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Unravelling the secrets of euro area inflation- a frequency decomposition approach

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1 Introduction

The role of money and credit for the economy, and especially for inflation, has always attracted a lot of attention in the economic literature (see, for instance, Friedman and Schwartz (1963), Bernanke (1993)) and, more recently, Nelson (2008), Benati (2009), Lucas and Nicolini (2015), Hevia and Nicolini (2017) as well as Anderson, Bordo and Duca (2017)). This paper addresses some key questions regarding the fundamental nature of the relationships among those variables and attempts to analyse them for the euro area by means of filter-design techniques. After decomposing the variables over different frequencies, regressions are carried out and the main drivers of inflation over different horizons are derived in a single-equation approach. Robustness checks are also carried out by choosing different combinations of explanatory variables, price measures (GDP deflator and house prices) and frequency horizons.

The paper is structured as follows. After a review of the literature and methodology, the basic framework applied in the analysis as well as the relevant variables are illustrated in more details. Afterwards, the results at different frequencies for HICP, the GDP deflator and house prices are provided. The final section concludes.

2 Review of the literature and methodology

The interplay of longer-term trends and business cycle momentum has attracted the interest of economists ever since. The related literature is vast and it is impossible to do justice to all approaches in this study. Among the most popular approaches are spectral analysis, log-linear trends, correlation analysis, best fitting polynomial regressions, filter design approaches, structural time series models, fractional integrated long memory processes, outlier identification and trend breaks with stochastic models (see Gallegati et al. (2017) and the literature review therein). Among these methods, spectral analysis and filter design techniques clearly stand out.

Ever since the earlier seminal articles (see, for instance Engle (1974)), it is a well-known fact that most (if not all) economic processes can be seen as the result of a combination of various components operating on different frequencies or, equivalently, in different spectrums.[1] Indeed, the theory of spectral analysis provides a rigorous framework for extracting specific frequency bands from the data, with the major limitation consisting of the fact that sta-

[1] Seen from that perspective, several issues then boil down to a closer understanding of the behaviour of time series at different frequencies. In the older literature, mostly the so-called “Fourier analysis” was used to study the cyclical nature of a time-series in the frequency domain. This, however, had the major disadvantage that, under the Fourier transformation, the time information of a time series got (at least partly) lost.

tionarity of the observed time series is a basic requirement for this method to be applied.

This precondition does not have to be met in case a filter-design approach is used. Similar to the spectral analysis, the filter-design approach regards a time series as the outcome of the interplay of various frequencies and the filter coefficients allow to isolate the various frequencies and, thus, the frequency components in the time domain. In the literature, this has initiated the development of a number of band-pass filters with the ones suggested by Baxter and King (1999) and Christiano and Fitzgerald (2003) probably being two of the most popular ones.

Technically speaking, band-pass filters remove both low and high frequencies from the time series. In case of the filter proposed by Baxter and King (1999), the business cycle component is isolated by applying a moving average to the time series under consideration.

In essence, the method relies on the use of a symmetric moving average to a time series y_t:[2]

$$(1) \qquad y_t^* = \sum_{h=-K}^{K} a_h y_{t-h} = a_0 y_t + \sum_{h=1}^{K} a_h (y_{t-h} + y_{t+h})$$

where K denotes the number of leads and lags. Starting from the Cramer representation of a zero mean stationary time series y_t, i.e.:

$$(2) \qquad y_t = \int_{-\pi}^{\pi} \xi(\omega) d\omega$$

which expresses the time series as the integral of random periodic components $\xi(\omega)$. It can then be shown that the filtered time series can be expressed in the following form:

$$(3) \qquad y_t^* = \int_{-\pi}^{\pi} a(\omega) \xi(\omega) d\omega$$

where the $a(\omega)$ denote the frequency response function of the linear filter. Moreover, the variance of the filtered series can be summarised by the following expression:

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[2] See Baxter and King (1999, p. 576 *ff*).

$$(4) \qquad \operatorname{var}(y_t^*) = \int_{-\pi}^{\pi} |a(\omega)|^2 f_y(\omega)\, d\omega$$

where $|a(\omega)|^2$ is the squared gain of the linear filter at frequency ω and $f_y(\omega)$ is the spectral density of the original series at frequency ω.

The Baxter-King filter can be shown to have a number of desirable properties. To begin with, it can be shown that the filter does not introduce any phase shift into the data. Second, the filter is able to render a stationary time series as an outcome. Third, the filter is insensitive to the presence of deterministic trends in the data. This notwithstanding, applying the filter to a time series is equivalent to losing K observations at the beginning and at the end of the series, hence necessitating a careful choice of the maximum lag length.

3 Economic framework

The general model underlying this study can be specified as follows:[3]

$$(5) \qquad dev(p)_t^f = \alpha_0 + \alpha_1 dev(m)_{t-1}^f + \alpha_2 dev(y)_{t-1}^f + \alpha_3 dev(x)_{t-1}^f + \varepsilon_t$$

where t stands for the time index and f denotes the frequency band. In terms of variables, p denotes prices, m and y represent a measure of the monetary aggregate and economic activity (such as real GDP), respectively, and x stands for a control variable. Moreover, the expression dev denotes the deviation from the respective sample mean (of the annual growth rates).

The choice of the money and GDP is justified on the basis of the ECB's monetary policy strategy (see ECB (1998, 1999a,b and 2003)) as well as by earlier work (see Gerlach and Svensson (2003)). Other variables are meant to reflect the fact that the euro area is an open economy.[4]

In the analysis presented in this paper, the following variables for the euro area are used (see **Annex 2** for more details): p denotes the harmonised index of consumer prices (HICP) or, alternatively, other price measures, such as the GDP deflator and house prices. The symbol m stands for the different monetary aggregates (M1, M2, M3 and loans to the private sector). The abbrevia-

3 See Andersson (2008, 2011).

4 In this respect, exchange rate measures, stock prices and oil prices are considered.

tion *y* represents three alternative measures, namely, either the output gap, real GDP or, alternatively, the unemployment rate. Finally, x denotes the euro exchange rate vis-à-vis the US dollar (or the nominal (effective) exchange rate of the euro) or, alternatively, oil prices.[5]

For all variables, a filter-design exercise is carried out to take explicitly into account the fact that the effects of the variables might unfold over different frequencies.[6] In line with Assenmacher-Wesche and Gerlach (2007), Andersson (2008 and 2011), Benati (2009) and Haug and Dewald (2012), we decompose developments in euro area consumer inflation into three time horizons, namely the short run (up to two years), the medium run (two to eight years) and the long run (eight years and beyond) using a variant of a Baxter-King filter.[7] We then regress the inflation variables on the set of variables mentioned above. In order to check our results for robustness, we run the estimations by using different combinations of monetary and real variables.

From a technical perspective, the estimations are carried out for the euro area by means of the GMM-estimation technique (Hansen 1982). The latter choice is justified by the need to correct for possible simultaneity issues.

4 Results

A simple graphical illustration of the technique outlined above starts from the decomposition of observed inflation over the past three decades into three main components, i.e. the "low frequency" component (i.e. those movements in inflation with a periodicity of more than 8 years); the "business cycle" component (defined as movements with a periodicity of more than 2 years, but less than 8 years) and the "irregular" component (defined as movements with a periodicity of less than 2 years).

