MONEY AND MONETARY POLICY THE ECB EXPERIENCE 1999-2006

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ABSTRACT

The paper analyses the practical experience of monetary analysis at the ECB since its beginning. The analysis is based on both a narrative description of the internal briefing and a quantitative evaluation of the forecast exercises. We exploit a rich data basis containing the vintages of data and models over the period in order to evaluate the role of money in the input and the output of monetary policy as it has been in real time.

1 INTRODUCTION

Since the announcement of the ECB's monetary policy strategy in October 1998, the "prominent role" assigned to money within it has been the subject of an intense debate. The purpose of this paper is to shed light on this debate from the perspective of ECB staff members who have been involved in the conduct of the monetary analysis over recent years. Our focus will not be on what the role of money should be in the ECB's strategy, but rather on the ECB's monetary analysis in practice and how it has evolved over time.

The paper presents both a narrative history of the ECB's monetary analysis and a quantitative evaluation of models used to construct money-based inflation risk indicators. To help the narrative history, we have also constructed qualitative indicators of the monetary analysis: an indicator of the input to the policy discussion, based on the coding of the words used in the quarterly monetary assessment on which the monetary analysis briefing is based; and two indicators of the output of the policy discussion, based on the words of the President's introductory statement of the press conference following the interest rate decision. The indicators of the output are similar to those developed by Gerlach (2004).

We address three issues: what tools have been used to conduct the monetary analysis and how have they evolved over time? what are the policy relevant signals drawn from the analysis conducted on the basis of these tools? and what

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impact have these signals exerted on monetary policy decisions? A number of appendices are attached to the paper, which offer more detailed descriptions of the tools and methods used to assess monetary developments since the introduction of the euro in January 1999.

A distinctive and still novel feature of the paper is the close attention it pays to ensuring a "real time" perspective on the evaluation of the ECB's monetary analysis. In other words, the paper attempts to characterize and evaluate the monetary analysis and its impact on interest rate decisions on the basis of the information that was available at the time the analysis was conducted and the policy decisions were taken. In both the simulated out-of-sample exercise on which the model evaluation is based and in the narrative history, the paper pays close attention to ensuring that the correct vintages of the monetary time series and analytical models are used. To do so, we draw heavily on the internal analysis prepared over the past eight years by the staff of the ECB and the experience of staff members who prepared that analysis. Indeed, an important aim of the paper is to confront two distinct real time perspectives on the ECB's monetary analysis.

The first, more practical perspective reflects the need to prepare briefing material on monetary developments for policy makers at the ECB in a timely way, so that it can inform monetary policy decisions. This is captured in the documentation that has been provided to the decision making bodies of the ECB on a quarterly basis since 1999. The other, more academic perspective reflects the growing recognition in the economic literature that any ex post evaluation of policy and policy analysis needs to control carefully for the information constraints faced by policy making institutions at the time their analysis was produced or decisions taken. The paper aims to combine the rigour implied by the second perspective with the anecdotal and experiential richness offered by the first.

The remainder of the paper is organized as follows. Section 2 provides an overview of the tools used in the ECB's monetary analysis and how they have evolved over time, referring as necessary to the more detailed descriptions in the appendices. This section concludes by identifying two data series that can form the basis of further, more quantitative analysis: first, a money-based forecast of inflation that can be seen as an incomplete summary of the monetary analysis undertaken by the ECB; and second, a categorization of the period since 1999 into four distinct phases, according to the policy-relevant signal stemming from the monetary analysis. Section 3 takes the former and conducts a thorough real time evaluation of the performance of the money-based inflation forecast. Section 4 takes the latter and presents a series of event studies illustrating how the monetary analysis has influenced interest rate decisions. On the basis of the results of these exercises, Section 5 presents some brief concluding remarks.

2 MONETARY ANALYSIS AT THE ECB

In taking interest rate decisions aimed at the maintenance of price stability in the euro area, the Governing Council of the ECB draws on both economic analysis and monetary analysis (ECB, 1999b and 2003b). The former attempts to identify the economic shocks driving the business cycle and thus embodies a thorough assessment of the cyclical dynamics of inflation. The latter analyses the monetary trends associated with price developments over the medium to longer term. While, in principle, there is no arbitrary segregation of the available data between the two forms of analysis, in practice the economic analysis is largely focused on developments in economic activity and price and cost indicators whereas the monetary analysis relies on a close scrutiny of the monetary aggregates, their components and counterparts, as recorded in the consolidated balance sheet of the euro area monetary financial institutions (MFIs) (ECB, 1999a and 2000b).

2.1 THE STRUCTURE OF BRIEFING: THE BROAD MACROECONOMIC PROJECTIONS EXERCISE AND THE QUARTERLY MONETARY ASSESSMENT

Although complemented by a large body of higher frequency material, on a quarterly basis the economic and monetary analyses become concrete in the form of two key exercises, the results of which are ultimately presented to the Governing Council.

The Broad Macroeconomic Projections Exercise (BMPE) is conducted by Eurosystem staff twice a year (for the June and December Governing Council meetings), with the ECB staff repeating the exercise in the intervening quarters.[2] The exercise uses conventional macroeconometric tools (including area-wide and multi-country models of the euro area), augmented by the judgmental input of sectoral and country experts, to produce projections of inflation and economic activity for the coming two to three years (ECB, 2000a). These projections are published, in the form of ranges, on the day the Governing Council discusses them and subsequently in the ECB Monthly Bulletin.

The Quarterly Monetary Assessment (QMA) is undertaken by ECB staff (drawing on the expertise of NCB staff as necessary). Three aspects of the assessment are particularly noteworthy. First, the monetary analysis is instrumental, in the sense that it is intended to shed light on the outlook for price developments and the implications for monetary policy rather than simply to explain monetary developments in their own right. Second, consistent with the view that the policy-relevant information in money is in its lower frequency or trend-like developments, the focus of this assessment is on identifying the underlying rate of monetary expansion that is related to inflation dynamics over the medium to longer term. Seen in this light, the quarterly frequency of the analysis looks through the often erratic month-to-month variations in monetary

2 The exercises conducted by ECB staff in the intervening quarters are defined Macroeconomic Projections Exercises (MPE). In the following, we will refer to BMPE to indicate both MPE and BMPE outcomes without distiguishing between the two.

growth.[3] Third, the analysis does not rely solely on developments in the key broad monetary aggregate M3. Rather a holistic assessment of the monetary data is made, encompassing the analysis of components, counterparts, sectoral contributions, financial accounts, financial prices and yields and other data sources as necessary.

2.2 THE QUARTERLY MONETARY ASSESSMENT

While the QMA has not been published in a systematic manner by the ECB, the analysis contained therein underpins the description and assessment of monetary developments regularly presented in the Monthly Bulletin, especially in the longer quarterly format of the commentary section. Moreover, many of the tools used in the QMA have been described in papers and articles produced by ECB staff (e.g. Masuch, Pill, and Willeke, 2001; ECB, 2004). A quantitative outlook for price developments derived from the monetary data in the QMA (so-called "money-based forecasts of inflation" or "money-based inflation risk indicators", as analysed in detail in subsequent sections of this paper) has been published on several occasions in the Monthly Bulletin (ECB, 2005a and ECB, 2006b, 2007).

The first QMA was produced in December 1999 and analysed data through the third quarter of 1999. Although the monetary analysis has faced several significant challenges in the ensuing years, the basis structure of the QMA has proved remarkably stable over this period. A first section simply describes the latest monetary data, placing them in the context of longer-term trends. A second section attempts to explain recent monetary dynamics, drawing on various interrelated tools (including econometric and statistical models, a thorough analysis of the components and counterparts of M3, and a detailed investigation of "special factors" influencing monetary developments) so as to recover a quantitative proxy for the prevailing underlying rate of monetary expansion corrected for shorter-term distortions. The final section transforms the appropriately filtered monetary series into an outlook for price developments, so as to permit an assessment of the risks to price stability implied by the monetary analysis.

From the outset, a key aspect of the analysis presented in the QMA has been an attempt to quantify both the contributions made by various explanations of monetary developments and their implications for the inflation outlook. Adopting such a quantitative approach has ensured continuity in the analysis from one quarter to the next, thereby maintaining its medium-term orientation. Moreover, this quantitative approach has led to the creation of a rich "real time" data set which can now, with the benefit of hindsight, be exploited to conduct a thorough ex post evaluation of the information content and policy relevance of the monetary analysis.

3 The monthly data are analysed in order to help identify specific "special factors" that may distort the data, but which are not reflective of underlying monetary dynamics. Monthly money data are not used to assess contemporaneous short-term inflation developments ("now-casting").

2.3 TOOLS USED IN THE QMA

While the basic structure of the QMA has remained stable over time, the nature of the analysis conducted has evolved through several phases, reflecting the successive challenges faced in interpreting the monetary data. With this in mind, when presenting the ECB's monetary analysis since 1999, it is useful to distinguish three broad sets of tools that have been employed, namely: (i) money demand equations; (ii) judgemental analysis; and (iii) reduced-form money-based forecasting or indicator models for inflation. The three types of tool have been used throughout Stage III in the preparation of the monetary analysis, although their relative importance has fluctuated over time as circumstances evolved. Moreover, as is apparent from the following discussion, the uses of the three types of tools are highly interrelated.

(i) MONEY DEMAND EQUATIONS AT THE ECB: SPECIFICATION AND USES

At the beginning of Stage III, the assessment of monetary developments was focused on an analysis of the deviations of M3 growth from the ECB's reference value of 4½%. In December 1998, the ECB defined a reference value for the annual growth rate of M3, which was derived so as to represent the rate of money growth over the medium term that would be consistent with the maintenance of price stability at that horizon. In line with the ECB's strategy, such deviations were viewed as triggers for further analysis to identify the cause of the deviation and assess its implications for the outlook for price developments (ECB, 1999b). Money demand equations constituted a natural starting point for this analysis. Appendix C describes the evolution of the specification and use of money demand models at the ECB in detail.

The role of money demand models may be best described as providing a semi-structural framework that allows judgemental factors stemming from a broad monetary analysis to be combined with results from standard money demand equations, as presented in Masuch, Pill and Willeke (2001). This approach is based on the assumption that a long-run money demand relation exists, but that the complex short-run relationships between money and its economic determinants makes them difficult to model in a single, consistent framework over time.

In practical terms, this approach takes concrete form in the use of Vector Error Correction (VEC) models to analyse and explain the evolution of M3. For example, the Calza, Gerdesmeier and Levy (2001) specification (henceforth CGL) – which has been the workhorse M3 money demand equation used in the QMA since 2001 Q1 – is a VEC model of order 2 (meaning that two lags of each variable modeled in the system are included). The CGL model embodies one stationary cointegration relation that is interpreted as the long-run demand for real money (m-p). This relationship takes a semi log-linear functional form, relating money demand to real GDP (y) and the spread between the short-term market interest (s) rate and the own rate of return on M3 (OWN):

$$m_t - p_t = k + 1.3 y_t - 1.1 (s_t - OWN_t) \qquad (2.1)$$

Using such a money demand framework in the QMA led to three types of conclusions. First, monetary dynamics were seen as complementing the information coming from the economic analysis. For example, money demand equations might suggest that strong monetary growth was a result of strong real income growth and/or a low level of interest rates in the economy. Strong monetary dynamics would thus be seen as confirmation of signals coming from conjunctural indicators. Indeed, some suggested that monetary data would be available sooner and may be more reliable than alternative indicators (Coenen and Wieland, 2001), although in practice this argument has played a modest role in the ECB analysis.

Second, money demand equations provided a vehicle to distinguish between monetary dynamics that were more transitory in nature and those which were more persistent. For example, in the model specification of Brand and Cassola (2004) the relatively steep euro area yield curve observed in late 1999 was viewed as implying a temporary dampening effect on monetary growth, such that the headline annual growth rate of M3 understated what was the underlying rate of monetary expansion relevant for comparison with the reference value. (Note that the derivation of the reference value implicitly assumed that the slope of the yield curve would be at its steady-state level, since it focused on the medium to longer-term relationship among money and other macroeconomic variables). Money demand equations were thus seen as offering a framework for translating the observed rate of M3 growth into an indicator that could be more meaningfully compared to the reference value.

Third, money demand equations gave a benchmark for assessing the liquidity situation, by identifying an equilibrium level of money demand. Given that the policy relevant signal in monetary developments was of a longer-term or lower frequency nature, measures of excess liquidity (rather than the current rate of M3 growth) could be viewed as more meaningful indicators since they accumulated past deviations of monetary dynamics from the normative rate consistent with price stability over the medium term. At a minimum, the money demand equation allowed an assessment to be made of the impact of the liquidity situation on monetary dynamics and was thus thought to allow a more meaningful comparison of prevailing M3 growth with the reference value. For example, if the money demand equation suggested that M3 growth was subdued because of a correction of excess liquidity accumulated in the past, (other things equal) this would be viewed less benignly in terms of inflationary pressures than the same subdued rate of monetary growth stemming from other determinants.

(ii) JUDGMENTAL ANALYSIS AND DEVELOPMENT OF CORRECTIONS/ ADJUSTMENTS TO M3

From the outset, it was clear that money demand equations alone would not be able to account for all the identifiable movements in M3. As a result – and as is the case with other macroeconomic models used in a policy context – the analysis based on money demand has always been complemented by and integrated with a broad judgemental investigation of monetary developments.

The quantification of this judgement has led to production of a (real-time) adjusted or corrected M3 series, which has been used as an input to the reduced-form money-based inflation forecast models that have been used in the QMA (see next sub-section).[4]

Broadly speaking, three main types of judgement can be identified in the ECB's analysis, with the relative importance of each having varied over time as conditions dictated.

