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# Money velocity and asset prices in the euro area

*Christian Dreger and Jürgen Wolters*<sup>1</sup>

**Abstract:** Monetary growth in the euro area has exceeded its target since several years. At the same time, the money demand function seems to be increasingly unstable if more recent data are used. If the link between money balances and the macroeconomy is fragile, the rationale of monetary aggregates in the ECB strategy has to be doubted. In fact, a rise in the income elasticity after 2001 can be observed, and may reflect the exclusion of real and financial wealth in conventional specifications of money demand. This presumption is explored by means of a cointegration analysis. To separate income from wealth effects, the specification in terms of money velocity is preferred. Evidence for the presence of wealth in the long run relationship is provided. In particular, both stock and house prices have exerted a negative impact on velocity after 2001 and lead to almost identical equilibrium errors. The extended error correction model is stable over the entire sample period and survive a battery of specification tests.

**Keywords:** Cointegration analysis, error correction, money demand, financial wealth, monetary policy

**JEL Classification:** C22, C52, E41

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# **1 Introduction**

The primary goal of the European Central Bank (ECB) is to maintain price stability. To achieve its goal the ECB has developed the so called two pillar strategy, where monetary aggregates play a crucial role. In particular, one pillar is based on the economic analysis of price risks in the short term, while the other one is built on the analysis of risks to price stability in the medium and long run. Given the complexity of the monetary transmission process central bankers often also use some simple rules of thumb (ECB, 2004). One such rule is based on the fact that inflation is always a monetary phenomenon in the medium to long term. The reference value for monetary growth is taken as a benchmark for assessing monetary developments and future inflation prospects. It is based on price stability which is seen to be consistent with consumer price inflation of below 2 percent. Potential output growth is estimated at 2-2.5 percent, and a negative trend in velocity lead to an increase of money growth in a range between 0.5 and 1 percent. Given these assumptions, the target for money growth has been set at 4.5 percent per annum.

Monetary conditions have become abnormally loose, as monetary growth has continuously exceeded its target. For example, M3 increased by 9.9 percent in 2006, after 7.3 percent in 2005. Due to a low inflation environment and a relatively flat term structure of interest rates agents shifted their portfolio towards safe and liquid assets. But price stability has been maintained until recently, thereby questioning whether the monetary strategy of the ECB is appropriate. If the link between money and prices turns out to be unstable, money growth is not well designed to inform about future inflation trends and to support policy decisions.

For monitoring the inflation process, a stable money demand function is extremely important, at least as a long run anchor (see ECB, 2004, p64). If this condition is met, money demand can be linked to the real sphere of the economy. But recent evidence has cast serious doubts concerning the robustness of the relationship. If data up to 2001 are used, standard money demand functions for the euro area can be firmly established, see Fagan and Henry (1998), Hayo (1999), Funke (2001), Coenen and Vega (2001), Brüggemann, Donati and Warne (2003), Brand and Cassola (2004), Holtemöller (2004a, b) and Brüggemann and Lütkepohl (2006). Extending the sample to a more recent period has often destroyed these findings, as a stable long run relationship between the variables could not be detected anymore, see Gerlach and Svensson (2003). To overcome this deficit, several authors worked with the core components instead of original variables, see Gerlach (2004) and Neumann and Greiber (2004). Others have extended the basic specification by including measures of uncertainty, see Greiber and Lemke (2005) and Carstensen (2006).

*-Figure 1 about here-*

Despite these results, Dreger and Wolters (2008) have reported strong evidence in favour of a stable long run equation for a standard set of explanatory variables. Nominal interest rates are embedded in an indirect way by the inclusion of the term structure. However, the income elasticity of money demand exceeds unity, and a permanent break occurred after 2001. Income elasticity has increased since then, see the scatterplot between real money balances and real GDP in figure 1. A break in this parameter has also

been detected by Lütkepohl, Teräsvirta and Wolters (1999) in case of the German M1 aggregate.<sup>2</sup>