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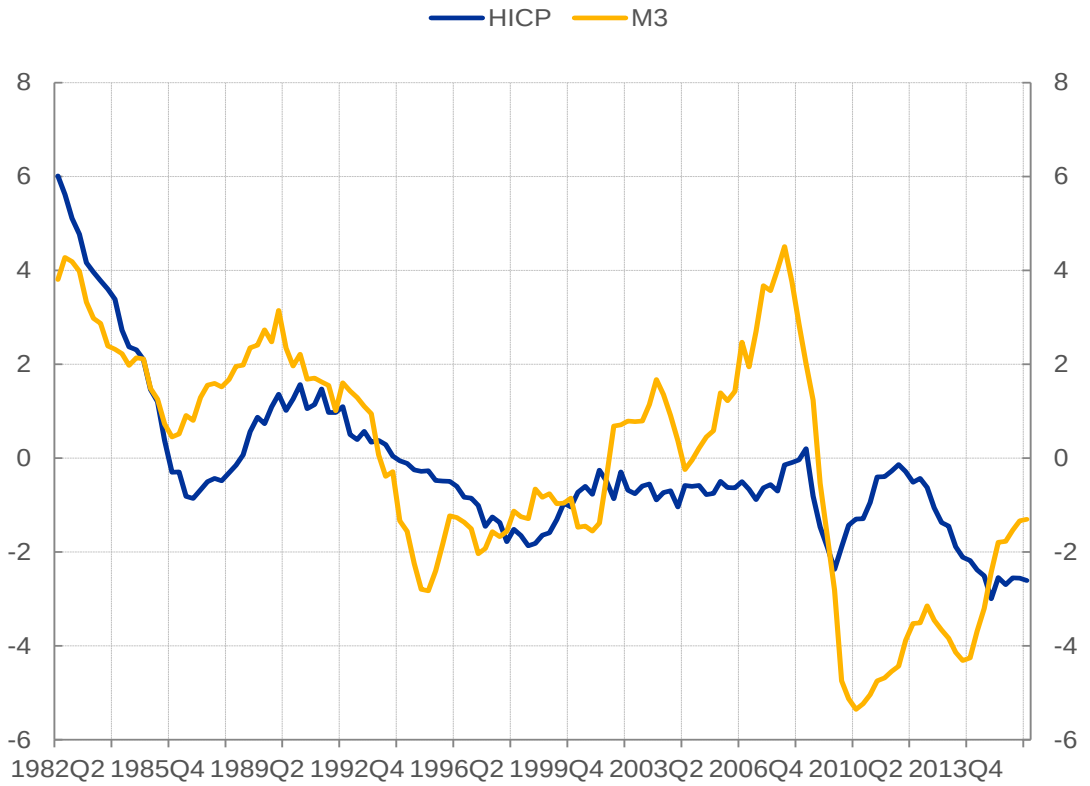
5 Moreover, euro area stock prices are included in the analysis in order to test for a possible role in the monetary policy transmission mechanism.

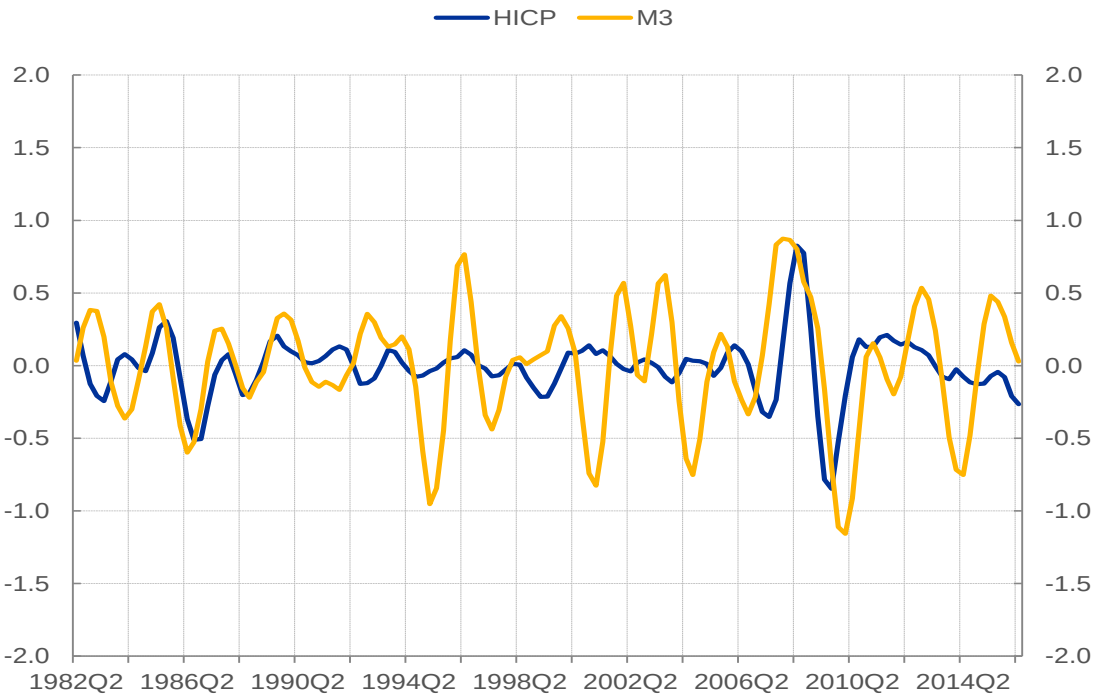
6 The only exception is the output gap, which is not decomposed but is kept unchanged in all specifications.

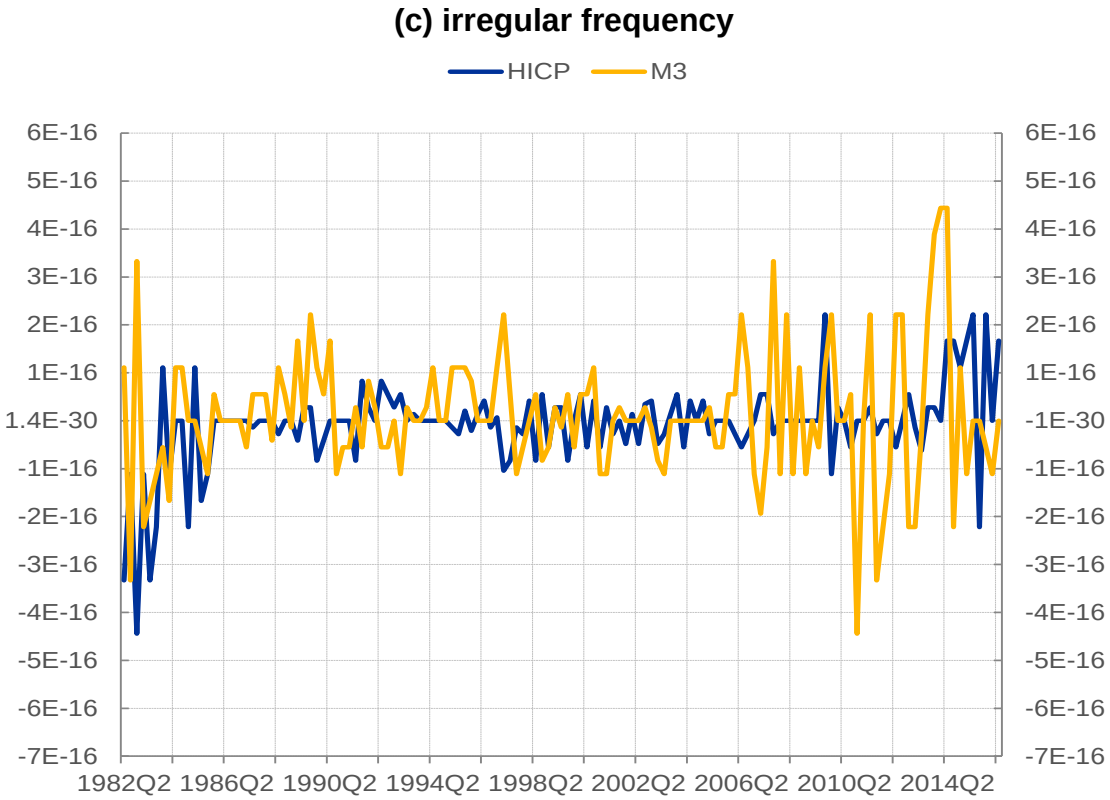
7 As a cross-check, theanalysis was also carried out using the Christiano-Fitzgerald filter. The results are available from the authors upon request.