First, judgemental adjustments to the monetary series used in the internal analysis have been made for various technical factors. One example is the adjustment made to M3 to account for the impact of the introduction of the Eurosystem's system of required reserves in January 1999. In some countries of the euro area, the introduction of remuneration of required reserves on terms similar to market rates at the start of Stage III removed an implicit tax on banking intermediation and thus led to the repatriation of funds, including from offshore accounts (such as in London). Such behaviour raised M3 growth, but was deemed unlikely to represent a risk to price stability as it simply represented a transfer of existing deposits from offshore to onshore accounts. The magnitude of this effect could be identified rather closely from the MFI balance sheet data and, in internal analysis, a correction to the M3 series could be introduced.[5]

Second, judgemental adjustments have been made to address specific statistical problems that have arisen in the data. Most important among such adjustments is the treatment of non-resident holdings of various marketable instruments issued by MFIs. In 1998, the ECB decided to define the broad monetary aggregate M3 to include these instruments (ECB, 1999a), even though at the start of Stage III the statistical framework to distinguish resident and non-resident holdings did not yet exist. This decision was based on two grounds: first, econometric evidence suggested that inclusion of marketable instruments led to marginal improvements in the stability and leading indicator properties of the resulting monetary aggregate; second, the overall stock of marketable securities was rather small compared with the stock of M3 and was thus thought at that time to have little practical importance. However, from mid-2000 (due to portfolio diversification in Asia, the specific attractiveness of some German MFI securities which enjoyed a state guarantee and tax reasons), non-resident holdings of these securities increased substantially, having an appreciable – but, from the statistical perspective, erroneous – impact on the growth rate of M3. Internal analysis relying on the monetary presentation of the balance of payments

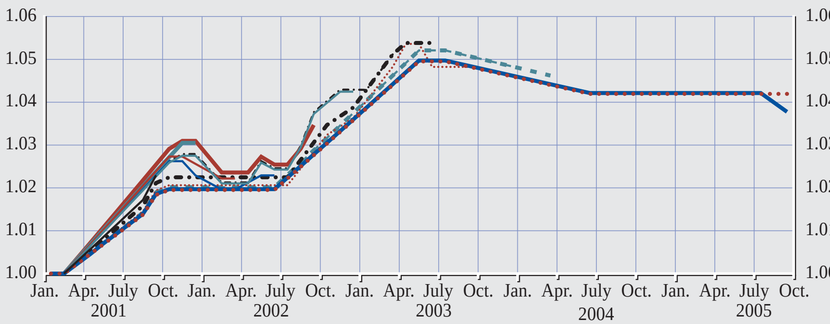
4 Note that the judgement has been applied by making an adjustment to the M3 series itself, rather than by introducing a velocity shift in the quantity equation and/or a dummy variable in a money demand equation. This choice largely reflects presentational concerns, since substantively there is little difference in deciding where the quantitative adjustment is introduced.

5 Other technical adjustments have been introduced for events such as the impact of the cash changeover on holdings of currency in the euro area (Fischer, Köhler, and Seitz, 2004), the volatile behavior of central government deposits in 2002-05 due to changes in the management of those deposits and the migration of inter-bank trading of repurchase agreements to electronic trading platforms operated by non-monetary financial institutions in the money-holding sector (Deutsche Bundesbank, 2005).

and various national data sources was able to construct a proxy measure for non-resident purchases of MFI marketable instruments. It was thus possible to create a quantitative measure of the "true" M3 series. However, these adjustments were deemed insufficiently reliable for use in official statistics. Thus for some time a gap emerged between the adjusted data underlying the internal analysis underpinning monetary policy decisions and the official published M3 series. Notwithstanding the ECB's efforts to highlight this gap in the monetary developments press release and the Monthly Bulletin, communication difficulties resulted in 2001 as interest rates were cut notwithstanding strong official M3 growth data, which was not representative of the internal analysis of the true underlying rate of monetary expansion. Eventually a revised official M3 series was published thereby closing the gap between the published data and the series used for internal analysis. As the statistical system underlying the production of the monetary data has improved and matured, the likelihood of such problems in the future has diminished. Nonetheless, this episode illustrates well the practical challenges faced by the ECB over the past eight years and the methods used to address and overcome them.

Third, judgmental adjustments have also been introduced to account for economic behaviour that was not captured by the conventional determinants of money demand included in the standard econometric models estimated and employed at the start of Stage III. The most prominent example of such adjustments concerns the portfolio shifts into monetary assets that took place between late 2000 and mid-2003, as a result of the heightened economic and financial uncertainty prevailing at that time. In an environment of falling equity prices (following the collapse of the dot.com boom in stocks) and geo-political tensions (the terrorist attacks of 11 September 2001 and the ensuing military conflicts in Afghanistan and Iraq), financial volatility rose and returns on risk-bearing assets fell. Seeking a safe haven from such developments, euro area residents shifted their wealth portfolio from riskier assets – in particular, foreign equities – into safe, liquid and capital-certain domestic assets contained in M3. The internal analysis identified these flows at an early stage on the basis of its scrutiny of the components and counterparts of M3 (ECB, 2003a and ECB, 2004). Specifically, on the components side, holdings of money market mutual fund shares/units – instruments typically used by households to "park" savings at a time of market volatility – rose substantially. On the counterparts side, the MFI net external asset position rose significantly, as euro area residents sold foreign securities to non-residents. Using this information and a broad set of other data (see Appendix B), ECB staff were able to construct quantitative, real-time adjustments for the impact of these portfolio shifts on headline M3 dynamics. The staff judged that these portfolio shifts were a temporary – albeit potentially prolonged – phenomenon, which would tend to unwind as economic, financial and geo-political conditions normalized. As such, the adjusted M3 series was more representative of the underlying trend rate of monetary expansion relevant for the outlook for price developments over the medium term than the official (unadjusted) M3 series. The internal analysis therefore viewed the adjusted series as providing the modal view of monetary developments, while recognizing both that the construction of the adjustments was surrounded by many uncertainties and that the strong M3 growth in the

Chart 1 Different vintages of real time adjustment factors for portfolio shifts



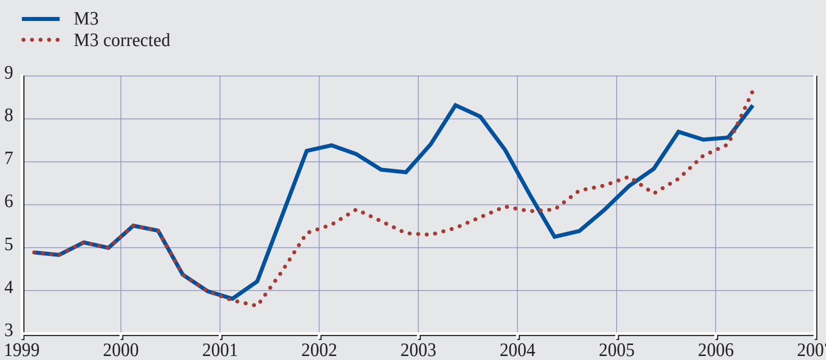
Note: The figure shows the vintages of the adjustment factors as available in real time. A value of 1.05 indicates that the level of M3 is corrected by 5%.

official (unadjusted) series caused by the surge of portfolio shifts implied upside risks to this interpretation of monetary dynamics (and thus the implied outlook for price developments over the medium to longer term).

The rich internal analysis underlying the identification and quantification of portfolio shifts eventually took final, concrete form in the construction of an adjustment factor (shown in Chart 1), which was used to adjust the level of headline M3 and produce a series corrected in real time for the estimated impact of portfolio shifts.

Three important messages stem from this chart. First, the adjustment made was timely, in the sense that the first adjustment for portfolio shifts was first introduced in 2001 Q3 for the data from 2001 Q2. Second, the real time assessment largely corresponds to the current ECB staff assessment of this period, since the quantified judgemental correction has not changed significantly as new vintages of data have become available. Finally, the adjustment made has been very significant in magnitude, peaking at over 5% of the money stock.

Chart 2 Annual growth rates of M3 and M3 corrected – latest available vintage



This is also reflected in the evolution of the annual growth rates for the official M3 series and the M3 series corrected for the estimated impact of portfolio shifts (on the basis of the latest vintage of data and analysis available as of today, see Chart 2).

A natural question that arises in this context is the relationship between the judgemental adjustments made to the M3 series to account for the estimated impact of portfolio shifts and the use of money demand equations discussed above. Indeed, it could be argued that rather than making such adjustments in a somewhat ad hoc judgemental manner, the structural explanation of portfolio shifts should be incorporated into a standard money demand. Indeed, some attempts in that direction have been made.[6]

However, the possibility of estimating the parameters associated with these additional variables rested on the availability of data through the period when the portfolio shifts were taking place (which was necessarily only available after a period of several quarters), whereas the real time analysis had to make such assessments as the portfolio shifts were occurring. Such augmented money demand equations – which implicitly provide estimates of the magnitude of portfolio shifts that correspond quite closely to the real time adjustments made by the ECB staff – are thus better seen as providing ex post support for the staff's judgemental assessment rather than a plausible alternative framework for making that assessment in real time.

More generally, when evaluating the judgemental analysis, it is important to recognize that measures to correct the M3 series were taken in real time on the basis of the encompassing staff assessment of monetary developments and before econometric evidence suggested instability in the standard money demand equations that were being used at that time. Thus these measures should be understood as an attempt to explain and quantify an economic phenomenon observed in real time, not as an attempt to "fix" a failing money demand specification. Indeed, given the very short samples of data available and the difficulty of estimating long-run structural parameters when the end of the sample is "contaminated" by temporary but significant deviations from normal long-run behavior, the reliability of conventional stability tests is open to question. By the same token, such adjustments were not made to re-establish leading indicator properties of money in a specific forecasting framework.

Nonetheless, the judgemental adjustments and the money demand models had to be reconciled to maintain the internal consistency of the analysis. In practice, two concrete measures were taken to achieve this. First, from 2001 Q4 onwards ECB staff fixed the parameters of the baseline money demand equation then used in the QMA (CGL) at the values estimated for the sample 1980 Q1 to

6 Greiber and Lemke (2005) and Carstensen (2003) tried to incorporate additional explanatory variables such as those used for the ECB judgemental correction into standard money demand specifications. The ex-post evaluation of such models is that while they fit the specific portfolio shifts period quite well, this came at the expense of introducing other anomalies in the money demand behavior at other points in the sample and, more importantly, did not lead to a more comprehensive explanation of monetary developments through 2006.

2001 Q2. Since then, this model has been treated as a historical benchmark for the analysis, recognizing that the stability of the specification in recent years (post-2001) on the basis of standard econometric tests is – at best – questionable. One could characterize the approach as a form of calibration, where the pre-portfolio shift period estimates are viewed as more representative of behaviour during "normal times" and thus as more reliable calibrated values than empirical estimates that include the post-2001 data.[7] Second, instability of M3 demand relative to this historical benchmark was seen as having been captured by a stochastic term in the money demand equation which represents identifiable economic factors beyond the conventional determinants of money demand. The analysis then focus on capturing this term through the judgemental assessment of portfolio shifts.

Given this approach, the monetary analysis and its communication have changed in nature. In particular, the instability of standard money demand specifications has inevitably complicated the assessment, explanation and – above all – presentation of deviations of M3 growth from the ECB's reference value. Since there is no reliable estimated money demand equation which covers the entire sample period, it is not possible to construct a decomposition of such deviations into the contributions of developments from the various conventional determinants of monetary dynamics on the basis used prior to 2001. As a result, the interpretation of such deviations – in particular, the identification of those which have implications for the outlook for price developments over the medium term – has lost meaning. For much of the 2001-04 period, the main reason for deviations of M3 growth from the reference value has been the impact of portfolio shifts, which are identified and quantified outside the money demand model. This has led to greater emphasis being placed on the M3 series corrected for the estimated impact of portfolio shifts in both the internal and external communication of the monetary analysis.

(iii) MONEY-BASED INFLATION FORECASTS AND INDICATORS

As a complement to the money demand equations and judgemental analysis, money-based forecasts and indicators of inflation have also been employed in the QMA. Over time, reduced-form money-based inflation forecast models (such as those proposed in Nicoletti-Altimari, 2001), based on the methodology outlined in Stock and Watson, 1999) have played a more prominent role. These are bivariate equations where an autoregressive equation for inflation is augmented by, respectively, the growth rate of M3 and the growth rate of M3 corrected for portfolio shifts. We will discuss the exact specification of these equations in the next section. Let us here just outline the forecasting model.

Define HICP inflation at time t as π_t. The bivariate models to forecast inflation at time $t + h$ is:

$$\pi_{t+h} = a + b_t\pi_{t-1} + \cdots b_p\pi_{t-p} + c_1x_{t-1} + \cdots + c_p x_{t-p} + \varepsilon_{t+h} \qquad (2.2)$$

7 Indeed, recursive estimation of money demand equations in the sample 1980-2001 would reveal several episodes of "instability" that turned out to be temporary when analyzed in the light of the full sample.

where x_t denotes the growth rate of either M3 or M3 corrected. At each time t the parameters are estimated and the estimates are used to produce a forecast.

The use of such simple indicator models can be seen as a straightforward method of transforming – in a rather mechanical way – the detailed monetary analysis into a outlook for price developments, which represents a "summary statistic" for the monetary analysis that can be discussed and digested both internally and externally.

Such simple bivariate forecasting models have increased in prominence over time at the expense of forecasts that were produced on the basis of money demand equations. Initially, the entire VEC system (of which the money demand equation was a part) was simulated to produce forward-looking paths of the key macroeconomic variables in the system, including inflation. Such an approach was discontinued from 2001, given that these models did not provide a satisfactory forecasting performance. Money demand equations continued to be used to provide a forecast of inflation based on the "real money gap" P-star models (as in Hallman, Porter and Small, 1991). Appendix C shows the form of the forecasting equation derived from these concepts. The P-star approach, however, has never been prominent in the QMA, since by the time it was introduced, greater reliance was already being placed on the bivariate approach in a context where the specifications of money demand underlying the P-star model were of questionable stability. Indeed, the rising prominence of the bivariate approach can be interpreted as one practical response to a situation from 2001 onwards where growing questions emerged about the stability of money demand equations used in the QMA.

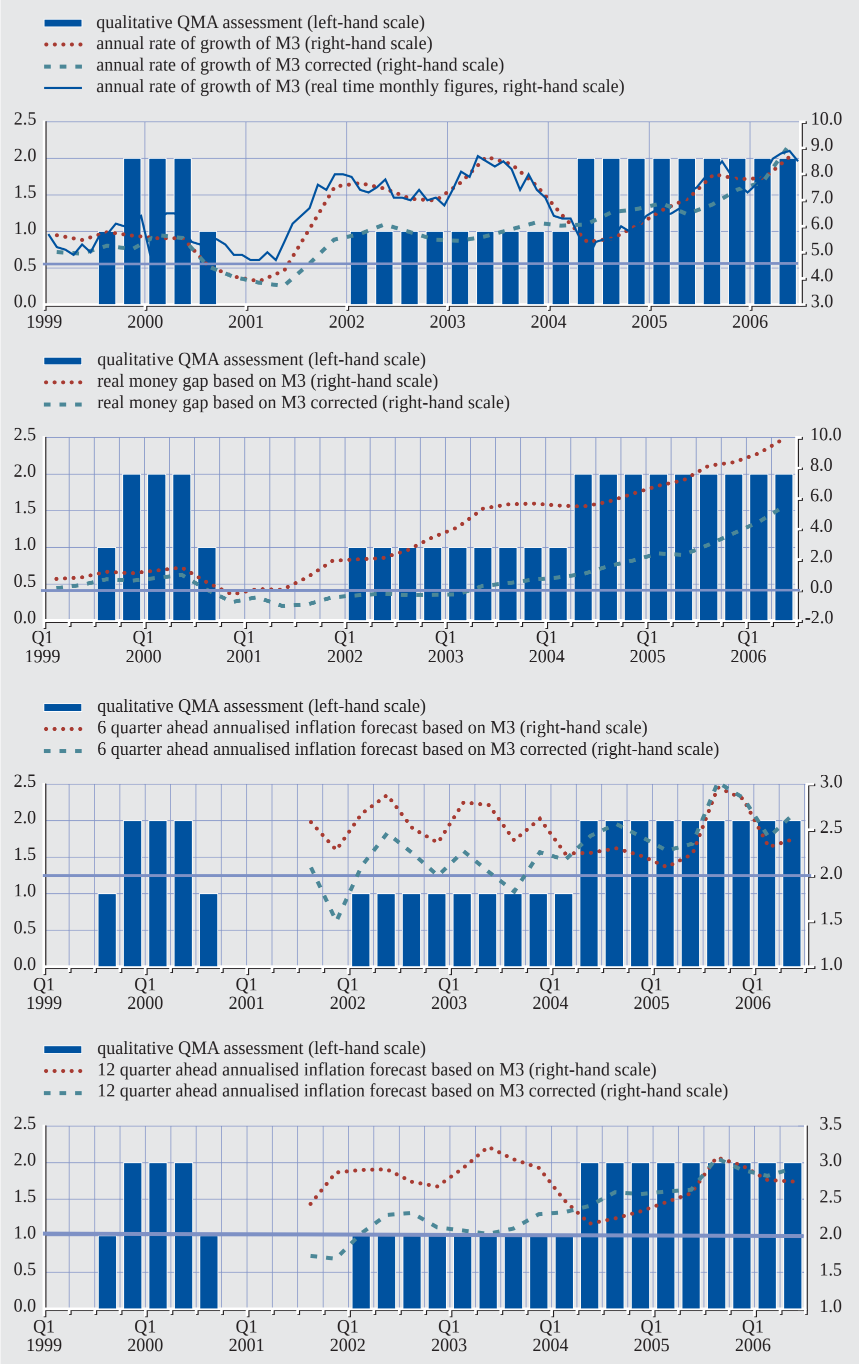
2.4 THE QMA: SUMMARY INDICATORS OF THE OVERALL ASSESSMENT

As we have seen, the evaluation of the risk for price stability produced by the QMA is rather complex, since it is based on a variety of approaches and models and relies on a significant degree of expert judgement. This raises the question of whether and how to characterize the "policy message" stemming from the monetary analysis. As suggested in the preceding section, the simple transformation of M3 and M3 corrected into a quantitative outlook for price developments on the basis of bivariate indicator models is one approach. This sub-section explores other characterizations to assess its robustness.

