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Relationships Between Nominal GDP and Financial Variables in OECD Countries

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STAFF MEMO

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NO. 4 | 2017

JON ELLINGSEN

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Relationships between nominal GDP and financial variables in OECD countries*

Jon Ellingsen[†]

April 5, 2017

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 contemporaneous 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

¹Note 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.

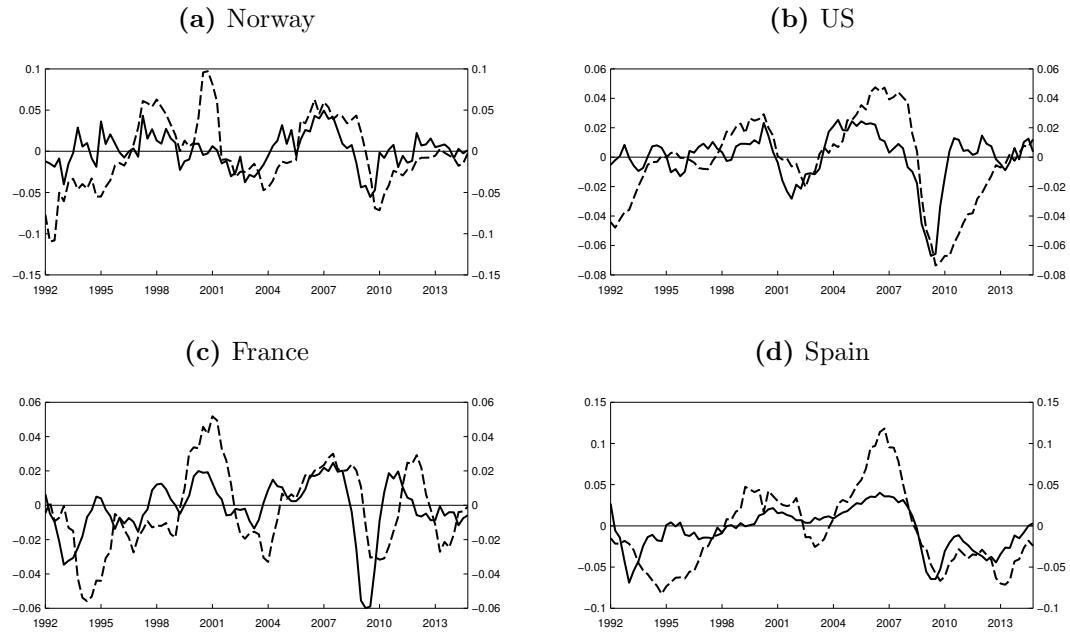


Figure 2. Nominal GDP (solid) and credit to households and NPISHs (dotted).

Gap of four-quarter-change. 1992Q1 - 2014Q4.