Chart 1: HICP and M3 developments at different frequencies
(a) long-run frequency



(b) business cycle frequency





Source: own estimations.
Note: money (M3) and HICP, both measured as (demeaned) annual growth rates.

A graphical representation of the relation between euro area HICP inflation and M3 growth is provided in **Chart 1**. The chart reveals that developments in the low frequency component of euro area inflation tend to mirror actual M3 developments quite closely and in a rather smooth fashion, but at a lower level. Just between 2005 and 2006 and from 2010 onwards a slight decoupling of the two series can be detected. By contrast, the business cycle component tends to swing considerably around the zero line, thereby illustrating in an impressive way the effects that business cycles may have on price developments. Finally, the irregular component follows a very volatile pattern.

In order to derive the fundamentals prevailing in the euro area at the current stage, we start our analysis by estimating the aforementioned specification for the euro area based on a sample spanning the period from 1980 Q1 to 2017 Q2. The tables **in Annex 1** show the results of the inflation equation for the different frequencies. For each block of the tables the regressions differ because of the monetary aggregates used (M1, M2, M3 and loans). The same applies for the real variables and the control variables.

The interpretation of the results for the HICP at the long-term horizon leads to the following conclusions. First, starting with the first part of **Table 1**, we find that the broader monetary measures (M2 and M3) add positively and significantly to inflation over longer horizons, and so do loan developments. The narrow monetary aggregate M1 generally shows a negative sign (albeit not significant in almost all specifications), in line with its predominant nature as a transaction variable. Real developments (as measured by the output gap) do not provide additional information, whereas the euro exchange rate vis-à-vis the US dollar seems to have a significant (negative) influence. In addition, when turning to the other parts of the table, the same results seem to hold in case real GDP growth is used instead of the output gap. At the same time, also a higher low frequency unemployment rate has a negative influence on inflation (see column III of the table). Omitting the exchange rate or adding stock or oil prices does not seem to improve the results in any substantial way (with one exception, where the interplay between loans, real GDP and stocks seems to lead to significant results).[8] It is also worth noting that the explanatory power is best over the longer-term horizon (not shown separately).

Over the medium term (see **Table 2**), positive and significant effects from real developments (shown in both the output gap and real GDP growth) emerge, as could be expected on the basis of Phillips curve considerations. Moreover, the exchange rate continues to exert a negative and significant influence also over the business cycle (albeit much weaker than over the long-term horizon). Finally, in some specifications, monetary developments (in the broader aggregates) and loan developments still add to the explanation of inflationary developments, albeit to a much lesser extent (as mirrored in the size of the coefficient).

Over shorter horizons (see **Table 3**), the results seem to indicate that none of the variables under consideration affects consumer inflation in a significant way and, thus, fluctuations in consumer inflation that last up to two years are either noise, or may be explained by past values or seasonal effects.

To sum up, it is interesting to note that, as the frequency increases, the fundamentals come to the fore. In particular, the results point to a close monitoring of monetary developments over longer horizons. By contrast, over short- to medium-term horizons, the output gap and the exchange rate (and, occasionally, monetary aggregates) seem to be of relevance. In line with other studies, we tend to interpret the results as lending support in favour of the ECB's two-pillar monetary policy strategy (see Andersen (2007)).

A number of robustness checks of the results achieved so far are also carried out. First, we replace the euro/dollar exchange rate with the nominal effective exchange rate. Overall, small differences can be detected, the only ex-

8 Stock prices are significant but the size of the coefficient seems rather small.

ception consisting of the fact that, at the lower frequency horizon, the exchange rate coefficients turn out to be less significant (see **Table 4** and **Table 5**).

The second robustness check consists in re-estimating the equations by using the GDP deflator to derive the measure of inflation (see **Table 6** and **Table 7**). In this case, the results for the monetary aggregates over the low frequency horizon continue to hold, but the results for the exchange rate turn out to be less significant. We attribute this to the fact that – by contrast to the GDP deflator – the HICP includes more items that are directly influenced by movements in the exchange rate. Turning to the business cycle frequency, real developments do not seem to play a role anymore.

Finally, we carry out an additional exercise based on a redefinition of the low and medium-run frequency horizon. More concretely, we now define the long run as a horizon exceeding 16 years, while the medium run comprises a period between 2 and 16 years (see **Table 8** and **Table 9**). The results again show that the broader monetary measures (M2 and M3) and loans add positively and significantly to inflation over longer horizons. Real developments (as measured by the output gap) have no explanatory power, whereas the exchange rate seems to have a significant influence. Over the business cycle, real developments seem to dominate inflationary developments, supported by significant developments in the exchange rate and oil prices.

5 An extension to house prices

Furthermore, our study is extended by analysing the driving forces of developments in house prices at different frequencies. The focus on house prices is justified on the basis of their importance both from a monetary policy perspective and also for financial stability considerations related to their interlinkages with monetary policy and real economic developments (see Nocera and Roma (2017), Moulton and Wentland (2017), IMF (2018)[9]). In fact, real estate property must be seen as the most important component of household wealth and housing expenditures essentially constitute a major part of households' financial budgets, thus being linked to households' consumption and savings behaviour and, ultimately, to consumer prices. Furthermore, a high level of money holdings might signal a large amount of liquidity being invested in potentially higher-yielding opportunities, which could fuel a bubble once a trend has been triggered and herding behaviour sets in. This is why rapidly rising house prices are often associated with an easing of credit conditions, increased spending and, ultimately, inflationary pressures.

In this context, money and credit play an important role. A vast literature il-

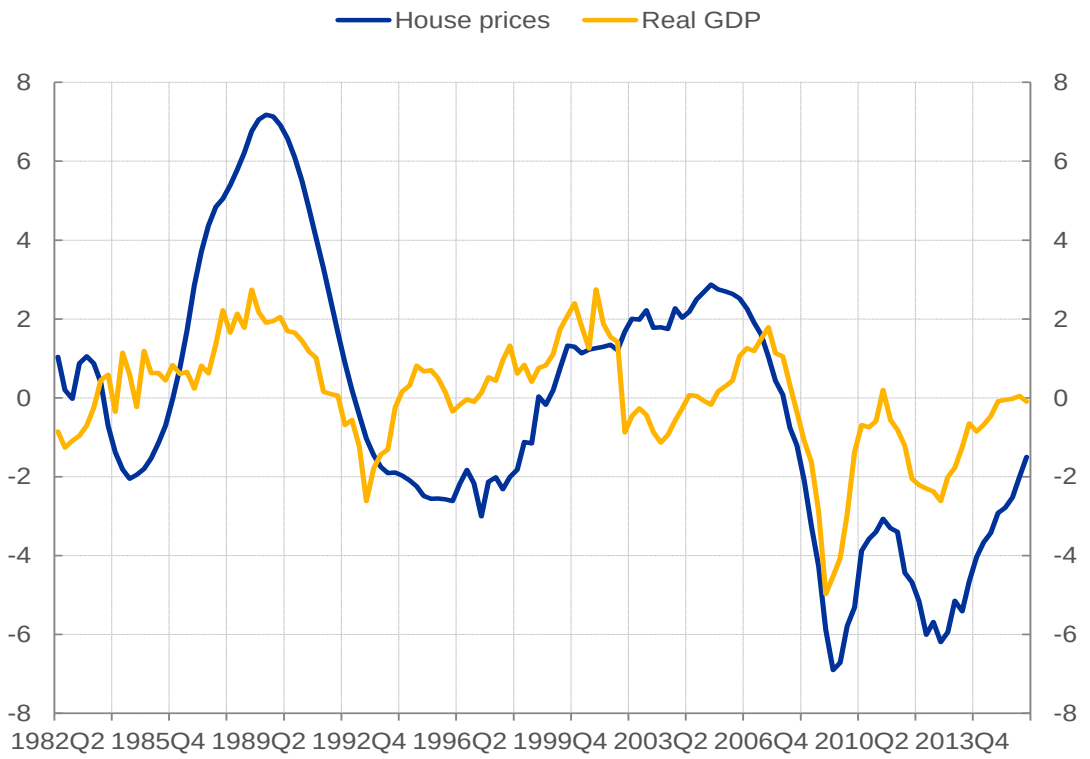
9 See especially Chapter 3.

lustrating the leading indicator property of money and credit for asset prices as well as the interaction between credit and asset prices (e.g. via the banks' leverage ratios and the financial accelerator) has been produced over the years (see, for instance, ECB (2010), Gerdesmeier et al. (2016) and all the references therein).

