Global Liquidity and Asset Prices in a Cointegrated VAR

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Abstract

This paper investigates the relationship between money/liquidity and asset prices on a global scale: To what extent is global liquidity important? How are interest rates affected by global monetary conditions? And how does this affect the ability of central banks to control inflation? We find evidence for a surge in global liquidity beginning in 2001, which has raised inflation rates and house prices, but has had limited effects on share prices. Furthermore, policy rates have indeed been unusually low given inflation levels.

Keywords: Global liquidity, inflation control, money demand, asset prices, cointegration
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1 Introduction

Studies at country-levels suggest that money does not matter for inflation nor long term interest rates even though economic theory generally prescribes a one-for-one relation in models emphasizing (super-)neutrality; see *inter alia* Hendry (2001) and Juselius (2007) for empirical analyses of inflation in the UK and Denmark, respectively. However, one reason for this finding may be that it is *global* liquidity that is important. Also, there is evidence for the existence of one common (worldwide) interest rate and/or inflation rate, see *inter alia* Ciccarelli and Mojon (2005), which exerts large influence on national rates yet is not controllable by a central bank. The purpose of this paper is to investigate the existence of a global money market in order to identify potential excess liquidity and analyse its interactions with global inflation and asset prices, as suggested by a number of authors, see Baks and Kramer (1999), Sousa and Zaghini (2004) and Ruffer and Stracca (2006).

Recently, global monetary conditions have received a lot of public interest, from the press, policymakers and market participants alike, but less so from academics. The fact that e.g. the European Central Bank (ECB) is becoming increasingly aware of the potential importance of global liquidity is illustrated by the following excerpts from a speech given by the Vice-President of the ECB, Lucas D. Papademos, on May 35, 2006:[1] *Ultimately, global inflation will be determined over the long term by the trend increase in global liquidity. The relationship between global trend money growth and long-term inflation will depend, however, on the way globalisation affects the rate of expansion of the productive capacity of all economies as well as on its effects on the factors and mechanisms that determine the "velocity of circulation of global money".*

The Economist has recently devoted two *Economics Focus* articles to the subject (February 8 and June 7, 2007).[2] The second one, "What goes around", argues that the importance of money depends on whether it is viewed as being determined by supply or demand. Monetarists believe the former where an oversupply of money creates inflation, new-Keynesians, among them many current policymakers, the latter where this is not the case and money may hence be ignored for policy purposes. The Economist asks whether "the pendulum has swung too far from monetarist overkill to monetary neglect", and cites

[1]See www.ecb.int/press/key/date/2006/html/sp060525.en.html.

[2]See www.economist.co.uk/finance/displaystory.cfm?story_id=8669202 and www.economist.co.uk/finance/displaystory.cfm?story_id=9301949.

Bank of England Governor Mervyn King who argued in a recent lecture that shifts can occur not just in the demand for money, but also in the supply. The topic was also taken up numerous times in the Financial Times. In a comment on June 15, 2007, Martin Wolf discusses whether the recent increase in UK money growth was due to supply or demand reasons and whether the Bank of England should pay attention to it.[3]

Central banks used to monitor money supply, based on the Friedman (1969) idea that "inflation is always and everywhere a monetary phenomenon", for which the stability of money demand was a necessary prerequisite: if a stable money demand relation exists then the central bank can control inflation via control of the money stock. The money targeting that this idea gave rise to was largely abandoned because empirical analyses often seemed to suggest instability of money demand relations. The Fed argues that money supply is so heavily distorted by offshore holdings and the shift away from bank lending towards securitisation that it is not important for decision-making in an inflation targeting regime. However, for the euro area stability has been established by a number of authors depending on the methodology employed in the analyses, see *inter alia* Coenen and Vega (1999) for a euro area money demand analysis. The ECB inherited its monetary policy strategy to a large extent from the Bundesbank which was rather successful in keeping inflation down via control of money supply. Hence, the ECB emphasizes a two-pillar strategy where besides a general assessment of various economic indicators a "prominent role" is assigned to monetary developments.

Today most central banks around the world, including the Bank of England, adhere to some form of inflation targeting, the foundations of which were laid down by, in particular, Woodford (2003), and which also became one of the main pillars of the literature on Dynamic Stochastic General Equilibrium (DSGE) models. The predominant idea is that money contains no additional information once inflation is included in the assessment of an economy based on e.g. a DSGE model. The main implication is that an interest rate rule should be used for monetary policy decisions in order to ensure credibility, transparency and accountability. Essentially, the recommendation to central bankers becomes that of an inflation targeting approach within a rule-based framework in order to avoid the problems argued to be associated with discretionary policy actions. Despite the theoretically appealing framework of DSGE models, their underlying assumptions are usually found to be invalid, see Franchi and Juselius (2007).

[3]See www.ft.com/cms/s/879b8e86-1ade-11dc-8bf0-000b5df10621.html.

A strand of (empirical) literature that uses cointegration analysis has often found that money is a redundant concept as far as inflation is concerned. In analyses such as Hendry (2001), Juselius (1992, 2007) and Tuxen (2006) it is found that money does not matter for prices in the longer run. Nevertheless, it is important to point out that the reason for this is fundamentally different from that proposed by the DSGE approach: cointegration analyses often find some type of money demand relationship to be approximately stable. However, the deviations from national money demand cointegrating relations play no important role for price changes. Rather, labour markets appear to be crucial determinants of inflation. Thus central bank policy, be it determined by money or inflation targeting, is simply not capable of controlling inflation by setting the short term interest rate and/or money supply, see Johansen and Juselius (2003) for an analysis of the issue of controllability of US monetary policy.

Thus, despite the fact that money demand tends to be stable at a national level, excess money does not appear to be important for goods and asset prices. The question is then whether it is global money/liquidity that matters instead: shifts in the money supply in any one country may be absorbed by demand elsewhere in today's linked financial markets, but simultaneous shifts in major economies may have significant effects on worldwide inflation, interest rates and asset prices.

2 Theoretical considerations

We want to investigate the impact of global liquidity as a result of loose monetary policy on asset prices and ultimately on inflationary developments. This section provides an overview of the relations suggested by conventional economic theory, i.e. by the neoclassical synthesis and more recent new-Keynesian models. Where no explicit reference is given the relations have simply been adapted from a standard macroeconomic textbook such as Blanchard (2000). We work directly with log-linear functional forms as this is the specification we will be working with in the CVAR framework.[4] To accommodate the monetarist view consider a traditional money demand relation,

$$m_r^D = \lambda_1 y_r + \lambda_2 \pi + \lambda_3 (I_l - I_s) \tag{1}$$

[4]Constant terms are likely to enter most relations but are left out in the theoretical specifications for simplicity. Potential or target values of a variable can be approximated by a linear trend term in the empirical analysis.

where m_r is the log of real money, superscript D denotes demand, y_r is the log of output (economic activity), I_l is the long-term interest rate (opportunity cost of holding cash), I_s is the short-term interest rate (own-interest rate on money holdings) and π is the rate of inflation; $\lambda_1 > 0$, $\lambda_2 < 0$ and $\lambda_3 < 0$ such that money demand reacts positively to a rise in the short rate and negatively to increases in the long rate and inflation. Excess liquidity would then be represented by money supply, m_r^S, exceeding the level of money demand as described by (1), possibly in deviation from real output.

On the other hand, if New-Keynesians are right about the crucial role of an interest rate rule we need to consider the existence of a Taylor (1993) rule such as,

$$I_s = \gamma_1(\pi - \pi^T) + \gamma_2(y_r - y_r^P) \tag{2}$$

where superscripts T and P indicate, respectively, the target and potential value of the variable in question; a stabilizing rule would have $1 < \gamma_1 < 2$ and $\gamma_2 > 0$ such that the policy rate is raised every time inflation and/or output rise above target. In a set-up with (2) as the description of policy, excess liquidity would be represented by a policy rate set lower than that dictated by the policy rule. Note that policy does not react to monetary developments.

