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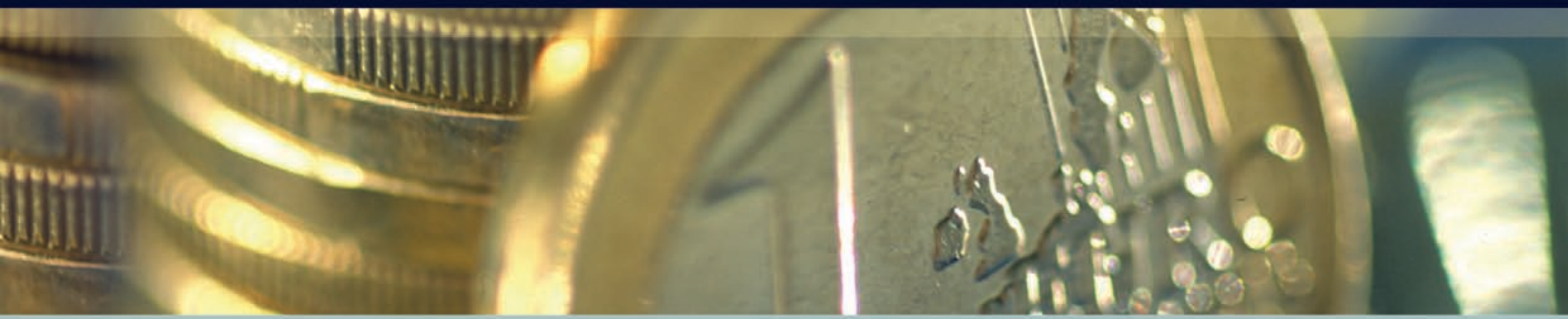

Heterogeneity in money holdings across euro area countries: the role of housing

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Heterogeneity in money holdings across euro area countries: the role of housing[*]

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Abstract

In this paper we examine why monetary aggregates of euro area Member States have developed differently since the inception of the euro. We derive a money demand equation that incorporates housing wealth and collateral as well as substitution effects on real money holdings. Empirically, we show that cross-country differences in real balances are determined not only by income differences, a standard determinant of money demand, but also by house price developments. Higher house prices and higher user costs of housing are both associated with larger money holdings. Country-specific money holdings are also connected with structural features of the housing market.

JEL: E41, E51, E52

Keywords: Money, housing, national contribution, euro area

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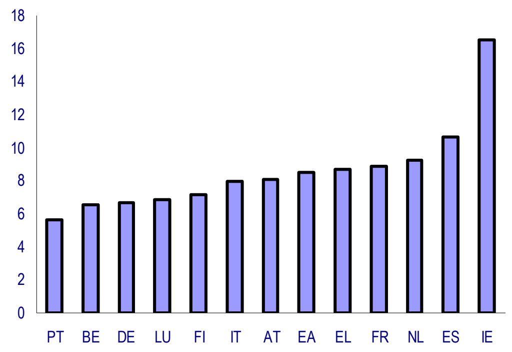
1 Introduction

From the outset the monetary policy framework of the ECB has stressed the importance of monetary variables. The special consideration of monetary variables is based on the generally accepted view that, in the long term, “inflation is a monetary phenomenon”, meaning that monetary growth in the medium to long term is associated with a rise in the general price level. Moreover, in the wake of the financial crisis, the role of money growth as a factor determining financial stability has been stressed more prominently again.[1] From a financial as well as price stability perspective, it is therefore important to understand the central determinants of monetary aggregates which is typically done in a money demand framework.

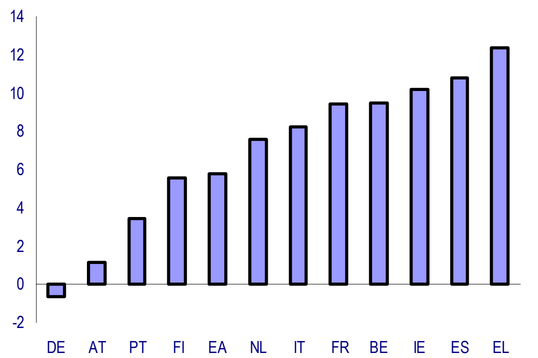
The current paper investigates the demand for money in the euro area with a special focus on the heterogeneity of monetary and housing market dynamics across euro area countries. From a policy point of view, this topic is of great importance as real and nominal divergence across euro area countries has been persistent and substantial. An investigation into the link between housing and money could help to understand determinants of that heterogeneity. In particular, housing markets could play a key role in explaining divergences in money across euro area countries. To the extent that these developments reflect intra-area disequilibria, a thorough review of the structural features of the housing market would be conducive to increasing intra-euro area cohesion and macro-financial stability.

Graph 1: **Growth of national contributions to M3 (1)**



(1) average annual nominal growth from 1999 to 2008 in %.
Source: ECB.

Graph 2: **House price growth (1)**



(1) average annual nominal growth from 1999 to 2008 in %.
Source: ECB and OECD.

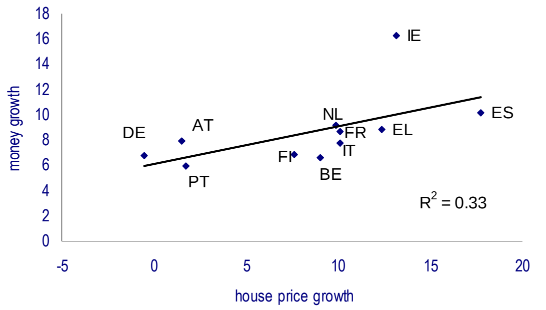
We start from the observation that monetary aggregates have behaved very differently across euro area Member States since the introduction of the euro. The heterogeneity in monetary dynamics among euro area countries is reflected in pronounced differences in the average annual growth of the national contributions to

[1] For example, some studies find that house price bubbles could be driven by excessive money or credit growth (Alessi and Detken 2009, Gerdesmeier, Reimers and Roffia 2009, Agnello and Schuknecht 2009, Eickmeier and Hofmann 2009).

M3 since 1999[2] For example, national contributions' annual rate of growth was 6.6 percent in Germany compared to 10.6 percent in Spain (average from 1999 to 2008).[3] Ireland recorded by far the strongest money growth with an average growth rate of more than 16 percent annually. To our knowledge, no recent contribution has studied the determinants of this heterogeneity within a money demand framework.

At the same time, house price developments have been even more diverse across euro area countries. Several countries experienced strong increases in house prices, which in the cases of Ireland and Spain reached double-digit average annual growth rates (Graph 2).[4] The central hypothesis of this paper is therefore, that differences in real house price developments have been among the central factors driving the heterogeneity in monetary dynamics. This hypothesis finds some graphical evidence in Figure 3. Countries with high growth rates for house prices, such as Spain, Ireland or Greece, also show high growth rates for national contributions to M3.[5]

Graph 3**: House prices and money in the euro area (1)**



(1) average annual growth from 1999 to 2008 in %
Source: ECB and OECD.

Earlier studies of money demand identified stable relationships between real balances, real income and interest rates in the euro area (see e.g. Calza, Gerdesmeier and Levy 2001). As a result of the strong monetary dynamics after 2001, traditional money demand specifications for the euro area that model the real M3 stock as function of real GDP and an interest rate variable (for example, the difference between the three-month money market rate and the return on M3 assets), leave a major part of monetary growth since 2001 unexplained. Several explanations for the monetary overhang have been given. For a time, the heightened economic and geopolitical uncertainties in the wake of the terrorist attacks of 11 September 2001 and the dramatic decline in stock prices between 2000 and 2003 were speaking for a demand-side-driven acceleration of monetary growth in the euro area. At that time, the response of households and enterprises included extensive portfolio shifts in favour of secure and liquid bank deposits which are part of M3 (Greiber and Lemke 2005, Carstensen 2006).

