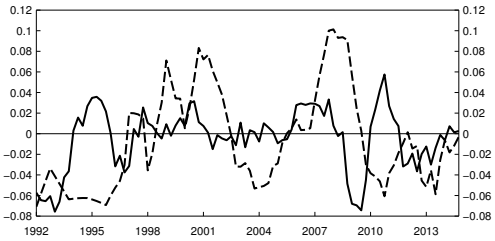
(p) Korea



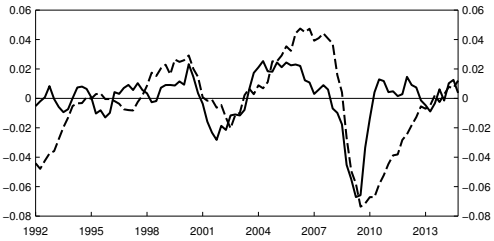
(q) Netherlands



(r) Portugal

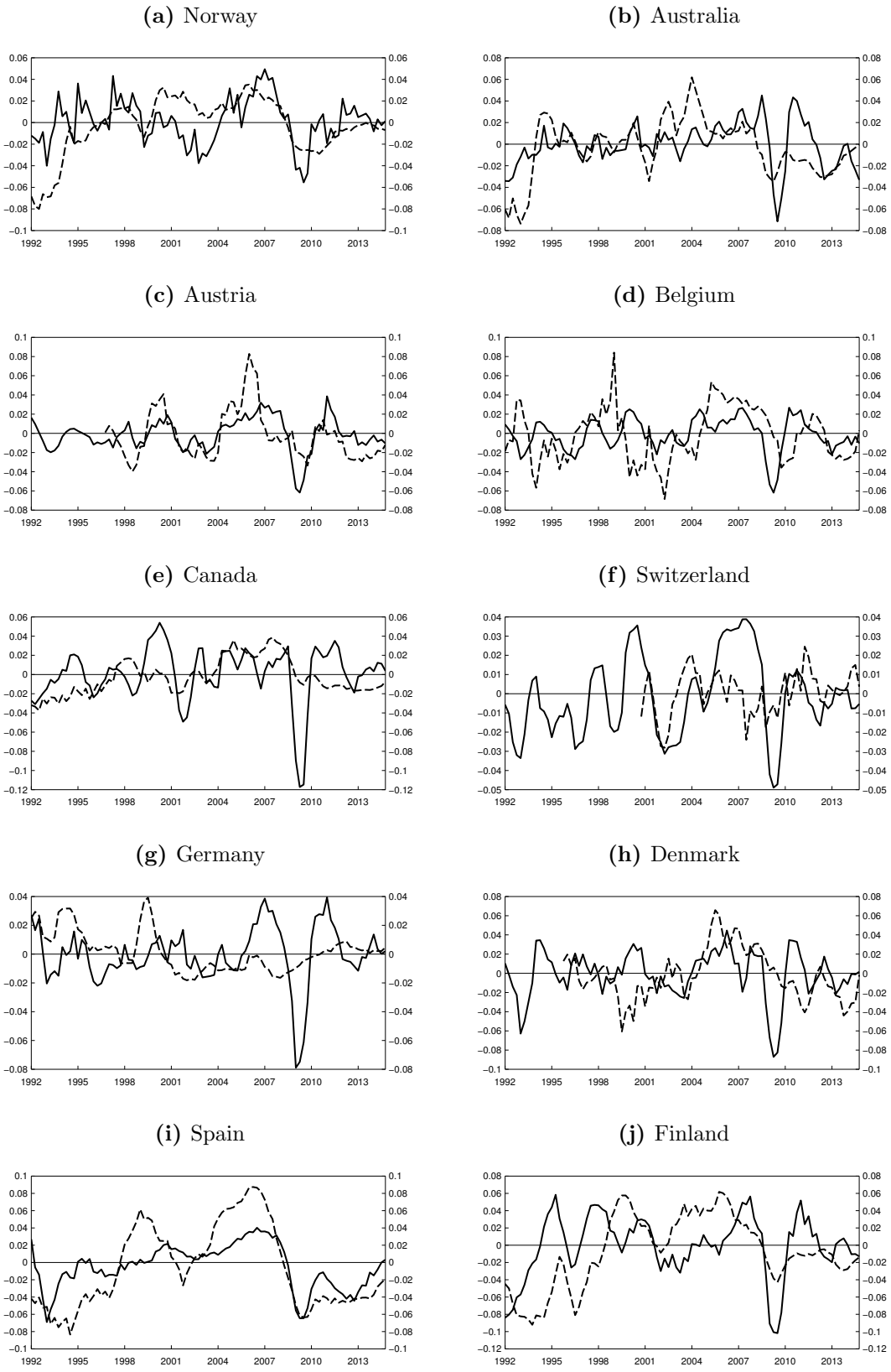


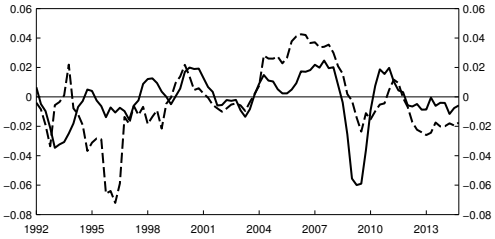
(s) Sweden



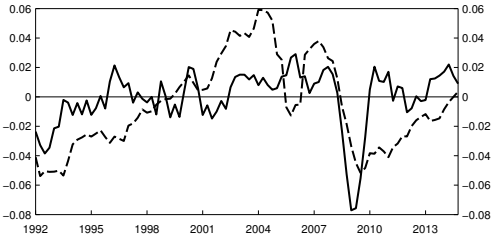
(t) USA

Figure 5. Nominal GDP (solid) and credit to households and NPISHs (dotted). Gap of four-quarter-change. 1992Q1 - 2014Q4.