The quantity theory postulates an income elasticity equal to unity. However, it is based on a narrow money concept. In models explaining broader money aggregates, the elasticity can exceed one, especially if wealth is not explicitly modelled. According to the seminal contribution of Friedman (1988), the holding of money is related to portfolio allocation. As equities have become an important storage of wealth, it is plausible that variations in equity markets could affect money demand. For example, a surge in asset prices may trigger a rise in demand for liquidity due to an increase in net household wealth. While this scale effect points to a positive impact of wealth, the substitution effect works in the opposite direction. Higher asset prices makes assets more attractive relative to money holdings. Therefore, the sign of the wealth variable is theoretically ambiguous. An income elasticity above one could point to a dominance of the scale effect in absolute value. In addition, the effects can be nonlinear, as money holdings might be more stimulated in a low inflation environment combined with a credible monetary policy.

The evidence on the presence of wealth effects is controversial. According to Fase and Winder (1998) wealth could be important to explain the demand for M2 and M3, but not for M1. But this study is based on data up to 1995, where standard models have also worked well. Using more recent information, Bruggeman, Donati and Warne (2003) have rejected an impact of share prices on a broader money aggregate. In contrast, Boone and van den Noord (2007) found positive impacts arising from the stock and the

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<sup>2</sup> The transitory change in the income elasticity between 1992 and 1994 occurs just after the fall of the iron curtain, where a negative growth rate in real income and a positive change in real money balances can be observed.

housing market. They are limited to the long run, and do not enter the short run dynamics. Greiber and Setzer (2007) reported evidence in favour of a long run money demand specification extended by real house prices or a measure of the housing stock. It should be noted, however, that causality can also run in the opposite direction since an expansionary monetary policy may provide ample liquidity and cause asset inflation (Adalid and Detken, 2007). Developments in the housing market have also consequences on the lending behaviour of banks (Greiber and Setzer, 2007).

In this paper, we present a robustness analysis regarding the long and short run relationships between money demand and wealth. Wealth is proxied by variables from the stock or housing market. According to Dreger and Wolters (2006) a wealth effect can be rejected in standard models if the income elasticity is not restricted. Nevertheless, the unrestricted model might blur the appropriate interpretation of the results, as part of the wealth impact could work through the income channel. To disentangle these effects, the income elasticity is restricted to unity, i.e. the presence of income in the relationship is solely interpreted from the transaction motive. Hence, money velocity has to be explained. In fact, this enables us to discuss the impacts of developments in wealth on money demand in a more realistic way. Moreover, it is investigated whether the break in the income elasticity can be traced to the exclusion of wealth.

The empirical analysis reveals a cointegrating relationship between velocity, inflation and wealth, where the latter is proxied by real stock and house prices. Both variables have shown a positive impact on velocity after 2001. The results are fairly robust, and the corresponding error correction model survives a battery of specification tests, including those for parameter stability.

The rest of the paper is organized as follows. Section 2 reviews the specification of the long run money demand function. In section 3, the series used in the empirical analysis are discussed. Specification and estimation of money demand functions in error correction form has been the customary approach to capture the nonstationary behaviour of the time series involved. Evidence regarding the cointegration properties is provided in section 4. In section 5, an error correction model for money velocity is presented. Section 6 concludes.

## 2 Money demand and velocity

A widely used specification of money demand is chosen as the point of departure. According to Ericsson (1998), the specification of the demand for a broad monetary aggregate leads to a long run relationship of the form

$$(1) \quad m_t - p_t = \delta_0 + \delta_1 y_t + \delta_2 w_t + \delta_3 R_t + \delta_4 r_t + \delta_5 \pi_t$$

where  $m$  is nominal money taken in logs,  $p$  is the log of the price level,  $y$  log of real income, representing the transaction volume in the economy, and  $w$  log of real wealth. In particular, the logs of real share prices ( $shr$ ) and real house prices ( $phr$ ) are used in the empirical part as concrete wealth measures. Opportunity costs of holding money are proxied by long ( $R$ ) and short ( $r$ ) term interest rates and the annualized inflation rate, i.e.  $\pi=4\Delta p$  in case of quarterly data. The index  $t$  denotes time.