To obtain a synthetic indicator of the overall assessment, we have coded the wording of the introduction of the QMA. The latter indicator is derived from coding the overall conclusion of the QMA concerning risks to price stability stemming from the monetary pillar, where the coding ranges from -2 (clear downward risks to price developments) to +2 (clear upward risks to inflation). Chart 3 plots the qualitative indicators against the evolution of both the official M3 series and the M3 series corrected for the estimated impact of portfolio shifts and other distortions identified by the judgemental analysis.

The chart shows that the growth rate of the M3 series corrected and the inflation forecasts based on this variable on one hand and the qualitative indicator on the

Chart 3 Qualitative assessment of the QMA, M3 and M3 corrected



Source: ECB, own calculations.
Note: The horizontal line in the two two charts represent the ECB's reference value from monetary growth. The horizontal line in the bottom two charts represents the ceiling of the ECB's quantitiative definition of price stability. The qualitative coding goes from -2 (clear downward risks to price stability) to +2 (clear upward risks to price stability).

other hand, evolve in similar patterns. In particular, the turning points in this series are aligned, which allows them to be used to identify several different phases of the signal drawn from the monetary analysis.[8]

More precisely, four phases are discernible from these summary indicators: early 1999-mid 2000; mid 2000-mid 2001; mid 2001-mid 2004; and mid-2004 onwards. Using these dates as a starting point, a deeper analysis of the material presented in the QMA suggests that these phases can be distinguished along three dimensions: first, the signal offered by the baseline of the monetary analysis with regard to risks to price stability over the medium to longer term (which is broadly captured by the money-based inflation forecasts); second, the degree of uncertainty surrounding the interpretation of monetary developments, which governs the strength of the policy signal that can be drawn from the monetary analysis; and third, the risks to the baseline outlook derived from the monetary analysis.

The first phase lasted from early-1999 through mid-2000, during which the monetary analysis pointed to upside risks to price stability at medium to longer-term horizons. The strength of this signal increased over the course of the period, as uncertainties surrounding the monetary data associated with the transition to Monetary Union (e.g. the impact of the change in the required reserves regime) receded.

The second phase lasted from mid-2000 until mid-2001. During this period, the monetary analysis pointed to a relatively benign outlook for price developments, with inflationary pressures at longer horizons diminishing over time. However, the monetary data published in real time (though not the more recent vintages of data) obscured this signal due to the statistical distortions to the M3 series. In both of these phases, the risks surrounding the signal offered by the monetary analysis were relatively balanced.

Between mid-2001 and mid-2004, the uncertainties surrounding the interpretation of monetary developments were multiplied by the incidence of portfolio shifts (first an inflow into monetary assets, and then an unwinding of those flows). The signal from the monetary analysis during this third phase was therefore blurred and thus weaker. While the baseline outlook for price developments constructed on the basis of the monetary analysis was rather benign in terms of implications for price stability, the risks to this outlook were viewed as skewed strongly to the upside given the accumulation of liquidity that was taking place. However, signals from monetary analysis among others could help to rule out any deflationary pressures in the period between late 2002 through the course of 2003. At that time, some commentators were concerned that the euro area might be heading for deflation and called for more aggressive loosening of monetary policy.

8 The growth in the official M3 series and the resulting inflation forecasts were used to make a risk assessment around the modal view captured by the corrected measures. This is supported by the qualitative indicator that mainly captures the pattern of the corrected measures.

Finally, from mid-2004 the monetary analysis pointed to increasing upside risks to price stability at medium to longer-term horizons. Over the course of this fourth phase, the signal stemming from the monetary analysis strengthened for two reasons. First, the analysis pointed to a strengthening of the underlying rate of monetary expansion over time. Second, the view that this strengthening of monetary dynamics was fundamentally different from the previous strengthening associated with portfolio shifts into money was progressively confirmed. This strengthening of the signal from the monetary analysis contrasts with the lack of clarity emerging in the real time data from the economic analysis, against the background of the emerging gap between soft and hard data. At the same time, given the accumulation of liquidity remaining from the 2001-03 period, the risks to this baseline view were also seen as skewed to the upside.

As shown in Chart 3, the M3 corrected-based inflation forecasts capture the transition from the third to the fourth phase (unavailability of such real time forecasts prior to 2002 limit the scope to assess other transitions). The next Section will evaluate the accuracy of such forecasts in tracking future inflation.

3 FORECASTING EVALUATION

In order to provide a structured quantitative assessment of the ECB's monetary analysis, this section describes a formal statistical evaluation of the money-based forecasts regularly presented in the QMA. Since only the bivariate money equations were consistently used for forecasting purposes, the evaluation will only focus on a small subset of the models used in the QMA.

In the previous Section we have described the assessment made in the QMA of the outlook for price stability. That assessment, as we have seen, embodies a rich set of quantitative and qualitative analyses of which the money based forecasts are only one element. The money-based forecasts should be seen as "summary statistic" capturing the broad thrust of the assessment, not as a "sufficient statistic" providing an exhaustive summary of the information extracted from monetary developments. Moreover, the forecast evaluation we discuss in this section will focus only on the first moment of the forecast (i.e. the baseline outlook) which does not capture the higher moments (e.g. the risks surrounding the baseline), typically of importance for monetary policy purposes. The question we will analyze is therefore narrower than establishing the role of the monetary analysis for the broad assessment of price stability.

Precisely, we will consider both the BMPE projections and the money-based forecasts and ask how well they each tracked future inflation and how they related to each-other (other models will be considered only to help the interpretation of results). This exercise has to be read in light of the fact that, in line with the ECB's strategy, the BMPE projections and money-based forecasts are prepared independently, to allow for cross-checking the assessment of price stability.

The analysis will mainly concentrate on the six quarter ahead horizon. This horizon was chosen to permit a comparison between the monetary analysis and the economic analysis[9] and because short-sample problems make longer horizon evaluations very unstable and therefore unreliable. A number of caveats should be taken into account in focusing on the six quarters horizon. First, since money is typically seen as containing information about the outlook for price developments over the medium to longer term, one may question the appropriateness of this horizon. To partly address this problem we will focus on the annualized rate of HICP inflation over the next six quarters. Second, the economic analysis is meant to provide signals for the short/medium outlook for price stability and then focusing only on the six quarters horizon does not allow an evaluation of the analysis over all its relevant horizons. However, we only look at the BMPE projections to provide a benchmark for the money based forecasts. A thorough evaluation of the BMPE is beyond the scope of this paper in particular as those projections (at least during the evalution period) were conditional on the assumption of a constant short-term interest rate over the projection horizon.

The evaluation of the money-based forecasts and the comparison of those forecasts with alternative benchmarks, is based on an out-of-sample exercise using data and models that were available to the forecasters in real time. To be able to conduct such analysis, we are exploiting a very rich data-base, containing all the vintages of data and models used at the ECB in the production of the QMA since 1999.

The structure of the exercise is as follows. We estimate the models using the sample 1980Q1-2000 Q3 and produce the first forecast for 2002Q1 (six quarter ahead). The next quarter, 2000 Q4, we will produce a new forecast, using data and models available up to then. For each subsequent quarters we will do the same so as to produce eighteen forecasts (corresponding to the period 2002 Q1-2006 Q2) that can be compared with the realized inflation. Notice that, as time progresses from 2000 Q3 to 2004 Q4 (last vintage we evaluate), not only do we have new data points, but also new vintages of data reflecting revisions to the time series and to the model specifications.

As has been observed by the literature, the historical evaluation of economic policy or, in our case, the evaluation of the analysis underlying monetary policy, is only possible if the informational assumptions are realistic in the sense of reflecting what people knew at the time the analysis was undertaken and policy decisions made. Based on this observation, for example, a large literature in the US has evaluated the size of revision errors of variables and key indicators such as the output gap and the implications of those revisions for historical interpretation of monetary policy (e.g. Orphanides, 2001). Recently, revisions of the structural forecasting model at the Federal Reserve Board have also been analyzed (e.g. Ironside and Tetlow, 2005). The present paper is the first to conduct a fully real time evaluation of the ECB money based forecasts which

9 The published Eurosystem – ECB staff macroeconomic projections (BMPE) have a maximum horizon of nine quarters.

takes in consideration not only the evolution of the data but also of the models. In addition, it evaluates those forecasts against relevant internal and atheoretical real time benchmarks.

In the next subsections, we provide details on the forecasting models, the procedures to prepare the forecasts and the statistics we use for the forecast evaluation. Finally we report the outcomes of the evaluation.

3.1 MODELS

In the first part of the paper, we have seen that several models have been used as inputs of the QMA. However, the only two money-based forecasting models that have been consistently used in the forecasting process throughout the period under consideration, are bivariate equations where an autoregressive equation for inflation is augmented, respectively, by the growth rate of M3 and the growth rate of M3 corrected.

We will consider these equations in the exact specification used by the QMA. In addition, we will also consider 11 alternative bivariate forecasts with selected nominal and real variables: GDP, short and long term nominal interest rates, the term spread, nominal wages, the unemployment rate, total employment, import prices, oil prices, the Euro-dollar exchange rate and unit labor costs. Bivariate equations including these variables constitute a useful benchmark for the ECB monetary models since these variables are alternative indicators of real and nominal pressures on inflation and because of the availability of real time data vintages for them. Precise definitions, sources and transformations are described in Appendix A. To preserve comparability of results, the equations specification is the same as that of the money-based forecasts.

The variable we are interested in forecasting is the annualized h-period change in HICP. Defining HICP at time *t* as P_t, the h-period annualized change is given by:

$$\pi_{t+h} = 100 * [(\frac{P_{t+h}}{P_t})^{4/h} - 1]$$

where *h* will be six quarters.[10]

For each vintage of data *v*, the bivariate models are nested by the following equation

$$\pi_{v,t+h} = a_v + b_v(L)\tilde{\pi}_{v,t} + c_v(L)x_{v,t} + \varepsilon_{v,t+h} \qquad (3.3)$$

where $\tilde{\pi}_{v,t} = 100 * [(\frac{P_t}{P_{t-2}})^{4/2} - 1]$[11] and $x_{v,t}$ denotes the four quarter moving average of the M3 or M3 corrected growth rate or one of the 11 alternative real

10 At the end of this section we will also show some results for the 12 quarters horizon.
11 The choice of the two quarter moving average for the money based inflation forecasts has been done in order to reduce the volatility of the forecasts.

and nominal variables and $b_v(L)$ and $c_v(L)$ are finite polynomial of order p in the lag operator L:

$$b_v(L) = 1 + b_{v1}L + \cdots + b_{vp}L^p$$
$$c_v(L) = 1 + c_{v1}L + \cdots + c_{vp}L^p.$$

We also present results from three benchmark models: a constant, set at 1.9% to capture the ECB's definition of price stability as "below but close to 2%", a simple univariate autoregressive model (AR) defined as:

$$\pi_{v,t+h} = f_v + g_v(L)\tilde{\pi}_{v,t} + \xi_{v,t+h} \tag{3.4}$$

and results from the random walk model computed in real time, defined as:

$$\pi_{v,t+h} = \pi_{v,t} + \epsilon_{v,t+h}.$$

Clearly, if in our sample the random walk turned out to be the best forecasting model for inflation, this would imply that inflation realized six quarters ago was the best forecast of today's inflation. In other words, this would imply that inflation is close to non forecastable since a naive forecast would perform better than more refined models.

In addition to the bivariate models based on single variables and the three benchmarks, we produce forecasts from combinations of individual forecasts where aggregation is achieved by simple averaging (equal weights). Formally,

$$\pi^{comb}_{v,t+h} = \frac{1}{N}\sum_{s=1}^{N} \pi^{\mathcal{M}_s}_{v,t+h}$$

where $\pi^{\mathcal{M}_s}_{v,t+h}$ denotes a generic individual forecast (produced by model $\mathcal{M}_s$) and N the number of forecasts being combined.

Finally, results are reported for the BMPE projections.[12] It should also be kept in mind that money based forecasts are finalized about 36 working days after the end of the last available quarter while the BMPE after around 43 working days and, in practice, without knowing or taking into account the results based on the money forecast.

3.2 FORECASTING PROCEDURES

Our prediction sample for the h = 6 forecast horizon is 2002 Q1-2006 Q2 (18 observations),[13] since money-based forecasts are only available from the QMA prepared in 2000 Q4 and based on data through 2000 Q3.

12 For the sake of simplicity and to allow the derivation of statistics, we use throughout the paper the mid points of the BMPE ranges.
13 For the h = 12 quarters ahead, the prediction sample is 2003 Q3-2006 Q2, with 12 observations.

To prepare the forecast we will follow the same steps actually followed by ECB internal practice. They are described in what follows.

MODEL SPECIFICATION

Lags for the dependent variables are chosen in each exercise by minimizing the Schwartz information criterion. The maximum allowed lag for inflation and the independent variables is 5. Due to the choice of the maximum lag and the fact that dependent and independent variables enter the forecasting models, respectively, in the form of six and four quarter moving averages, 14 data points are lost at the beginning of the sample. Thereby, the first observation for the dependent variable in the regressions is 1983 Q3 in each exercise.