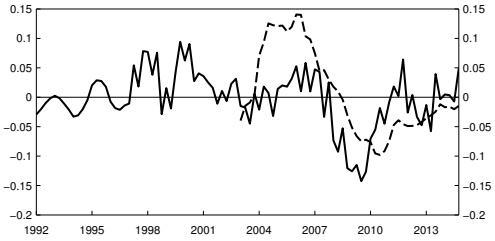




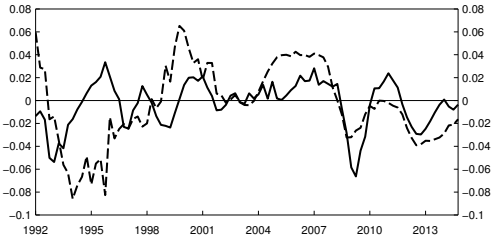
(k) France



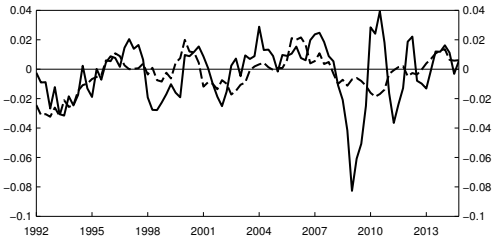
(l) UK



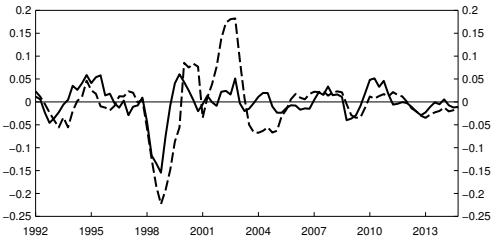
(m) Ireland



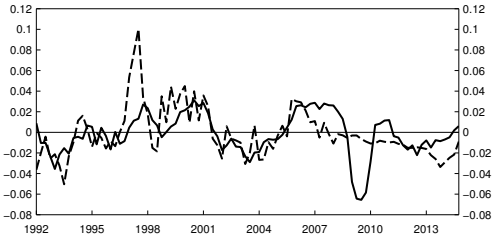
(n) Italy



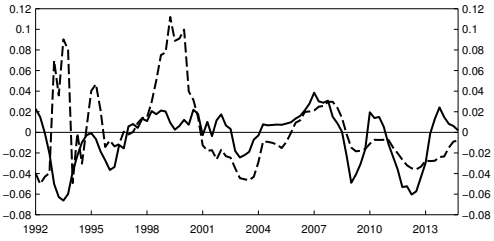
(o) Japan



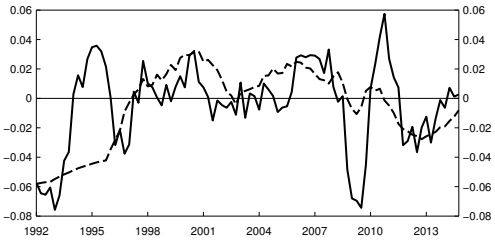
(p) Korea