[2] National contributions to euro area M3 do not include currency in circulation. Note also that a country's national contributions to euro area monetary aggregates are defined as liabilities of domestic monetary financial institutions (MFI) to the whole euro area non-MFI sector. As such, e.g, German households' and enterprises' short-term deposits held with branches and subsidiaries of German MFIs in Luxembourg are part of Luxembourg's contribution to euro area M3. However, the amount of deposits from and loans to euro area residents outside the domestic country is very low. As such, it can be assumed that national contributions to M3 are driven by macroeconomic developments in the individual euro area countries.

[3] Moreover, M3 dynamics have been varying substantially over time, as can be seen in Figures A1 and A2 of the appendix.

[4] Figures A3 and A4 in the appendix show the heterogenous profiles of the time series.

[5] Omitting Ireland form the graph still leaves a positive and significant relation between housing and money.

After around mid-2004, however, such special effects have no longer been boosting monetary growth. Instead, the monetary expansion was driven by a marked increase in lending. At the same time, the macroeconomic development in the euro area in the 2004 to 2007 period was characterised by a very sharp increase in the price of assets, in particular house prices. The more recent literature on aggregate money demand in the euro area accounts for these developments and explains the sharp credit-driven money growth in the post-2004 period by incorporating developments in asset markets. A number of studies extends conventional money demand functions by including housing or financial wealth variables (Boone and van den Noord 2008, Greiber and Setzer 2007, de Santis et al. 2008, de Bondt 2009, Beyer 2009). One important conclusion that can be drawn from these studies is that monetary developments at times cannot be fully explained by real income or interest rates and that asset market developments need to be included.

The remainder of the paper is structured as follows. The next section derives a money demand equation from a theoretical model incorporating wealth/collateral as well as substitution effects. In section 3, we develop our empirical specification that is particularly suited to uncover the heterogeneity of monetary dynamics across euro area countries. Our empirical results, presented in section 4, show that differences in money holdings across euro area countries can be explained by key features of the housing market as well as differences in real-economy developments. Finally, we draw some policy conclusion (section 5).

2 Housing in the money demand equation

Empirical approaches to money demand that incorporate housing have often been subject to the criticism that they were not underpinned by a structural model. Authors therefore questioned the stability of the ad-hoc empirical relation on the basis of a missing theoretical foundation. In this section, we try to remedy this by deriving a money demand model that is augmented by housing market developments.

Standard specifications for money demand equations usually comprise a rather narrow range of explanatory variables. Money demand varies with the volume of activity or transactions and the price level in line with the quantity theory of money. In addition, money demand is assumed to decrease if the interest rate rises, because the opportunity cost of holding liquidity as opposed to bonds increases. We propose to augment the standard money demand relationship with explanatory variables that capture the possible impact of house prices on money demand.

In a seminal paper, Friedman (1988) classified the possible relationships between asset prices and money demand into wealth, substitution, and transaction effect:

- The *wealth effect* stems from the fact that money is a store of value and as such serves as an alternative to holding other assets such as housing or financial wealth. An increase in house prices leading to differences between existing and desired portfolio composition, can then be associated with a rise in the portfolio demand for real balances in order to adjust the portfolio composition to the desired equilibrium.

- In contrast to the wealth effect, a *substitution effect* postulates that changes in the relative attractiveness of different assets alter the individual's portfolio structure. Specifically, an (expected) rise in house prices, *ceteris paribus*, renders this type of investment more attractive than holding money balances and causes a portfolio shift into housing and away from money.
- The *transaction effect* captures that housing sales and purchases mirrored in price and volume movements imply a rise in the need for money due to a simple transaction motive. This effect is possibly amplified by a rise in the number of transactions on the housing market during housing boom episodes (Stein 1995).

The wealth and substitution effects are both *portfolio effects*, but carry opposite signs and therefore are partly offsetting each other. The sign of the total portfolio effect of house prices on money demand is thus ambiguous and can only be determined empirically.

A further important aspect of the relation between housing and money stems from the *collateral effect* of household's assets. Higher house prices increase the collateral values of homes and improve home owners' access to loans, fostering credit and money growth. Due to asymmetric information distribution on credit markets, agents' ability to borrow depends on the value of their collateral (Iacoviello 2004, 2005). Since housing wealth is an important balance sheet variable, it determines the borrowing constraints faced by agents. Higher collaterals reduce the influence of asymmetric information and improve lending conditions. Thus there is a direct link between housing and loan developments. Moreover, in the spirit of Kiyotaki and Moore (1997) housing property may act as a catalyst which amplifies the effects of monetary policy.

In order to illustrate how the portfolio (wealth and substitution) and collateral effects could enter the money demand equation we set up a model that combines the two. It takes the standard model for money and consumption as a starting point, and extends it with housing as an argument in the utility function. Housing is considered to be both a consumer durable that delivers utility in the form of housing services, and a (real) asset that serves as a store of wealth akin to bonds and cash balances. Following Iacoviello (2004) and others we split the household sector in 'lenders' and 'borrowers'. The lenders are assumed to finance their homes with own savings and to hold bonds, whereas the borrowers are assumed to take up mortgage loans to finance their homes – hence they face a collateral constraint.

The optimisation decision faced by the *lenders* is:

(1) $$\max_{C_t^l, \frac{M_t^l}{P_t}, H_t^l} E_0\left[\sum_{t=0}^{\infty} \beta^t U\left(C_t^l, \frac{M_t^l}{P_t}, H_t^l\right)\right]$$

subject to the flow of funds constraint:

(2) $$C_t^l + \frac{B_t^l}{P_t} + \frac{M_t^l}{P_t} + \frac{Q_t}{P_t}\left(H_t^l - H_{t-1}^l\right) = Y_t^l + R_{t-1}\frac{B_{t-1}^l}{P_{t-1}} + \frac{P_{t-1}}{P_t}\frac{M_{t-1}^l}{P_{t-1}}$$

where $Y_t, C_t^l, B_t^l, P_t, M_t^l, Q_t, H_t^l, R_t$ denote, respectively, real income, real consumption, bonds, the price level of consumption, money balances, the house price level, the volume of housing services and the real gross rate of return. The superscript *l* denotes that the variable refers to the lenders, E_t is the expectations operator and β^t is the rate of time preference. Households derive utility from the stock of housing whereas expenditure on housing must equal the change in the stock times its current price. The latter is the cash flow associated with residential investment. The real gross rate of return is defined by the Fisher parity equation:

(3) $$1 + i_t = R_t \frac{E_t P_{t+1}}{P_t}$$

where i_t denotes the nominal interest rate.

The borrowers are assumed to have the same utility schedule as the lenders, the only asymmetry being that the former are assumed to be myopic i.e. the discount factor is equal to unity for the present and zero for the future. Accordingly, the optimisation problem faced by the *borrowers* reads:

(4) $$\max_{C_t^b, \frac{M_t^b}{P_t}, H_t^b} U\left(C_t^b, \frac{M_t^b}{P_t}, H_t^b \right)$$

The borrowers are subject to a flow of funds constraint and a collateral constraint:

(5) $$C_t^b - \frac{B_t^b}{P_t} + \frac{M_t^b}{P_t} + \frac{Q_t}{P_t}\left(H_t^b - H_{t-1}^b\right) = Y_t^b - R_{t-1}\frac{B_{t-1}^b}{P_{t-1}} + \frac{P_{t-1}}{P_t}\frac{M_{t-1}^b}{P_{t-1}}$$

(6) $$R_t \frac{B_t^b}{P_t} \leq \frac{E_t Q_{t+1}}{E_t P_{t+1}} H_t^b$$

where the superscript *b* denotes the borrowers. It is important to note that the variable B_t^b now stands for borrowing, not lending, and hence its sign turns negative in the flow of funds constraint. The collateral constraint is saying that the lenders demand a gross return on the loan that is covered at least by the expected value of the home. Iacoviello (2004) proves that this constraint will always be binding, and we will simply assume this to be the case here. The collateral constraint is essential because the discounted disutility of future sacrifices of consumption to service the mortgage debt is zero in this set-up; without the collateral constraint the amount of borrowing would be indefinite.