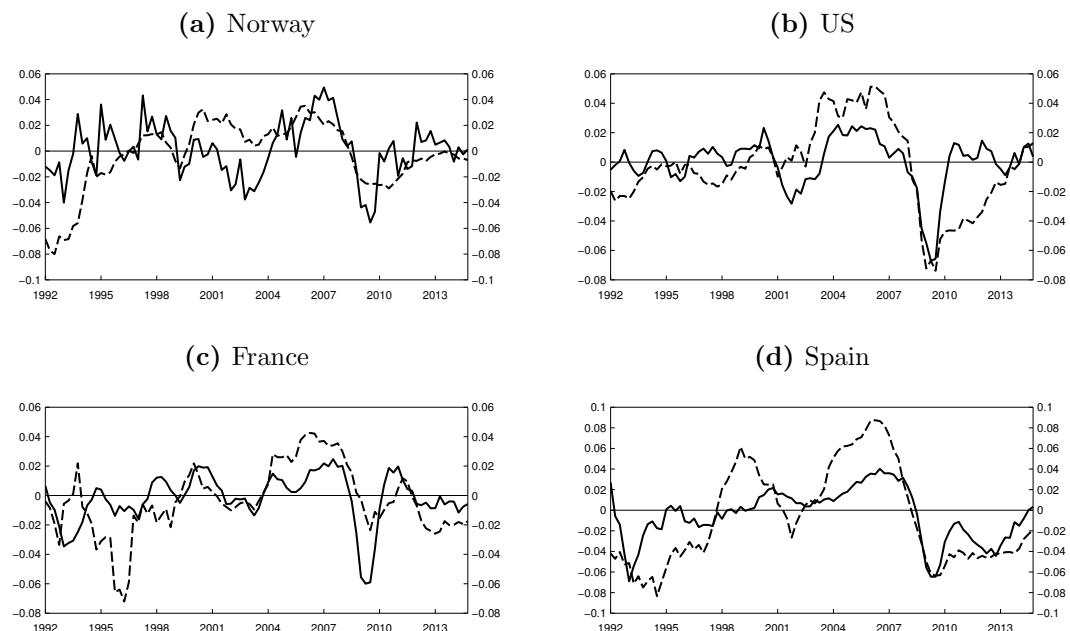
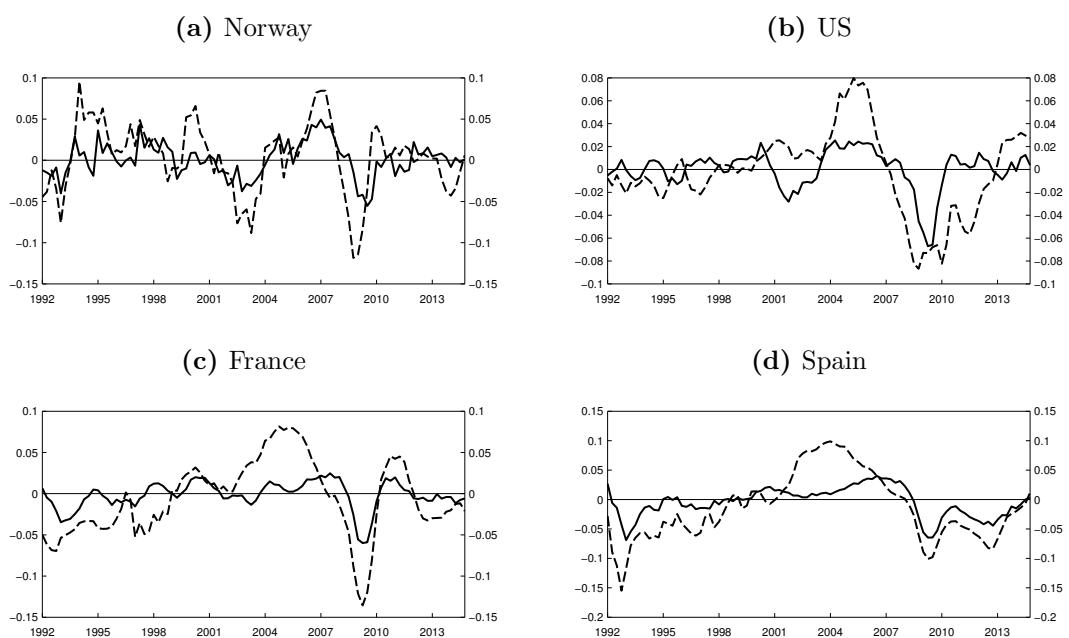


Figure 3. Nominal GDP (solid) and house prices (dotted). Gap of four-quarter-change. 1992Q1 - 2014Q4.



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{gdp}_t and \widetilde{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

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

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

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

³Nominal 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.