Price homogeneity is assumed to be valid as a long-run condition. In fact, the money stock and the price level might be integrated of order 2, I(2). If these variables are cointegrated, real money balances could be I(1). Then, the long run homogeneity restriction

is appropriate to map the money demand analysis into an I(1) system, see Holtemöller (2004b). According to textbook presentations, income should have a positive effect on nominal and real money balances. Wealth is a second scale variable with an ambiguous sign. Due to multicollinearity problems, income and wealth effects cannot be easily separated. This is achieved by restricting the income elasticity to unity. For Germany, Wolters, Teräsvirta and Lütkepohl (1998) have reported a long run elasticity of 1. Then, equation (1) can be rewritten in terms of the inverse of money velocity

$$(2) \quad m_t - p_t - y_t = \delta_0 + \delta_2 w_t + \delta_3 R_t + \delta_4 r_t + \delta_5 \pi_t.$$

Although opportunity costs have been rather low in recent years, velocity has decreased, probably due to wealth effects. Typical models in the literature differ in the inclusion of opportunity costs, see Golinelli and Pastorello (2002) for a survey. If the costs refer to earnings of alternative financial assets, possibly relative to the own yield of money balances, which could be proxied by the short term interest rate, their coefficients are expected to be negative. The own yield exerts a positive impact. As inflation represents the costs of holding money in spite of holding real assets, it should enter with a negative sign.

### **3 Data and preliminary analysis**

Since the introduction of the euro on January 1, 1999 the ECB is responsible for the implementation and conduction of monetary policy in the euro area. As the time series under the new institutional framework are too short to draw robust conclusions, they have to be extended by artificial data. Usually, euro area series prior to 1999 are ob-



tained by aggregating national time series, see for example Artis and Beyer (2004). Different aggregation methods are available and can lead to different results. By comparing aggregation based on methods using variable or fixed period exchange rates, Bosker (2006) has emphasized that the differences are substantial prior to 1983, in particular for interest and inflation rates. However, they are almost negligible for money demand variables from 1983 onwards. The European Monetary System started working in 1983, and the financial markets of the member countries have become much more integrated since then. Therefore, the observation period in this study is 1983.1-2006.4, where quarterly seasonally adjusted series are used.

Nominal money balances are taken from the ECB monthly bulletin database and refer to M3 and end of period values. The short and long term interest rates are also obtained from this source and defined by the 3month Euribor and 10 years government bond rate, respectively. Nominal and real GDP as a proxy for income are taken from Eurostat, the latter defined as chain-linked volumes with 2000 as the reference year. The GDP deflator (2000=100) is defined to be the ratio of nominal to real GDP multiplied by 100. Due to evidence presented by Holtemöller (2004a), the Brand and Cassola (2004) GDP data should be used in earlier periods, as these data yield stable and economically interpretable results. Note that this choice does not affect any conclusions in this paper, as instability of money demand is only a problem in recent years. In order to obtain real money balances the nominal money stock is deflated with the GDP deflator.

The inverse of money velocity is the difference between the logs of money balances and log income. Wealth is approximated either by the log of share (*shr*) or house prices (*phr*). As data for the euro area is not available over the whole time span, the Morgan Stanley stock market index for Europe is used instead to capture developments in share

prices. House prices are measured by the residential property price index (all dwellings) taken from the Bank of International Settlement, see Borio and Lowe (2002). Since this index is reported on an annual basis, missing values are generated by linear interpolation. Both share and house prices enter the analysis in real terms, i.e. they are deflated by the GDP deflator. Figure 2 displays the development of series in levels (A) and first differences (B) in the 1983.1-2006.4 period.

*-Figure 2 about here-*

All variables are integrated of order 1,  $I(1)$ , implying that they are nonstationary in the levels representation, but stationary in their first differences. The results of the integration tests are omitted here to save space, but can be obtained from the authors upon request. This well known result holds for different observation periods, see the results in the aforementioned empirical studies.