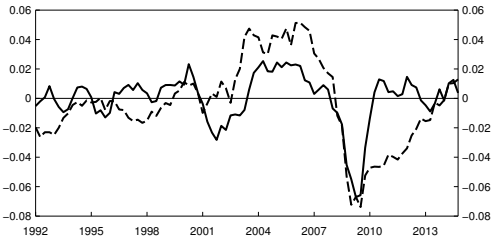
(q) Netherlands



(r) Portugal

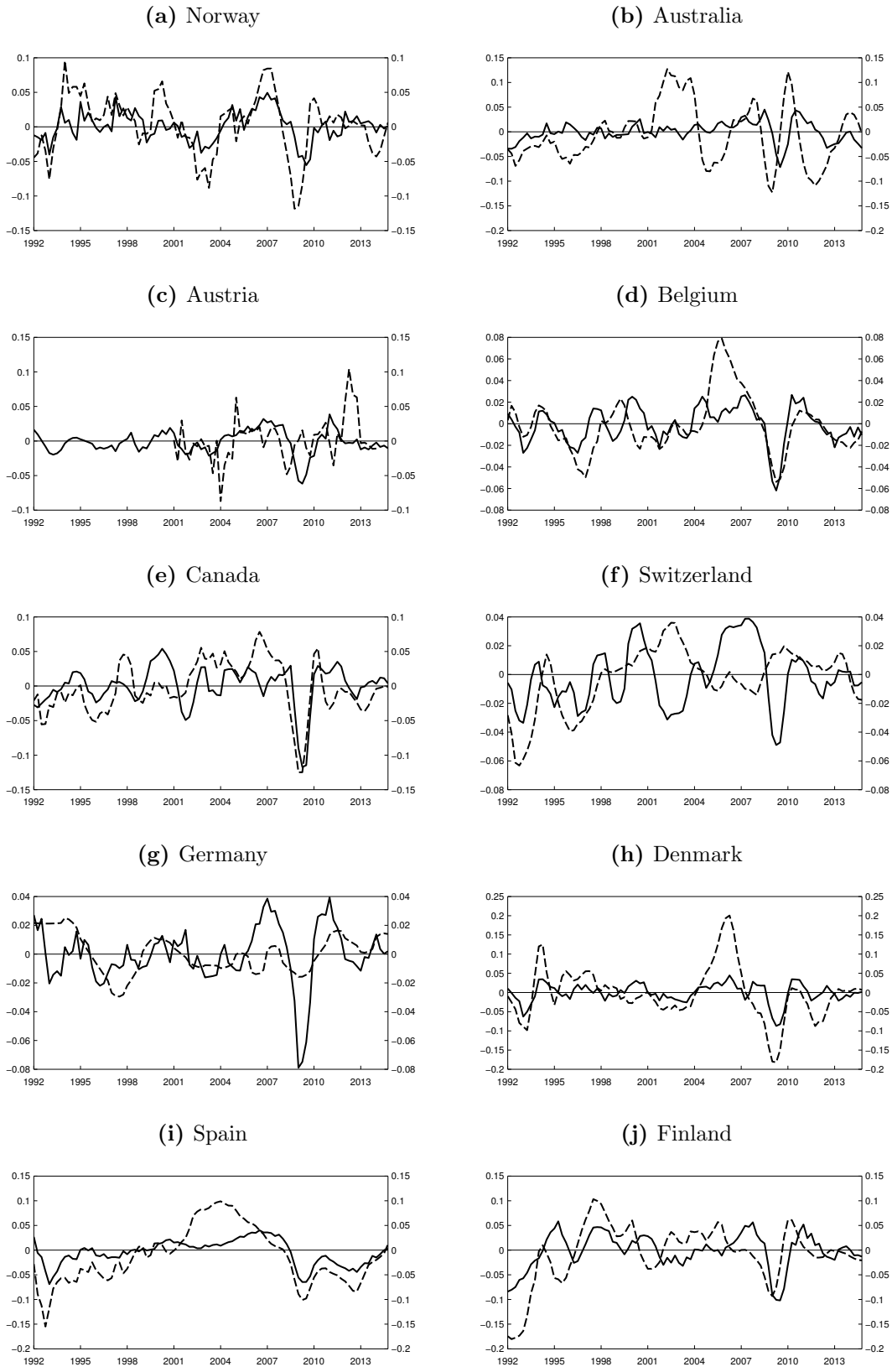


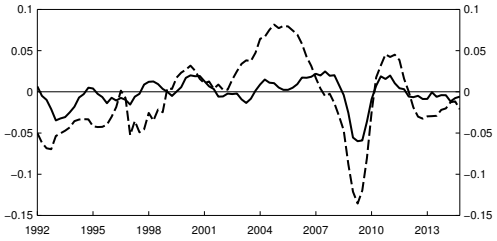
(s) Sweden



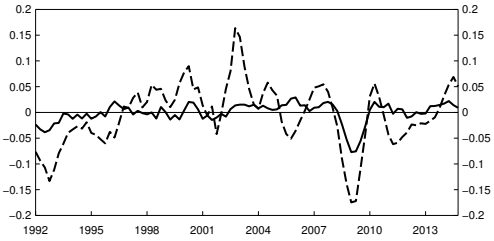
(t) USA

Figure 6. Nominal GDP (solid) and house prices (dotted).
Gap of four-quarter-change. 1992Q1 - 2014Q4.

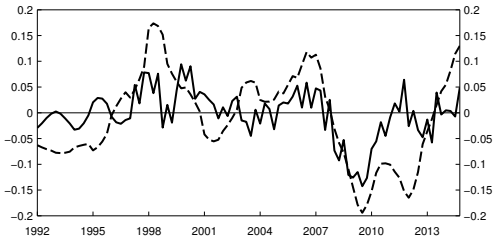




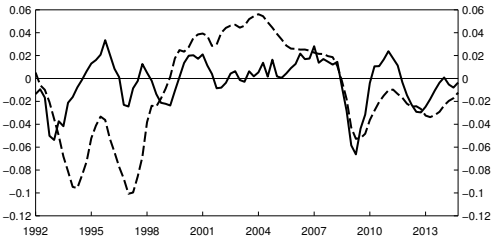