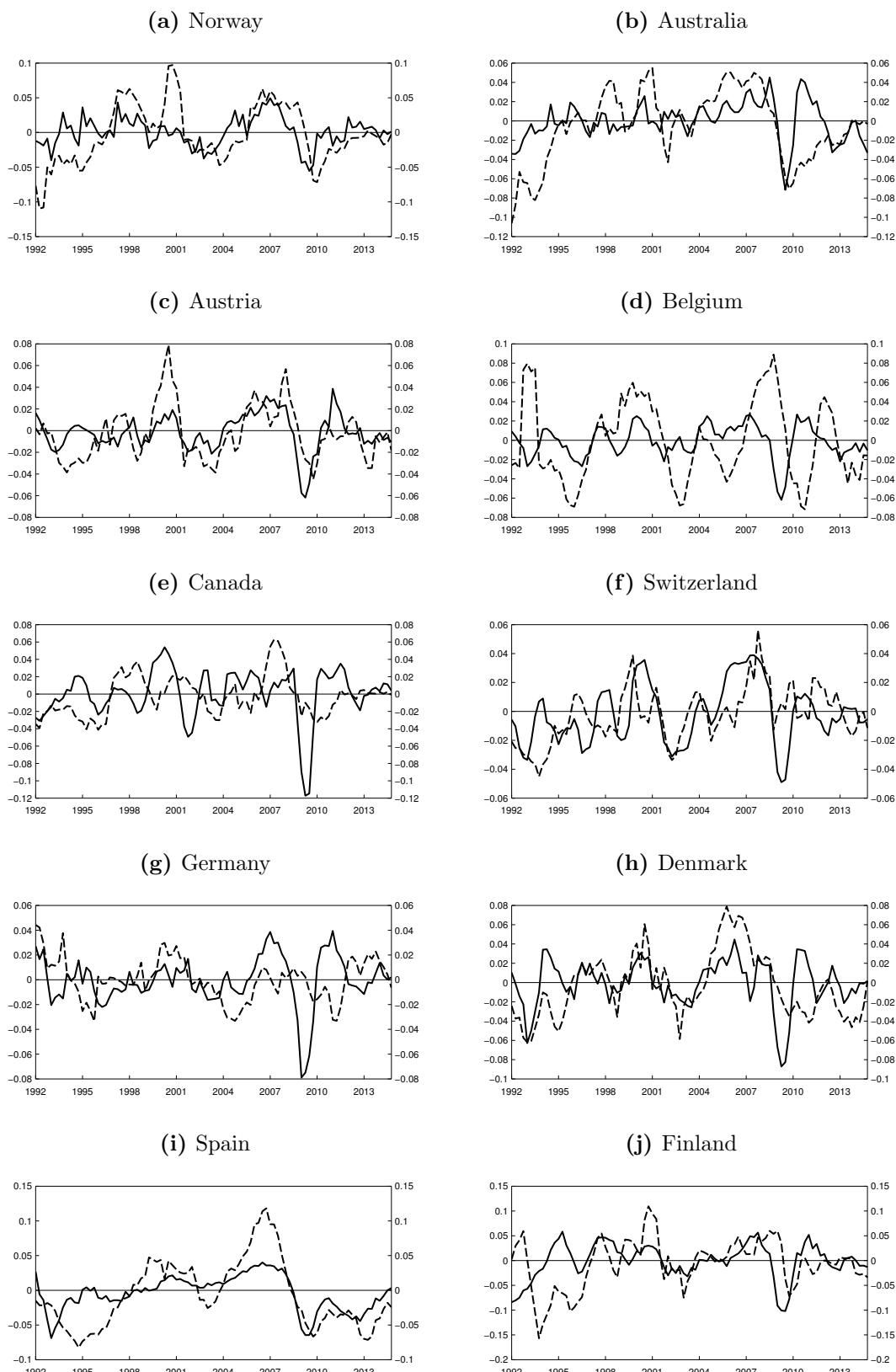
3) Credit to households from 1995Q4.

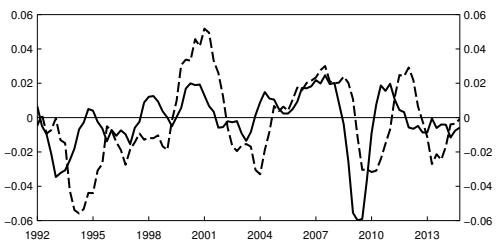
4) Credit to households removed due to short sample.

5) House prices until 2014Q1.