## **4 Cointegration analysis**

In systems involving money velocity, wealth, nominal interest rates and inflation, at least one cointegration relationship should be interpreted in terms of a velocity equation in the style of (2). To explore the cointegration properties of different sets of variables, the Johansen (1995) trace test is used as the workhorse, see table 1 for the results. The lag length of the VARs is estimated by the Schwarz criterion and equal to 1 throughout

the analysis. All models are estimated with an unrestricted constant to capture possible linear trends in the level representation.

There is a strong indication for exactly one cointegrating vector given that the inflation rate enters the system. Note that velocity cointegrates with inflation, but neither with the short nor long term interest rate. Thus, interest rates are only important in an indirect way. In fact, if the real interest rate is constant, fluctuations in inflation preceptions will lead to proportional changes in the nominal interest rate. Furthermore, nominal interest rates may be included in the equilibrium relationship via the term structure, as the latter is stationary ( $p$ -value 0.028). These results replicate the findings reported in Dreger and Wolters (2006, 2008).

*-Table 1 about here-*

Although velocity and inflation are cointegrated, the basic relationship appears to be unstable because of the structural break after 2001, see Dreger and Wolters (2008). For that reason, the set of variables is extended to cover measures of financial wealth. Since standard money demand functions have worked quite well when data up to 2001 are used, wealth variables enter only after this period. In particular, real share and house prices arise as the product of the particular wealth variable and a step dummy equal to 1 from 2002.1 until the end of the sample and 0 earlier. The presence of wealth variables does not alter the cointegration rank. On the other hand, they cannot simply be removed from the cointegrating space, as the exclusion restrictions are soundly rejected. In the

$(m-p-y, w, \pi)$  systems, the chi square values are 10.10 ( $p$ -value 0.001) for share and 9.82 ( $p$ -value 0.002) for house prices.

In the following, the cointegration vectors is estimated from the  $(m-p-y, w, \pi)$  systems. Since it contributes to slightly more precise estimates, the term structure of interest rates is also included. This also improves the economic content of the relationship, but does not affect the cointegration parameters in a substantial way. The cointegrating relationships

$$(3a) \quad ec(shr) = (m - p - y) - \underset{(0.004)}{0.031} shr + \underset{(0.652)}{6.475} \pi + \underset{(1.251)}{5.967} (R - r)$$

$$(3b) \quad ec(phr) = (m - p - y) - \underset{(0.007)}{0.057} phr + \underset{(0.656)}{6.512} \pi + \underset{(1.258)}{6.047} (R - r)$$

do not show any substantial divergencies across the different wealth measures (standard errors in parantheses). Higher real share and house prices will lead to an increase in inverse velocity, as the rise in real money balances will overcompensate a possible acceleration in real GDP, the latter due to higher consumption of private households, see for example Lettau and Ludvigson (2004) on this point. In addition, higher inflation and a rise in the term structure are expected to lower inverse velocity, because the demand for real money holdings is reduced. The error correction terms are plotted in figure 3 in a mean adjusted form.

*-Figure 3 about here-*

The mean adjusted error correction terms do not differ at all, implying that the choice of the wealth variable does not affect the long run evidence. Therefore, the subsequent analysis can be safely restricted to one equation, where the choice is on (3b). The deviations from the long run do not indicate abnormal behaviour over the entire period. Inverse velocity is not high when compared to historical standards. Instead, inverse velocity is more or less in line with its long run equilibrium level. Based on these results, no convincing evidence for a monetary overhang can be obtained, see also Dreger and Wolters (2008).

## 5 Error correction modeling

Whether or not the cointegrating relationship can be interpreted in terms of an equation explaining inverse velocity can be inferred from a conditional error correction model. This approach may lead to constant coefficients even if a shift is present in the reduced form. Given the identification problems in full systems, a structural model for an individual variable might be easier to develop using the single equation context.