These two central relationships emphasized by different strands of the literature suggest the following information for the analysis,[5]

$$\Theta = (m_r, y_r, p, I_s, I_l) \tag{3}$$

Given the choice of variables to enter the analysis as in (3), a number of other macroeconomic relations suggest themselves. First, a term structure relation as suggested by the expectations hypothesis (EH), see Cox, Ingersoll, and Ross (1985) with the k periods to maturity rate being an average of expected future one period rates plus a risk premium,[6]

$$I_k = \frac{1}{k}\Sigma_{j=1}^{k} I_{1,j}^e + \rho(k) \tag{4}$$

where superscript e denotes the expected value of the variable in question, subscript k denotes the specific time to maturity involved, $k \in \{s, l\}$, i.e. either the short term or the long term, and $\rho(k)$ is a risk premium which likely depends positively k. The cointegration

[5]In order to cast the system in terms of I(1) variables only we need to do the nominal-to-real transformation (NRT); we thus end up with a system formulated in terms of real variables and a nominal growth rate, i.e. the inflation rate, π. We discuss the NRT below in section 5.

[6]The EH is essentially a no-arbitrage condition.

implication of the EH in its simplest form is that among r interest rates there should exist $(r-1)$ cointegrating relations such that the spread between every two rates of different maturities is stationary, possibly around a constant. Second, an aggregate demand (AD) - or alternatively an IS - relation

$$y_r^D = y_r^P + \tau_1(I_k - \pi) \tag{5}$$

with $\tau_1 < 0$. Third, a Phillips curve (PC) specified in terms of the output gap,

$$\pi = \delta_1(y_r - y_r^P) \tag{6}$$

where $\delta_1 > 0$. Finally, the Fisher parity which is essentially a definition of the real rate of interest,

$$I_{r,k} \equiv I_k - \pi_k^e \tag{7}$$

where I_r is the real rate. Notwithstanding the fact that relation (4) and (7) involve expected variables, we only use actual values of the variables in the empirical analysis.

The relations provide inspiration as to what relations to look for during the identification process in the Johansen procedure.

2.1 Extending the information set

Since we are particularly interested in relationships between liquidity and asset prices, we will also consider prices of equity, housing and oil. Housing serves a dual role in the economy by means of its function both as a consumption and an investment object. Demand factors determine prices while the housing stock is inelastic in the medium term and thus prices may overshoot, but ultimately supply factors pin down prices. The demand curve for housing is usually assumed to be downward sloping at any time, whereas the supply curve shifts from being vertical in the short run to horizontal in the long run. The fundamental value of houses is determined by the price of land as well as construction costs for new houses less the income that can be earned from letting. Rental income is in turn determined by the utility of housing on the one side and on the other user costs which depend on e.g. the rate of depreciation, maintenance costs and the structure of the tax system. Though there may be temporary effects from the business cycle (GDP) and the level of interest rates these cannot have permanent effects on the price of housing.[7]

[7] The recent housing boom in the OECD countries has been caused by factors such as falling nominal interest rates, an economic upturn, liberalisation of capital markets making access to credit easier, and finally by demographic factors leading to more single person households.

On the other hand, buying shares would usually be done with returns in mind alone and thus considered solely an investment decision.

Financing the purchase of equity will also often be very different from that of housing; the latter usually requires a mortgage whereas buying shares is funded through a myriad of financial products. Even though there are a number of micro level reasons for treating housing and equity differently, the information set that we have available at the global level does not allow us to distinguish and we therefore treat the two price indices identically and simply refer to these as asset prices.

We now modify the relationships discussed above to take these three prices into account. There is no obvious reason why asset prices should enter the money demand equation, but central banks may decide to target asset prices. A modified policy rule takes the form,

$$I_s = \gamma_1(\pi - \pi^T) + \gamma_2(y_r - y_r^P) + \gamma_3(q - q^T) \tag{8}$$

where q is the log of real asset prices and could be a vector including both stock and house prices, i.e. $q = (s_r, h_r)'$. We expect $\gamma_3 > 0$. Due to wealth effects, q potentially also enters the AD relation, see Smets (1997) and Disyatat (2005),

$$y_r^D = y_r^P + \tau_1(I_k - \pi) + \tau_2 q. \tag{9}$$

with $\tau_2 > 0$. In the New-Keynesian model employed by Goodhart and Hofmann (2007) asset prices do not enter the PC. However, oil prices are viewed as decisive for inflation as they represent the price of an important raw material and thus are a crucial component of the marginal costs of firms. The revised PC takes the form,

$$\pi = \delta_1(y_r - y_r^P) + \delta_2 oil_r \tag{10}$$

where $\delta_2 > 0$. Finally, a number of no-arbitrage conditions would be expected to hold. Risk-adjusted returns to investment in different assets should be equalized according to the efficient market hypothesis provided that risk adjustment is done properly (Fama (1970)). Equating *risk-adjusted* expected returns to investment in equity/housing on the one side and bonds on the other, we obtain

$$\Delta_k q^e = (I_k - \pi_k)^e + \kappa(k, q) \tag{11}$$

where $\kappa(k, q)$ is a risk premium which is allowed to depend on the investment horizon and the type of asset in question. Note that in the light of the equity premium puzzle, see *inter alia* Mehra and Prescott (1985), a constant may be required as well. It is important to distinguish between *ex ante* and *ex post* returns: risk-adjusted expected returns should be the same for all types of investments. Otherwise risk-free arbitrage is expected and efficient markets would instantly eliminate such possibilities; however, actual outcomes may differ from expectations and invalidate (11).

Another relation could be a demand equation for asset prices, see Disyatat (2005):

$$q = \omega_1(y_r - y_r^P) + \omega_2(I_s - \pi) \tag{12}$$

where $\omega_1 > 0$ and $\omega_2 < 0$. In addition, it may be necessary to allow for some form of bubble component in (11) and (12). Such a time varying bubble could potentially be related to the build-up in liquidity such that the following relation replaces for example (11),

$$\Delta_k q^e = (I_k - \pi_k)^e + \kappa(k, q) + \phi_1(m_r - y_r) \tag{13}$$

but could also feature in (12). $\phi_1 > 0$ suggests that a liquidity surplus - defined as money in excess of GDP - may initiate an asset price bubble. One implication of the bubble element is that a (sudden) decline in liquidity may cause the bubble to burst and thereby lead to a severe credit crunch which in turn could threaten financial stability.

Again these relations could be tested in the cointegration framework, allowing for the inclusion of asset prices, i.e. stock or house prices, as well as the oil price.

3 Survey of existing studies

So far, there is a striking absence of journal articles on global liquidity and in particular on its relation to asset price developments. The topic has mainly been discussed in working papers from various international financial institutions such as BIS, IMF, as well as in publications by central banks and investment banks. No agreement exists as to which measure of global liquidity is the appropriate one. Below we provide brief summaries of the main papers within the literature, paying special attention to the liquidity measure employed, the theoretical considerations provided, and the econometric methods used by each.

3.1 Baks and Kramer (1999)

Liquidity measure: Two concepts of liquidity, market and monetary, are used, but the focus is on the latter. Three (six) different measures: GDP-weighted growth rate series, simple sum US dollar aggregate, Divisia indices of global money growth (using both narrow and broad money). Based on these, excess money growth variables are constructed by subtracting the average growth rate of nominal GDP. Also construct ex-country (ROW) indices where one of the G3 countries is excluded. Narrow money is found to have a stronger relationship with asset prices as do Divisia and simple sum measures.

Theoretical considerations: 1.) liquidity may cause inflation if demand increases for a fixed supply of assets, 2.) a booming economy may lead to both increased liquidity and to a rise in asset prices, and finally 3.) increased liquidity causing lower interest rates may in turn cause stock prices to increase due to a reduction in the discount factor. This points to two channels for transmission, a push and a pull channel; the former suggests a positive correlation between global/foreign money growth and domestic asset prices (lower returns); the latter suggests a negative relationship.

Data: 1971-1998 (quarterly series); G7 countries

Methodology and results: Principal components analysis: first principal component has high explanatory power for all individual country growth rates. Calculation of simple contemporaneous correlations (as well as at business cycle frequencies) between excess money growth and real asset returns: negative correlation with interest rates and positive correlation with stock returns. Regressions to check for direct effects: i.) real asset returns on lagged returns and excess money growth: same results as from the simple correlations, ii.) cross-country monetary spillovers using the ROW indices: evidence of push channel. Granger causality tests to check for indirect effects: US excess money leads - and is led - by Japanese excess money. GARCH(2,2) model to check for volatility spillovers.