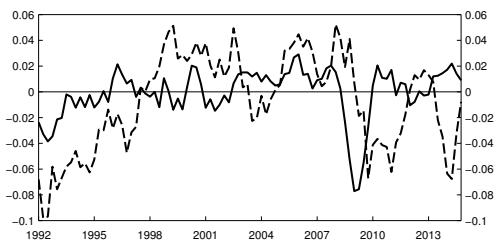
Appendix E. Graphs

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

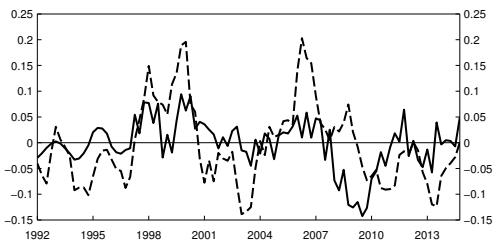




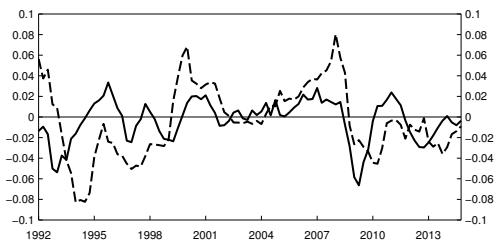
(k) France



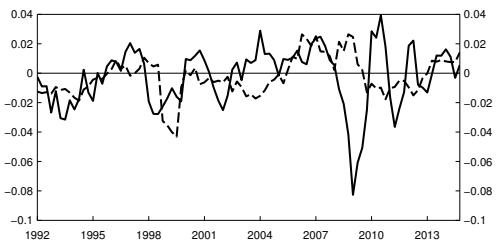
(l) UK



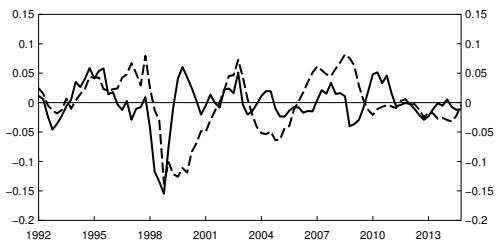
(m) Ireland



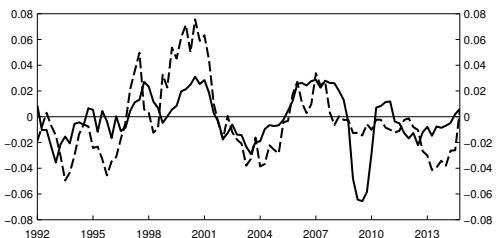
(n) Italy