Compared to consumer prices, house prices can be found at an earlier stage of the transmission mechanism. In this respect, house prices might be subject to a variety of partly reinforcing, partly contradicting effects, such as income effects, substitution effects and other direct and indirect effects.

Turning to the results (see **Table 10** and **Table 11**), at the lower frequency all monetary aggregates (including loans) seem to prove sizable and significant, with the expected positive sign. While the output gap does not show any remarkable effect, real GDP exerts a strong and significant impact in all specifications. The strong and positive effect of the exchange rate can be explained by an income effect. An appreciation is equivalent to cheaper imports and, thus, more purchasing power available for spending, thus driving house prices up. Stock prices seem to show a substitution effect. No impact of oil prices on house prices can be detected at the lower frequency.

Chart 2: House prices and real GDP developments at long-run frequency



Source: own estimations.
Note: low frequency real GDP and house prices, both measured as (demeaned) annual growth rates.

Chart 3: House prices and loan developments at long-run frequency

Source: own estimations.
Note: low frequency loans to the private sector and house prices, both measured as (demeaned) annual growth rates.

As for the business cycle frequency, mainly real developments seem to dominate house prices, whereas exchange rates show no significant impact.

A graphical representation of house price developments and real GDP and loans at low frequency shows that they tend to co-move closely, also over the most recent period (see **Charts 2** and **Chart 3**).

6 Conclusions

The analysis carried out in this paper suggests that, within a single-equation framework, the interlinkages between, money, loans, inflation and real GDP vary across frequency. As the frequency increases, the fundamentals come to the fore. An application of the technique to house prices also shows the close interrelation of loans and house prices developments at the lower frequency. In our view, this speaks not only in favour of a medium-term orientation to be followed by the monetary authority but also for a constant and close monitor-

ing of real, monetary developments and exchange rate developments. This notwithstanding, the results should not be interpreted as if, over shorter horizons, it would not be necessary to carefully watch and analyse economic data. In this respect, it has to be kept in mind that in any point in time, the actual data are composed of signals convoluted over different frequencies.

An encompassing analysis of all variables under review at any point in time is needed and recommendable. Of course, a more detailed analysis of the interplay of leads and lags and of the causalities of all factors is warranted.[10] This is left for future research.

[10] It might, for instance, be considered to replace the single-equation framework with some VAR analysis.

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Annex 1. Tables

Table 1: Frequency Decomposition for HICP – long run (>8 years)

	I				II				III				IV				V				VI				VII			
M1	-0.003				-0.108				**-0.103*** **				-0.046				**-0.157***				-0.045				0.015			
	-0.03				*-1.31*				*-4.02*				*-0.52*				*-1.74*				*-0.48*				*0.15*			
M2		**0.368*** **				**0.384*** **				0.038				**0.396*** **				**0.420*** **				**0.428*** **				**0.419*** **		
		3.26				*3.53*				*0.96*				*3.65*				*3.77*				*4.20*				*4.18*		
M3			**0.294*** **				**0.336*** **				**0.066** **				**0.350*** **				**0.379*** **				**0.401*** **				**0.361*** **	
			3.24				*3.77*				*2.20*				*4.05*				*4.03*				*5.02*				*4.51*	
Loans				**0.186*** **				**0.291*** **				0.054				**0.312*** **				**0.333*** **				**0.311*** **				**0.243*** **
				3.00				*4.18*				*1.59*				*4.87*				*5.75*				*5.23*				*4.29*
Output gap	0.286	**0.354***	0.187	0.125																					0.196	0.195	-0.022	-0.070
	1.36	*1.93*	*1.10*	*0.67*																					*0.95*	*0.87*	*-0.11*	*-0.35*
Real GDP growth					0.199	0.121	-0.082	-0.299					0.132	0.092	-0.094	-0.318	0.035	0.011	-0.172	**-0.425** **	0.112	0.070	-0.122	-0.279				
					1.46	*0.87*	*-0.57*	*-1.20*					*0.98*	*0.68*	*-0.68*	*-1.35*	*0.26*	*0.08*	*-1.21*	*-2.21*	*0.81*	*0.52*	*-0.87*	*-1.24*				
Unemployment									**-0.094*** **	**-0.098*** **	**-0.095*** **	**-0.102*** **																
									-14.30	*-13.01*	*-12.46*	*-11.61*																
Exchange rate	**-0.040** **	**-0.042***	**-0.047*** **	**-0.041** **	**-0.048*** **	**-0.050** **	**-0.046** **	**-0.036** **	**0.029*** **	**0.020** **	0.016	**0.029*** **																
	-2.43	*-1.89*	*-2.26*	*-2.41*	*-2.87*	*-2.25*	*-2.31*	*-2.03*	*4.62*	*1.99*	*1.63*	*2.95*																
Stock prices																	**0.027** **	0.019	**0.023** **	**0.029** **								
																	2.42	*1.57*	*2.00*	*2.29*								
Oil prices																					0.007	0.012	**0.019** **	0.006	0.004	0.009	**0.016***	0.003
																					0.71	*1.40*	*2.29*	*0.68*	*0.43*	*1.08*	*1.89*	*0.30*

Source: own estimations based on the GMM-methodology, figures rounded. Sample period: 1980 Q1-2017 Q2.

Notes: t-statistics in italics. Instruments consist of two lags of the explanatory variables included in each equation. (***), (**) and (*) denote significance at 1%, 5% and 10%, respectively. "Short run" is defined as covering the frequency up to two years, "medium run" as covering the frequency from two to eight years and the "long run" as covering the frequency of eight years and beyond. All variables expressed as deviations of the annual percentages changes from their mean, with the exception of the output gap and the unemployment rate. The exchange rate is represented by the euro exchange rate vis-à-vis the US dollar.