3.2 Sousa and Zaghini (2004)

Liquidity measure: Simple sum of monetary aggregates for the included countries/regions converted into euro using PPP exchange rates. Alternative measure also mentioned based on GDP weights and monetary aggregate indices; the two different measures "move closely together".

Theoretical considerations: Increasingly high degree of capital markets integration; a pull and a push channel (see above)

Data: 1981 - 2001 (quarterly); euro area, US, UK, Japan and Canada

Methodology and results: Graphical analysis: G5 (excl. euro area) vs. euro area broad money growth rates, G5 global liquidity vs. GDP and the deflator. SVAR model in the short rate, real GDP, M3, the GDP deflator and the real effective exchange rate: two benchmark models (different identification schemes) using only domestic variables are estimated in order to identify "true monetary policy shocks": impulse response analysis and forecast error variance decompositions. A marginal approach based on the two SVARs, i.e. the addition of a global liquidity aggregate, is then used to analyse how euro area variables respond to foreign money: shocks to global liquidity matter for price and output fluctuations in the euro area; evidence of a push channel.

3.3 Rüffer and Stracca (2006)

Liquidity measure: Construct excess broad money variables for each country imposing unit coefficient on nominal GDP; for the G5 construct measures of external monetary conditions by excluding US, euro area and Japan in turn. Robustness checks using narrow money and direct PPP exchange rate weights in aggregation - similar results.

Theoretical considerations: Effect of an expansionary monetary shock in i.) a Mundell-Fleming model - expenditure switching effect ("beggar thy neighbour"), ii.) a New Open Economy model with nominal rigidities - intertemporal switching effect ("prosper thy neighbour"), finally there is the possibility of iii.) direct transmission of shocks - cost-push effect (firms' marginal costs change). Distinction between leader and follower country, but what about equally sized areas/countries? Monetary aggregates as a spectrum of yields.

Data: 1980 - 2004 (quarterly); 15 countries worldwide including some emerging markets, but for the G5 more data available and part of the analysis is done for these only.

Methodology and results: Dynamic factor analysis: make the series stationary first using different transformations, investigate how large a share of the variance of each variable is explained by the common factor. Granger causality tests: limited evidence of causation running from the excess liquidity common factor to the individual countries'. Global SVAR model in real GDP, GDP deflator, nominal broad money, nominal short term rate (plus real asset price index); Choleski ordering imposed. For the G5 aggregates excess money appears to be a useful measure of the stance of monetary policy and has information value over and above the short rate on a global level. Also estimate G4 model and add domestic variables, i.e. real GDP, GDP deflator, broad money, short rate and real effective exchange rate. Impulse reponse analysis to analyse the impact of an expansionary global monetary policy shock: significant spill-over to euro area and to some extent to Japan, but former behaves as a small open economy; effects on "leader"

US more limited. Variance decomposition analysis: similar results.

4 Methodology

We use the cointegrated VAR (CVAR) model for identifying long-run relationships, $\beta'\mathbf{x}_t$, and short-run adjustment dynamics, α, see *inter alia* Johansen (1996) and Juselius (2007). The association between global liquidity and asset prices has not been investigated using this framework before. In fact, based on our literature review so far it appears that the potential relations between asset returns and liquidity have solely been studied by means of OLS regressions, SVAR models and in some cases panel cointegration tests, see Yeyati and Rozada (2005). We believe that there is room for improvement here, i.e. we propose that a CVAR analysis could be useful in this context as it allows us to take proper account of the non-stationarity of the data, i.e. look for cointegration properties in the data, and at the same time disentangle short- and long-run dynamics.

The analysis proceeds in two stages: Firstly, a global model using superior aggregation methods is estimated. Secondly, national models are estimated which include both domestic and foreign variables in order to investigate spillover effects.

4.1 Data description and aggregation issues

We use quarterly times series for 1982:4 to 2006:4 for France, Germany, Italy, Japan, United Kingdom (UK) and United States (US) and aggregate these to obtain "global series" as described below. The starting point was chosen to coincide with renewed interest rate targeting of the Fed after the end of the so-called "new operating procedures" in September 1982.

Table 1 provides an overview of the data series used. All data are taken from EcoWin and Datastream except house prices which were provided by the BIS. The German reunification is treated such that prior to 1991:1, growth rates in the Western German variables were used to splice the data series and construct historical data for Germany as a whole. Estimations are conducted using seasonal dummies and variables are log-transformed (denoted by lower case names) except interest rates which are divided by 400 for estimation purposes.

There is a range of problems in aggregating national series to a global level. From a purely economic point of view there is the obvious complication that no well-defined monetary (or fiscal) policy exists on a global level. However, it is in essence the focus

Variable	Description	Source
y	Nominal output (GDP)	OECD EOL
m	Broad money stock	National sources[8]
p	GDP deflator (implicit)	OECD EOL
I_s	Short term interest rate (3-month deposit rate)	OECD EOL
I_l	Long term interest rate (10-year government bond rate)	OECD EOL
h	House price index	BIS[9]
s	Share price index (key national indices)	OECD MEI[10]
oil	Crude oil price (F.O.B. spot brent)	OECD EOL

Table 1: Overview of variables and data sources

of this paper to investigate how money markets in different countries play together on a global level. Exchange rate movements pose the main technical problem in aggregation. Various choices exist in choosing an aggregation method; i.e. whether one should aggregate levels or growth rates; use constant or variable weights; convert data measured in national currency into a common currency using fixed or current rates, and/or adjust by price levels or not.

The non-stationarity induced by integrated times series and structural breaks imply that no optimal aggregation method exists. However, Beyer, Doornik, and Hendry (2001) (henceforth BDH) discuss various criteria for a useful aggregate measure and propose the following:

- A unique price series should be obtained in the sense that the aggregate of the individual deflators coincides with the deflator of the aggregates.
- When a variable increases/decreases in every member state the aggregate should do so as well.
- Aggregation should work correctly when a common currency is used.[11]

We use the method suggested by BDH for construction of global data from the national

[8]For most countries M3 is used except in the case of the UK and Japan where M4 and M2 plus cash deposits is used, respectively. Note also that US M2 growth was used to extrapolate the USM3 series from 2006:1 and onwards when publication of M3 was discontinued.

[9]BIS calculation based on national sources. Series for the US and UK are quarterly throughout, for France, Italy and Japan semi-annual series were interpolated to create quarterly series, and for Germany annual series were interpolated.

[10]France: Paris Stock Exchange SBF 250, Italy: ISE MIB Storico Generale, Japan: TSE Topix, UK: FTSE 100, US: NYSE Composite, Germany: CDAX.

[11]The focus on the latter point is due to the fact that the BDH method originally was proposed as a means of constructing historical euro zone data.