ESTIMATION OF MODELS AND PRODUCTION OF FORECAST

The forecasting models are estimated by simple OLS. For each exercise, we estimate in sample the relationship between annualized inflation over the next h quarters, inflation lags and those of the monetary or non monetary variables. The estimated OLS coefficients are then applied to the last available observations in sample to produce a direct forecast of inflation six periods ahead. More formally, defining a_v^{ols}, $b_v(L)^{ols}$ and $c_v(L)^{ols}$ as the filters (with the implied coefficients) for the bivariate models estimated with data relative to vintage v and up to time t, the inflation forecast is defined as

$$\pi^x_{v,t+h} = a_v^{ols} + b_v(L)^{ols}\tilde{\pi}_{v,t} + c_v(L)^{ols}x_{v,t}$$

The same procedure is adopted to produce the autoregressive forecast.

Forecast errors e_t for the generic forecast from model M are defined as

$$e_{t+h} = \pi^{\mathcal{M}}_{v,t+h} - \pi_{t+h}$$

where actual inflation π_{t+h} is defined as that observed at the time of the last available vintage (i.e. 2006 Q2).

Finally, the random walk forecast which we use as one of our naive benchmarks is defined as

$$\pi^{RW}_{v,t+h} = \pi_{v,t}.$$

UPDATE

After a forecast based on vintage v, the database is updated to vintage $v+1$. The new forecast, based on the new data, takes into account one more data point but also revisions in the history of the variables. The last vintage available for the forecasting evaluation is 1980 Q1-2004 Q4, related to the exercise performed in 2005 Q1.

3.3 STATISTICS OF FORECASTING EVALUATION

The statistics used for the forecasting evaluation are the mean squared forecast error ($MSFE = \frac{1}{T}\sum_{t=1}^{T} e^2_{t+h}$, where T=18 in our case), the bias ($Bias = \frac{1}{T}\sum_{t=1}^{T} e_{t+h}$) the standard deviation of the forecast ($SDF = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\pi^{\mathcal{M}}_{v,t+h} - \frac{1}{T}\sum_{t=1}^{T}\pi^{\mathcal{M}}_{v,t+h})^2}$) and the relative mean squared errors

$$Rel.MSFE = \frac{MSFE^{\mathcal{M}}}{MSFE^{uni}}$$

where $MSFE^{\mathcal{M}}$ and $MSFE^{uni}$ are, respectively, the mean squared errors of forecast of the generic model *M* and of a univariate benchmark (autoregressive or random walk in this paper).

Finally, since the MSFE is affected by both the variance of the errors and the bias, that is

$$MSFE = \frac{1}{T}\sum_{t=1}^{T}(e_{t+h} - \frac{1}{T}\sum_{t=1}^{T} e_{t+h})^2 + Bias^2$$

we will report results for both components.

3.4 EXERCISES AND RESULTS

EXERCISE 1: BMPE AND MONETARY MODELS

Table 1 illustrates the results for seven alternative models (indicated in column one): the AR model, the random walk, the BMPE, the two monetary equations and the simple average between the BMPE and the M3 growth equation (BMPEM3).

Column two indicates the mean square forecast error (MSFE) and columns three and four the ratio between the MSFE of the model relative to, respectively, the random walk (RW) and the univariate AR. The following columns report bias, standard deviation of the forecasts, variance of the forecast error and bias squared.

Results can be summarized as follows.

1. Both the equations augmented with the official M3 data and BMPE projections are outperformed by the random walk and naive models and they are biased.

2. The equation augmented by M3 corrected indeed corrects the bias, but retains and partly accentuates the excess volatility observed for the M3 model, as it can be seen from the relative high value of the variance of the forecast and of that of the forecast error relatively to the BMPE. The consequence is that it is outperformed by the random walk in terms of the MSFE criterion.

Table 1 Internal forecasts

Model	MSFE	MSFE/RW	MSFE/AR	Bias	SD fore.	Var. f.e.	*Bias*^{2}
AR	0.18	1.76	1	0.16	0.48	0.15	0.03
RW	0.10	1	0.57	0.12	0.25	0.09	0.01
1.9%	0.09	0.92	0.52	-0.27	0	0.02	0.07
BMPE	0.24	2.40	1.37	-0.45	0.20	0.04	0.20
M3	0.19	1.86	1.06	0.28	0.23	0.11	0.08
M3c	0.11	1.04	0.59	0.01	0.27	0.11	0
BMPEM3	0.05	0.48	0.28	-0.08	0.10	0.04	0.01

3. The random walk outperforms all models in terms of the MSFE criterion except the constant 1.9% inflation (and this by less than 1%) and, most strikingly, the simple average between money growth and BMPE projections. The latter forecast achieves an improvement of over 50% with respect to the random walk.

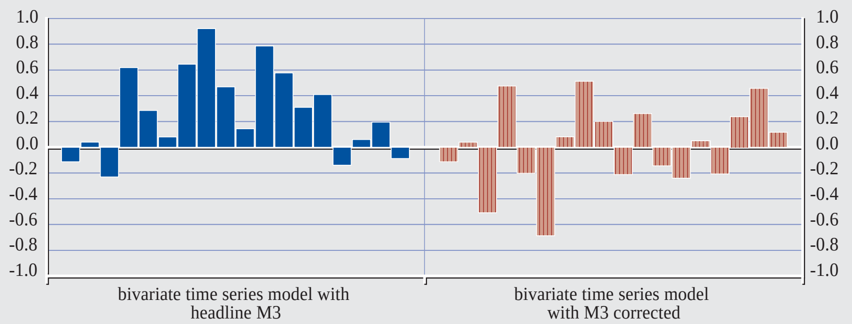
That simple statistical benchmarks outperform the internal forecasts is not a surprising result. Similar findings have been produced for the US (see, for example, Atkeson and Ohanian, 2001 and Giannone, Reichlin, and Sala, 2004). It should also be noted that forecasts for the euro area produced by other institutions such as the IMF and the OECD are very correlated with the BMPE projections.[14] What is more interesting for our discussion, is the fact that M3 and BMPE projections have large systematic biases with opposite sign.

Chart 4 reports the forecast errors of the M3 and M3 corrected based forecasts. The forecast based on M3 has systematically over-predicted inflation over the relevant sample period. This feature is corrected by the forecast derived from M3 corrected which, although very volatile, is centered around actual inflation. The latter result suggests that the judgemental assessment of monetary developments succeeded in capturing average inflation, although this did not correct for the excessively volatile forecast.

Moreover, Table 1 shows that the Mean Squared error of Forecasting on the BMPE projections is to a very significant extent owing to the (negative) bias component. Coupled with the low volatility of the BMPE forecast errors this allows to conclude that BMPE projections have systematically under-predicted six quarter ahead annualized inflation.[15]

Excessive volatility is corrected by the BMPE-M3 combination. The latter forecast is not only smooth, but also unbiased. The bias correction is mechanically explained by the fact that the combination is an average of a forecast which is biased upward and a forecast which is biased downward while the adjustment

Chart 4 Forecast errors of real time M3 and M3 corrected based forecasts



14 In the regular presentation of the BMPE outcomes in the Monthly Bulletins the ECB publishes also forecasts from other public and private institutions.
15 For additional evidence on this point, see Pill and Rautanen (2006).

of the high volatility of the M3 forecast is achieved by the smoothing effect of averaging models.

Visual inspection of Chart 4 and results in Table 1 suggest that, although the BMPE projections are strongly biased downward, they are the only ones that track inflation dynamics. A formal way to assess whether M3 provides an improvement beyond what achieved by the BMPE for what concerns dynamics (i.e. after having netted out the bias), is to test whether the M3 based forecast is not encompassed by the BMPE projection.

More precisely, the question we address is whether it is possible to find a convex linear combination of the BMPE projections $(\pi^B_{v,t+h})$ and money $(\pi^M_{v,t+h})$ forecasts that *significantly* outperforms the BMPE projections. A simple regression procedure to address this question has been suggested by Harvey, Leybourne and Newbold (1998) and references in West (2006).

Assume that the relationship between realized inflation and the combination of forecasts is:

$$\pi_{t+h} = k + (1-\lambda)\pi^B_{v,t+h} + \lambda\pi^M_{v,t+h} + \eta_{t+h} \quad (3.5)$$

where we allow for a bias term k owing to the fact that the BMPE projections and the monetary forecasts are biased. The OLS estimate for λ in this equation minimizes the sum of the squared errors η_{t+h}, hence it provides the estimate of the optimal weights in the forecast combination. Moreover, if λ is significantly different from zero, the forecast $\pi^M_{v,t+h}$ adds information to (i.e. it is not encompassed by) $\pi^B_{v,t+h}$.

By subtracting $\pi^B_{v,t+h}$ from both sides of equation (3.4), we obtain:

$$u^B_{t+h} = k + \lambda(\pi^M_{v,t+h} - \pi^B_{v,t+h}) + \eta_{t+h} \quad (3.6)$$

where $u^B_{t+h} = \pi_{t+h} - \pi^B_{v.t+h}$.

Table 2 shows results for both the M3 and M3 corrected inflation forecasts. Since long horizon forecast errors can be autocorrelated, the standard errors reported in parenthesis in Table 2 are corrected by the Newey-West procedure.

Results in Table 2 show that, at the 5% level we cannot reject the hypothesis that the monetary forecasts are not encompassed by the BMPE projections. This further suggests that money helps forecasting beyond the BMPE projections.

Table 2 Encompassing tests: results

Parameter	κ	λ
M3	0.27*** (0.06)	0.24** (0.09)
M3 corrected	0.35*** (0.04)	0.22** (0.08)

Newey-West corrected standard error in parenthesis. Three stars indicate the coefficients is significant at 1% level, two stars at 5% level, one at 10% level.

Notice the value of λ suggests that, after controlling for the constant (and therefore for the bias), the optimal combination between the M3 based forecasts and the BMPE projections should attribute a weight of 24% to the M3 based forecast.

However, back of the envelope calculations from the results in Table 1 show that the combination that sets the bias to zero gives a weight of $^2/_3$ to the M3 based forecast.

This is because the M3 based forecast is better apt capturing inflation on average over the period while the BMPE projections are better apt capturing inflation fluctuations around the mean.

This implies that whether the M3 based or to the BMPE projections should have more weight in the combination depends on the relative weight of the bias and the variance of the forecast errors in one's loss function. This, in turn, depends on whether one's objective is the forecast of average inflation or of its fluctuations around the mean.

For the minimization of the mean squared error of forecasting, which gives equal weight to the variance and the bias, the optimal combination assigns approximately equal weight to the two forecasts.

EXERCISE 2: CAN WE ACHIEVE THE SAME REDUCTION OF THE MSFE BY COMBINING THE BMPE WITH INDICATORS OTHER THAN MONEY?

Here we will consider the alternative eleven bivariate equations based on our selected variables as well as their combination, the combination of all nominal variables and the combination of real variables (all combinations are computed as simple averages).[16]

The questions we we want to ask here are: (i) can we identify one or a set of variables that scores better than the single indicators considered so far? (ii) does M3 have a special role or there are other indicators that generate bias correction if combined with the BMPE projections?; (iii) does an average of nominal variables generate the same bias correction achieved by M3?

16 Results based on principal components rather than averages give very similar results.

Table 3 reports MSFE for different models and the analysis of the bias and the variance.

Table 3 Alternative bivariate forecasts

Model	MSFE	MSFE/RW	MSFE/AR	Bias	SD fore	Var. f.e.	*Bias*^{2}
Gdp	0.22	2.19	1.25	-0.01	0.48	0.22	0
Unemp	0.27	2.65	1.51	0.18	0.49	0.24	0.03
Emp	0.29	2.85	1.62	0.16	0.52	0.26	0.03
Impp	0.17	1.65	0.94	0.13	0.33	0.15	0.02
Oilp	0.19	1.87	1.06	0.14	0.36	0.17	0.02
Exc	0.20	2.01	1.14	0.17	0.36	0.17	0.03
Sir	0.23	2.28	1.30	0.19	0.44	0.20	0.04
Lir	0.23	2.27	1.29	0.23	0.40	0.18	0.05
Spread	0.18	1.73	0.99	0.06	0.39	0.17	0
Wages	0.10	0.96	0.55	-0.13	0.21	0.08	0.02
Ulc	0.12	1.20	0.68	0.10	0.26	0.11	0.01
Combtot	0.16	1.63	0.91	0.09	0.36	0.15	0.01
Combreal	0.25	2.48	1.39	0.11	0.49	0.24	0.01
Combnom	0.15	1.45	0.81	0.09	0.32	0.13	0.01

Notes: The row Gdp in the table refers to the bivariate model augmented with Gdp, Sir with the nominal short term interest rate, Lir with nominal long term interest rate, Spread with the term spread, Wages with wages, Ulc with unit labor costs, Unemp with unemployment, Emp with employment, Impp with import prices, Oilp with oil prices, Exc with the exchange rate. Combtot, combreal and combnom are, respectively, the combinations of the forecast with all the 11 variables, the real and the nominal. Precise definitions can be found in Appendix A.

The results can be summarized as follows.

1. All bivariate models are outperformed by the random walk with the possible exception of nominal wage growth.

2. No model produces the reduction of MSFE that we have seen for the M3-BMPE combination.

3. Most models, both nominal and real, have a positive bias.

4. All nominal variables perform better than the BMPE and so does the average of all nominal variables (see Table 2 for comparison).

The fact that most models have positive bias, suggests that variables other than M3 can be used in combination to the BMPE projections to correct the bias.

As for dynamics, we can assess whether variables other than M3 are not encompassed by the BMPE by running the same encompassing test considered for M3 and M3 corrected.

Table 4 reports results from the encompassing tests.

Table 4 Are alternative forecasts encompassed by BMPE?

Parameter	α	λ	
Gdp	0.42*** (0.05)	0.08	(0.08)
Unemp	0.41*** (0.06)	0.06	(0.09)
Emp	0.43*** (0.06)	0.04	(0.09)
Impp	0.35*** (0.05)	0.16**	(0.08)
Oilp	0.40*** (0.04)	0.08	(0.08)
Exc	0.33*** (0.03)	0.18***	(0.05)
Sir	0.39*** (0.06)	0.10	(0.08)
Lir	0.39*** (0.10)	0.09	(0.08)
Spread	0.39*** (0.06)	0.12	(0.09)
Wages	0.36*** (0.04)	0.29***	(0.09)
Ulc	0.35*** (0.06)	0.19**	(0.10)
Combtot	0.38*** (0.05)	0.13*	(0.08)
Combreal	0.42*** (0.06)	0.06	(0.09)
Combnom	0.36*** (0.05)	0.15**	(0.08)

Wage and exchange rate growth rates are not encompassed by the BMPE at 1% confidence level, while the growth rate of unit labor costs and import prices are not encompassed at the 5% confidence level. Money is therefore not the only variable not to be encompassed by the BMPE.