Table 2: Frequency Decomposition for HICP – medium run (>2 but <8 years)

	I				II				III				IV				V				VI				VII			
M1	-0.058***				-0.112***				-0.001				-0.111***				-0.132***				-0.121***				-0.097***			
	-2.69				-4.35				-0.03				-3.26				-3.78				-3.86				-3.50			
M2		0.063				0.069				-0.017				0.090*				0.111*				0.078**				0.018		
		1.59				1.33				-0.30				1.78				1.91				2.28				0.55		
M3			0.054				0.127***				-0.071				0.156***				0.162***				0.100**				0.049	
			1.43				2.38				-1.14				2.73				3.07				2.07				1.57	
Loans				0.196**				0.220***				0.269***				0.251***				0.257***				0.198***				0.123*
				2.50				4.20				2.28				3.93				4.45				3.24				1.93
Output gap	0.069***	0.098***	0.086***	0.069***																					0.041*	0.060**	0.060**	0.048*
	2.61	3.63	3.39	2.64																					1.88	2.25	2.37	1.91
Real GDP					0.213***	0.161***	0.184***	0.153***					0.187***	0.145***	0.172***	0.148***	0.162***	0.146**	0.160***	0.144***	0.062**	0.124***	0.126***	0.066***				
					3.71	2.91	3.80	4.03					3.05	2.65	3.81	3.87	2.69	2.08	2.68	2.99	2.12	2.94	3.08	2.58				
Unemployment rate									-1.208***	-1.202***	-1.435***	-0.817*																
									-3.37	-3.86	-3.83	-1.81																
Exchange rate	-0.013***	-0.010**	-0.010**	-0.008*	-0.012***	-0.010**	-0.013***	-0.012***	-0.010	-0.008	-0.003	0.009																
	-3.23	-2.33	-2.48	-1.72	-2.88	-2.04	-2.68	-2.64	-0.88	-0.94	-0.33	0.86																
Stock prices																	0.004*	-0.001	0.001	0.001								
																	1.73	-0.37	0.28	0.25								
Oil prices																					0.010***	0.009***	0.008***	0.008***	0.009***	0.009***	0.008***	0.008***
																					6.48	5.24	4.78	5.96	6.50	6.06	5.36	6.77

Source: see Table 1.
Notes: see Table 1.

Table 3: Frequency Decomposition for HICP – short run (<2 years)

	I		II		III		IV		V		VI		VII	
M1	-0.112		0.176		-0.033		-0.254		-0.337		0.181		-0.321	
	-0.47		*0.63*		*-0.20*		*-0.31*		*-0.53*		*0.33*		*-0.15*	
M2	1.077		0.077		0.010		0.335		0.284		0.080		-0.166	
	0.96		*0.17*		*0.06*		*0.64*		*0.57*		*0.28*		*-0.25*	
M3	0.146		0.311		0.027		0.456		0.165		0.094		0.096	
	0.43		*0.77*		*0.13*		*1.10*		*0.48*		*0.20*		*0.26*	
Loans	-0.013		-0.176		-0.006		-0.050		-0.075		-0.002			0.026
	-0.09		*-1.13*		*-0.06*		*-0.35*		*-0.54*		*-0.02*			*0.23*
Output gap	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.03	*-1.06*	*-0.78*	*-0.12*									*0.08*	*-0.24*
Real GDP			0.142	-0.020	0.367	-0.128	0.092	0.527	0.029	0.113	-0.083	0.026	-0.014	0.170	0.042	0.083	0.018									
			0.50	*-0.06*	*0.56*	*-0.47*	*0.24*	*0.80*	*0.12*	*0.34*	*-0.23*	*0.08*	*-0.06*	*0.33*	*0.16*	*0.12*	*0.08*									
Unemployment rate							0.010	-0.003	-0.014	-0.017																
							0.33	*-0.12*	*-0.58*	*-0.57*																
Exchange rate	-0.024	-0.271	-0.085	0.030	-0.017	0.067	-0.045	0.115	0.051	**0.053***	0.044	**0.060***														
	-0.68	*-0.66*	*-0.60*	*0.42*	*-0.51*	*0.41*	*-0.46*	*1.40*	*1.55*	*1.65*	*1.55*	*1.77*														
Stock prices													-0.039	0.005	0.000	-0.007										
													-0.68	*0.17*	*0.00*	*-0.31*										
Oil prices																	0.004	0.004	0.007	0.003	0.007	0.007	0.012	0.008		
																	0.36	*0.27*	*0.22*	*0.20*	*0.13*	*0.28*	*0.47*	*0.56*		

Source: see Table 1.
Notes: see Table 1.

Table 4: Frequency Decomposition for the HICP – long run (>8 years)

	I			II			III			IV			V			VI			VII		
M1	-0.088			-0.230***			-0.091***			-0.046			-0.157*			-0.045			0.015		
	-1.01			-3.02			-3.26			-0.52			-1.74			-0.48			0.15		
M2		0.327***			0.320***			0.054			0.396***			0.420***			0.428***			0.419***	
		3.78			3.52			1.17			3.65			3.77			4.20			4.18	
M3			0.271***			0.313***			0.088***			0.350***			0.379***			0.401***			0.361***
			4.77			4.56			2.65			4.05			4.03			5.02			4.51
Loans			0.185***			0.263***			0.050			0.312***			0.333***			0.311***			0.243***
			3.16			4.16			1.51			4.87			5.75			5.23			4.29
Output gap	0.318	0.455***	0.305**	0.223															0.196	0.195	-0.022	-0.070
	1.62	2.75	2.01	1.22															0.95	0.87	-0.11	-0.35
Real GDP					0.282***	0.192*	0.046	-0.169			0.132	0.092	-0.094	-0.318	0.035	0.011	-0.172	-0.425**	0.112	0.070	-0.122	-0.279				
					2.89	1.67	0.37	-0.89			0.98	0.68	-0.68	-1.35	0.26	0.08	-1.21	-2.21	0.81	0.52	-0.87	-1.24				
Unemployment rate							-0.088***	-0.095***	-0.094***	-0.097***																
							-13.04	-11.26	-11.57	-10.48																
Exchange rate	-0.022	-0.050	-0.063*	-0.035	-0.012	-0.043	-0.063*	-0.029	0.035***	0.025*	0.015	0.041***														
	-0.65	-1.45	-1.91	-1.05	-0.38	-1.13	-1.65	-0.90	4.17	1.77	1.23	3.16														
Stock prices																0.027**	0.019	0.023**	0.029**							
																2.42	1.57	2.00	2.29							
Oil prices																			0.007	0.012	0.019**	0.006	0.004	0.009	0.016*	0.003
																			0.71	1.40	2.29	0.68	0.43	1.08	1.89	0.30

Source: see Table 1.
Notes: see Table 1. In this table, the exchange rate is represented by the nominal effective exchange rate.

Table 5: Frequency Decomposition for the HICP – medium run (>2 but <8 years)

	I				II		III		IV		V		VI		VII	
M1	-0.069***				-0.113***		-0.024		-0.111***		-0.132***		-0.121***		-0.097***	
	-3.17				-4.71		-0.65		-3.26		-3.78		-3.86		-3.50	
M2		0.090**				0.082		-0.023		0.090*		0.111*		0.078**		0.018
		2.29				1.53		-0.37		1.78		1.91		2.28		0.55
M3			0.084**			0.150***		-0.067		0.156***		0.162***		0.100**		0.049
			2.20			2.80		-0.91		2.73		3.07		2.07		1.57
Loans				0.255***				0.251**		0.251***			0.257***		0.198***		0.123*
				3.61				2.23		3.93			4.45		3.24		1.93
Output gap	0.069***	0.100***	0.080***	0.051*											0.041*	0.060**	0.059**	0.048*
	2.65	3.51	3.34	1.87											1.88	2.25	2.37	1.91
Real GDP					0.183***	0.130**	0.155***	0.114***	0.187***	0.145***	0.172***	0.148***	0.162***	0.146**	0.160***	0.144***	0.062**	0.124***	0.126***	0.066***
					3.36	2.28	3.29	2.68	3.05	2.85	3.81	3.87	2.69	2.08	2.68	2.99	2.12	2.94	3.08	2.58
Unemployment rate							-1.109***	-1.332***	-1.480***	-0.838**										
							-2.70	-4.60	-3.82	-2.13										
Exchange rate	-0.024***	-0.016**	-0.017**	-0.022***	-0.018**	-0.014*	-0.018**	-0.020**	-0.025***	-0.015*	-0.011	-0.008								
	-3.20	-2.08	-2.26	-3.17	-2.33	-1.68	-2.30	-2.52	-2.99	-1.81	-1.09	-0.68								
Stock prices													0.004*	-0.001	0.001	0.001				
													1.73	-0.37	0.28	0.25				
Oil prices																	0.010***	0.009***	0.008***	0.008***
																	6.48	5.24	4.78	5.96