From the first order conditions of these problems, and assuming log-linear utility, an aggregate money demand equation can be derived which reads (see the mathematical annex):

$$\log\frac{M_t}{P_t} = \delta\log\frac{b_t}{d} + \log C_t + \log\frac{Q_t}{P_t}$$

$$+\lambda\log\frac{H_t^b}{C_t^b}\left[1-\frac{B_t^b}{Q_t H_t^b}\right]+(1-\lambda)\left[\log\frac{H_t^l}{C_t^l}(i_t-\rho_t)-\log i_t\right] \quad (7)$$

where

$$\rho_t = \frac{E_t Q_{t+1} - Q_t}{Q_t} \quad (8)$$

denotes the expected rate of house price inflation, *λ* is the weight of credit-constrained households (borrowers) in aggregate money demand, b_t stands for shifts in preferences for holding money and *d* is the weight of housing in the (log-linear) utility function.

Equation (7) says that aggregate money demand is a function of the autonomous trend in money preference (*b*), aggregate (non-housing) consumption, *C*, the real house price, *Q/P*, the net real housing wealth of credit-constrained home-owners (scaled to consumption), the real user cost per unit of housing capital (given by the nominal interest rate less the expected house price increase, again scaled to consumption and with a positive sign because an increase in the user cost of housing leads to a substitution away from housing towards cash balances) and the interest rate (with the usual negative sign). It is important to note that the neat linear homogeneity of the equation disappears for more complex utility functions than the log-linear function, but the basic relationship would still hold. On the other hand, it needs to be stressed also that equation (7) is by no means intended as an all-encompassing theory but rather as an illustration as to how relatively straightforward behavioural assumptions can give rise to house prices being a determinant of money demand.

3 Empirical model and data

The aim of the paper is to analyse the determinants of the observed heterogeneity of money holdings across euro-area countries with a particular view to the role of different developments of the housing market. Our money demand equation is specified in a panel model that includes housing variables alongside the standard determinants of money and is suited to uncover differences across countries. As such, the empirical specification is intended to empirically illustrate the importance of housing market developments for money demand in a general way without strictly following our theoretical money demand equation.

A special feature of the model is that all variables are measured in deviations to the euro area average.[6] As has been shown by Setzer and Wolff (2009), a central

[6] Greece and Luxembourg were excluded from the analysis due to missing data.

advantage of estimating the money demand function in difference to the euro area average is that it allows taking out drivers of money demand that are common to all countries. Such a procedure avoids the problem of formulating precise proxies for unexplained shifts in aggregate money balances. Greiber and Lemke (2005) show, e.g., that changes in financial and economic uncertainty, which are highly correlated across euro area countries, lead to temporary portfolio shifts and this may distort the link between money and prices. By taking out these global shocks, the approach permits to focus on the heterogeneity of money demand across euro area countries. In other words, the approach does not aim to explain aggregate euro area money holdings but rather focuses on uncovering the differences in money holdings across countries. Nevertheless, as the estimated elasticities reflect the same underlying parameters as in the aggregate money demand estimation (see Setzer and Wolff 2009), our approach is also able to provide evidence on the money-housing nexus at the aggregate level.

Econometrically, this approach is similar to a panel estimation which includes time fixed effects. The difference to fixed time effects estimations is that time fixed effects cater for the unweighted annual average of all variables while our approach takes out the weighted average developments of the variables.[7] In other words, real money holdings are measured relative to the real money holdings of the euro area and all other variables are also measured relative to the euro area values. Moreover, the model includes country fixed effects to allow for constant country-specific preferences for money holdings.[8] Specifically, we estimate the following relation:

$$\tilde{m}_{it} - \tilde{p}_{it} = f(\tilde{y}_{it}, \tilde{i}_{it}, (\tilde{q}_{it} - \tilde{p}_{it})) \quad (9)$$

where variables are measured in deviations from the euro area average as symbolized by the tilde. The variables *m*, *p*, *y* and *i* denote nominal national contributions to M3, the GDP deflator, real GDP, and the short-term interest rate variable (three months money market rate). The variable *q* corresponds to the nominal residential property price index. All variables except the interest rates are seasonally adjusted and they are computed in log differences to the euro area average (in case of GDP, M3 and GDP-weighted house prices) or relative to the euro area value in case of the interest rate..

The coefficients on the variables are assumed to be homogenous across countries. It is clear, however, that in a macroeconomic panel, there is usually some variation in the reaction coefficients across countries. As has been shown by Pesaran and Smith (1995), in a static case, if the coefficients differ randomly, a pooled estimation gives unbiased estimates of coefficient means. The estimated coefficients should thus be interpreted as the average cross-country reactions to the underlying variables. However, in the robustness section, we will also show that the estimated coefficients do not hinge on a small subset of countries and are fairly robust when omitting a number of countries.

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[7] For example, we use the house price index for the euro area as a whole and not an unweighted average of the house prices of all euro area countries.

[8] We do not include a deterministic trend on the assumption that exogenous shifts in money preferences are uniform across the euro area, i.e. $b_{it} - b_t = 0$.

Money balances were deflated with the GDP deflator. For the monetary aggregates we use quarterly data for national contributions to M3.[9] The sample ranges from 1999Q1 to 2008Q4 in the baseline specification. Quarterly data for GDP and the GDP deflator are from Eurostat. Housing developments in the euro area are approximated by residential property price indices from the ECB. For some countries, data were only available on lower frequency (semi-annual or annual). Missing values were generated by linear interpolation.

Regarding the interest rate variable, it is very difficult to come up with a good measure of the opportunity cost of holding money that is specific to the individual euro area country. The more short term the interest rate, the more integrated the financial market becomes, and individual interest rates do not differ from the euro area aggregate. At the longer end of the maturity spectrum, significant differences can be found across euro area countries. However, these differences partly reflect different risk assessments of e.g. government bonds (see for example Hallerberg and Wolff 2008). In this sense, they are ill-suited to capture opportunity costs of holding money as higher risk assessment (fuelled e.g. by economic and financial uncertainty) may lead to higher money holdings due to precautionary portfolio shifts (Greiber and Lemke 2005). Moreover, domestic money holders can invest money in other euro area money or bond markets at little cost. Since 1999, with the removal of exchange rate risk, the opportunity costs of holding money are therefore rather similar across euro area countries. For sake of completeness, we nevertheless include a three-month interest rate, for which small variations are observable. In addition, we use alternative opportunity cost measures such as the spread between the ten year government bond yield and the three month interest rate (see also Coenen and Vega 2001) as well as the HICP inflation rate (see also Dreger and Wolter 2009). As will be shown below, our central results remain unaffected by the use of these alternative opportunity cost measures.[10]

Table 1: Panel unit root and stationarity tests

		M3	GDP	Interest rate	House price	H_0
Hadri	Z(tau)	8.748	15.004	14.517	12.67	Stationarity
	p-value	0.00	0.00	0.00	0.00	
IPS	t-bar	-1.385	-1.058	2.575	-1.877	Unit root
	p-value	0.63	0.9336	1.00	0.082	

Note: Hadri test: Null hypothesis is that all time-series in the panel are stationary processes. Controlling for serial dependence in the errors and heteroskedastic

[9] The national contributions are computed from the "Aggregated balance sheet of euro area monetary and financial institutions, excluding the eurosystem" published by the ECB by adding and subtracting the following items: 2.2-2.2.1-2.2.2-2.2.3.2.3-2.2.3.3.2+2.3+2.4-2.4.3. Obviously, this definition excludes money in circulation. However, the latter is of relatively lower importance for the monetary dynamics in a country as it accounts for less than 8% of the aggregate M3 in the euro area.