Notice that, since the variables considered in Table 4, unlike M3, do enter as input of the BMPE, these results might suggest that either the restrictions implied by the BMPE distort their signal or the assumptions embedded in the BMPE projections on the future path of variables that are treated exogenously in the underlying models hinder the accuracy of the projections.

Since there are variables other than M3 that are biased upward and that are not encompassed by the BMPE, we now consider each of them in combination with the BMPE projections.

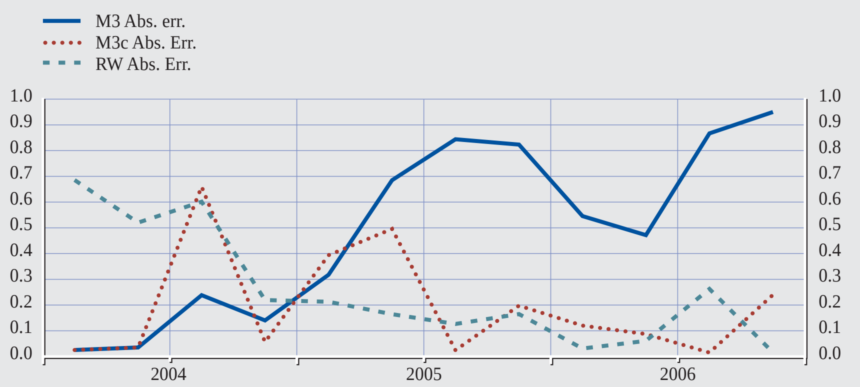
Results are reported in Table 5.

Table 5 Combinations with BMPE

Model	MSFE	MSFE/RW	MSFE/AR	Bias	SD fore	Var. f.e.	*Bias*^{2}
Gdp	0.13	1.31	0.74	-0.23	0.28	0.08	0.05
Unemp	0.10	1.00	0.57	-0.14	0.28	0.08	0.02
Emp	0.11	1.12	0.64	-0.14	0.30	0.09	0.02
Impp	0.08	0.79	0.45	-0.16	0.18	0.06	0.02
Oilp	0.09	0.91	0.52	-0.16	0.21	0.07	0.02
Exc	0.07	0.73	0.42	-0.14	0.17	0.06	0.02
Sir	0.09	0.86	0.49	-0.13	0.26	0.07	0.02
Lir	0.08	0.80	0.45	-0.11	0.24	0.07	0.01
Spread	0.10	1.02	0.58	-0.20	0.22	0.06	0.04
Wages	0.12	1.19	0.68	-0.29	0.13	0.04	0.08
Ulc	0.08	0.78	0.44	-0.18	0.16	0.05	0.03
CombAR	0.08	0.78	0.44	-0.14	0.21	0.06	0.02
CombRW	0.07	0.68	0.39	-0.17	0.16	0.04	0.03

Note: CombAR and CombRW in the last two rows refer, respectively, to the combination of the BMPE projections with the univariate autogressive and random walk forecasts.

Chart 5 M3, M3 corrected and random walk. Absolute forecast errors for annualized inflation 12 quarters ahead



Clearly, nominal variables in combination with the BMPE outperform the forecasts based on bivariate models seen in Table 3. Combining BMPE with nominal variables seems to be a good idea both for smoothness (variance of forecast error) and for bias correction. However, all forecasts are still biased downward like the BMPE. This suggests that the M3-BMPE success is due to the fact that both models have large bias of opposite sign. Notice that, the bivariate model based on M3 has a larger bias than all bivariate models of Table 3. The result of M3-BMPE combination is due to the fact that we are combining two models which produce forecasts that are systematically biased in opposite directions.

As a last exercise, we have conducted an evaluation of the forecast at twelve quarter ahead since money is typically considered to help forecasting in the medium and long run.

Unfortunately, due to the very short prediction sample, which, for this exercise, is 2004 Q3-2006 Q2 (twelve observation), results are not robust and should not be trusted.

Chart 5 provides absolute forecast errors for the random walk and for the money based forecasts at the horizon h = 12 quarters ahead. They show that M3 corrected forecast errors are similar to those of the random walk and are quite volatile.

3.5 WHAT CAN WE CONCLUDE FROM THE QUANTITATIVE EVALUATION?

Overall, the results of the quantitative exercise can be summarized as follows.

- The forecasts based on the M3-BMPE average model combination produce a striking result in terms of reduction of the MSFE relatively to the random walk. This result has to be better understood. In particular, it should be evaluated whether the opposite sign of the systematic bias can be explained formally and exploited in future refinements of the monetary analysis.

- M3 based inflation forecasts are not encompassed by the BMPE, which suggests that models based on money may have a role in helping to track the dynamics of inflation. Although encompassing tests show that other nominal variables can do the job of M3 for what concerns the tracking of dynamics, the bias correction is achieved by M3 in combination with the BMPE and not by the combination of BMPE with other nominal variables.[17]

- The forecast based on M3 corrected is dominated in terms of MSFE by the BMPE-M3 combination, but it is unbiased. This suggests that the real time analysis of monetary developments succeed in obtaining a good estimate of average inflation, although this comes at the cost of an excessively volatile forecast.

To sum up, the forecast evaluation suggests that monetary developments do contain information about the outlook for inflation (at least when focusing on the specific annualized HICP inflation over the next six quarters measure). Given the constraints surrounding and specificities of the exercise, drawing firm conclusions at this stage on the basis of such a short sample would be unwise. Certainly, the performance of the money-based forecasts needs to be monitored closely in the future and this section can be seen as describing a framework within which to conduct such monitoring in a structured way, which over time will lead to more meaningful tests of the validity of the ECB's monetary analysis. In the meantime, we can conclude that, on the evidence provided by the forecast evaluation exercise, one would not reject the hypothesis that there is information in monetary aggregates about the inflation outlook that is potentially relevant for monetary policy decisions.

4 MONEY AND MONETARY POLICY: NARRATIVE EVIDENCE

4.1 MONETARY ANALYSIS AND MONETARY POLICY DECISIONS

Sections 2 and 3 addressed the question of whether there is information in monetary developments that is relevant for monetary policy makers. Against this background, it is natural to assess how the ECB's monetary analysis has, in practice, influenced monetary policy decisions since the introduction of the single monetary policy in 1999.

One way to confront this question is to adopt the narrative approach to identifying monetary policy actions, pioneered by Friedman and Schwartz (1969) and used more recently in a series of papers on the Federal Reserve by Romer and Romer (1989; 1994). Approached in this way, what relationship emerges between the monetary analysis and the ECB's interest rate decisions?

17 Although the combination of the BMPE projections and the bivariate forecast based on the nominal long term interest rate achieves a result relatively close to that of the BMPE-M3 combination in terms of bias correction.

Chart 6 Policy rate and main monetary and economic indicators

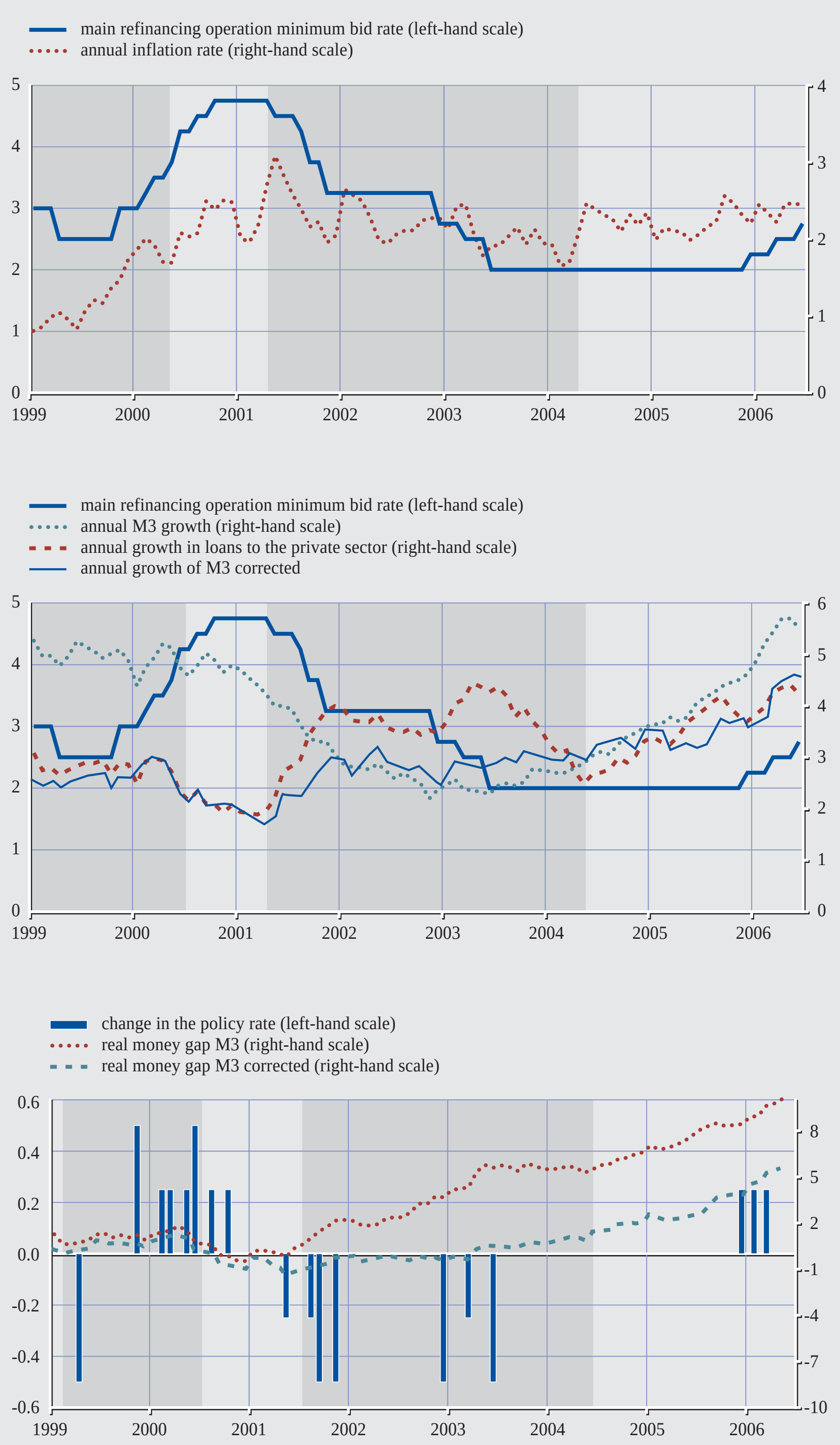
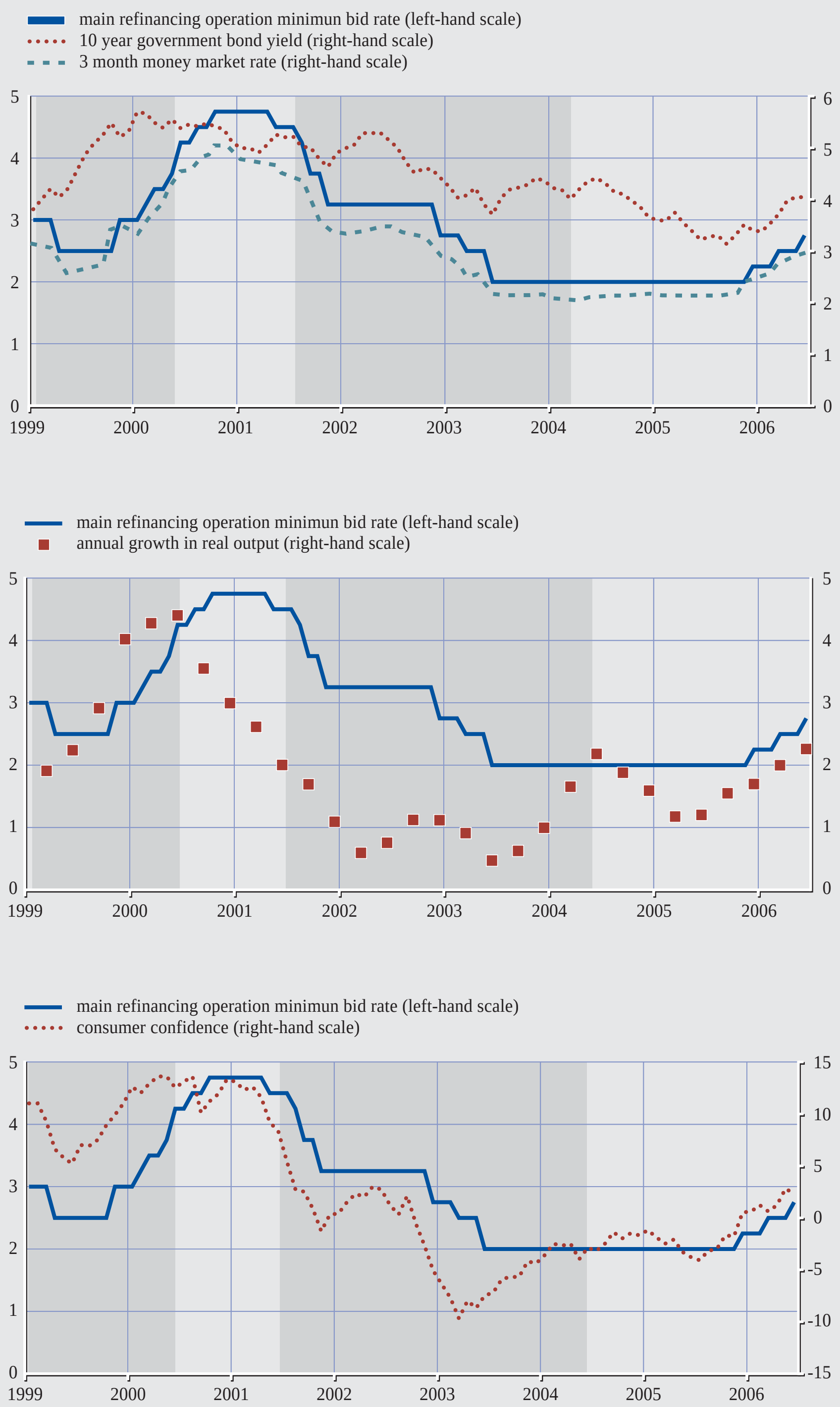


Chart 6 Policy rate and main monetary and economic indicators (cond't)



To address this key question, the remainder of this section provides a relatively detailed narrative summary of developments in the monetary analysis over the period 1999-2006 and their relationship with the four distinct phases of the monetary analysis identified in Section 2. In support of the narrative, Chart 6 shows the evolution of key macroeconomic time series since 1999.[18]

Given the objective of this paper, the discussion focuses rather narrowly on the impact of the monetary analysis on monetary policy decisions, thereby inevitably neglecting the important role of the economic analysis. Hence this discussion is not intended to offer a comprehensive description of how interest rate decisions have been made, but rather to identify more clearly what the input from the monetary analysis has been to that decision making process. Since there has been a high degree of correlation between the signal emanating from the monetary analysis and the economic analysis, from an analytical perspective identifying the distinct role of the former in interest rate decisions remains problematic.