	I				II		III		IV		V		VI		VII	
M1	-0.069***				-0.113***		-0.024		-0.111***		-0.132***		-0.121***		-0.097***	
	-3.17				-4.71		-0.65		-3.26		-3.78		-3.86		-3.50	
M2		0.090**				0.082		-0.023		0.090*		0.111*		0.078**		0.018
		2.29				1.53		-0.37		1.78		1.91		2.28		0.55
M3			0.084**			0.150***		-0.067		0.156***		0.162***		0.100**		0.049
			2.20			2.80		-0.91		2.73		3.07		2.07		1.57
Loans				0.255***				0.251**		0.251***			0.257***		0.198***		0.123*
				3.61				2.23		3.93			4.45		3.24		1.93
Output gap	0.069***	0.100***	0.080***	0.051*											0.041*	0.060**	0.059**	0.048*
	2.65	3.51	3.34	1.87											1.88	2.25	2.37	1.91
Real GDP					0.183***	0.130**	0.155***	0.114***	0.187***	0.145***	0.172***	0.148***	0.162***	0.146**	0.160***	0.144***	0.062**	0.124***	0.126***	0.066***
					3.36	2.28	3.29	2.68	3.05	2.85	3.81	3.87	2.69	2.08	2.68	2.99	2.12	2.94	3.08	2.58
Unemployment rate							-1.109***	-1.332***	-1.480***	-0.838**										
							-2.70	-4.60	-3.82	-2.13										
Exchange rate	-0.024***	-0.016**	-0.017**	-0.022***	-0.018**	-0.014*	-0.018**	-0.020**	-0.025***	-0.015*	-0.011	-0.008								
	-3.20	-2.08	-2.26	-3.17	-2.33	-1.68	-2.30	-2.52	-2.99	-1.81	-1.09	-0.68								
Stock prices													0.004*	-0.001	0.001	0.001				
													1.73	-0.37	0.28	0.25				
Oil prices																	0.010***	0.009***	0.008***	0.008***
																	6.48	5.24	4.78	5.96

Source: see Table 1.
Notes: see Table 4.

Table 6: Frequency Decomposition for the GDP deflator – long run (>8 years)

	I				II				III				IV				V				VI				VII			
M1	0.081				0.037				**0.057***				0.069				-0.050				0.062				0.148			
	0.62				*0.29*				*1.92*				*0.53*				*-0.42*				*0.52*				*1.23*			
M2		**0.524*** **				**0.528*** **				0.029				**0.533*** **				**0.610*** **				**0.483*** **				**0.503*** **		
		4.95				*4.84*				*0.82*				*5.06*				*6.01*				*4.53*				*4.92*		
M3			**0.455*** **				**0.479*** **				0.029				**0.489*** **				**0.525*** **				**0.457*** **				**0.444*** **	
			5.99				*5.84*				*0.94*				*6.56*				*6.77*				*5.76*				*6.00*	
Loans				**0.300*** **				**0.321*** **				0.010				**0.322*** **				**0.351*** **				**0.351*** **				**0.324*** **
				7.25				*5.28*				*0.56*				*5.31*				*6.54*				*5.70*				*7.21*
Output gap	0.117	0.084	-0.135	-0.270																					0.214	0.074	-0.155	-0.273
	0.50	*0.37*	*-0.65*	*-1.17*																					*0.83*	*0.32*	*-0.71*	*-1.12*
Real GDP					0.160	0.116	-0.086	-0.275					0.132	0.124	-0.058	-0.271	0.065	-0.058	**-0.247***	**-0.492** **	0.213	0.211	-0.002	-0.240				
					0.98	*0.76*	*-0.55*	*-1.09*					*0.80*	*0.82*	*-0.38*	*-1.07*	*0.34*	*-0.39*	*-1.80*	*-2.19*	*1.31*	*1.43*	*-0.01*	*-0.92*				
Unemployment rate									**-0.144*** **	**-0.137*** **	**-0.135*** **	**-0.133*** **																
									-23.54	*-23.88*	*-19.68*	*-20.00*																
Exchange rate	0.004	-0.003	-0.009	-0.005	-0.005	-0.006	0.000	0.005	**0.042*** **	**0.037*** **	**0.037*** **	**0.035*** **																
	0.13	*-0.10*	*-0.33*	*-0.19*	*-0.20*	*-0.20*	*0.00*	*0.17*	*7.39*	*4.01*	*3.70*	*3.84*																
Stock prices																	**0.026***	**0.031** **	**0.037*** **	**0.038** **								
																	1.91	*2.44*	*3.50*	*2.55*								
Oil prices																					**-0.022** **	**-0.02*** **	**-0.015** **	**-0.028*** **	**-0.024*** **	**-0.017** **	**-0.011**	**-0.027*** **
																					-2.50	*-2.65*	*-2.01*	*-4.12*	*-2.64*	*-2.19*	*-1.44*	*-3.43*

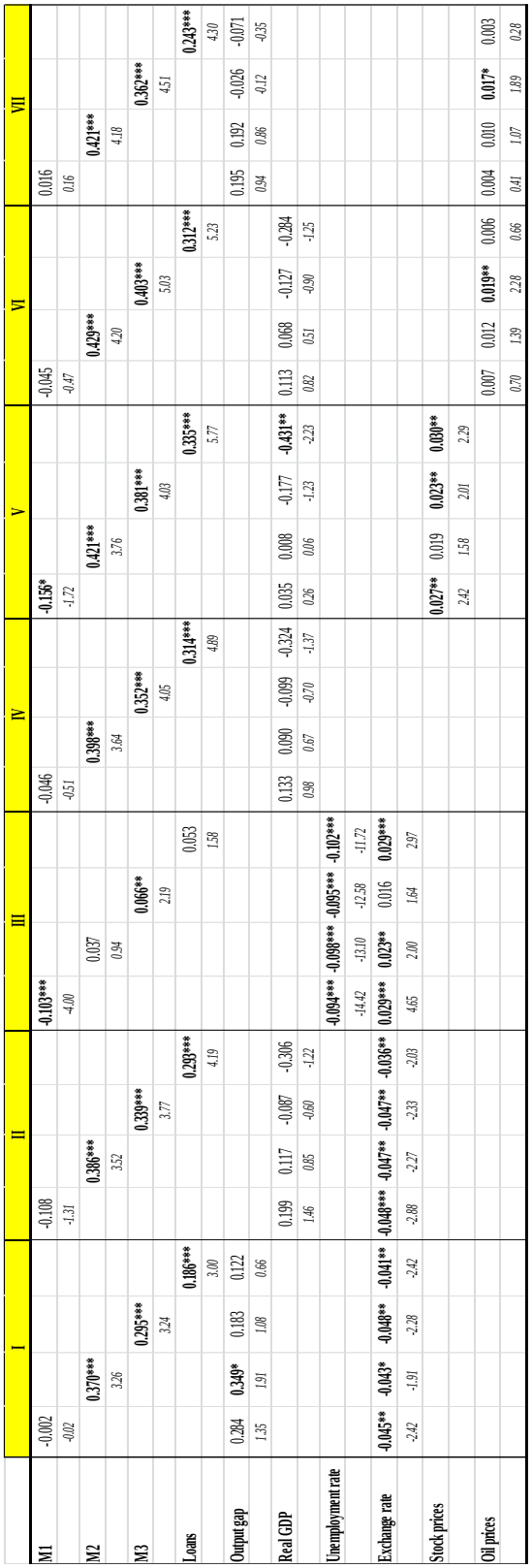
Source: see Table 1.
Notes: see Table 1.