At the initial stage of the estimation process, the contemporaneous values and the first two lags of the changes of all variables, a constant and the error correction term (3b) are considered. Variables with the lowest and insignificant  $t$ -values are eliminated subsequently, where the 0.1 level is used. The final relationship

$$(4) \quad \Delta(m - p - y)_t = 0.043_{(3.66)} - 0.034_{(3.60)} ec_{phr,t-1} + 0.847_{(4.81)} \Delta phr_t - 1.262_{(3.91)} \Delta phr_{t-1} + 0.599_{(2.17)} \Delta phr_{t-2} \\ - 0.235_{(2.61)} \Delta \pi_{t-1} - 0.358_{(1.95)} \Delta R_t - 0.419_{(2.29)} \Delta r_{t-1} + 0.440_{(2.36)} \Delta r_{t-2} + 0.025_{(3.58)} d902$$

T=96 (1983.1-2006.4)

R<sup>2</sup> adj=0.42

SE=0.007

JB=0.32 (0.85)

LM(1)=0.64 (0.43)

LM(4)=0.38 (0.82)

ARCH(1)=0.01 (0.94)

ARCH(4)=0.11 (0.98)

RESET(1)=0.22 (0.64)

RESET(2)=0.48 (0.62)

show supporting evidence for a velocity equation. The numbers in parantheses below the coefficient estimates are *t*-values. According to the negative value of the error correction terms, excess money would reduce inverse velocity, as one expects in a stable model. While house prices are also relevant in the short run, share prices are important only in the long run, see equation (3a). Furthermore, changes in the short and long term interest rates and inflation are part of the short run dynamics. In addition, an impulse dummy equal to 1 in 1990.2 and 0 otherwise is included in the short run specification to control for German unification.

*-Figure 4 about here-*

Standard tests do not point to specification errors. *LM* is a Lagrange Multiplier test for no autocorrelation in the residuals up to order 1 and 4. The *p*-values shown in parantheses indicate, that no problems with autocorrelated residuals occur. *ARCH* is a Lagrange multiplier test for no conditional heteroskedasticity. Again, the residuals do not exhibit such kind of behaviour. Furthermore, they are distributed as normal, as indicated by the Jarque-Bera (*JB*) test. Moreover, the Ramsey *RESET* test does not point to a misspecifi-

cation of the equation. The cusum of squares test does not indicate any structural break in the regression coefficients, see figure 4. Overall, the empirical evidence in favour of a stable velocity equation for the euro area is strongly supported by the error correction analysis.

## **6 Conclusion**

In this paper we examine money velocity in the euro area, where special emphasis is given to the issue of stability and wealth effects. In fact, many researchers have detected instabilities in the money demand function especially when data after 2001 are included in the analysis. Such a result casts serious doubts concerning the rationale of monetary aggregates in the monetary strategy of the ECB. In contrast to the bulk of the literature, we report strong evidence in favour of a stable velocity relationship, which is one cornerstone of monetary policy.

This result can be achieved by including inflation and wealth in the cointegration vector, where the latter is measured either by real share or house prices. Evidence for the presence of wealth in the long run relationship is provided. In particular, both stock and house prices have exerted a negative impact on velocity after 2001. The extended error correction model is stable over the sample period and survives a battery of specification tests.