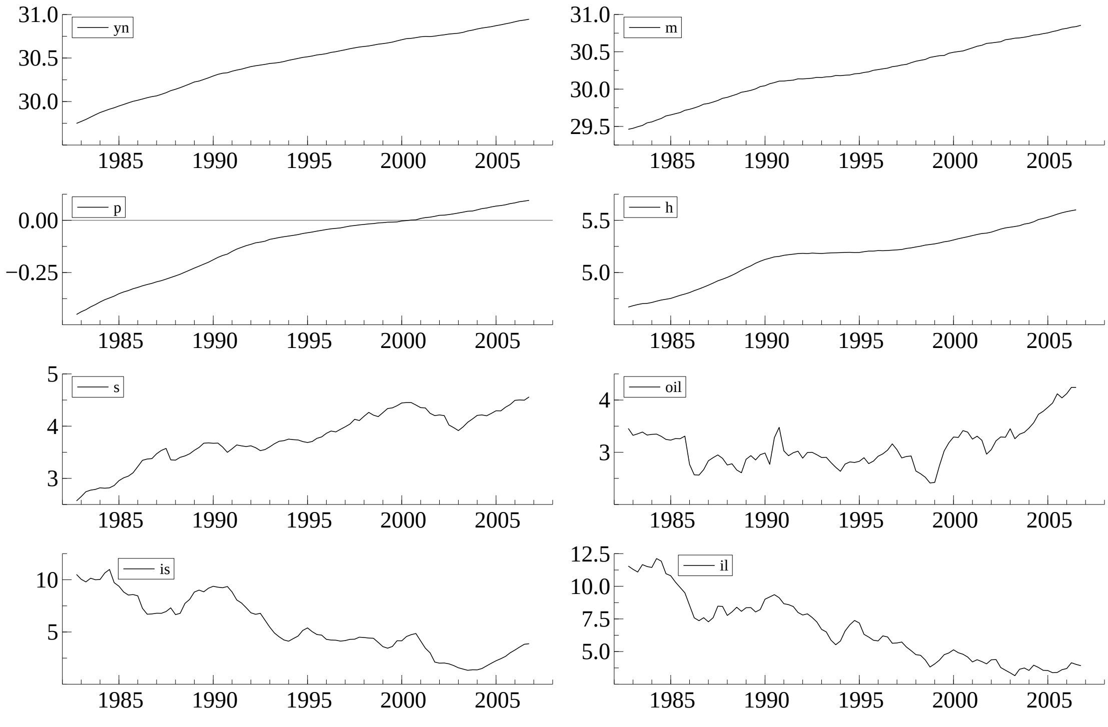

Figure 1: All series except for interest rates in logs, 1982:4-2006:4

series. The method employs variable weights to aggregate growth rates and proceeds in the following four steps:

1. Calculate weights based on the relative share of the variable in question (in a common currency).

2. Calculate within country growth rates of each variable (in national currency).

3. Aggregate growth rates using weights.

4. Cumulate aggregate growth rates to obtain aggregate levels (choose value to "anchor" series with, e.g. final aggregated level from the first step as terminal value).

For conversion of national data to a common currency (the US dollar) actual exchange rates from the OECD were used in the first step. We implemented the above procedure to aggregate money (nominal) and GDP (nominal and real) and then calculated the implicit GDP deflator. Interest rates as well as house and share price indices were aggregated using real GDP weights.[12] Figure 1 shows the aggregated global series.

[12]As an alternative and robustness check, we converted national data into US-dollar denominated

It should be noted that there is a potential problem with the price series constructed using the BDH method as pointed out by Beyer and Juselius (2007): if PPP is not satisfied in the base year then the choice of base year can seriously influence the weights. However, in practice it is almost impossible to find a year in which PPP is bilaterally fulfilled for all countries - even if only approximately. Here we used the year 2000 as the base.

4.2 The CVAR

As mentioned above, the statistical model to be employed is the CVAR, which we introduce in this section. The unrestricted VAR model of order k with p endogenous variables is given by

$$\mathbf{x}_t = \Pi_1 \mathbf{x}_{t-1} + ... + \Pi_k \mathbf{x}_{t-k} + \phi \mathbf{D}_t + \varepsilon_t, \qquad t = 1, 2, ..., T, \tag{14}$$

where $\mathbf{x}_t$ is a vector of the p variables at time t, Π_i are $p \times p$ matrices of parameters with $i = 1, ...k$, $\mathbf{D}_t$ a vector of deterministic components with a vector of coefficients ϕ, and ε_t is a $p \times 1$ vector of errors. We assume that the error terms are identically and independently distributed and follow a Gaussian distribution, $\varepsilon_t \sim iid\ N_p(\mathbf{0},\Omega)$, where Ω denotes the variance-covariance matrix of the errors.

However, if the levels of a time series are non-stationary, non-sense results may occur if the non-stationarity is ignored. A vector model in differences may be estimated since differences of I(1) data yield I(0) processes, but if there is cointegration between variables, omitted variable bias is the result. Most real macroeconomic time series are I(1) and hence we need to estimate a model in differences, allowing for cointegration. The VAR(k) model can also be expressed as an error or vector equilibrium correction model (VECM($k-1$)) which is formulated in terms of differences as follows

$$\Delta \mathbf{x}_t = \Pi \mathbf{x}_{t-1} + \Gamma_1 \Delta \mathbf{x}_{t-1} + ... + \Gamma_{k-1} \Delta \mathbf{x}_{t-k+1} + \phi \mathbf{D}_t + \varepsilon_t, \tag{15}$$

where $\Pi = -(\mathbf{I} - \Pi_1 - .... - \Pi_k)$ and $\Gamma_i = -\sum_{j=i+1}^{k} \Pi_j$. Henceforth, we will mainly look at the VECM representation, i.e. the CVAR, which assembles the long-run information of the data in Π: the hypothesis of cointegration is tested in a reduced-rank framework such that $\Pi = \alpha\beta'$, where the coefficients in the β-matrix, may be interpreted as long-run coefficients and those in the α-matrix as adjustment coefficients, indicating speed of

data using a PPP-adjusted exchange rate. Given the BDH method of aggregation, this only matters for the weights and the terminal value, and we find that all the results below hold using both actual and PPP-adjusted exchange rates.

adjustment back to the long-run equilibrium. Short-run properties are contained in the Γ_is.

4.2.1 The Global CVAR model

The global CVAR uses the following data vector in order to analyse the dynamics of the global money market:

$$\mathbf{x}_t^{global} = (m_r, y_r, \Delta p, I_s, I_l, h, s, oil)'_t, \tag{16}$$

where m_r is real money, y_r is real GDP, Δp is the inflation rate, I_s is the short term interest rate and I_l the long term interest rate; h is an index for the price of housing, s is a stock price index, and *oil* is the oil price (all variables measured on a global scale, i.e. aggregated where appropriate).

4.2.2 National CVAR models

National CVARs with specifications similar to (16) but including foreign variables (possibly constructed using trade weights) are estimated, i.e.

$$\mathbf{x}_t^{national} = (m_r, y_r, \Delta p, I_s, I_l, ppp, z^*)'_t \tag{17}$$

where z^* is a vector of (country-specific) foreign variables which might be assumed weakly exogenous, and $ppp = e - p + p^*$ is a real exchange rate constructed such that its definition "complies" with that of z^*. (17) is simply the "standard model" of the domestic money market augmented with the foreign variables.

5 Empirical findings from the global CVAR

To avoid invalid inference we start with a system specified in nominal variables only and test the validity of the nominal-to-real transform (NRT). Despite the fact that the transformation is rejected we continue estimation and inference within the real system but bearing in mind that there may be a small I(2) component left in the transformed variables. We estimate a CVAR in the global variables as in (16).[13] This is done in the following steps:

1. Estimate a "standard" money market CVAR model, and identify long-run relations,

$$\mathbf{x}_t^{global} = (m_r, y_r, \Delta p, I_s, I_l)'_t. \tag{18}$$

[13]Estimations were performed using CATS in RATS, see Dennis (2006).

2. Expand the information set by adding asset price variables like share, house and oil prices to see how the rank of Π and results relating to weak exogeneity change.

In principle, the cointegrating relations identified within one information set should still be found if more variables are added to the information; this is the idea used by *inter alia* Juselius (2007). For example, it can be useful to start from a relatively small information set and observe whether the rank changes when additional variables are added. If the rank increases there exists some cointegrating relation(s) including the new variable(s). On the other hand, if the rank is unchanged, adding the extra variable(s) introduces additional common stochastic trend(s).

However, there is a caveat to the above invariance property: the cointegrating relations are not invariant to reductions in the information set. This poses a problem in the practical implementation of the outlined procedure as it may be possible to identify more economically relevant relations by revising some of the previously identified cointegrating relationships. Hence, the stepwise procedure is merely adopted as a way of easing the identification procdeure, i.e. we will not strictly fix the cointegrating relations of the basic model when considering extended versions of it.

5.1 The basic global CVAR

The first step requires choosing an adequate lag length and rank for the model, making sure that the model is well-specified. Results of the mis-specification analysis are reported in Table 2, which shows that there may be some auto-correlation at lags 1 and 2, but that ARCH or non-normality do not appear to be an issue. Imposing restrictions below reduces the auto-correlation problem. Besides the seasonal dummy variables and a restricted trend t, we included four impulse dummies: for 1984:4, for 1986:2, for 1987:1 and for 1988:1, just after the stock-market crash in the final quarter of 1987, i.e.

$$\mathbf{D}_t = (Dp\_84\_4, Dp\_86\_2, Dp\_87\_1, Dp\_88\_1)'_t,$$

where DP_YY_Q denotes a permanent impulse dummy taking the value one in year YY quarter Q and zero elsewhere. A shift dummy, $Ds_{01:2}$ is introduced in 2001:2 and kicks in until the end of the sample. Its role is discussed below in more detail. The lag length, k, was determined on the basis of auto-correlation tests, i.e. using the smallest number of lags conditional on there not being much auto-correlation, which is found to be $k = 2$.