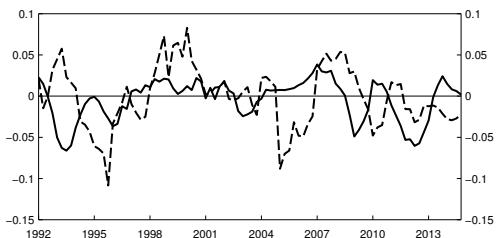
(o) Japan



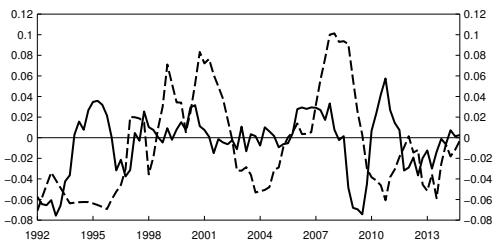
(p) Korea



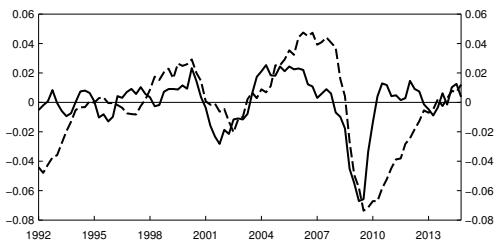
(q) Netherlands



(r) Portugal

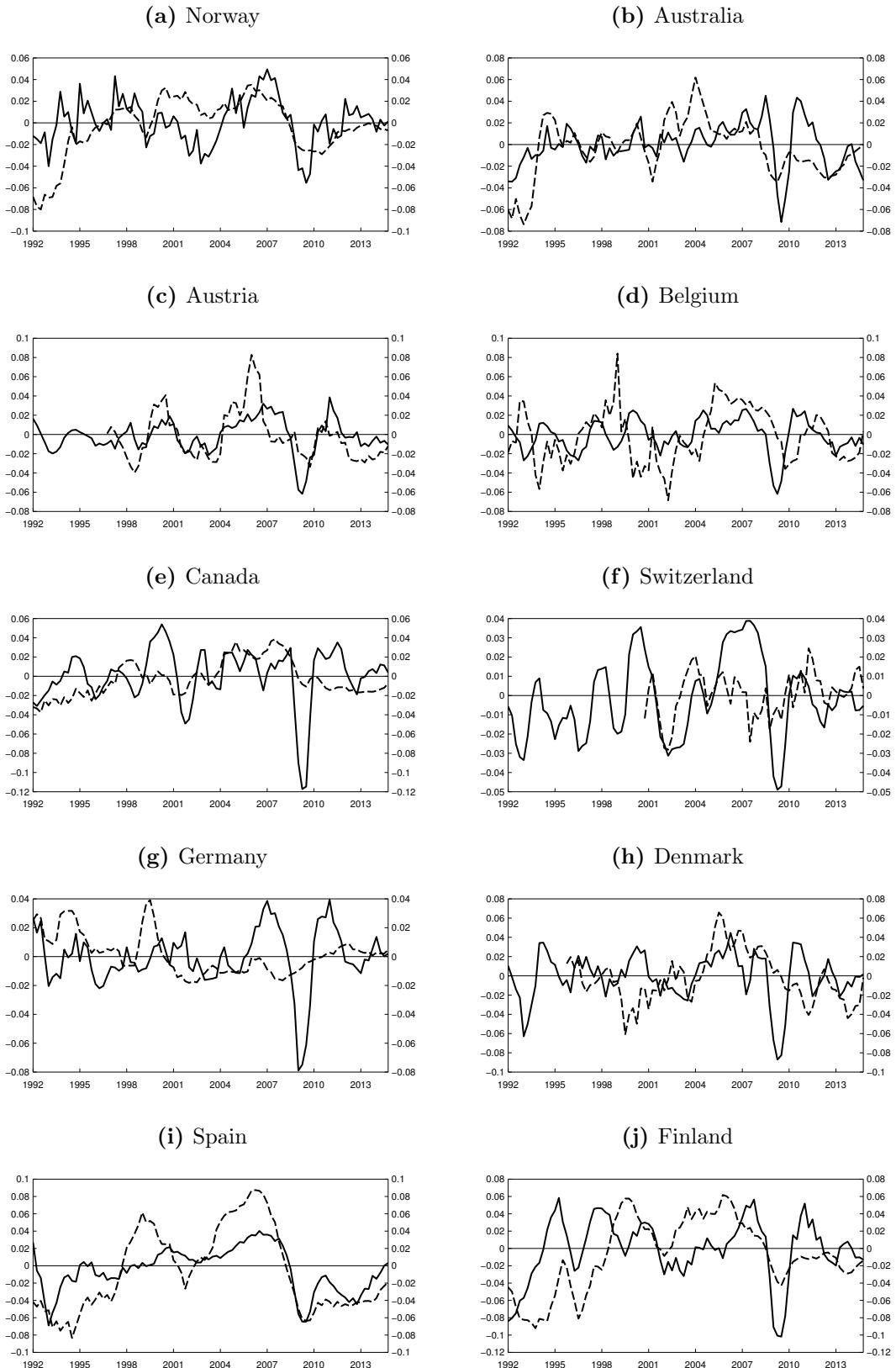


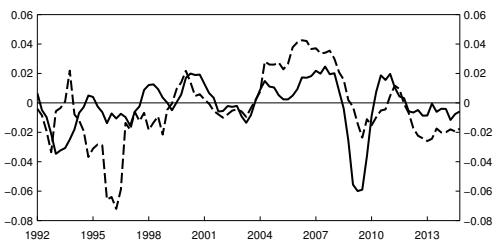
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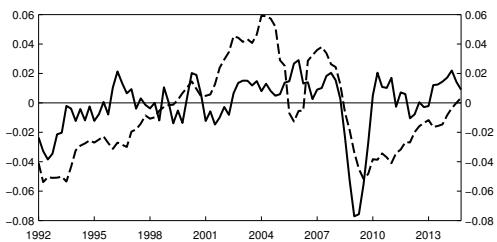
(t) USA