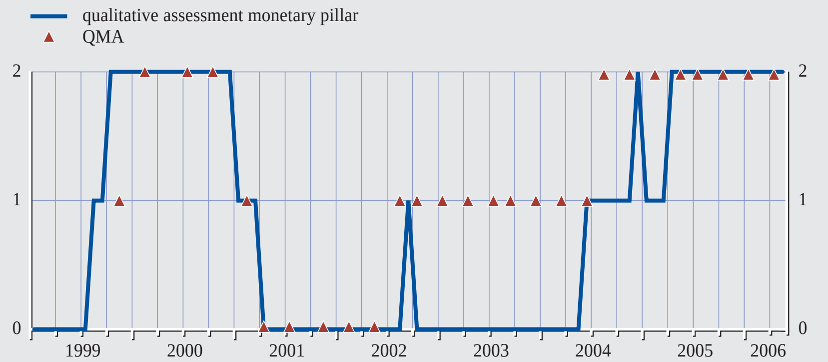
One way to shed light on the key issue of how important a role monetary analysis has played in policy decisions is to investigate more closely the actual decision-making process. To this end, an indicator has been constructed to capture the Governing Council's assessment of the intensity of the risks to price stability deriving from the monetary analysis, at least insofar as this is reflected in the language used in the President's Introductory Statement following the ECB's monetary policy meetings.[19] (A positive value of the index indicates an upside risk to price stability.) Of course, just as with the other synthetic quantitative indicators introduced in Section 2 and the money-based inflation forecasts evaluated in Section 3, such indicators should be seen as a simple and imperfect summary of the information in the Introductory Statement, not as a comprehensive assessment of the views expressed therein.

Using this indicator, a very simple assessment of how the Governing Council treats the monetary analysis can be made. More concretely, some insight into the Governing Council's interpretation of the analysis can be obtained by investigating how the "input" to their discussions – captured in simple form by the qualitative indicator of the overall thrust of the QMA (introduced in Section 2 and constructed along similar lines) – is transformed into the "output" that rationalizes and explains monetary policy decisions in the Introductory Statement – as captured by the qualitative indicator described in the previous paragraph. The comparison of these two indicators over the period since January 1999 is shown in Chart 7.

18 Note that the figures show the latest vintage of the data, which needs to be kept in mind when assessing some of the narrative discussion.

19 Other authors, like Gerlach (2004), have also attempted to construct such indicators of the intensity of the risks to price stability stemming from the monetary analysis on the basis of the Introductory Statement. The indicator used in this paper (and shown in Chart 7) is strongly correlated with other similar indexes constructed elsewhere in the literature.

Chart 7 QMA and Introductory Statement's assessment of risks to price stability stemming from monetary analysis



Note: The qualitative coding goes from -2 (clear downward risks to price stability) to +2 (clear upward risks to price stability).

Overall, the input and output series follow a very similar pattern, suggesting that the internal staff analysis provided via the QMA has generally been endorsed by the Governing Council, at least in the sense that its main elements have been reproduced in the Introductory Statement. Although only tentative conclusions can be drawn, this would be consistent with the Governing Council assigning some significance to the monetary analysis in taking interest rate decisions for the bulk of the period since 1999. However, the generally high correlation between monetary analysis input and output to the Governing Council's discussion has not been uniform through the entire sample period. The exceptional episodes are treated in more detail in the narrative analysis below.

PHASE 1: EARLY 1999 - MID-2000

At the outset of Monetary Union, M3 growth rose from levels close to the 4½% reference value that had been announced in December 1998 to rates well above 5% (see Chart 6). This strengthening of headline monetary dynamics took place in an environment where consumer price inflation was very low by historical standards and the economic outlook was uncertain (in the aftermath of the Asian and Russian economic crises of 1997-98). At that time, the observed strengthening of monetary growth was associated in part with a variety of technical factors (discussed in Section 2), notably the impact of the introduction of the remuneration of required reserves at essentially market rates. More generally, given the inevitable uncertainty introduced by the regime shift to Monetary Union, at that time all data were treated with some circumspection. In this context, higher monetary growth on the headline M3 definition was not necessarily seen as reflective of the underlying rate of monetary expansion and, as such, was not deemed an impediment to the decision to cut interest rates by 50bp in April 1999. In the course of 1999, the reliability of the monetary data became better established. Moreover, the M3 data pointed to continued strength of monetary dynamics, which could no longer be accounted for on the basis of special factors associated with the start of Monetary Union. The view that monetary growth had strengthened was consistent with the signals identified from the economic analysis, with the outlook for economic activity in the euro area improving and inflation and inflationary pressures rising. Against this background, interest rates were raised by a total of 225bp in a series of steps through mid-2000, starting with a 50bp rise in November 1999.

With the benefit of hindsight, the narrative assessment of the monetary analysis during this period points to a number of issues. First, in general developments in the data were treated with some caution, as it was recognized that the start of Monetary Union and the introduction of new statistical systems had raised the uncertainty surrounding the published statistics. Second, broadly speaking, the signal extracted from monetary developments during this period was that of building inflationary pressures pointing overall towards a need to raise interest rates. This signal strengthened over the course of 1999 and into early 2000, both on account of stronger M3 growth and as the special uncertainties associated with the new policy regime and novel data series dissipated somewhat. Third, in retrospect, policy relevance was attached to developments in monetary growth which – by the standards of subsequent years – now look rather modest. Fourth, with the exception of the first few months of 1999, the signal stemming from the monetary analysis was broadly consistent with that derived from the economic analysis.

Overall, one can conclude that from mid-1999 through mid-2000 the monetary analysis pointed to inflationary pressures and a need to raise interest rates, which was reflected in monetary policy decisions. However, since a broadly similar signal was extracted from the economic analysis over this period, it remains difficult to identify the relative weights of the monetary and economic analysis on the decision making process.

PHASE 2: MID 2000 - MID-2001

By mid-2000 – and, in part, reflecting the increases in short-term interest rates – headline M3 growth showed some moderation, especially with regard to its shorter-term dynamics which, at annualized rate, fell below the reference value of 4½%. Translated into an outlook for price developments, the moderation in the rate of monetary expansion was seen as pointing to some easing of inflationary pressures at medium-term horizons. Although the changes in monetary dynamics on which this assessment was based look modest by the standards of subsequent developments, at the time they were interpreted as suggesting that the monetary policy actions from November 1999 had served to contain inflationary risks. The analysis thus pointed to a change in the broad outlook for monetary policy, implying first a stabilization of and then scope to lower the level of short-term interest rates. Again, with the benefit of hindsight, this narrative assessment suggests that the broad signal from the monetary analysis is consistent with the actual path of interest rat decisions during this period, with the key rate in the Eurosystem's main refinancing operations peaking at 4.75% in October 2000. However, since the economic analysis provided a similar general message – notably with concerns of a slowdown in economic activity stemming from the sharp correction in global equity markets and weaker growth in the United States – the importance of the monetary information in driving policy decisions is difficult to identify separately ex post. Overall, in the first two years of Monetary Union, an ex post narrative assessment of the signal derived from the monetary analysis suggests that this was consistent with the broad thrust of interest rate decisions. However, from early 2001 onwards the situation is more complicated.

In early 2001, the economic analysis pointed to some deterioration in the outlook for economic activity. However, monetary growth on the headline M3 measure – at least on the basis of the data published at that time – strengthened relative to what had been previously expected. Prima facie, the two forms of analysis therefore appeared to give somewhat contradictory signals, with the economic analysis pointing to some moderation of inflationary pressures in the medium term[20] whereas the monetary developments suggested an intensification. In May 2001, interest rates were cut despite continued strong M3 growth (and publication of an annual growth rate of M3 for March 2001 at the end of April – just before the Governing Council meeting at which the decision was taken – that exceeded market expectations by 0.5pp).[21]

Based on the reaction of market interest rates at the time of the policy announcement, the decision to cut key ECB interest rates in May 2001 came as a surprise to market participants. They appear to have concluded that the apparent strengthening of monetary dynamics relative to what had been originally anticipated strongly reduced the likelihood of an interest rate cut in May. However, the internal assessment of the underlying trend rate of monetary growth was quite different from that suggested by a naive mechanical inspection of the published headline M3 growth figures. Not only had the underlying rate of monetary expansion moderated since early 2000 (as was also apparent in the published figures), but the annual growth rate of M3 corrected for the internal estimate of non-resident holdings of marketable instruments issued by MFIs had fallen substantially below the ECB's reference value of 4½%. Thus, viewed in an encompassing manner and contrary to the naive signal offered by the published M3 data, the monetary analysis pointed to reasons to cut interest rates, in line with the signals stemming from the economic analysis.

To emphasize: the comprehensive internal monetary analysis undertaken at the ECB in early 2001 not only did not act as an impediment to the interest rate cuts observed from May 2001, but rather signaled the need for them, thereby supporting the conclusions of the economic analysis. Although the ECB publicly referred to the need for the crucial data correction in a qualitative way, external observers did not appreciate the significance of such guidance for the interpretation of monetary developments and appear to have concluded, at least in part, that the monetary analysis was being ignored in favor of the economic analysis.

20 However, the economic analysis pointed to some short term upside risks due to one-off shocks.

21 Note that subsequent revisions to the M3 data deriving from a correction of the statistical issues discussed in Section 2 have reduced the strength of M3 growth during this period in the latest vintages of the data and are thus not visible in Chart 6.

PHASE 3: MID-2001 - MID-2004

From mid-2001, monetary developments were also influenced by the impact of portfolio shifts into safe and liquid monetary assets, in the environment of heightened economic and financial uncertainty that followed the global stock market correction and the terrorist attacks of 11 September 2001. Annual M3 growth started to rise more strongly from mid-2001 on account of these portfolio shifts. In the face of these developments, the internal analysis of monetary developments recognized three key issues.

First, the magnitude and causes of these portfolio shifts appeared to be unprecedented and, as such, analysis and interpretation of the monetary data was surrounded by more than usual uncertainty. In consequence, the signal stemming from the monetary analysis was more blurred – and thus weaker – than had been the case in preceding years.

Second, the baseline or modal view developed by the monetary analysis treated the portfolio shifts as a temporary development, which would be reversed once financial market conditions normalized. As such, the strengthening of monetary growth associated with the portfolio shifts was not deemed to reflect a pick-up in the underlying rate of monetary expansion, which would signal inflationary pressures at medium to longer horizons. Rather it was seen as confirming the evidence from the economic analysis – apparent in the sharp decline in business and consumer sentiment surveys and measures of economic activity – that the private sector was retrenching in the face of the high degree of uncertainty.

Finally, although the baseline conclusions derived from the monetary analysis pointed to a rather benign interpretation of stronger M3 growth, the risks surrounding this baseline were viewed as heavily skewed towards upside risks to price stability. In particular, the accumulation of liquidity resulting from strong money growth was deemed to constitute a risk of inflationary pressures should it lead to stronger spending in a context where consumer and business sentiment were to recover as heightened uncertainties receded.

The signal drawn from the monetary analysis in the periods of strong portfolio shifts into money (late 2001 and late 2002 through early 2003) were therefore rather nuanced. On the one hand, strong M3 growth on the official headline measure was not seen as an impediment to the interest rate cuts that were prompted by the economic analysis. These cuts led to a progressive lowering of the minimum bid rate in the Eurosystem's main refinancing operations, which reached the historically low level of 2% in June 2003. On the other hand, growth in the internal M3 series corrected for the estimated impact of portfolio shifts (which was subsequently published in the Monthly Bulletin) remained quite sustained and, of itself, did not point to a need for interest rate cuts over this period. Both conclusions were viewed as rather tentative and thus did not provide a strong signal for monetary policy.

Overall, the monetary analysis appears to have played a more subdued role in guiding the broad outlook for short-term interest rate decisions in this period, although the upside risks to the modal rather benign view of strong M3 growth developed in the internal analysis may have acted as a break on more aggressive interest rate cuts in 2002-03, when many commentators were calling for a substantial further easing of monetary policy at a time when deflationary risks were identified by some. Moreover, the portfolio shifts into money themselves demonstrated the confidence of the euro area private sector in the soundness of the European banking sector, which may have served to allay fears of debt deflation and financial crisis that some observers argued implied a need for more aggressive easing.

At this point, it is worth commenting further on Chart 7 and the relationship between the input provided by the QMA to the Governing Council's discussions and the output of those discussions as reflected in the Introductory Statement. Indeed, the main exception to the generally strong correlation between the input and output measures of the monetary analysis is the period from mid-2002 through mid-2004. During this period, the staff assessment – while embodying a baseline view that strong monetary growth and the consequent accumulation of liquidity stemming from portfolio shifts was rather benign in terms of the outlook for price developments over the medium term – emphasized that the risks to this baseline view were heavily skewed to the upside. In other words, while the most likely outcome was that inflationary pressures coming from monetary dynamics were modest, it was hard to construct a scenario on the basis of the monetary data where deflationary risks would emerge, whereas there were scenarios where inflation could rise significantly. By contrast, output of the Governing Council's discussion as reflected in its communication via the Introductory Statement tended to downplay the role of the monetary analysis in general and, in particular, did not place such emphasis on the upside risks to the baseline interpretation of monetary dynamics.

This discussion sheds important light on the oft-repeated question of how much "weight" is assigned to the monetary analysis in the Governing Council's interest rate setting process. Two important points can be made. First, the weight assigned to the monetary analysis has varied over time, as the clarity and reliability of the policy-relevant signal coming from monetary developments (relative to those offered by the economic analysis) has fluctuated. It is clear that the Governing Council chose to discount some of the signals coming from monetary indicators at a time when portfolio shifts implied that monetary developments were harder to interpret than usual. Second, the decision to form a somewhat different assessment from the input from the staff when communicating the monetary analysis suggests that the Governing Council undertook an active discussion of how the analysis and monetary developments themselves should be interpreted. Thus throughout Stage III – and in particular when portfolio shifts were at their height – the Governing Council has fulfilled its commitment, as embodied in the ECB's monetary policy strategy, to analyze monetary developments closely and assess their relevance for interest rate decisions, while eschewing any mechanical policy response to the evolution of a particular aggregate.

With the cessation of major military operations in Iraq by mid-2003, financial and economic uncertainty began to recede and portfolio allocation started to normalize. As had been anticipated in the baseline scenario of the monetary analysis, annual M3 growth moderated substantially between mid-2003 and mid-2004 as past portfolio shifts into monetary assets unwound. However, consistent with a symmetric interpretation of the impact of portfolio shifts on the policy-relevant signal in monetary developments, this fall in headline M3 growth was not interpreted as a signal that further interest rate cuts were warranted. Rather it was seen as providing evidence from the monetary side corroborating the view that the levels of uncertainty and risk aversion – which had proved to be a brake for consumption and investment spending during the economic slowdown - were returning to historical norms. Indeed, the internal M3 series corrected for the estimated impact of portfolio shifts continued to grow at a sustained (and slightly increasing) rate through this period, supporting the view that the underlying rate of monetary expansion was not being reflected in the substantially lower rate of headline M3 growth.