[10] For most countries the three-month Treasury bill is employed, except for the Netherlands, Portugal, Finland and Spain for which we use the deposit rate. Data for money and interest rates are obtained from official ECB statistics.

disturbances across units (lag truncation=2). IPS is the Im-Pesaran-Shin test with the null hypothesis that all time series in the panel are realizations of a unit root process.

To assess the time series properties of the data, we examine the degree of integration of the variables. The null hypothesis of the Hadri (2000) stationarity test can be clearly rejected in all cases implying that not all time series in our panel are stationary. Findings from the IPS test suggest that the null hypothesis that all time series contain a unit root cannot be rejected (Table 1). The results are not sensitive to the number of lags.

We therefore test for panel co-integration. Table 2 provides the statistics of the Phillips Peron group tests and the ADF test. The test indicates that the null hypothesis of no cointegration can be rejected. Hence, we base our main estimations on a panel co-integration framework. However, it should also be taken into consideration that panel co-integration and unit root tests have notoriously low power. Moreover, from an economic point of view, it is debatable to what extent the variables, which are measured in deviation from the euro area average, can exhibit a unit root. While this can locally be the case, it appears unlikely that the deviation would also exhibit a unit root in the long run.

Table 2: Results of panel cointegration tests

		Rho statistic	p-value
$\tilde{m}-\tilde{p},\tilde{y},\tilde{i},\tilde{q}-\tilde{p}$	Group PP	-2.463	0.007
	Group ADF	-2.457	0.007

Note: Pedroni (1999) group tests for null of no cointegration among a multivariate vector (group rho statistic). Tests are performed with the automatic lag selection criterion by Akaike Schwarz.

Hence, in order to be sure that our results are not an artefact of the wrong econometric procedure applied, we proceed with two different methodologies. In line with the time series evidence, however, we rely on a panel co-integration framework as the specification tests indicate that this is appropriate. As robustness check, we show the results of a simple fixed effects approach, which would be appropriate if the variables were stationary and not co-integrated. For the co-integration approach, we perform the estimation by dynamic ordinary least squares with one lead and one lag (DOLS(-1,1)). Dynamic OLS was originally developed by Stock and Watson (1993); Kao and Chiang (2000) analyze its properties in a panel context.[11] Our money demand equation takes then the following form:

$$
\begin{aligned}
&\ln(\tilde{M}_{it}/\tilde{P}_{it}) = \beta_1 \ln(\tilde{Y}_{it}/\tilde{P}_{it}) + \beta_2 \tilde{i}_{it} + \beta_3 \ln(\tilde{Q}_{it}/\tilde{P}_{it}) + e_{it} \\
&+ \rho_{11}\Delta(\ln(\tilde{Y}_{i,t+1}/\tilde{P}_{i,t+1})) + \rho_{12}\Delta(\ln(\tilde{Y}_{i,t-1}/\tilde{P}_{i,t-1})) + \rho_{21}\Delta(\tilde{i}_{i,t+1}) + \rho_{22}\Delta(\tilde{i}_{i,t-1}) \\
&+ \rho_{31}\Delta(\ln(\tilde{Q}_{i,t+1}/\tilde{P}_{i,t+1})) + \rho_{32}\Delta(\ln(\tilde{Q}_{i,t-1}/\tilde{P}_{i,t-1}))
\end{aligned}
\tag{10}
$$

11 See also Kao et al. (1999) and Pesaran and Smith (1995).

where the tilde again symbolizes deviations from the euro area average, and $e_{it} = u_i + \varepsilon_{it}$ with u_i being the country fixed effects and ε_{it} is an error term with the usual properties. The inclusion of leads and lags of the first difference of the regressors improves the efficiency in estimating the co-integration vector, which is given by (-1, β_1, β_2, β_3). It is important to note that Kao and Chiang (2000) show that ε is by definition auto-correlated. When estimating equation (10), appropriate correction for the autocorrelation needs to be performed. We employ the correction of Newey and West (1994). Moreover, our standard errors are robust with respect to arbitrary heteroskedasticity. Finally, the estimation results presented constrain the short- as well as long-run dynamics to be the same across the countries. However, as a robustness check, we also allowed for different short-run dynamics for the countries. The main results were unaffected when estimating the less restrictive model.

4 Empirical results

4.1 Main results

Table 3 presents the estimation of the corresponding dynamic OLS estimations. Column A displays the coefficients of a benchmark specification that includes only real income and short-term interest rates and thus the traditional explanatory variables of a money demand equation. The magnitude of the income elasticity is in line with previous research (compare, e.g., Calza, Gerdesmeier and Levy 2001, Carstensen 2006, De Santis et al. 2008, Setzer and Wolff 2009). The interest rate elasticity is positive and not significant. The non-significance is consistent with our theoretical model (*viz*. equation (7)), which predicts ambiguous effects of interest rates on money. Moreover, as described above, one should be cautious with respect to the interpretation of the interest rate semi-elasticity as there has been a high co-movement in interest rates across euro area countries after 1999. This results in a low cross-country variation of the time series in our sample period.

Column B displays the augmented money demand model, with real house prices included. The coefficient of the house price variable is highly significant indicating that higher house prices lead to larger holdings of real balances. This suggests that the wealth and collateral effects are important determinants of money holdings. This view is further supported by the fact that the income elasticity falls when house prices are included in the estimation. This confirms the notion that the income elasticity in traditional money demand specifications (i.e. those that exclude wealth variables) also captures some of the wealth and collateral effects.

The absolute value of the house price coefficient is relatively small, but non-negligible. A one percentage point increase in real house prices (compared to the euro area average) leads, ceteris paribus, to a rise above-euro area average rise in real money holdings of 0.09 percentage point. However, this value has to be interpreted against the background of the heterogeneous house price developments in the individual euro area countries which considerably exceed differences in monetary dynamics. As such, even a relatively small house price elasticity may provide a sizeable explanatory factor in explaining monetary heterogeneity.

Table 3: *Results of money demand estimation, dynamic OLS specification, sample 1999q1-2008q4*

	A	B	C	D	E	F	G	H	I
Real GDP	1.57***	1.43***	1.38***	1.63***	1.48***	1.43***	1.56***	1.42***	1.38***
	(11.21)	(10.16)	(10.48)	(11.66)	(10.48)	(10.78)	(12.58)	(11.52)	(11.53)
Short-term interest	1.08	0.75	1.92						
	(0.26)	(0.20)	(0.46)						
Inflation rate				6.19*	5.87*	5.87*			
				(1.85)	(1.91)	(1.88)			
Interest rate spread							-0.46	0.13	0.11
							(0.30)	(0.08)	(0.07)
Real house price		0.09***	0.08***		0.09***	0.09***		0.09***	0.09***
		(2.87)	(2.68)		(2.92)	(2.73)		(3.09)	(2.83)
Δ real house price (+1)			-0.58*			-0.58*			-0.62*
			(-1.73)			(-1.73)			(-1.87)
N	380	380	370	380	380	370	380	380	370
R^2	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998

*Note: All variables are measured in difference to the euro area average. t-values are below the coefficient estimates in brackets. ***, **, * indicates significance at a 1, 5, 10 percent level, respectively.*

Assuming constancy of the remaining variables, Table 4 displays –in a somewhat simplified way- the share of the deviation in money growth that is explained by house price developments for each euro area country (last column). In half of the countries in our sample, national house price developments explain at least a third of the deviation in money growth from the euro area average. For France, Austria and Spain in particular, the wealth and collateral effects of housing seem to have been important as there has been a close money-housing nexus. By contrast, house prices do not provide any explanation for below-average money growth in Belgium, Finland and Italy, suggesting that other factors (including the above described substitution effects between money and housing) are more important drivers of the monetary dynamics in these countries (Table 4).