Table 7: Frequency Decomposition for the GDP deflator – medium run (>2 but <8 years)

	I			II			III			IV			V			VI			VII		
M1	-0.020			**-0.056***			**-0.074***			**-0.056****			**-0.111*****			**-0.053****			-0.031		
	-0.68			*-1.93*			*-1.74*			*-1.98*			*-3.32*			*-2.05*			*-1.15*		
M2		0.008			-0.032			**0.154****			-0.057			-0.071			-0.022			0.013		
		0.19			*-0.66*			*2.18*			*-1.00*			*-1.23*			*-0.44*			*0.31*		
M3			0.063			0.043			**0.198*****			0.041			0.025			0.046			0.038	
			1.24			*0.93*			*4.94*			*0.76*			*0.51*			*1.20*			*0.89*	
Loans					**0.100***							0.093			0.095			**0.116****				0.039
			0.026		*1.82*			0.133				*1.49*			*1.53*			*2.07*				*0.58*
Output gap	0.023	0.022	0.021	0.042				*1.36*											**0.050****	**0.046***	**0.049***	**0.059****
	1.08	*0.85*	*0.80*	*1.41*															*2.20*	*1.85*	*1.82*	*2.04*
Real GDP					-0.045	**-0.086***	-0.054	-0.029		-0.026	-0.069	-0.036	-0.017	**-0.132*****	**-0.115***	-0.071	-0.073	0.034	-0.013	0.042	0.055			
					-1.36	*-1.78*	*-1.35*	*-1.08*		*-0.81*	*-1.45*	*-0.87*	*-0.59*	*-3.28*	*-1.88*	*-1.25*	*-1.58*	*0.88*	*-0.22*	*0.70*	*1.55*			
Unemployment rate									-0.008	-0.184	-0.077	0.123												
									-0.03	*-0.81*	*-0.38*	*0.30*												
Exchange rate	0.002	0.001	0.002	0.002	0.006	0.008	0.006	0.002	-0.004	-0.008	-0.006	-0.003												
	0.31	*0.20*	*0.28*	*0.23*	*0.89*	*1.15*	*0.89*	*0.27*	*-0.59*	*-1.45*	*-1.21*	*-0.51*												
Stock prices													**0.016*****	**0.014*****	**0.010****	**0.008***								
													3.59	*2.87*	*2.00*	*1.86*								
Oil prices																	**-0.007*****	**-0.006*****	**-0.008*****	**-0.008*****	**-0.007****	**-0.007****	**-0.007****	**-0.007*****
																	-3.34	*-2.97*	*-3.32*	*-4.05*	*-3.94*	*-3.95*	*-3.49*	*-3.95*

Source: see Table 1.
Notes: see Table 1.

Table 8: Frequency Decomposition for HICP – long run (>16 years)



	I			II			III			IV			V			VI			VII		
M1	-0.002			-0.108			**-0.103*** **			-0.046			**-0.156***			-0.045			0.016		
	-0.02			*-1.31*			*-4.00*			*-0.51*			*-1.72*			*-0.47*			*0.16*		
M2		**0.370*** **			**0.386*** **			0.037			**0.398*** **			**0.421*** **			**0.429*** **			**0.421*** **		
		3.26			*3.52*			*0.94*			*3.64*			*3.76*			*4.20*			*4.18*		
M3			**0.295*** **			**0.339*** **			**0.066** **			**0.352*** **			**0.381*** **			**0.403*** **			**0.362*** **	
			3.24			*3.77*			*2.19*			*4.05*			*4.03*			*5.03*			*4.51*	
Loans			**0.186*** **			**0.293*** **			0.053			**0.314*** **			**0.335*** **			**0.312*** **			**0.243*** **	
			3.00			*4.19*			*1.58*			*4.89*			*5.77*			*5.23*			*4.30*	
Output gap	0.284	**0.349***	0.183	0.122															0.195	0.192	-0.026	-0.071
	1.35	*1.91*	*1.08*	*0.66*															*0.94*	*0.86*	*-0.12*	*-0.35*
Real GDP					0.199	0.117	-0.087	-0.306			0.133	0.090	-0.099	-0.324	0.035	0.008	-0.177	**-0.431** **	0.113	0.068	-0.127	-0.284				
					1.46	*0.85*	*-0.60*	*-1.22*			*0.98*	*0.67*	*-0.70*	*-1.37*	*0.26*	*0.06*	*-1.23*	*-2.23*	*0.82*	*0.51*	*-0.90*	*-1.25*				
Unemployment rate									**-0.094*** **	**-0.098*** **	**-0.095*** **	**-0.102*** **														
									-14.42	*-13.10*	*-12.58*	*-11.72*														
Exchange rate	**-0.045** **	**-0.043***	**-0.048*** **	**-0.041*** **	**-0.048*** **	**-0.047** **	**-0.047** **	**-0.036** **	**0.029*** **	**0.022** **	0.0016	**0.029*** **														
	-2.42	*-1.91*	*-2.28*	*-2.42*	*-2.88*	*-2.27*	*-2.33*	*-2.03*	*4.65*	*2.00*	*1.64*	*2.97*														
Stock prices															**0.027** **	0.019	**0.023** **	**0.030** **								
															2.42	*1.58*	*2.01*	*2.29*								
Oil prices																			0.007	0.012	**0.019** **	0.006	0.004	0.010	**0.017***	0.003
																			0.70	*1.39*	*2.28*	*0.66*	*0.41*	*1.07*	*1.89*	*0.28*

Source: see Table 1

Notes: see Table 1. In this table, "short run" is defined as covering the frequency up to two years, "medium run" as covering the frequency from two to sixteen years and the "long run" as covering the frequency of sixteen years and beyond.

Table 9: Frequency Decomposition for HICP – medium run (>2 but <16 years)

	I				II			III			IV			V			VI			VII		
M1	-0.058***				-0.112***			-0.001			-0.111***			-0.132***			-0.122***			-0.097***		
	-2.70				-4.35			-0.03			-3.26			-3.78			-3.86			-3.50		
M2		0.064				0.069			-0.017			0.091*			0.111*			0.078**			0.018		
		1.59				1.33			-0.30			1.78			1.92			2.28			0.55		
M3			0.055			0.127**			-0.071			0.156***			0.162***			0.100**			0.049		
			1.44			2.39			-1.13			2.73			3.07			2.07			1.57		
Loans				0.196**			0.220***			0.269**			0.251***			0.257***			0.198***			0.123*	
				2.50			4.20			2.28			3.93			4.46			3.25			1.93	
Output gap	0.070***	0.101***	0.088***	0.071***																0.042*	0.062**	0.060**	0.049*	
	2.61	3.63	3.59	2.64																1.88	2.25	2.37	1.92	
Real GDP					0.213***	0.161***	0.184***	0.153***			0.187***	0.145***	0.172***	0.148***	0.161***	0.147**	0.160***	0.143***	0.062**	0.124***	0.126***	0.066***		
					3.71	2.91	3.80	4.02			3.05	2.85	3.82	3.87	2.69	2.08	2.68	2.99	2.13	2.94	3.08	2.38		
Unemployment rate								-1.288***	-1.202***	-1.434***	-0.817*													
								-3.37	-3.87	-3.83	-1.82													
Exchange rate	-0.013***	-0.01**	-0.01**	-0.008*	-0.012***	-0.010**	-0.013***	-0.012***	-0.010	-0.008	-0.003	0.009												
	-3.24	-2.24	-2.49	-1.73	-2.88	-2.04	-2.68	-2.64	-0.89	-0.95	-0.33	0.86												
Stock prices														0.004*	-0.001	0.001	0.001							
														1.73	-0.38	0.27	0.25							
Oil prices																		0.010***	0.009***	0.008***	0.008***	0.009***	0.008***	0.008***
																		6.48	5.24	4.78	5.95	6.50	6.06	5.36	6.77

Source: see Table 1.
Notes: see Table 8.