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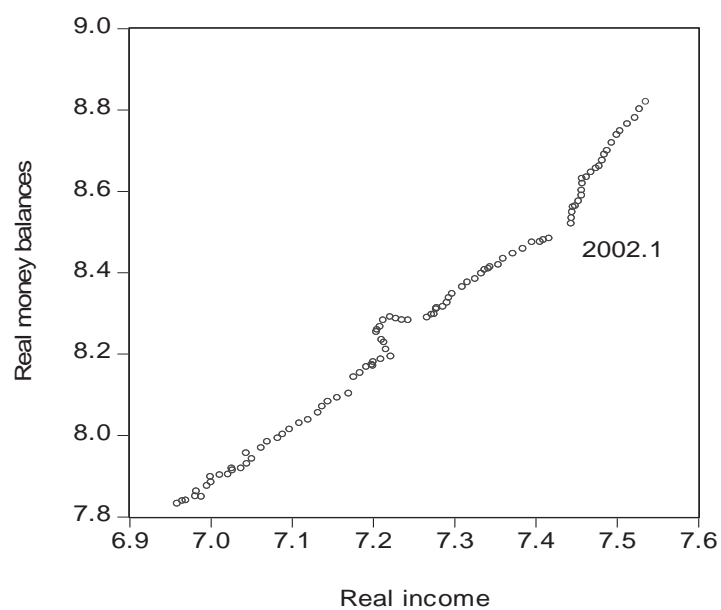
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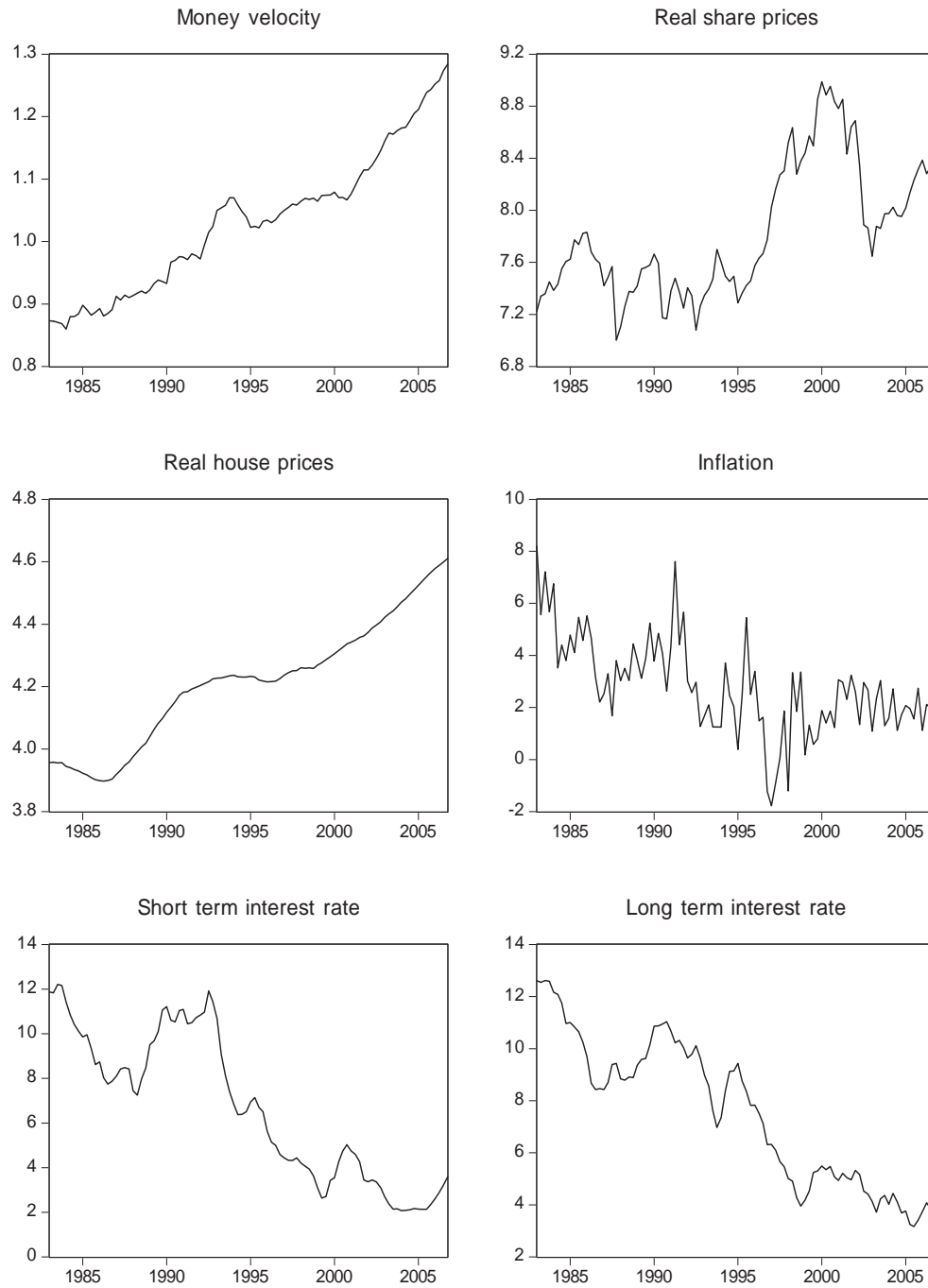
Figure 1: Structural break in income elasticity