Table 4: Deviation from EA money growth explained by house price elasticity

Country	M3 growth		House price growth		Deviation from EA money growth explained by house price elasticity (assuming elasticity of 0.09 and constancy of other variables)
	average annual % change 1999-2008	deviation of EA average (percentage points)	average annual % change 1999-2008	deviation of EA average (percentage points)	
EA	8.4		6.2		
AT	7.9	-0.5	1.5	-4.6	81%
BE	6.6	-1.8	9.0	2.9	-14%
DE	6.8	-1.6	-0.5	-6.7	37%
ES	10.1	1.7	17.7	11.6	60%
FI	6.9	-1.5	7.6	1.5	-9%
FR	8.6	0.2	10.1	4.0	144%
IE	16.3	7.9	13.1	7.0	8%
IT	7.7	-0.7	10.1	4.0	-53%
NL	9.2	0.8	9.9	3.7	45%
PT	5.9	-2.5	1.7	-4.4	16%

Note: The deviation of EA money growth which is explained by house price developments is calculated under ceteris paribus assumption by multiplying the country-specific average annual deviation of house price growth from the euro area average with the estimated house price elasticity of 0.09 (see Table 3) and dividing it by the country-specific average annual deviation of the country-specific M3 growth. M3 growth does not include currency in circulation.

Column C in Table 3 further extends the model to include future changes in real house prices. This variable intends to capture expectations about future house price increases (assuming rational expectations) and thus serves as a variable to assess the importance of substitution effects. The variable is negative (as predicted by the theoretical model) and significant at the 10 percent level, suggesting that substitution effects between money and housing have played an important role, despite the different degrees of liquidity of both assets (see also Boone and van den Noord 2008 for a similar result).

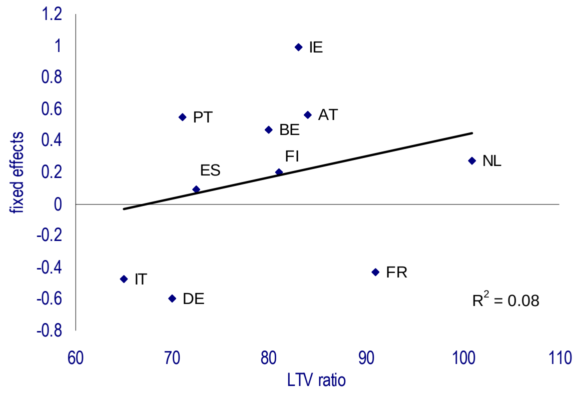
The remaining columns corroborate these results using alternative opportunity costs measures. Specifications D to F replace short-term rates by inflation as inflation may be a measure of the return on holding goods (see also Dreger and Wolters 2010).Models G to I use the difference between the long-term and the short-term interest rates as opportunity cost measure. The long-term rate is defined as the yield on the 10 year government bond. The positive effects stemming from the wealth and collateral channel remain to be reflected in a highly significant positive house price elasticity, while the negative substitution effect remains to be significant as well, although to a somewhat lesser extent. The results regarding opportunity cost measures are somewhat less robust, documenting the difficulty of capturing differences in opportunity cost of money holdings across euro area countries.

Our theoretical model in chapter 2 suggests that institutional aspects of housing markets are also important. Recent studies have found important heterogeneity in the transmission of monetary policy on house prices depending on the structural and institutional features of the mortgage market (Maclennan et al 1998, Calza et al. 2007, Muellbauer and Murphy 2008). However, one problem with accounting for institutional differences is the nature of the available data. Institutional characteristics change little over time, if available in the form of time series all, so that time series analysis with such data is precluded.

We therefore relate unexplained country-specific preferences for holding money to institutional features of the housing market. The country-specific preference for holding money is captured by the country-specific fixed effects. Specifically, we therefore relate our country-specific fixed effects to the loan to value ratios (LTV) to first time buyers and to the home ownership rate. A high LTV ratio is akin to a lower collateral constraint. As less equity is required for a house purchase, a higher share of the property can be financed by loan. The creation of a new loan is likely to go along with the creation of new deposits, suggesting that the effects of house prices on money are likely to be marked in economies with high LTV ratios.

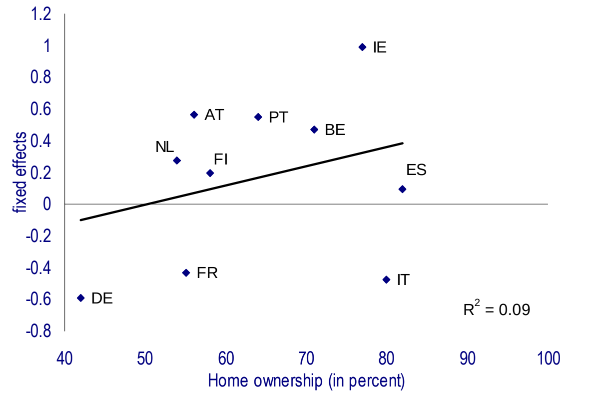
Graph 6 indeed provides some evidence for this hypothesis as we find a positive relation between the LTV and the fixed effect. Hence, ceteris paribus, a country where the LTV ratio is high tends to have larger real balances as households can relatively easily obtain financing to purchase property. France and the Netherlands could be seen as outliers in the Figure. In the Netherlands this could be related to tax incentives which push up the LTV to extremely high levels nominally for tax purposes, but in reality there are offsetting endowments by households in the form of life insurance and other (tax exempt) saving vehicles (see van den Noord (2005) . In France, the LTV ratio for all homeowners is on average comparatively low. The LTV on new home purchases shown in the figure is therefore not representative for the entire economy. Abstracting just from France increases the R^2 to 25%. Abstracting from both countries would raise the slope of the relationship substantially.

Graph 6: Loan to value ratios and fixed effects (1)



(1) Fixed effects are taken from the regression B. Loan to value ratios are taken from ECB (2009).

Graph 7: Home ownership and fixed effects (1)



(1) Fixed effects are taken from the regression B. Home ownership rates are taken from IMF (2009).

As regards home ownership, we also find a positive relationship as higher home ownership is associated with a higher fixed effect (Graph 7). Hence, all other things equal, money holdings are higher in countries with high home ownership ratios. This may be explained by the transaction motive of money demand which is likely to be stronger if home ownership is higher, but it is also consistent with theoretical considerations according to which the wealth effect of housing should increase with a higher share of home ownership. Italy is a clear outsider in this case, possibly related to cultural forces as dwellings are often a parental gift and thus housing transactions are not necessarily associated with the raising of housing loans (ECB 2009). Removing Italy from the table increases the R^2 to 36%.

4.2 Robustness checks

As a first robustness check, we estimate our money demand specification with standard fixed effects. The estimation of that model yields very similar results, with the coefficients of our main variable of interest hardly change (see Table 5). There is now even stronger evidence for the existence of substitution effects between money and housing.

In view of the heterogeneity of euro area countries, our results could be sensitive to changes in the cross-section or time dimension of our sample. Table 6 presents robustness tests with regard to the exclusion of individual countries. In columns A-C, we exclude the largest EMU country, Germany, as it might unduly influence the estimates because of its size. Moreover, in further sub-sample tests we exclude the three countries with the highest real money growth between 1999 and 2008, namely Ireland, Spain and France (columns D to F) as well as the two countries with the lowest monetary growth rates since the introduction of the euro, namely Portugal and Belgium (columns G to I).