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

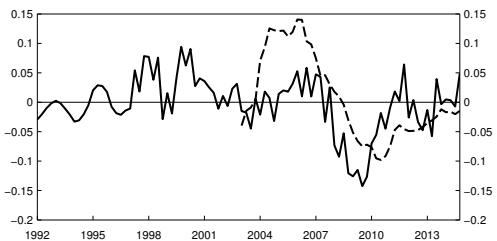




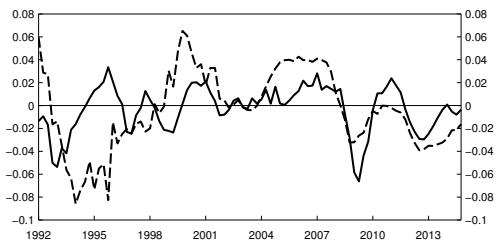
(k) France



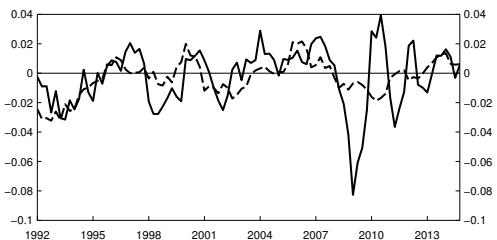
(l) UK



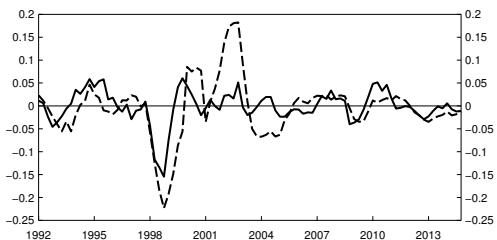
(m) Ireland



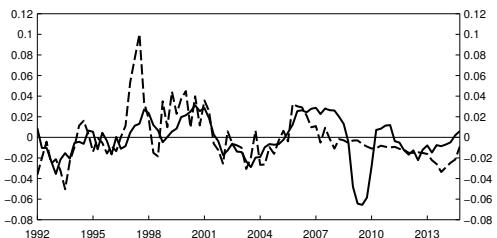
(n) Italy



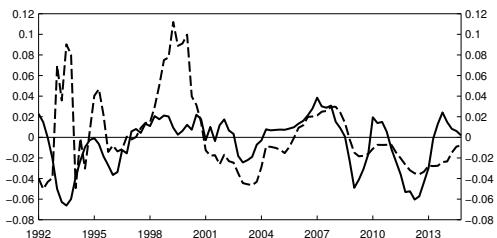
(o) Japan



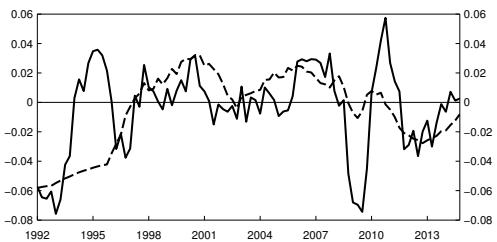