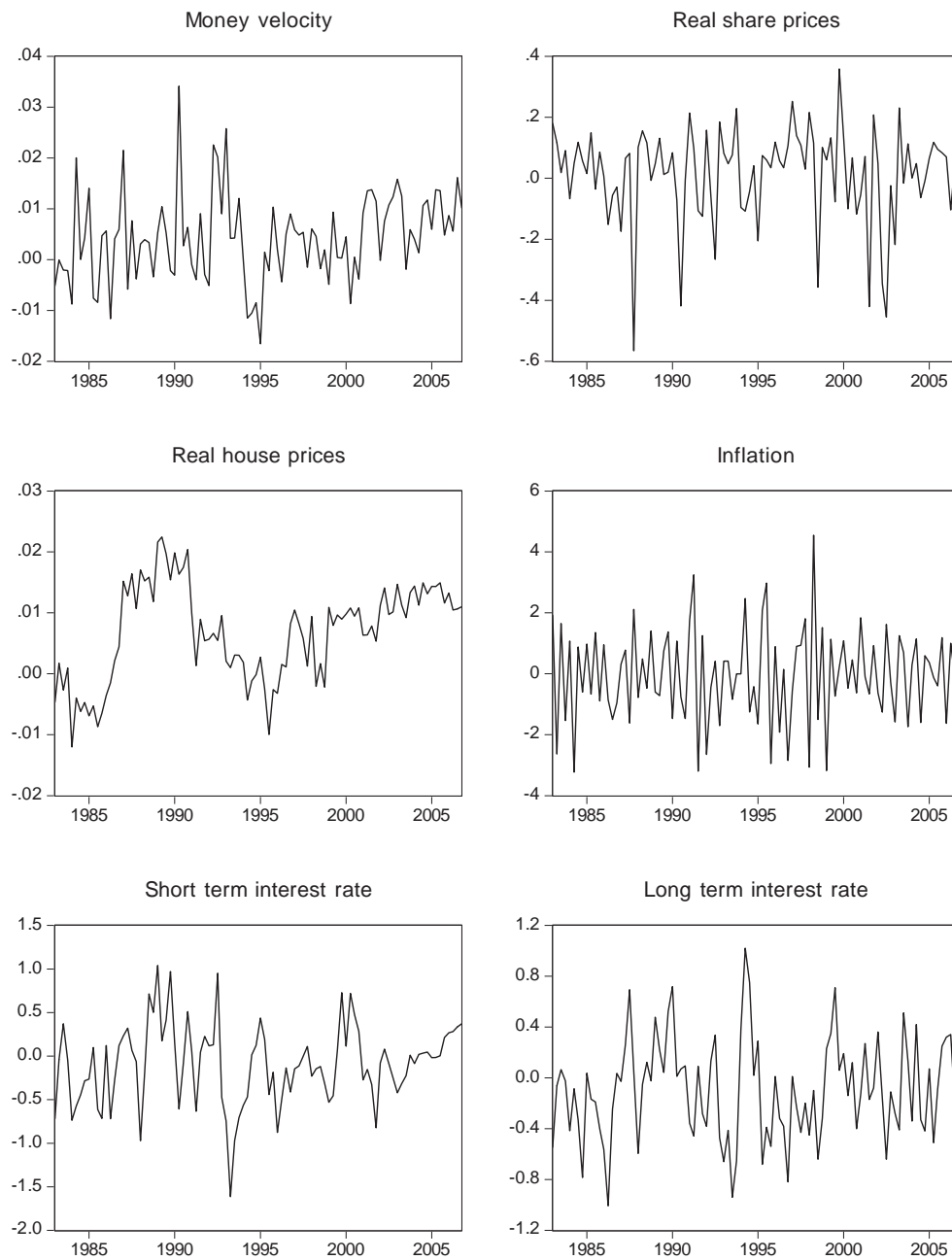
Note: Sample period 1983.1-2006.4. Increase in income elasticity from 2002.1 onwards.