Lag	Test statistic	p-value
LM tests for no auto-correlation:		
1	$\chi^2(25) = 38.583$	[0.041]
2	$\chi^2(25) = 52.291$	[0.001]
3	$\chi^2(25) = 21.723$	[0.652]
4	$\chi^2(25) = 30.571$	[0.204]
Test for normality:		
	$\chi^2(10) = 5.745$	[0.836]
LM tests for no ARCH-effects:		
1	$\chi^2(225) = 227.208$	[0.446]
2	$\chi^2(450) = 456.927$	[0.401]
3	$\chi^2(675) = 718.790$	[0.118]
4	$\chi^2(900) = 972.213$	[0.047]

Table 2: Vector mis-specification tests

Robustness with respect to this choice is checked, however, for the final specification of the model.

The rank r of the Π-matrix is chosen given the evidence from several indicators. The trace test (see Johansen (1996)) is the most formal of them, and indicates a rank of 3. The unrestricted α-matrix and plots of the unrestricted cointegrating relations also suggest that $r = 3$ may be an appropriate choice. Similarly, the roots of the system strongly support a rank of 3: when restricting the rank to 3, the highest non-unit root is only 0.677, while it is still above 0.9 for $r = 4$. Hence, we argue that $r = 3$ is most convincing.

The following long-run specification for $r = 3$ proved robust to several lag lengths (3 and 4), and is here reported for $k = 2$. Restrictions were not rejected with a p-value of 0.354 ($\chi^2(4) = 4.401$).

First cointegrating relation: a money demand relationship,

$$\underbrace{(m_r - y_r)_t}_{\text{excess money}} + \underset{[5.868]}{9.106}\Delta p + \underset{[10.890]}{22.784}\underbrace{(I_l - I_s)_t}_{\text{interest rate spread}} - \underset{[-16.506]}{0.181} Ds_{01:2} \sim I(0) \tag{19}$$

Second cointegrating relation: a monetary policy rule à la Taylor but with no role for detrended output, or a Fisher relation,

$$I_{s,t} - \underset{[-20.331]}{1.879}\Delta p_t + \underset{[9.128]}{0.006} Ds_{01:2} \sim I(0) \tag{20}$$

Third cointegrating relation: an AD-like relationship,

$$\underbrace{(y_{r,t} - \underset{[-26.119]}{0.501}\, t)}_{\text{output gap}} + \underset{[9.715]}{12.258}\underbrace{(I_l - \Delta p)_t}_{\text{real interest rate}} + \underset{[5.906]}{0.052} Ds_{01:2} \sim I(0) \tag{21}$$

Since the real interest rate should not exhibit a systematic trend, $y_{r,t} - 0.5t$ may be regarded as detrended output or the output gap. The linear trend is divided by 100 in the estimation, so a trend coefficient of 0.5 implies 0.5 percent quarterly or 2 percent annual growth, which seems reasonable. No weak exogeneity conditions were imposed in addition to the long-run restrictions. The α- and β'-matrices based on 3 cointegrating vectors are as follows:

$\boldsymbol{\alpha}$	α_1	α_2	α_3
Δm_r	-0.024 [-1.287]	0.754 [2.065]	-0.081 [-2.653]
Δy_r	0.054 [5.185]	0.926 [4.565]	-0.113 [-6.660]
$\Delta^2 p$	0.008 [1.276]	0.463 [3.865]	0.000 [0.034]
ΔI_s	0.002 [0.626]	-0.081 [-1.649]	0.001 [0.157]
ΔI_l	-0.007 [-2.474]	-0.028 [-0.475]	-0.011 [-2.147]

$\boldsymbol{\beta}'$	m_r	y_r	Δp	I_s	I_l	$D_{01:2}$	t
β'_1	1.000 [NA]	-1.000 [NA]	9.106 [5.868]	-22.784 [-10.890]	22.784 [10.890]	-0.181 [-16.506]	0.000 [NA]
β'_2	0.000 [NA]	0.000 [NA]	-1.879 [-20.331]	1.000 [NA]	0.000 [NA]	0.006 [9.128]	0.000 [NA]
β'_3	0.000 [NA]	1.000 [NA]	-12.258 [-9.715]	0.000 [NA]	12.258 [9.715]	0.052 [5.906]	-0.501 [-26.119]

The role of the shift dummy is apparent in Figures 2 and 3, which show the long-run relations without and with the shift dummy. There appears to be a break in the relations in early 2001, around the time when stock markets incurred heavy losses and monetary policy was loosened. This has an interesting interpretation: it implies that monetary conditions were abnormally loose after 2001 as has often been argued. The residuals of the first cointegration relation in (19) are above their long-run mean when excluding the shift dummy - an indication that real money was indeed in excess of what might have been expected given output and interest rates. Residuals of the second cointegrating relation in (20) are below their long-run mean of zero (again excluding the shift dummy), which suggests that short-term interest rates were lower than in previous periods relative to prevailing inflation rates albeit no by much. Since about 2004, residuals of both relations show a tendency to revert back to their long-run equilibrium.

Figure 4 shows that there may also have been a downward shift in the level of global output relative to the level of the long term real interest rate, which may be due to the fact that as inflation has started to pick up, central banks around the world have raised policy rates but this has had very limited or no effect on long rates, thus leaving a very

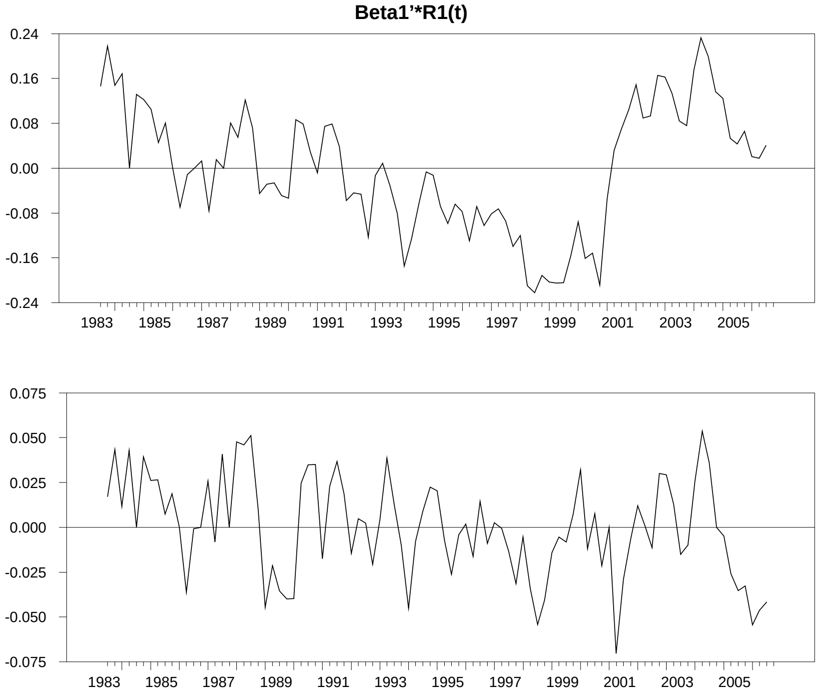

Figure 2: Long-run relation between excess money and the interest spread, ex- and including shift dummy

low real interest rate which output has not fully kept up with. Overall, these preliminary findings reveal the existence of excess global liquidity and it remains to be investigated how this has affected prices on assets such as stocks, housing and oil.

From the model alone, we cannot say whether the disequilibrium in the money demand relation was due to a sudden exogenous shift in demand or supply. On the one hand, in the absence of any obvious change in financial regulations on a G-6 scale and given loose monetary policy, it is tempting to ascribe it to an increase in supply. On the other hand, it may also be due to a sudden risk-averseness in investor after the stock market crash, shifting their wealth from financial assets to checking accounts. In light of the results presented below for the extended model, this is unlikely, though, as share prices do not play a role in the money demand relation of the extended model.