(k) France



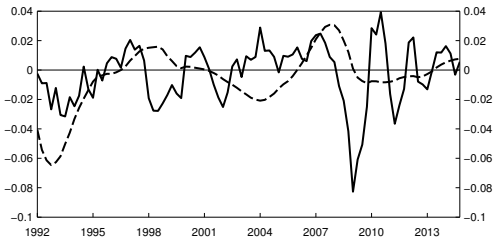
(l) UK



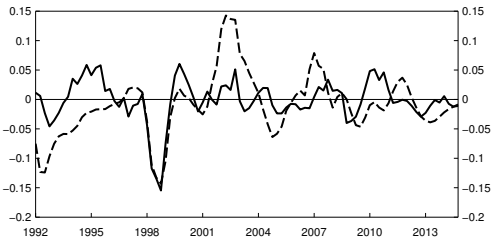
(m) Ireland



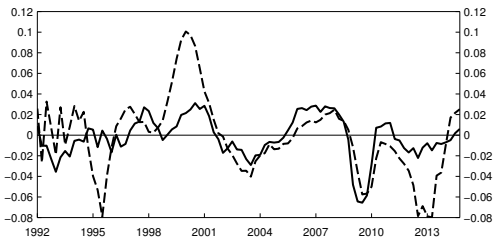
(n) Italy



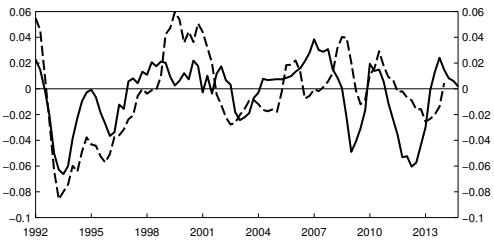
(o) Japan



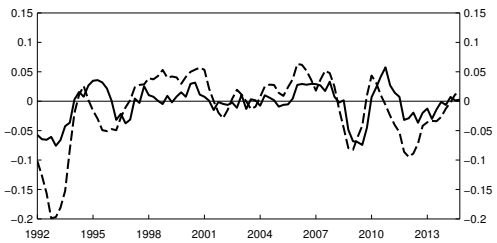
(p) Korea



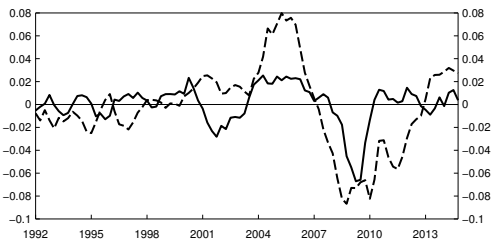
(q) Netherlands



(r) Portugal



(s) Sweden



(t) USA