Figure 2: Variables used in the empirical analysis

A Levels

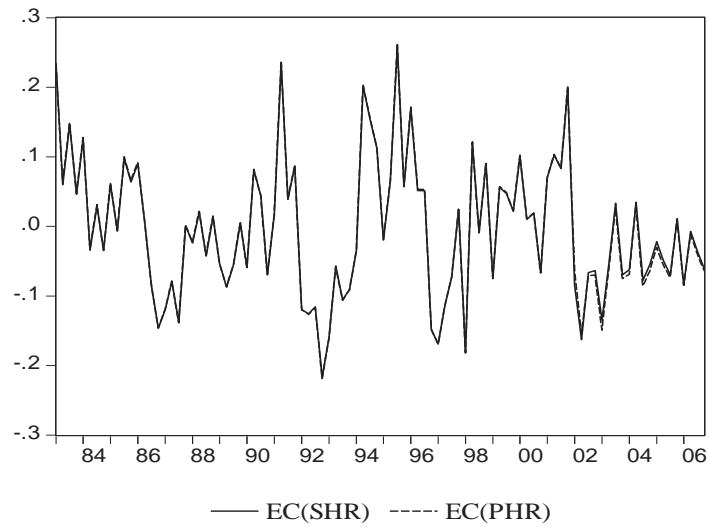


## B First differences



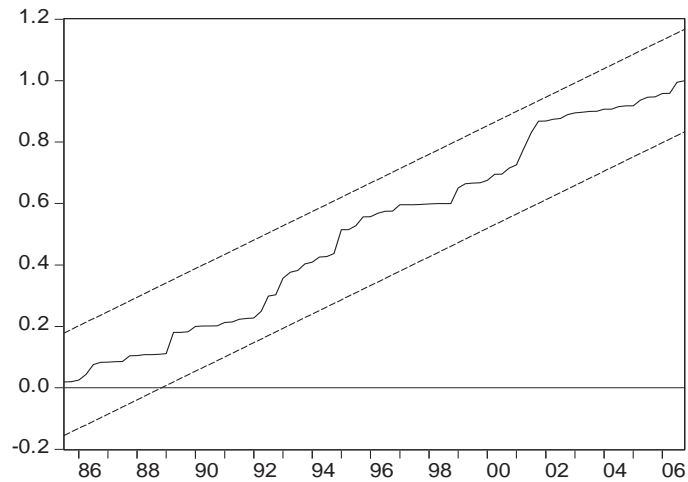
Note: Sample period 1983.1-2006.4. Real share and house prices in logs. Inflation calculated on the base of the GDP deflator.

Figure 3: Error correction terms for different wealth measures



Note: Sample period 1983.1-2006.4, mean adjusted, *shr*= share, *phr*= house prices, both deflated by the GDP deflator.

Figure 4: Cusums of squares



Note: Sample period 1983.1-2006.4. Dotted lines refer to 0.05 significance.

Table 1: Cointegration tests for sample period 1983.1-2006.4

Variables	Rank null hypothesis	Johansen trace test	
		Share prices	House prices
$m-p-y, r$	0	9.15	
	1	3.16	
$m-p-y, R$	0	7.68	
	1	1.18	
$m-p-y, \pi$	0	32.22**	
	1	3.50	
$m-p-y, w$	0	11.33	10.73
	1	3.41	3.14
$m-p-y, w, r$	0	18.29	17.69
	1	7.63	7.36
	2	3.41	3.03
$m-p-y, w, R$	0	15.23	14.67
	1	6.31	5.83
	2	0.90	0.83
$m-p-y, w, \pi$	0	49.92**	49.15**
	1	10.75	10.22
	2	3.78	3.51

Note: All models estimated with unrestricted constant. A (\*), \*, \*\* denotes significance at 0.1, 0.05 and 0.01 level. Critical values are from MacKinnon, Haug and Michelis (1999). Lag order of 1 in underlying VAR models (level specification), according to the Schwarz criterion.