Tests for constancy in the parameters reveal the break to some extent when the shift dummy is excluded, but overall do not reject constant parameters in the model. The tests are based on Hansen and Johansen (1999); particularly useful are the tests for constancy of the log-likelihood value and of β, which are shown in Figures 5 and 6. They indicate that there are no problems related to constancy in the concentrated model ($R1_t$), which

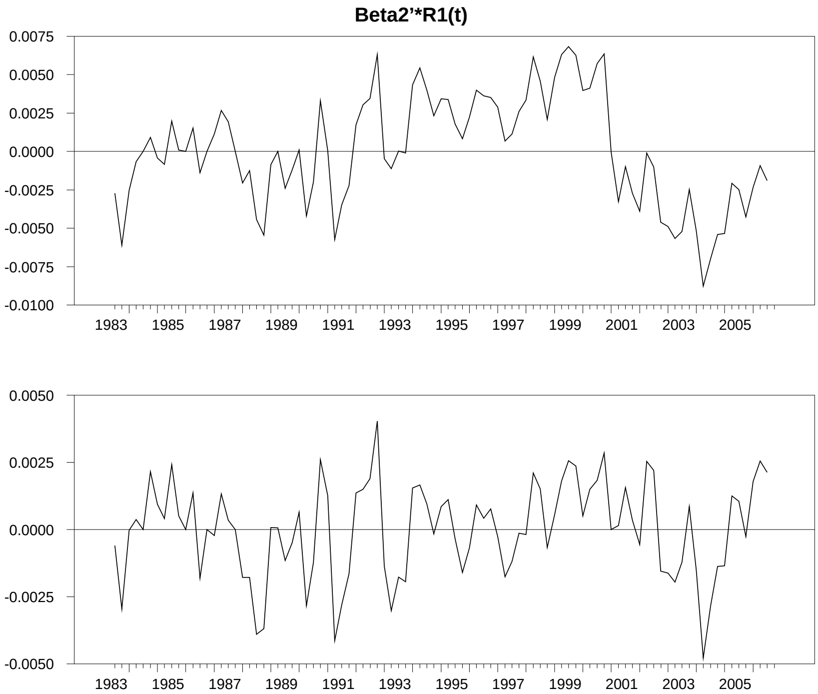

Figure 3: Long-run relation between the short rate and inflation, ex- and including shift dummy

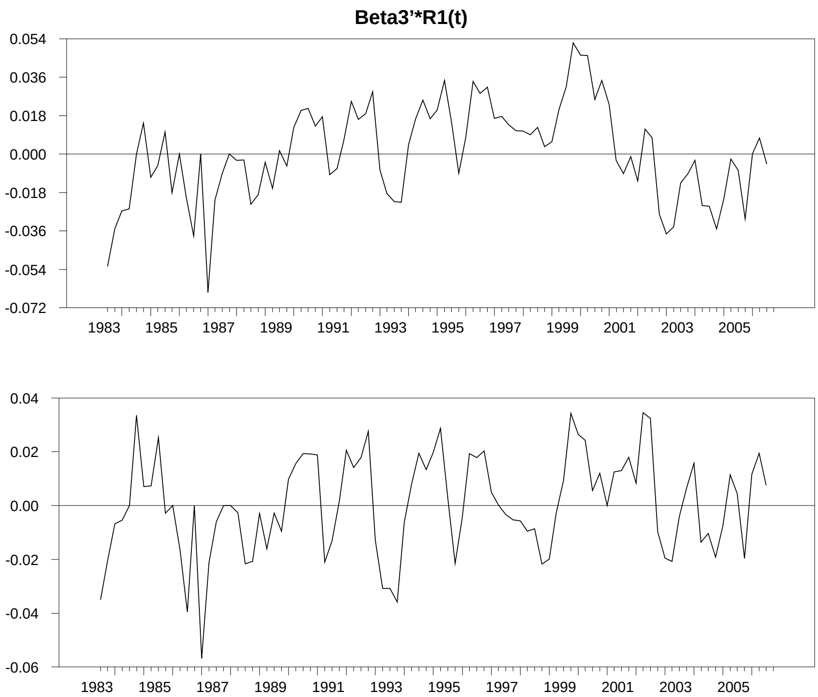

Figure 4: Long-run relation between output and real interest rate, ex- and including shift dummy

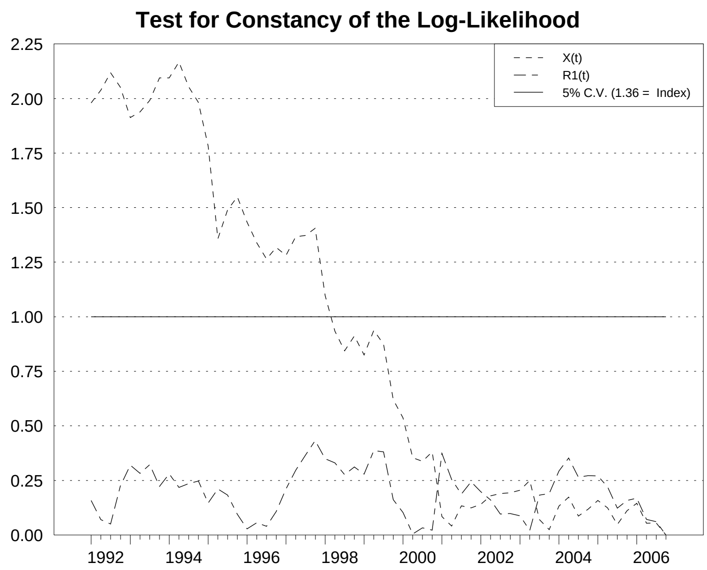

Figure 5: Recursively calculated log-likelihood

is what we are interested in for long-run purposes.

5.2 Allowing for asset prices

Extending the basic model by increasing the information set does not change the validity of the cointegrating relations identified earlier but weak exogeneity could change. Augmenting the data vector (18) with a global real house price index, h_r, and a global real share price index, s_r, we have,

$$\mathbf{x}_t^{global} = (m_r, y_r, \Delta p, I_s, I_l, h_r, s_r)'_t, \tag{22}$$

The following dummies are needed in order to ensure normally distributed residuals,

$$\mathbf{D}_t = (Dp\_84\_4, Dp\_87\_1, Dp\_87\_4)'_t$$

As shown in Table 3, mis-specification tests are not much affected by the inclusion of the new variables, except that possibly some ARCH effects are introduced and normality is an issue for share prices. ARCH effects are not detrimental to the analysis, as shown by Dennis, Hansen, and Rahbek (2002), and normality only if skewness diverges from the normality assumption rather than kurtosis, see Gonzalo (1994). For share prices the main issue appears to be kurtosis. Auto-correlation is again left in the second lag, but this improves as identification progresses. Hence, we continue with $k = 2$.

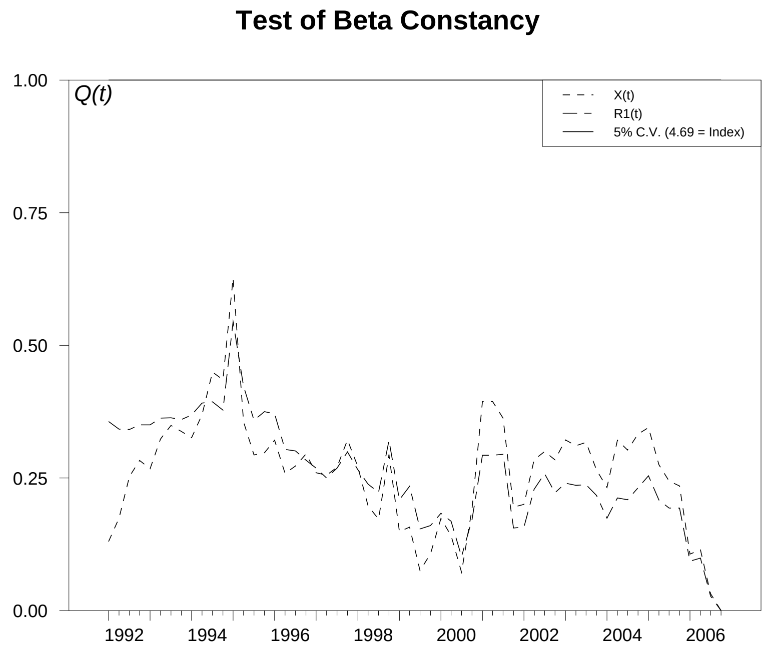

Figure 6: Recursively calculated tests of the constancy of β

Regarding the rank of the system, the trace test indicates that a rank of 5 is appropriate. This leaves the largest companion form root at 0.951 which is quite high, while that for $r = 4$ is only 0.886. The unrestricted cointegrating relations and α-coefficients seem to almost suggest $r = 6$ which is unlikely. This may be due to the fact that real house prices may have an I(2) component. From an economic point of view $r = 4$ makes most sense, because it is plausible that the system is driven by a real, a nominal and an asset price shock (i.e. three common trends). For now, we proceed with results both for $r = 4$ and $r = 5$ as they are complementary.