(p) Korea



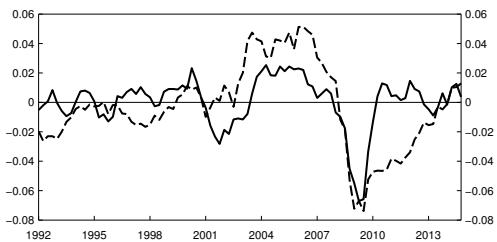
(q) Netherlands



(r) Portugal

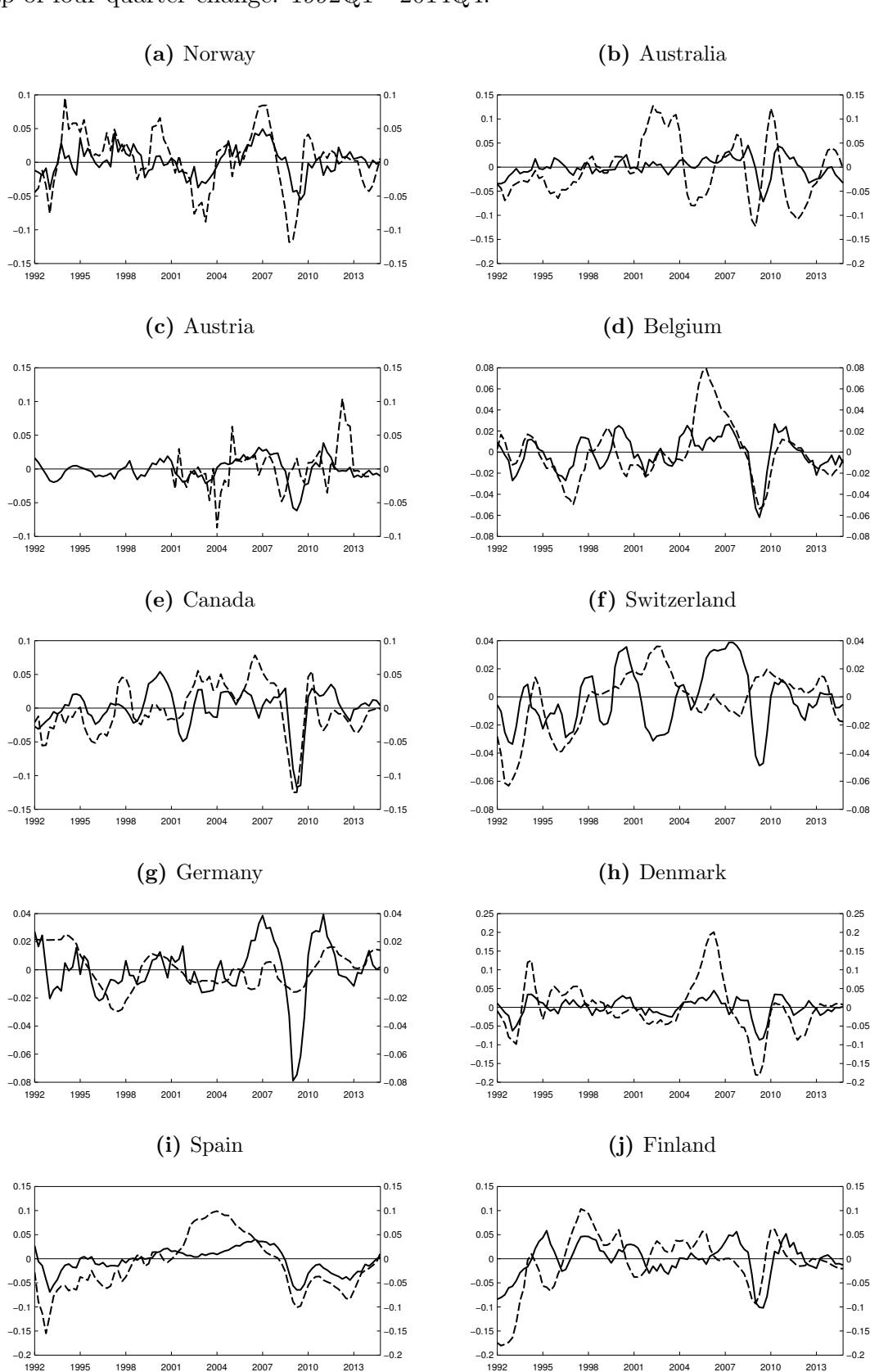


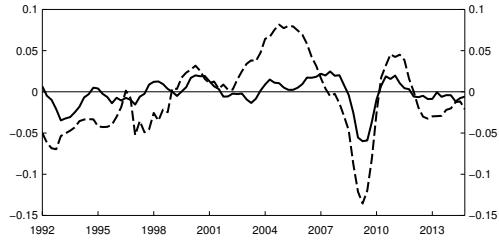
(s) Sweden



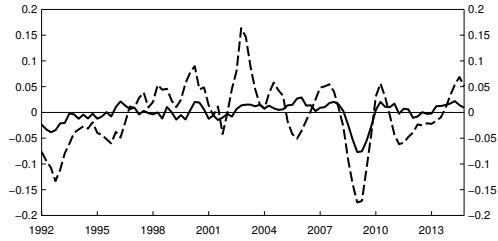
(t) USA

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

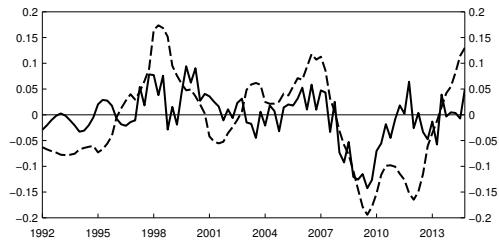




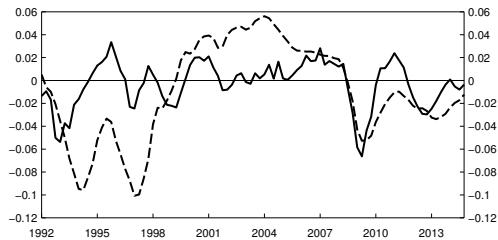
(k) France