Table 5: Results of money demand estimation, fixed effects specification, sample 1999q1-2008q4

	A	B	C
Real GDP	1.56***	1.44***	1.42***
	(21.49)	(18.22)	(17.84)
Short-term interest	0.55	0.21	0.61
	(0.21)	(0.08)	(0.21)
Real house price		0.09***	0.09***
		(3.67)	(3.29)
Δ real house price (+1)			-0.40***
			(-2.47)
N	390	390	380
R^2 (within)	0.56	0.58	0.59

*Note: All variables are measured in difference to the euro area average. t-values are below the coefficient estimates in brackets. ***, **, * indicates significance at a 1, 5, 10 percent level, respectively. Estimation method is fixed effects.*

This robustness check reveals a considerable degree of sub-sample stability. The income elasticity does hardly change compared to our baseline scenario and consistently falls when house prices developments are taken into account. Also the wealth effects remain significant. It is, however, less significant in the group excluding the low money growth group, especially when the user cost of housing is included. Here, the evidence for substitution effects is very strong. Overall, the robustness check therefore supports our hypothesis of the importance of housing market developments. Economic growth and house prices explain a significant part of the cross-country heterogeneity of real balances. These findings are not driven by a small subset of countries but rather reflect a rather constant pattern of determinants of cross-country differences in money holdings. In other words, cross-country differences in money holdings can be explained by a number of observable variables and the empirical relations appear to be rather stable across the countries.

Table 6: Results sensitivity analysis, fixed effects estimation, sample 1999q1-2008q4

	A	B	C	D	E	F	G	H	I
Real GDP	1.57***	1.43***	1.41***	1.23***	1.14***	1.19***	1.46***	1.40***	1.37***
	(20.56)	(16.57)	(16.27)	(7.2)	(7.14)	(7.23)	(22.76)	(20.01)	(19.76)
Short-term interest	-3.19	-0.57	0.28	1.91	-1.36	-1.12	1.16	0.90	1.68
	(-0.97)	(-0.17)	(0.08)	(0.61)	(-0.46)	(-0.33)	(0.47)	(0.37)	(0.62)
Real house price		0.11***	0.11***		0.17***	0.17***		0.05**	0.03
		(3.32)	(3.12)		(6.3)	(6)		(2.04)	(1.36)
Δ real house price (+1)			-0.34**			-0.14			-0.68***
			(-1.97)			(-0.75)			(-3.80)
N	351	351	342	273	273	266	312	312	304
R^2	0.56	0.58	0.58	0.18	0.29	0.30	0.65	0.66	0.67
Removed	DE	DE	De	IE, ES, FR	IE, ES, FR	IE, ES, FR	PT, BE	PT, BE	PT, BE

*Note: All variables are measured in difference to the euro area average. t-values are below the coefficient estimates in brackets. ***, **, * indicates significance at a 1, 5, 10 percent level, respectively.*

4.3 Comparison with the pre-EMU period

A potentially interesting issue is whether the creation of the single currency itself has been a factor in shaping the relationship between house prices and money demand. Our hypothesis is that when countries still maintained there own currencies, current account constraints were more binding and therefore housing needed to be financed largely domestically, whereas after the creation of the single currency cross-border capital flows were unhampered by exchange rate risk. As a result, before monetary union money growth would reflect predominantly national monetary policy setting whereas in monetary union cross-country differences in money growth could also reflect capital flows associated with different investment opportunities in real estate and its financing.

Against this backdrop, we apply our specification to the pre-EMU period (Table 7). The estimation results for the period 1990q1 to 1998q4 document a clear robustness regarding the income elasticity. Thus, we find no evidence for a structural change regarding the link between income and money holdings after 1999. However, in the earlier sample, we find an insignificant house price elasticity. House price developments have only become an important parameter of money holdings with the introduction of the common currency. This finding is corroborated in an estimation covering the entire sample, which is documented in the last column of Table 7. There we clearly find that only after 1999, house price developments have become a significant determinant of money as suggested by the highly significant interaction parameter between house prices and the dummy variable "EMU" which is denoted one for the period after 1999q1 and zero otherwise.

This finding is consistent with our above hypothesis but also with previous studies analyzing the link between interest rates, consumer prices and housing wealth in the euro area (Weber, Gerke, Worms 2009), who find similar effects for the entire EMU period. Importantly, our result does not result from lower variation in house prices in the pre-EMU period. In fact, the heterogeneity in house prices across euro area countries has been high also in the pre-EMU period.However, one additional possible explanation for the fact that housing emerges as a relevant variable determining money only with EMU is related to the process of financial liberalisation and innovation. This process has generally eased the access of credit to borrowers. For instance, innovations in credit markets have facilitated the access to standardised credit for lower-income borrowers and reduced financial constraints for homebuyers. Moreover, as a result of the property price boom and a rise in homeownership rates, households were increasingly able to withdraw equity in the post-1999 period (ECB 2009). This boosts consumption spending and aggregate demand, and might support the link between house prices and money after 1999.

Table 7: Results sensitivity analysis, dynamic OLS, pre-EMU sample (1990q1-1998q4/2008q4)

	A	B	C	D	E	F	G
Real GDP	1.36***	1.39***	1.37***	1.41***	1.36***	1.39***	1.40***
	(18.88)	(17.04)	(17.73)	(17.11)	(18.88)	(17.11)	(19.24)
Short-term interest	0.61*	0.56*					2.5***
	(1.87)	(1.76)					(5.04)
Inflation rate			-1.82***	-1.74***			
			(-3.52)	(-3.36			
Interest rate spread					-0.53	-0.49	-0.49
					(-1.64)	(-1.53)	(-1.53)
Real house price	-0.01	-0.02	0.00	-0.01	-0.01	-0.02	-0.04
	(-0.47)	(-0.72)	(0.03)	(-0.29)	(-0.27)	(-0.59)	(-1.27)
Real house prices*EMU							0.14***
							(2.67)
Δ real house price (+1)		-0.21		-0.22		-0.22	
		(-0.98)		(-1.08)		(-1.06)	
N	360	360	360	360	360	360	740
Sample	1990q1-1998q4	1990q1-1998q4	1990q1-1998q4	1990q1-1998q4	1990q1-1998q4	1990q1-1998q4	1990q1-2008q4
R^2	0.999	0.999	0.999	0.999	0.999	0.999	0.995

*Note: All variables are measured in difference to the euro area average. t-values are below the coefficient estimates in brackets. ***, **, * indicates significance at a 1, 5, 10 percent level, respectively.*

5 Conclusions

Monetary analysis remains an essential ingredient of the economic analysis on which monetary policy decisions in the euro area are based, so it is important to establish a stable relationship between real-economy developments and money aggregates. We find it striking that both money demand and real-economy developments have been rather diverse across the member countries of the euro area – a challenging situation for economic policy making.

Against this background, this study presents a theoretical and empirical analysis of the determinants of money holdings across euro area countries. Specifically, we derive a money demand specification that includes apart from the usual determinants of money demand (real income, interest rates and inflation) developments in the housing sector. The empirical specification is based on an innovative model featuring housing wealth, collateral and substitution effects. Housing wealth and collateral effects imply a positive relationship between money demand and house prices, while the substitution effect implies a negative relationship between the expected increase in house prices and money demand.

The empirical specification allows us to analyze the determinants of the strong differences in monetary dynamics of euro area Member States. It resorts to an idea originally proposed by Setzer and Wolff (2009), in which all variables are measured in deviation from the euro area average. In this way, we can control for unobserved common shocks to money demand that affect all countries. Differences in the monetary dynamics across euro area Member States are related to differences in the economic fundamentals determining money demand.