For $r = 4$ the first two relations are similar to those of the basic model, except that there appears to be a (weak) role for share prices in the monetary policy rule. The third relation is no longer an AD equation, but instead an inflation equation, where inflation moves with real money and output. The trend is left unrestricted, but can be decomposed such that it detrends real money and output. Estimating the trend coefficient in two separate (non-stationary) long-run relations with only money or output and the trend gives trend coefficients of -0.7 and -0.5, respectively. Hence, we would expect a trend coefficient of around 0.08 in the third relation. With 0.1 it is slightly above that, but not by much. The fourth equation may be interpreted as a relation determining house prices, including detrended money (where the difference in the coefficient on money and

Lag	**Test statistic**	**p-value**
LM tests for no auto-correlation:		
1	$\chi^2(49) = 61.632$	[0.106]
2	$\chi^2(49) = 78.989$	[0.004]
3	$\chi^2(49) = 42.848$	[0.719]
4	$\chi^2(49) = 65.147$	[0.061]
Test for normality:		
	$\chi^2(14) = 25.508$	[0.030]
LM tests for no ARCH-effects:		
1	$\chi^2(784) = 815.555$	[0.211]
2	$\chi^2(1568) = 1711.036$	[0.006]
3	$\chi^2(2352) = 2482.059$	[0.031]
4	$\chi^2(3136) = 2604.000$	[1.000]

Table 3: Vector mis-specification tests

trend is accounted for by the trend coefficient of -0.7 discussed above), which may be interpreted as a bubble element. In addition, the real share price index is found to be weakly exogenous.

The set of restrictions gives a p-value of 0.449 ($\chi^2(10) = 9.898$), and α and β' are estimated as:

$\boldsymbol{\alpha}$	α_1	α_2	α_3	α_4
Δm_r	−0.064 [−3.681]	0.691 [2.721]	1.521 [6.262]	−0.048 [−3.868]
Δy_r	0.033 [2.779]	0.363 [2.067]	0.607 [3.608]	−0.012 [−1.372]
$\Delta^2 p$	0.016 [2.589]	0.316 [3.564]	−0.304 [−3.588]	0.015 [3.552]
ΔI_s	0.009 [3.151]	−0.097 [−2.352]	−0.035 [−0.883]	0.006 [3.140]
ΔI_l	−0.004 [−1.090]	−0.112 [−2.190]	−0.063 [−1.277]	0.004 [1.509]
Δh_r	−0.005 [−0.391]	0.018 [0.088]	0.022 [0.113]	−0.062 [−6.351]
Δs_r	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]

$\boldsymbol{\beta'}$	m_r	y_r	Δp	I_s	I_l	h_r	s_r	$D_{01:2}$	t
β'_1	1.000 [NA]	−1.000 [NA]	8.875 [6.917]	−22.801 [−10.747]	22.801 [10.747]	0.000 [NA]	0.000 [NA]	−0.175 [−16.396]	0.000 [NA]
β'_2	0.000 [NA]	0.000 [NA]	−1.983 [−14.216]	1.000 [NA]	0.000 [NA]	0.000 [NA]	−0.002 [−1.209]	0.006 [7.990]	0.000 [NA]
β'_3	−0.046 [−4.511]	−0.094 [−4.466]	1.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	−0.006 [−3.785]	0.106 [10.079]
β'_4	−1.631 [−11.350]	0.000 [NA]	−17.589 [−7.294]	17.589 [7.294]	0.000 [NA]	1.000 [NA]	−0.194 [−5.604]	0.000 [NA]	1.437 [10.916]

Turning to $r = 5$, there is evidence for both an AD and inflation equation, in addition to the money demand relation, monetary policy rule and house price equation. The money demand relation and monetary policy rule are again very similar to the basic model. Restrictions are accepted with a very high p-value of 0.994 ($\chi^2(3) = 0.080$), and α and β' are given by:

$\boldsymbol{\alpha}$	α_1	α_2	α_3	α_4	α_5
Δm_r	-0.077 [-3.914]	0.417 [1.238]	0.040 [1.416]	1.677 [6.153]	-0.056 [-4.163]
Δy_r	0.061 [4.887]	0.895 [4.173]	-0.071 [-3.964]	0.238 [1.370]	0.006 [0.658]
$\Delta^2 p$	0.024 [3.574]	0.494 [4.269]	-0.023 [-2.373]	-0.404 [-4.316]	0.020 [4.325]
ΔI_s	0.007 [2.120]	-0.123 [-2.213]	0.003 [0.544]	-0.025 [-0.563]	0.005 [2.323]
ΔI_l	0.003 [0.675]	0.027 [0.423]	-0.019 [-3.524]	-0.157 [-2.996]	0.008 [2.961]
Δh_r	-0.006 [-0.396]	-0.058 [-0.218]	0.016 [0.719]	0.134 [0.619]	-0.062 [-5.844]
Δs_r	0.575 [2.837]	7.001 [2.016]	-0.923 [-3.184]	-3.917 [-1.393]	0.323 [2.343]

$\boldsymbol{\beta}'$	m_r	y_r	Δp	I_s	I_l	h_r	s_r	$D_{01:2}$	t
β_1'	1.000 [NA]	-1.000 [NA]	8.780 [6.915]	-23.338 [-11.563]	23.338 [11.563]	0.000 [NA]	0.000 [NA]	-0.177 [-16.788]	0.000 [NA]
β_2'	0.000 [NA]	0.000 [NA]	-1.938 [-18.215]	1.000 [NA]	0.000 [NA]	0.000 [NA]	-0.001 [-1.078]	0.006 [8.291]	0.000 [NA]
β_3'	0.000 [NA]	1.000 [NA]	-17.508 [-10.448]	0.000 [NA]	17.508 [10.448]	0.000 [NA]	0.000 [NA]	0.060 [4.963]	-0.458 [-18.112]
β_4'	-0.047 [-4.813]	-0.099 [-4.976]	1.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	-0.006 [-3.998]	0.110 [10.926]
β_5'	-1.672 [-11.448]	0.000 [NA]	-18.983 [-7.761]	18.983 [7.761]	0.000 [NA]	1.000 [NA]	-0.215 [-6.269]	0.000 [NA]	1.508 [11.308]

A drawback of the extended model is that recursive estimation highlights some problems around parameter constancy. This may be partly due to the size of the system and the limited number of observations, which is why we do not place a great weight on the tests.