Table 10: Frequency Decomposition for house prices – long run (>8 years)

	I			II			III			IV			V			VI			VII		
M1	0.932***			0.234			0.593**			0.111			0.499***			0.128			0.938***		
	4.52			1.49			2.55			0.59			2.64			0.70			4.13		
M2		0.715***			0.683***			0.440			0.719***			0.792***			0.731***			0.822***	
		3.57			4.44			1.63			4.66			5.00			4.74			4.19	
M3			0.779***			0.732***			0.368*			0.725***			0.760***			0.740***			0.858***
			6.53			7.19			1.87			7.02			7.38			6.99			8.58
Loans				0.683***			0.468***			0.348***			0.443***			0.478***			0.476***			0.696***
				7.18			4.72			2.63			5.84			4.92			6.48			9.53
Output gap	1.421***	0.627	0.184	-0.060															1.789***	0.662	0.282	0.059
	2.95	1.31	0.40	-0.14															3.32	1.32	0.61	0.13
Real GDP					1.600***	1.560***	1.276***	0.982***				1.726***	1.592***	1.305***	1.159***	2.120***	1.736***	1.398***	1.325***	1.715***	1.606***	1.296***	1.174***	
					6.81	8.65	8.23	4.13				6.63	8.45	7.87	5.34	7.37	7.35	6.98	4.22	6.60	8.30	7.13	5.30	
Unemployment rate									-0.125***	-0.016	-0.007	-0.075**												
									-3.05	-0.42	-0.17	-2.21												
Exchange rate	0.109**	0.075*	0.062	0.097***	0.136***	0.094***	0.075**	0.098***	0.172***	0.039	0.045	0.137**												
	2.42	1.92	1.63	2.83	3.46	2.62	2.20	2.81	4.18	0.53	0.70	2.30												
Stock prices													-0.097***	-0.071***	-0.050***	-0.060***								
													-5.35	-4.28	-3.18	-3.44								
Oil prices																	-0.008	-0.009	0.003	-0.018	0.005	0.015	0.021*	-0.014
																	-0.44	-0.74	0.31	-1.38	0.25	1.14	1.77	-1.22

Source: see Table 1.
Notes: see Table 1.

Table 11: Frequency Decomposition for house prices – medium run (2< to <8 years)

	I				II				III				IV				V				VI				VII			
M1	0.105				0.000				0.082				-0.008				-0.005				0.019				0.057			
	1.52				*0.00*				*0.88*				*-0.12*				*-0.08*				*0.32*				*0.76*			
M2	**0.197****				**0.284*****				0.020				**0.319*****				**0.199****				**0.212*****				**0.131***			
	2.18				*2.89*				*0.16*				*3.22*				*2.07*				*2.80*				*1.90*			
M3		0.076				**0.285*****				-0.071				**0.331*****				**0.218****				**0.227*****				0.084		
		0.78				*3.30*				*-0.52*				*3.69*				*2.42*				*2.88*				*1.07*		
Loans			0.120				0.166				**0.554*****				**0.216***				**0.210***				**0.232****				0.036	
			0.95				*1.49*				*3.51*				*1.91*				*1.90*				*2.09*				*0.29*	
Output gap	**0.105****	**0.082*****	0.067	0.051																					**0.111*****	**0.093*****	**0.085*****	**0.089*****
	2.06	*2.05*	*1.48*	*1.20*																					*3.08*	*2.87*	*2.58*	*2.87*
Real GDP					**0.533*****	**0.507*****	**0.518*****	**0.421*****					**0.569*****	**0.605*****	**0.631*****	**0.542*****	**0.462*****	**0.490*****	**0.532*****	**0.396****	**0.429*****	**0.507*****	**0.524*****	**0.443*****				
					4.32	*3.87*	*4.15*	*3.88*					*4.46*	*4.58*	*4.92*	*4.73*	*3.81*	*3.81*	*4.32*	*3.38*	*5.77*	*5.68*	*5.63*	*5.85*				
Unemployment rate									**-2.143*****	**-1.759*****	**-2.029*****	-0.001																
									-2.98	*-2.90*	*-2.98*	*0.00*																
Exchange rate	0.004	0.001	-0.005	-0.004	-0.002	0.002	-0.001	-0.005	0.016	0.013	0.018	0.019																
	0.35	*0.11*	*-0.38*	*-0.31*	*-0.20*	*0.18*	*-0.12*	*-0.46*	*0.66*	*0.62*	*0.88*	*0.84*																
Stock prices																	**0.014***	0.007	0.006	**0.011***								
																	1.72	*1.42*	*1.13*	*1.76*								
Oil prices																					**0.014*****	**0.011*****	**0.012*****	**0.012*****	0.016***	0.014***	0.015***	0.015***
																					5.87	*4.14*	*4.36*	*4.71*	*4.73*	*4.79*	*4.97*	*5.06*

Source: see Table 1.
Notes: see Table 1.

Annex 2. Data description and sources

Variable	Description	Source
HICP	Harmonised Index of Consumer Prices (HICP) – overall index. Before January 1992 national Consumer Price Indices (CPIs, excluding owner occupied housing, except for Spain). Overall index for EA19 countries.	ECB, ECB calculations, Eurostat
GDP deflator	GDP Deflator for EA19 countries, seasonally adjusted, 2005 = 100.	ECB, ECB calculations, Eurostat
House prices	Residential property prices, new and existing dwellings, in good & poor condition, based on aggregating euro area country residential property prices, using GDP weights at PPP exchange rates.	Residential Property Price Index Statistics, ECB, own calculations
M1	Harmonised monetary aggregate M1 "adjusted" stock, based on aggregating euro area country harmonised M1 series using the irrevocable fixed exchange rates. Adjusted after October 1997 for the effect of reclassifications, other revaluations, exchange rate variations and the euro area enlargements.	ECB, ECB calculations
M2	Harmonised monetary aggregate M2 "adjusted" stock, based on aggregating euro area country harmonised M2 series using the irrevocable fixed exchange rates. Adjusted after October 1997 for the effect of reclassifications, other revaluations, exchange rate variations and the euro area enlargements.	ECB, ECB calculations
M3	Harmonised monetary aggregate M3 "adjusted" stock, based on aggregat-	ECB, ECB calculations

	ing euro area country harmonised M3 series using the irrevocable fixed exchange rates. Adjusted after October 1997 for the effect of reclassifications, other revaluations, exchange rate variations and the euro area enlargements.	
Loans to the private sector	Loans to the private sector (adjusted after October 1997 for the effect of reclassifications, other revaluations, exchange rate variations and the euro area enlargements), total maturity, all currencies combined. Based on aggregating euro area country harmonised loans series using the irrevocable fixed exchange rates.	ECB, ECB calculations
Real GDP	The quarterly series are calculated by aggregating national GDP data using the irrevocable fixed exchange rate. See Brand, Gerdesmeier and Roffia (2002).	ECB, ECB calculations, Eurostat
Unemployment rate	Unemployment as percentage of labour force in EA19 (fixed composition), seasonally adjusted, but not working day adjusted.	ECB, Eurostat
Euro exchange rate vis-à-vis the US -dollar	Exchange rate USD/1EUR(ECU), spot at 2.15 PM (CET), monthlyaverage	BIS
Nominal effective exchange rate	ECB Nominal effective exch. rate of the Euro against, EER-38 group of trading partners.	ECB
Stock prices	EMU-DS market - Price Index, closing price.	BIS
Oil prices	World market prices, crude oil, USD basis, HWWA, 1990=100.	BIS

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