Our empirical findings provide support for our model. By estimating euro area money demand in national deviations from the area average, we show that cross-country differences in monetary dynamics can be explained to a large extent by asymmetries in house price developments on top of different income developments. We find robust evidence that housing wealth as captured by house prices has been a significant determinant of money holdings since 1999. Moreover, in line with our theoretical model, we show that lower user costs of housing lead to a substitution away from money holdings. Sensitivity analyses suggest that these results are stable and do not depend on the money-housing nexus in some individual euro area countries only.

Interestingly, our results provide less evidence for a role of housing prior to the adoption of the single currency in 1999. In that period there may have been a closer relationship between local income and house price developments, with the role of cross border capital flows more limited. Since the launch of the single currency, fairly large cross-country differences in price fluctuations of assets occurred despite a single monetary policy, reflecting the impact of large capital flows. A simple analysis of the money-price relationship which does not take explicit account of such a development in asset markets then misses an important determinant of cross-country monetary and credit dynamics.

Our findings point to a potentially promising new line of research which at some point may have implications for the interpretation of the monetary policy framework in the euro area. No explicit consideration of cross-country differences in house prices is needed in a monetary context as long as h these broadly move in concert with income, as was the case before 1999. However, after 1999 high money growth in several euro area countries has been a reflection of excessive house price developments. These developments were less apparent at the aggregate level, and yet could eventually have systemic and financial stability risks for the euro area as a whole.

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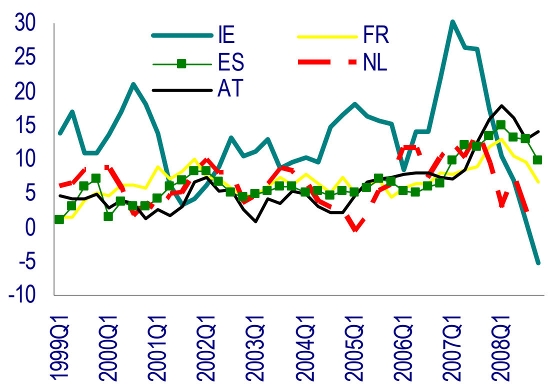
Annex A

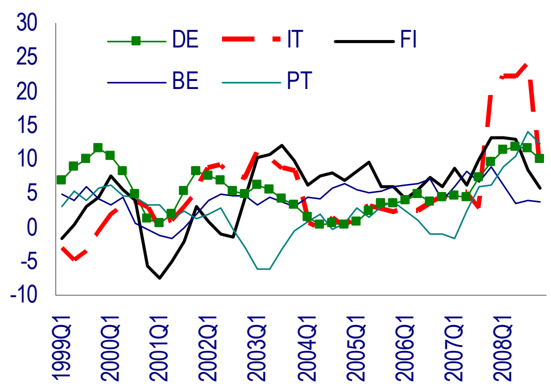
Graphs A1 to A4 display real money and nominal house price growth in the euro area from 1999 to 2008. They show that there is substantial variation of the variables not only across countries but also within each individual country in time.

Graph A1**: M3 real, euro area Member States** (1)



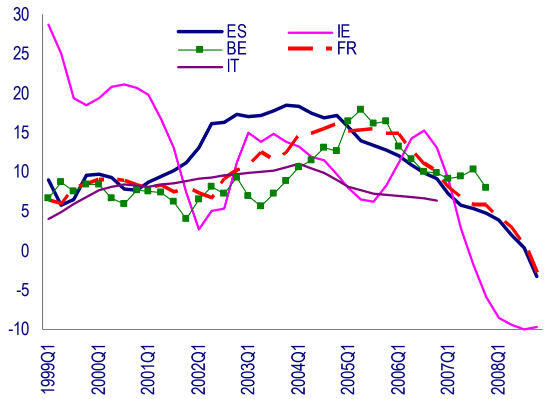
(1) real growth rates on year earlier in %.
Source: ECB.

Graph A2: **M3 real, euro area Member States** (1)



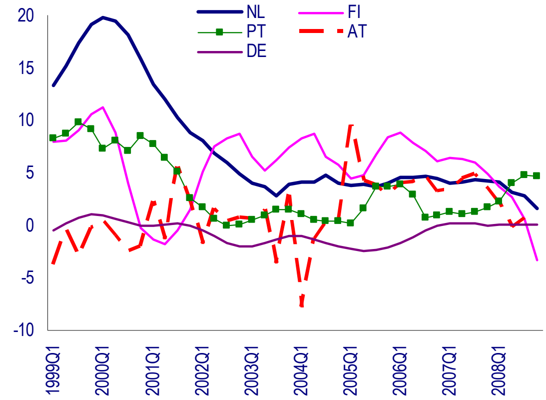
(1) real growth rate on year earlier in %.
Source: ECB.

Graph A3**: House prices (1)**



(1) nominal growth rates on year earlier in %.
Source: ECB and OECD.

Graph A4 **House prices (1)**



(1) nominal growth rates on year earlier in %.
Source: ECB and OECD

Annex B

In this Annex we derive the first order conditions for the theoretical model proposed in equations (1) to (8) in the main text and subsequently derive an aggregate money demand equation from these conditions.

Deriving the first order conditions for the lenders

To derive the first order conditions from the problem described in equations (1) to (3) for the lenders we need to compute the Bellman equations for the problem. The household inherits from the past $\frac{B_{t-1}^l}{P_{t-1}}, \frac{M_{t-1}^l}{P_{t-1}}$ and H_{t-1}^l, i.e., bonds, money and the home. We define the state variable ω_{t-1} as:

(A1)
$$\omega_{t-1} = \frac{Q_t}{P_t} H_{t-1}^l + R_{t-1} \frac{B_{t-1}^l}{P_{t-1}} + \frac{P_{t-1}}{P_t} \frac{M_{t-1}^l}{P_{t-1}}$$

This implies that the budget constraint can be rewritten as:

(A2)
$$\frac{B_t^l}{P_t} + \frac{M_t^l}{P_t} + \frac{Q_t}{P_t} H_t^l = \omega_{t-1} + Y_t^l - C_t^l$$

The transition equation for the new state variable is:

(A3)
$$\omega_t = \frac{E_t Q_{t+1}}{E_t P_{t+1}} H_t^l + R_t \frac{B_t^l}{P_t} + \frac{P_t}{E_t P_{t+1}} \frac{M_t^l}{P_t} =$$
$$\frac{E_t Q_{t+1}}{E_t P_{t+1}} H_t^l + \frac{P_t}{E_t P_{t+1}} \frac{M_t^l}{P_t} + R_t \left[-\frac{M_t^l}{P_t} - \frac{Q_t}{P_t} H_t^l + \omega_{t-1} + Y_t^l - C_t^l \right]$$

After some re-arranging this yields:

(A4)

$$\omega_t = R_t \left[\omega_{t-1} + Y_t^l - C_t^l \right] - \left[R_t \frac{Q_t}{P_t} - \frac{E_t Q_{t+1}}{E_t P_{t+1}} \right] H_t^l - \left[R_t - \frac{P_t}{E_t P_{t+1}} \right] \frac{M_t^l}{P_t}$$

The Bellman equation for the problem then reads:

(A5)
$$V_t(\omega_{t-1}) = \max_{C_t^l, \frac{M_t^l}{P_t}, H_t^l} E_0\left[U\left(C_t^l, \frac{M_t^l}{P_t}, H_t^l\right) + \beta V_{t+1}(\omega_t)\right]$$

The first order conditions with respect to consumption, real money and housing read:

(A6)
$$\frac{\partial U}{\partial C^l} + \beta V'(\omega_t)\frac{\partial \omega}{\partial C^l} = 0 \Rightarrow \frac{\partial U}{\partial C^l} = \beta R_t V'(\omega_t)$$

(A7)
$$\frac{\partial U}{\partial (M^l/P)} + \beta V'(\omega_t)\frac{\partial \omega}{\partial (M^l/P)} = 0 \Rightarrow \frac{\partial U}{\partial (M^l/P)} = \beta\left[R_t - \frac{P_t}{E_t P_{t+1}}\right]V'(\omega_t)$$

(A8)
$$\frac{\partial U}{\partial H^l} + \beta V'(\omega_t)\frac{\partial \omega}{\partial H^l} = 0 \Rightarrow \frac{\partial U}{\partial H^l} = \beta\left[R_t \frac{Q_t}{P_t} - \frac{E_t Q_{t+1}}{E_t P_{t+1}}\right]V'(\omega_t)$$

Putting the results for real money and consumption together yields:

(A9)
$$\frac{\dfrac{\partial U}{\partial (M^l/P)}}{\dfrac{\partial U}{\partial C^l}} = \frac{R_t - \dfrac{P_t}{E_t P_{t+1}}}{R_t} \Rightarrow \frac{\dfrac{\partial U}{\partial (M^l/P)}}{\dfrac{\partial U}{\partial C^l}} = \frac{i_t}{1+i_t}$$

This is the standard result that would also be obtained by including only money and consumption in the utility function, and therefore it is not very interesting for our purposes. However, putting the results for real money and housing together does yield an interesting relationship:

(A10)
$$\frac{\dfrac{\partial U}{\partial (M^l/P)}}{\dfrac{\partial U}{\partial H^l}} = \frac{R_t - \dfrac{P_t}{E_t P_{t+1}}}{R_t \dfrac{Q_t}{P_t} - \dfrac{E_t Q_{t+1}}{E_t P_{t+1}}} \Rightarrow \frac{\dfrac{\partial U}{\partial (M^l/P)}}{\dfrac{\partial U}{\partial H^l}} = \frac{i_t}{\dfrac{Q_t}{P_t}\left[1 + i_t - \dfrac{E_t Q_{t+1}}{Q_t}\right]}$$

This equation says that the marginal utility of money relative to that of housing will increase if the real price increases and if the expected increase in the house price (the expected capital gain) falls. In fact, the term in the denominator represents the user cost of housing capital. Hence, if the user cost of housing capital increases, the marginal utility of money decreases relative to that of housing, i.e. the amount of real cash balances held by the household will increase relative to the amount of housing services.

Deriving the first order conditions for the borrowers

Substituting the collateral constraint (6) in the flow of funds constraint (5) and rearranging yields:

(A11)

$$C_t^b + \frac{Q_t}{P_t}\left(H_t^b - H_{t-1}^b\right) + R_{t-1}\frac{B_{t-1}^b}{P_{t-1}} + \frac{M_t^b}{P_t} - Y_t^b - \frac{E_t Q_{t+1} H_t^b}{R_t P_t} - \frac{P_{t-1}}{P_t}\frac{M_{t-1}^b}{P_{t-1}} = 0$$

If ϕ_t is the Lagrange multiplier, the first order conditions read:

(A12) $$\frac{\partial U}{\partial C^b} = \frac{\partial U}{\partial\left(M^b/P\right)} = \phi_t$$

(A13) $$\frac{\partial U}{\partial H^b} = \phi_t \frac{Q_t}{P_t}\left[1 - \frac{E_t Q_{t+1}}{R_t Q_t}\frac{P_t}{E_t P_{t+1}}\right]$$

This implies that:

(A14) $$\frac{\dfrac{\partial U}{\partial\left(M^b/P\right)}}{\dfrac{\partial U}{\partial H^b}} = \frac{1}{\dfrac{Q_t}{P_t}\left[1 - \dfrac{E_t Q_{t+1}}{R_t Q_t}\dfrac{P_t}{E_t P_{t+1}}\right]}$$

Or, after substituting the collateral constraint (5) in this result:

(A15) $$\frac{\dfrac{\partial U}{\partial\left(M^b/P\right)}}{\dfrac{\partial U}{\partial H^b}} = \frac{1}{\dfrac{Q_t}{P_t}\left[1 - \dfrac{B_t^b}{Q_t H_t^b}\right]}$$

This equation effectively says that the relative utility of money (compared to housing) will decrease if the net wealth position of households increases. The net wealth, in turn, is a positive function of the real house price.

Deriving the aggregate money demand equation

In order to derive money demand equations for the two groups of households (which together determine aggregate money demand), we need to specify the utility function. For the sake of convenience we assume a log-linear utility function, noting that more complex utility functions would not lead to a fundamentally different relationship in terms of its signs. So, the utility function reads:

(A16) $$U\left(C_t^j, \frac{M_t^j}{P_t}, H_t^j\right) = \log C_t^j + b_t^{\delta} \log \frac{M_t^j}{P_t} + d \log H_t^j, \; j = l, b$$

where b_t stands for shifts in preferences for holding money. Aggregate money demand M is determined as:

(A17) $$\log M_t = (1-\lambda)\log M_t^l + \lambda \log M_t^b$$

where λ denotes the weight of money demand of credit-constrained households (borrowers) in total money demand.

Combining equations (A10) and (A16) yields the following money demand equation for the *lenders*:

(A18) $$\frac{M_t^l}{P_t} = \frac{b_t^{\delta}}{d} C_t^l \frac{Q_t}{P_t} \frac{H_t^l}{C_t^l} \frac{(i_t - \rho_t)}{i_t}$$

where $\rho_t = \frac{E_t Q_{t+1} - Q_t}{Q_t}$ denotes the expected rate of house price inflation.

Combining equations (A15) and (A16) yields for the *borrowers*:

(A19) $$\frac{M_t^b}{P_t} = \frac{b_t^{\delta}}{d} C_t^b \frac{Q_t}{P_t} \frac{H_t^b}{C_t^b} \left[1 - \frac{B_t^b}{Q_t H_t^b}\right]$$

Converting equations (A18) and (A19) in logs, combining them with the aggregation identity (A17) and assuming that λ can be used to approximate the weight of credit constrained households in aggregate consumption then yields the aggregate money demand equation (7) in the main text.

Annex C

Table A1: Results sensitivity analysis, dynamic OLS estimation, sample 1999q1-2008q4

	A	B	C	D	E	F	G	H	I
Real GDP	1.58***	1.41***	1.37***	1.27***	1.17***	1.19***	1.42***	1.35***	1.31***
	(11.12)	(10.16)	(10.05)	(3.39)	(3.42)	(3.39)	(9.66)	(9.28)	(9.84)
Short-term interest	-2.84	0.68	2.67	2.50	-0.93	0.12	2.35	1.98	3.17
	(-0.52)	(0.12)	(0.44)	(0.41)	(0.16)	(0.02)	(0.66)	(0.63)	(0.88)
Real house price		0.11***	0.11***		0.18***	0.18***		0.03	0.02
		(2.30)	(2.23)		(4.99)	(4.82)		(1.31)	(0.90)
Δ real house price (+1)			-0.50			-0.04			-0.82***
			(-1.43)			(-0.12)			(-2.20)
N	342	342	342	380	380	370	380	380	370
R^2	0.997	0.997	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Removed	DE	DE	DE	IE, ES, FR	IE, ES, FR	IE, ES, FR	PT, BE	PT, BE	PT, BE

Note: All variables are measured in difference to the euro area average. t-values are below the coefficient estimates in brackets. ***, **, * indicates significance at a 1, 5, 10 percent level, respectively.