PHASE 4: MID-2004 ONWARDS

Through the course of 2004, the analysis of a broad set of indicators (see Appendix B) provided evidence of a further unwinding of portfolio shifts, albeit at a slower pace than would have been anticipated on the basis of historical norm (derived from behaviour in the two decades prior to the start of Monetary Union) for the elimination of accumulated liquidity holdings. Yet headline annual M3 growth increased from mid-2004 and has remained on a sustained upward trend through mid-2006.

The drivers of monetary dynamics during this period were judged to be quite different from those underlying strong monetary growth between 2001 and 2003 (ECB, 2006b). On the counterparts side, M3 growth was driven by strengthening credit expansion. On the components side, monetary growth has derived largely from the dynamism of the more liquid components of M3. Such characteristics have led to the conclusion that the strengthening of monetary growth since mid-2004 reflects the then prevailing low level of interest rates in the euro area and, latterly, the recovery of economic activity and associated improvements in consumer and business sentiment. Moreover, the strengthening of headline M3 growth has been seen as broadly representative of the underlying rate of monetary expansion and this indicative of growing upside risks to price stability over time.

Given the uncertainties experienced in the preceding years and the low frequency nature of the information in money, the strengthening of monetary dynamics from mid-2004 did not have an immediate impact on interest rate decisions, but rather cumulated over time. Through the course of 2005, the interpretation of the strengthening of monetary growth and the accumulation of liquidity was viewed as progressively more reliable and thus offered an intensifying signal of the need for interest rate increases to address upside risks to price stability over medium to longer-term horizons. Interest rates were raised by 25bp in December 2005 and a progressive withdrawal of monetary accommodation has followed.

It should be recalled that, at the time, many observers viewed the decision to start raising interest rates in December 2005 as potentially premature, given question marks that they identified regarding the robustness and sustainability of the economic recovery in the euro area and the low rate of so-called core inflation measures (such as inflation of the HICP excluding energy and unprocessed food prices). Indeed, at that time it was common to identify a gap between the strength of the so-called “soft data” (i.e. surveys of business and consumer confidence) and the “hard data” (i.e. concrete statistics, such as retail sales, industrial production and national accounts indicators). Moreover, an intense debate was pursued over whether headline or core measures of inflation should be given greater prominence in the policy debate, with the former being elevated, in part due to oil price rises, but the latter more subdued. In short, a degree of uncertainty surrounded the economic analysis, while, on balance, pointing to upside risks. Nevertheless, the relatively stark signal of longer-term inflation risks offered by the monetary analysis by the last quarter of 2005 may have played an important role in the decision to raise interest rates in December (Trichet, 2006).

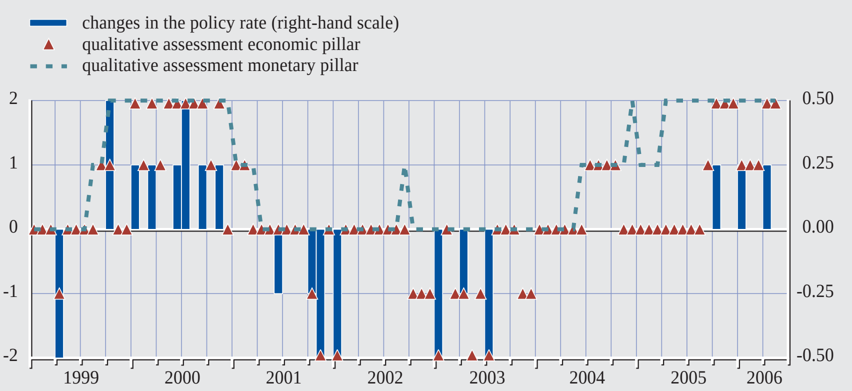
4.2 THE PRESENTATION OF MONETARY ANALYSIS AND ITS ROLE IN INTEREST RATE DECISIONS

Another issue concerns the relative importance of the monetary analysis (as compared with the economic analysis) in explaining interest rate decisions. Using the same qualitative indicator of the language used in the Introductory Statement that underlies Chart 7, Chart 8 shows a comparison with an equivalent indicator (constructed using the same methodological approach) for the economic analysis. For reference, the time series of changes in key ECB interest rates made since the start of the single monetary policy in January 1999 is also shown.

A number of observations can be made on the basis of Chart 8.

First, as is reflected in the narrative discussion, there is a high degree of collinearity between the communication regarding the monetary and economic

Chart 8 Qualitative assessment of risks to price stability from monetary and economic pillar in Introductory Statement



Note: The qualitative coding goes from -2 (clear downward risks to price stability) to +2 (clear upward risks to price stability).

analyses, which presumably reflects the typically common thrust of the analyses themselves. This makes identifying the independent effect of monetary analysis – at least insofar as it is captured in the official communication – difficult to assess.

Second, there are two broad exceptions to this generally collinear picture. Between mid-2001 and mid-2003, the monetary analysis as described in the Introductory Statement pointed to relatively balanced risks to price stability, whereas the economic analysis saw risks on the downside. Overall, the successive cuts of interest rates of this period suggest that the economic analysis played the decisive role in explaining monetary policy decisions. The substantive reasons behind this approach, notably the high degree of uncertainty attached to the interpretation of monetary developments at that time, have been outlined in preceding sections. The second exception concerns 2005, where for most of the year the monetary analysis pointed to upside risks, whereas the economic analysis suggested a more balanced outlook. Although with some lag, the progressive increase of official interest rates from December 2005 were – in real time – motivated to an important degree by the monetary analysis. Again the reasons for such communication – notably the uncertainties surrounding the interpretation of the economic analysis at a time when "soft" and "hard" data were giving somewhat contradictory signals – have been described in previous sections.

5 CONCLUSIONS

The paper has analysed three issues. First, in the interests of transparency and to promote a better understanding of the ECB's approach over the past eight years, the paper is intended to provide a rich description of the ECB's monetary analysis, the tools on which it is based and the evolution of these tools over time. Second, almost eight years after the introduction of the euro in January 1999, the paper attempts to offer some evaluation of the monetary analysis. Finally, we assess qualitatively what has been the role of the monetary analysis in policy decisions.

As regards the first question, a number of key points should be underlined. First, describing the ECB's framework for monetary analysis is complicated by the changing nature of that framework over time. The tools and methods used have evolved significantly over the past eight years, as practical solutions have been sought to the various challenges faced by monetary analysis in real time. Second, one important aspect of this evolution has been the rising importance of judgmental adjustments to the monetary series at the expense of a focus on conventional specifications of money demand. This shift of emphasis reflects both, on the one hand, the recognition that a structural or behavioural explanation of monetary developments is required in order to assess their possible implications for the outlook for price stability and, on the other hand, the failure of conventional money demand equations to offer convincing structural explanations of the monetary dynamics observed in the euro area, especially during the portfolio shifts phase. Third, in parallel with the rise of such adjustments, reduced form money-based inflation forecasts have come to play a more prominent role in the presentation of the monetary analysis. In sum, the ECB's monetary analysis is much richer and broader than is sometimes recognized, drawing on a much broader set of monetary, financial and economic data to understand what implications monetary developments have for the outlook for price stability.

In this context, it is also important to emphasize two aspects of the ECB's monetary analysis that are not always well understood outside. First, money demand is no longer seen as the centre-piece of the framework for monetary analysis. Conducting a rich monetary analysis is thus not contingent on the stability or otherwise of any single specification of money demand for a particular monetary aggregate. Second, the focus of the analysis is at the medium to longer-term horizon. The use of monetary aggregates to help forecast inflation or growth dynamics in the coming few months is not a core element of the ECB's monetary analysis.

Turning to the second question, it should be recognized from the start that the medium-term orientation of the monetary analysis complicates the assessment. By treating the real time dimension of the evaluation seriously, the sample periods available for the evaluation conducted in this paper are short, the degrees of freedom for econometric work are thus not numerous and consequently the scope to draw strong, policy-relevant conclusions is limited. This having been said, what conclusions can be drawn? First, the forecast evaluation suggests that there is information in monetary developments about future inflation dynamics beyond that which is contained in conventional macroeconomic forecasts or projections. Moreover, the fact that the inflation forecasts stemming from the monetary analysis and the economic analysis have biases of opposite sign, which are largely eliminated by combining the two forecasts can be seen as evidence in support of the view (offered in Issing 2006) that taking two complementary but distinct perspectives on the inflation outlook has made the ECB's analysis more robust and avoided the potentially the big mistakes that could have been made if an exclusive focus on either the monetary or the economic analysis had been taken. Second, the evaluation suggests that the ECB staff have been able to use judgment to identify and quantify in real time various factors affecting monetary developments that were not captured in conventional money demand equations. Related to this, the forecast evaluation demonstrates that monetary aggregates corrected on the basis of the expert judgment have been used to produce forecasts of inflation that have proved to be unbiased, if excessively volatile. Of course, whether the use of judgment in this manner will continue to be successful in the future is an open question, and we certainly recognize that past success is not necessarily a guide to future performance. With this in mind, it will remain crucial to continuously evaluate and systemize the monetary analysis and, in particular, its judgmental element.

Finally, to evaluate the role of monetary analysis in interest rate decisions, we distinguish between phases in which the signal from monetary analysis was in line with that from economic analysis from those in which it was not. Clearly the latter periods are the most informative for our question. Moreover, we try to assess the degree of clarity of the two respective signals over time and link it to the policy decision. We conclude that, although, in general, there was a broad correspondence between the two analysis and it is therefore difficult to assess their separate role, it appears that the economic pillar prevailed in influencing the decision when the monetary pillar gave a blurred signal.

Looking forward, this paper can be seen as offering a framework – the real time forecast evaluation – for monitoring one summary measure of the signal offered by the monetary analysis in a structured and systematic way. Moreover, it can also be seen as identifying a challenge for the monetary analysis, namely – now that data are more plentiful, both in terms of time series length and sectoral and instrument coverage – to systematize the procedures by which judgmental adjustments are made.

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6 APPENDIX A: DESCRIPTION OF THE REAL TIME DATABASE

Our real time database provides a snapshot of the exact data available to the ECB forecasters at the time they prepared their forecast.

It includes 14 variables. HICP is the target variable for both the money based and the BMPE projections.

The M3 and M3 corrected series are the main inputs to the Quarterly Monetary assessment. They are notional stocks and might differ from official data due to the corrections of statistical distortions (see Section 2.3 and Appendix B).

The other 11 variables are input to the BMPE projections. The exchange rate is the USD/EURO(ECU), BIS source. Oil prices are taken from the world market prices database of the BIS and refer to crude oil, USD basis. Short and long term nominal interest rates are ECB estimates from national sources for the pre-1999 period. Short interest rates are three months money market rates, while long rates are 10 years government bond yields. The term spread is given by the difference between long and short term nominal interest rates. The latter variables and wages, unit labor costs, the unemployment rate, total employment and import prices are taken from the BMPE forecast database for all the exercises from 2003 Q3 to 2005 Q1. For the exercises before 2003 Q3, we relied on the data input files of the area wide model (AWM). The only exception is unemployment data, which were taken from the AWM input files for the exercises from 2000 Q4 to 2001 Q3 (i.e. vintages 2000 Q3 to 2001 Q2) and from the Orange Book for the exercises between 2001 Q4 and 2003 Q2.

Table 6 provides an overview of the main features of the real time database. Columns two to four report the definitions of the variables, the transformations adopted to achieve stationarity (0=levels, 1=first differences and 2=first differences of logarithms) in the forecasting exercises and whether the variables are seasonally adjusted in real time or not. The fifth column reports the release date of the variables, i.e. how many days after the end of the quarter a given variable is first released.

Revisions in the generic variable Y in vintage v are computed as the difference between the last available annual growth rate in vintage v and the corresponding growth rate in the last available vintage (2006 Q2), that is:

$$rev_{y,t} = \left[y_{t,t} - y_{t,t-4} \right] - \left[y_{2006Q2,t} - y_{2006Q2,t-4} \right]$$

where y indicates the natural logarithm of Y.

In order to provide a description of the data uncertainty faced in real time forecasting, we compute statistics on the data revisions for the 18 vintages that we evaluate. Column five reports the average revision in the annual growth

Table 6 Real time database

Variable	St. Tr.	SA	Release	Mean	M.A.	M.A./ M.A.Y
HICP	2	SA	t+15	-0.10	0.12	0.04
M3	2	SA	t+26	-0.21	0.30	0.04
M3 Corrected	2	SA	t+26	-0.01	0.33	0.05
GDP	2	SA	t+45	0.23	0.24	0.11
Short Term Interest Rate	1	NSA	t	0	0	0
Long Term Interest Rate	1	NSA	t	0	0	0
Term Spread	0	NSA	t	0	0	0
Wages	2	SA	t+104	0.06	0.27	0.06
Unit Labor Costs	2	SA	t+104	0.09	0.28	0.09
Unemployment	1	SA	t+32	0.10	0. 12	0.23
Employment	2	SA	t+90	0.26	0.27	0.27
Import Prices	2	SA	t+80/90	-0.09	0.70	0.16
Oil Price	2	NSA	t	0	0	0
Exchange Rate	2	NSA	t	0	0	0

rates of each variable[22], column six the average absolute value of the revisions and column seven the ratio of the average absolute revision to the average of absolute values of the variable.

All variables are seasonally adjusted in real time, except the interest rates, oil prices and the exchange rate.

As for the date of release[23], interest rates, exchange rates and oil prices are available at any time. The first release of HICP is available after 15 days from the end of the quarter it refers to. Monetary aggregates become available 26 days after the end of the quarter. Real variables are less timely. In particular, since 2003 a flash estimate of GDP is available 45 days after the end of the quarter. Before 2003, the first available GDP release was the regular first release, available between 61 and 70 days after the end of the quarter. In the sample we evaluate, total employment was available 90 days after the end of the quarter[24]. The latest releases in our database are wages and unit labor costs, only available 104 days after the end of the quarter.

Column five shows that real variables, wages and unit labor costs tend to be revised upward, while import prices, HICP and M3 downward. The mean revision in M3 corrected is very close to zero.

22 Except for unemployment and interest rates for which we report the average revision in the 4 quarters difference.
23 Notice that some variables, for example the money aggregates, are available at shorter frequency than the quarter. However, the forecasting exercises are conducted at a quarterly frequency, so we report here the date in which the data for the former quarter become first available.
24 From 2006 Q1, total employment becomes available 74 days after the end of the quarter.

Column six reports the mean of the absolute value of the revisions, an absolute measure of the size of the revisions. Financial variables are not revised. The most revised variable is import prices. HICP is among the least revised variables, while M3 and M3 corrected among the most revised. Since the mean of the revision in M3 corrected is close to zero, the result in column seven is explained by the fact that revisions in M3 corrected alternate in sign across vintages. Wages and unit labor costs are revised almost as much as M3 and considerably more than HICP.