Further augmenting (22) with the real crude oil price index, oil_r, we get

$$\mathbf{x}_t^{global} = (m_r, y_r, \Delta p, I_s, I_l, h_r, s_r, oil_r)_t', \tag{23}$$

Since we are estimating a global model, we do not *a priori* impose weak exogeneity on oil prices, and indeed their adjustment coefficients turn out to be highly significant. No additional dummies are needed, and roots suggest a rank of 5. The following restrictions on α and β are accepted with a p-value of 0.172 ($\chi^2(6) = 9.026$):

$\boldsymbol{\alpha}$	α_1	α_2	α_3	α_4	α_5
Δm_r	-0.120 [-3.566]	-0.102 [-0.347]	0.111 [1.193]	0.266 [3.123]	-0.045 [-2.217]
Δy_r	0.078 [3.858]	0.127 [0.719]	-0.180 [-3.214]	-0.057 [-1.107]	0.030 [2.417]
$\Delta^2 p$	0.038 [3.395]	0.496 [5.041]	-0.055 [-1.759]	-0.076 [-2.660]	0.021 [2.988]
ΔI_s	0.011 [2.109]	-0.107 [-2.414]	-0.015 [-1.052]	-0.016 [-1.242]	0.006 [2.054]
ΔI_l	0.012 [1.934]	-0.066 [-1.236]	-0.065 [-3.808]	-0.057 [-3.667]	0.013 [3.578]
Δh_r	-0.028 [-1.119]	0.072 [0.326]	0.083 [1.190]	0.069 [1.080]	-0.065 [-4.211]
Δs_r	-0.346 [-1.033]	-2.018 [-0.692]	2.129 [2.299]	2.196 [2.598]	-0.299 [-1.468]
Δoil_r	4.333 [4.425]	-9.135 [-1.070]	-11.581 [-4.274]	-12.798 [-5.173]	2.759 [4.636]

$\boldsymbol{\beta}'$	m_r	y_r	Δp	I_s	I_l	h_r	s_r	oil_r	$D_{01:2}$	t
β_1'	1.000 [NA]	-1.000 [NA]	7.647 [8.186]	-21.598 [-15.088]	21.598 [15.088]	0.000 [NA]	0.000 [NA]	0.000 [NA]	-0.174 [-20.051]	0.000 [NA]
β_2'	0.000 [NA]	0.000 [NA]	-1.942 [-15.772]	1.000 [NA]	0.000 [NA]	0.000 [NA]	-0.002 [-1.265]	0.000 [NA]	0.006 [9.427]	0.000 [NA]
β_3'	0.000 [NA]	1.000 [NA]	-3.096 [-4.519]	0.000 [NA]	3.096 [4.519]	0.000 [NA]	-0.088 [-9.812]	0.009 [2.182]	0.000 [NA]	-0.462 [-32.593]
β_4'	-0.120 [-2.610]	-0.835 [-11.840]	1.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	0.000 [NA]	0.014 [2.969]	-0.048 [-7.885]	0.631 [15.530]
β_5'	-1.864 [-12.302]	0.000 [NA]	-25.964 [-10.741]	25.964 [10.741]	0.000 [NA]	1.000 [NA]	-0.278 [-7.964]	0.000 [NA]	0.000 [NA]	1.838 [13.842]

The first two relations are familiar from the basic and previous extended model. Oil prices now feature in the AD equation, while the shift dummy is excluded from the relation, suggesting that it acted as a proxy for oil prices. A perverse effect seems to be present between oil and inflation in the fourth relation.The fifth equation - the house price relation - remains unchanged.

The identification schemes for the β-matrices presented above are accompanied by interesting adjustment dynamics in the α-matrices: In all cases, interpretation of the relations is helped by strong equilibrium correction in certain variables. For example, money strongly reacts to the money demand equation, the short term interest rate to the monetary policy rule, output to the AD-equation, inflation to the inflation-equation and house prices to the house price equation. This is not to say that other variables do not adjust to the same relations. In fact there will always be some feedback between variables, and it is not the aim to establish clear-cut causation, but rather to present an accurate picture of how variables move together over the long-term. Adjustment dynamics may also be distorted by the shift dummy.

There is limited evidence that house prices increase as liquidity expands, other than from adjustment to the house price equation itself. Evidence for share prices is mixed, given that it is weakly exogenous for $r = 4$. Interestingly, inflation increases with excess money (as defined by the first relation). It also increases with the monetary policy rule, a result which central banks will not like. Finally, the short term interest rate rises in response to the money demand equation and the house price equation, pointing to some adjustment by central banks in response to liquidity and asset price inflation.

6 Conclusion

As policymakers are developing a renewed interest in monetary conditions, in particular on a global level, empirical analysis is needed to evaluate the role global money plays, and what consequences may arise for monetary policy. This paper presented evidence that monetary policy of major economies was indeed unusually loose in the early years of the new millennium, and that a global liquidity glut existed. The liquidity glut is being taken back, but its effects may persist for some time yet.

A stable global money demand equation was estimated, to which inflation and interest rates adjust positively. House prices also appear to have risen as a consequence, while the impact on share prices is less clear. A shift dummy was needed to accommodate the exogenous shift in the money demand relation, and we have argued a shift in money supply is the more plausible explanation. If this is the case, central banks should worry about the liquidity glut as it is likely to lead to upward inflationary pressures which may manifest themselves with long lags.

References

Baks, K. and C. Kramer (1999). Global liquidity and asset prices: Measurement, implications, and spillovers. IMF Working Paper No 168.

Beyer, A., J. A. Doornik, and D. F. Hendry (2001). Constructing historical euro-zone data. *Economic Journal 111*, 308–327.

Beyer, A. and K. Juselius (2007). Does it matter how to measure aggregates? The case of monetary mechanisms in the Euro area. Manuscript.

Blanchard, O. (2000). *Macroeconomics* (2nd ed.). Prentice-Hall.

Ciccarelli, M. and B. Mojon (2005). Global inflation. ECB Working Paper No 537.

Coenen, G. and J. L. Vega (1999). The demand for M3 in the euro area. *ECB Working Paper 6*.

Cox, J. C., J. E. Ingersoll, and J. S. A. Ross (1985). A theory of the term structure of interest rates. *Econometrica 53*(2), 385–408.

Dennis, J. G. (2006). *CATS in RATS - Cointegration Analysis of Time Series, Version 2*. Evanston, Illinois: Estima.

Dennis, J. G., E. Hansen, and A. Rahbek (2002). ARCH innovations and their impact on cointegration rank testing. *Working paper, Centre for Analytical Finance, University of Copenhagen (www.caf.dk) 22*.

Disyatat, P. (2005). Inflation targeting, asset prices and financial imbalances: conceptualizing the debate. *BIS working paper, Bank for International Settlements, Basle 168*.

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance 25*, 383–417.

Franchi, M. and K. Juselius (2007). Taking a dsge model to the data meaningfully. *Economics discussion Papers No. 6*.

Friedman, M. (1969). The optimum quantity of money. In *The Optimum Quantity of Money and Other Essays*. Aldine, Chicago.

Gonzalo, J. (1994). Five alternative methods of estimating long-run equilibrium relationships. *Journal of Econometrics 60*, 203–233.

Goodhart, C. and B. Hofmann (2007). *House prices and the macroeconomy - Implications for Banking and Price Stability* (1st ed.). Oxford University Press, Oxford.

Hansen, H. and S. Johansen (1999). Some tests for parameter constancy in the cointegrated var. *Econometrics Journal 2*, 306–333.

Hendry, D. F. (2001). Modelling UK inflation, 1875-1991. *Journal of Applied Econometrics 16*, 255–275.

Johansen, S. (1996). *Likelihood-based Inference in Cointegrated Vector Auto-regressive Models*. Oxford: Oxford University Press.

Johansen, S. and K. Juselius (2003). Controlling inflation in a cointegrated VAR model with an application to US data. *www.econ.ku.dk/okokj.dk*.

Juselius, K. (1992). Domestic and foreign effects on prices in an open economy: The case of Denmark. *Journal of Economic Modelling 14*(4), 401–428.

Juselius, K. (2007). *The Cointegrated VAR Model: Econometric Methodology and Macroeconomic Applications*. Oxford: Oxford University Press.

Mehra, R. and E. C. Prescott (1985). The equity premium: A puzzle. *Journal of Monetary Economics 15*, 145–161.

Ruffer, R. and L. Stracca (2006). What is global excess liquidity, and does it matter? ECB Working Paper No 696.

Smets, F. (1997). Financial assets prices and monetray policy: theory and evidence. *BIS working paper, Bank for International Settlements, Basle*.

Sousa, J. and A. Zaghini (2004). Monetary policy shocks in the euro area and global liquidity spillovers. ECB Working Paper No 309.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy 39*, 195–214.

Tuxen, C. K. (2006). An empirically relevant model of inflation in the euro area. Master's thesis, Department of Economics, University of Copenhagen.

Woodford, M. (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton University Press.

Yeyati, E. L. and M. G. Rozada (2005). Global factors and emerging market spreads. Business School Working Paper, Universidad Torcuato Di Tella.