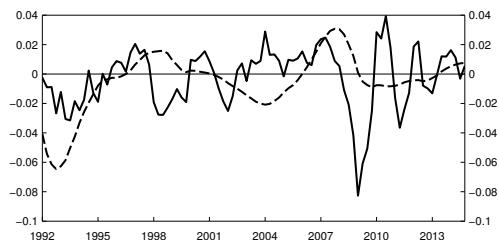
(l) UK



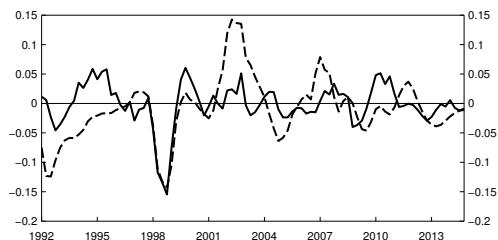
(m) Ireland



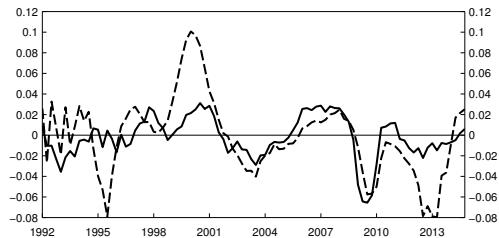
(n) Italy



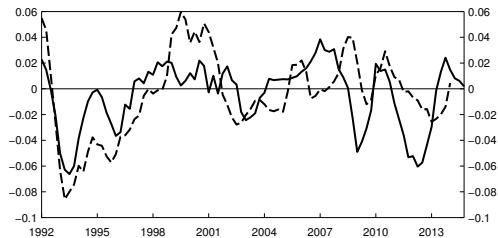
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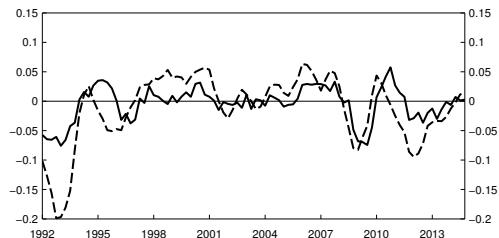
(p) Korea



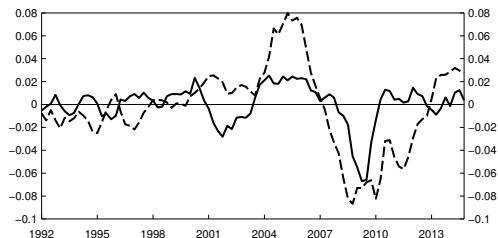
(q) Netherlands



(r) Portugal



(s) Sweden



(t) USA