However, more volatile variables are more likely to be more revised, as well. Hence, column seven reports the ratio of the mean absolute revision in each variable to the mean absolute value of the variable itself. In relative terms, M3 and M3 corrected are among the least revised variables and the most revised variables turn out to be employment and unemployment.

7 APPENDIX B: JUDGMENTAL CORRECTION TO M3

When trying to extract those medium- to longer-term signals from money that are relevant for future inflation developments in real time, it is necessary to try to identify/correct for the recent short- to medium term components of M3 developments at the current end of the time series that are assumed to be unrelated to future risks to price stability, given the well-known end-point problem in signal extraction. Those corrections often have to be judgemental by nature, as a precise quantification, in particular in real time, is seldom available. This annex lists and motivates the main judgemental corrections that had been performed for M3 in real time between 1999 and 2006 and lays out the procedures that have let to the final quantification. In general, for deriving those quantifications, the ECB monetary analysis relied on a framework that was characterised by four main elements:

- A broad monetary and institutional analysis.
- A monitoring of short-term forecast errors from a univariate time series model of euro area monetary aggregates.
- A direct quantification method of factors that are assumed to be unrelated to risks to price stability using information from reporting agents, market participants and National Central Banks.
- Whenever a direct quantification was not possible, a quantification was performed by using intervention variables in the univariate time series model for the monetary aggregates, whenever possible, accompanied by alternative quantification for robustness reasons and further verified by a set of indicators related to the problem.

7.1 JUDGEMENTAL CORRECTIONS RELATED TO THE STATISTICAL DEFINITION OF MONETARY AGGREGATES

NEW REPORTING SYSTEM FOR MFI BALANCE SHEET STATISTICS IN JANUARY 1999

The introduction of a new MFI reporting scheme is likely to have distorted monetary developments around January 1999, as suggested by anecdotal evidence in combination with significant one-step-ahead forecast errors in January 1999 from univariate time series models for M3. The potential distortion for measuring M3 has been quantified together with the impact of the introduction of a remunerated minimum reserve system, which is described in the next section and entered the time series of M3 corrected for special factors that have been used in the Quarterly Monetary Assessment (QMA).

NON-RESIDENT DEMAND FOR MARKETABLE INSTRUMENTS IN 2000 AND 2001

At the outset of Monetary Union, in the construction of the monetary statistics securities not held by euro area MFIs were, on the basis of anecdotal evidence, assumed to held solely by the euro area money holding sector. However, due to portfolio diversification in Asia and the specific attractiveness of some German MFI securities with a state guarantee, the demand from abroad (i.e. from non-residents) for such paper increased significantly after the start of Stage III, and in particular in late 2000 and early 2001. Since such holdings remained within the published data (although conceptually they fell outside the definition of M3), this distorted the euro area M3 aggregate and diminished its role as an indicator for risks to domestic price stability. The strong increase in the issuance of foreign currency denominated MFI short-term debt securities, reports from traders about an increased interest in euro area MFI short-term debt securities by Asian banks, direct information from MFIs and balance of payment statistics allowed in real time to identify the measurement problem in M3. The official exclusion of non-resident holdings of marketable instruments has been done in two steps. First, in May 2001, non-resident holdings of money market fund shares/units were excluded from M3, using mainly direct information from money market funds on the residency of the holder. Second, in November 2001, non-resident holdings of MFI short-term debt securities were excluded from M3, mainly based on information on the type of first holder in security settlement systems. Before those corrections of M3 had been officially introduced, the M3 series corrected for special factors that was used in the QMA embodied (for the period late 2000 to late 2001) an estimated correction for non-resident holdings of all marketable instruments. After the official data was revised, it transpired that this correction had been a very precise estimate (the difference between the real time internal corrected series and the final revised official series was small, with a maximum 10 basis points difference in the annual rate of growth of M3, see Chart 9 and 10). By contrast, the problem of non-resident holdings of marketable instruments distorted the published annual rate of growth of M3 in real time by considerably more than 100 basis points at the peak of the effect in early 2001.

Chart 9 Real time assessment of non-resident holdings of marketable instruments

(Different vintages of internal estimates of annual M3 growth corrected for non resident holdings)

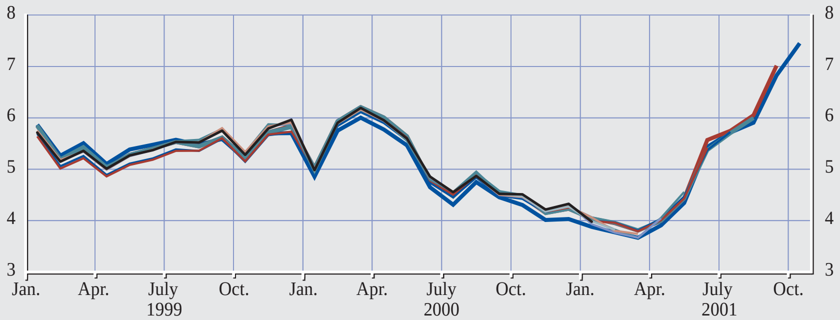
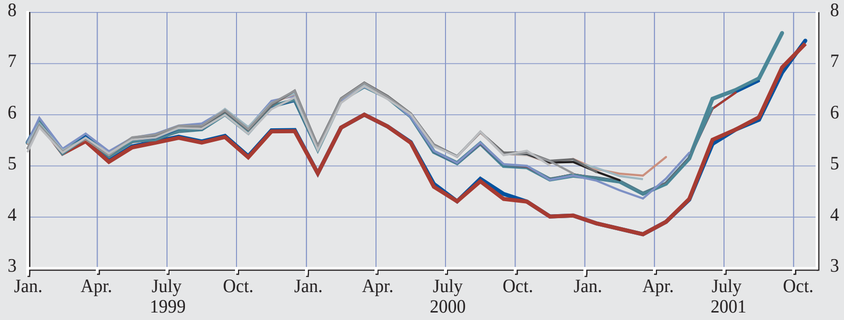


Chart 10 Real time assessment of non-resident holdings of marketable instruments

(Different vintages of official figures of annual M3 growth)



NON-RESIDENT DEMAND FOR EURO BANKNOTES

Due to the features of banknotes, the holder of banknotes is unknown to the reporting agents. It has thus been decided when defining monetary aggregates that all banknotes outside the hands of euro area Monetary Financial Institutions can be assumed to be held by the euro area money holding sector. Studies (see for example Fischer, Köhler, Seitz, 2004) suggested however, that already for the euro legacy currencies, this assumption had not been true. In fact, it was estimated that around EUR 35 billion of euro legacy banknotes had been used outside the euro area in the late nineties, mainly in Central and Eastern Europe. The introduction of euro banknotes in January 2002 led to some dynamics in those holdings. In the run-up to the euro cash changeover, euro legacy banknotes returned to the NCBs from abroad and had been substituted to a significant extent with euro denominated deposits in Eastern and Central Europe and partly substituted with US dollar and Swiss franc banknotes. After the euro cash changeover, the demand for euro banknotes from abroad seems to have been recovering quickly and can be estimated to be between EUR 60 billion and EUR 100 billion in mid 2006. Potential distortions to M3 stemming from the non-resident demand for euro banknotes had been regularly analysed in the QMA. However, given a large amount of uncertainties concerning the dynamics of the demand, this judgemental correction had not been introduced into the series of M3 corrected for judgemental factors.

CHANGES IN THE MANAGEMENT OF CENTRAL GOVERNMENT DEPOSITS BETWEEN 2002 AND 2005

Due to changes in the management of central government deposits in some euro area countries, highly volatile developments in central government deposits increased significantly the short-term volatility of M3, thus adding short-term noise in M3 in particular in 2003. In order to smooth this short-term volatility, flows of central government deposits had been added to M3 flows between early 2002 and early 2005 when deriving the series of M3 corrected for special factors that was used in the Quarterly Monetary Assessment.

ELECTRONIC TRADING PLATFORMS OF SECURITY DEALERS REPLACING INTERBANK OPERATIONS IN THE SECURITY MARKET, IN PARTICULAR IN 2005

In several countries, repurchase operations that were previously undertaken between credit institutions, have been switched to electronic trading platforms operated by security dealers resident in the euro area. As such transactions switch from being interbank operations to transactions intermediated by other financial intermediaries (OFIs), they may enter the definition of M3 and thus blur the evolution of underlying monetary dynamics. Based on information from the Deutsche Bundesbank (2005) and a number of other euro area central banks, this impact of financial innovation, most probably unrelated to future risks to price stability, had been corrected in particular in 2005 Q2 and 2005 Q3, where the impact of such operations on M3 had been sizeable. This correction was quantified with the univariate reg-ARIMA model as described in the next section and entered the series of M3 corrected from the Quarterly Monetary Assessment 2005 Q4 onwards.

7.2 JUDGMENT ON ECONOMICALLY MOTIVATED CORRECTIONS

INTRODUCTION OF A REMUNERATED MINIMUM RESERVE SYSTEM IN JANUARY 1999

The change to a remunerated minimum reserve system led to a repatriation of funds, especially from the UK to Germany without necessarily implying increased risks to euro area price stability. Anecdotal evidence and available data from branches and subsidiaries of German MFIs in the UK helped to form a judgemental view on the shape and size of the short-term effect. Together with the introduction of a new reporting scheme for the MFI balance sheet in January 1999, this effect was quantified with an intervention variable in a univariate reg-ARIMA model of M3 and entered the time series of M3 corrected for special factors in the QMA from 2000 Q4 onwards.

IMPACT OF THE EXTRAORDINARY LEVEL OF UNCERTAINTY ON MONEY DEMAND BETWEEN 2001 AND 2003 AND ITS REVERSAL BETWEEN MID 2003 AND MID 2004 AND LATE 2005

In the microeconomic theory of money demand, a central rationale for holding money is uncertainty, in particular surrounding future income, prices and interest rates. Money is portrayed as serving three main functions: unit of account; medium of exchange; and store of value. Each of these functions alleviates, at least to some extent, problems faced by households and firms as a result of uncertainty. Since the demand for money arises, at least in part, from a need to insure against uncertainties, developments in the demand for money are influenced by the prevailing level and character of uncertainty in the economy. Yet at the macroeconomic level, empirical models of money demand typically do not include measures of uncertainty as explanatory variables. In other words, some part of the evolution of monetary developments reflects the evolution of unobservable and, therefore, from the central bank's perspective, uncertain variables, which will always remain difficult to explain or check in the context of formal econometric models (ECB, 2005b). Given the elevated level of global geopolitical and financial market uncertainty between 2000 and

2003, the interplay between econometric models and judgement played an important role in assessing monetary developments of that period. Four sets of indicators have been used over time to study the potential impact of uncertainty and risk on monetary developments: real economic indicators; financial market indicators; developments in the components and counterparts of M3 and financial accounts/balance of payments indicators. In this respect, it must be noted that certain indicators provide first order evidence on uncertainty, such as financial market volatility, whereas others can only be seen as contributing second order information on the impact of such uncertainty, as for example developments in the net external asset position of MFIs or in money market fund shares/units. A first set of indicators which are thought to contain information on uncertainty are consumer confidence indicators and changes in the unemployment rate, both of which may reflect uncertainties about future income. A second group of indicators consists of price and volatility measures in financial markets, which capture uncertainties that affect the portfolio decisions of the euro area money-holding sector. With respect to equity prices, several channels relating monetary dynamics to stock price performance can be identified. During "normal" periods, the long-term wealth effect – higher stock prices imply higher wealth and thus higher money holdings in a balanced portfolio – dominates the relationship between money and stock prices. However, at extremes (e.g. sharp corrections in equity prices), a short-term substitution effect is likely to dominate over the longer-term wealth effect, as savers seek a safe haven from volatility in stock markets by holding safe and liquid monetary assets. The dominance of this substitution effect between equity and money in certain periods of high uncertainty suggests that stock prices can be a useful indicator of potential portfolio shifts into and out of money, at least on an episodic basis. Developments in the Dow Jones Eurostoxx Index might thus give some indications of portfolio shifts in such periods. Within the group of financial market indicators, financial market volatility measures (i.e. measures associated with variation in the second-order moments of prices) capture risks priced into financial markets. One such measure is the implied volatility of stock price indices derived from options prices on the index. A high value of such measures would indicate a reduced ability to predict futures asset price developments, possibly leading to actions by investors to reduce their exposure to these risks and, thus, a switch into lower-yielding but capital certain and more liquid monetary assets. The response of economic agents to global financial market uncertainties is potentially asymmetric and/or non-linear – they may respond quickly to significant losses, but more slowly to proportional gains. Risk measures designed to capture the impact of uncertainty on money demand should therefore take into account the impact of a time-varying risk aversion on the part of investors, which is likely to increase after profound losses. One possible measure of risk aversion that takes these regularities into account is the conditional correlation between stock returns and long-term government bond returns. This measure should constitute a reasonable proxy for risk aversion because government bond markets are less sensitive to shifts in investors' attitudes towards risk than equity markets. During periods of heightened risk aversion, the prices of the two asset classes should move in opposite directions (i.e. display a negative correlation). Otherwise investors would leave the equity market and buy bonds. In normal periods, by contrast, standard approaches to asset allocation would suggest a positive correlation between stock and bond returns, as low interest rates support equity prices. For robustness reasons, alternative indicators of risk appetite have also been used. One of these alternative indicators is the earnings yield premium in the euro area (i.e. the difference between the earnings yields for equity and the real long-term interest rate). Such an indicator reflects investors' perception of the risk premium. Turning to monetary indicators which may capture the effect of uncertainty on the demand for money, experience has shown that a detailed analysis of the components and counterparts of M3 is crucial. Such analysis often helps to explain aggregate M3 growth and facilitates the detection of the underlying driving factors. Specifically, in times of increased global uncertainty, the analysis of the net external asset position of MFIs is of particular interest, given a stronger home-bias of investors during periods of heightened geopolitical uncertainty. In such periods, one may expect portfolio flows into monetary assets to constitute a significant source of increased money demand, by contrast with more normal circumstances when money creation largely occurs via credit expansion. A similar form of analysis has been applied to the components of M3, in particular to developments in money market fund (MMF) shares/units. There are two reasons why the analysis of money market fund shares/units may reflect the impact of uncertainty on the demand for money. First, at times of high uncertainty investors may park money in money market fund shares/units, in part because the attractiveness of these funds at such times is likely to be high, given that they are capital-certain and liquid. Second, a large proportion of household share holdings are held through equity funds. Relatively limited switching costs between investment funds and money market funds, remuneration close to market interest rates and the high liquidity of money market funds allow the move out of equity funds into money market funds at times of uncertainty and permit a relatively fast reversion into equity funds at times of increasing confidence[25]. The fourth group of indicators have been constructed from balance of payments data and from financial account data. Balance of payments statistics offer a breakdown of the net external asset position of euro area MFIs. This breakdown permits the separate analysis of portfolio investment in equity, debt securities and direct investment in the euro area against the portfolio investment in equity, debt securities and direct investment abroad by euro area non-MFIs. Furthermore, an indicator of the estimated net purchase of non-monetary securities by the consolidated money holding sector was developed and regularly analysed. This quantitative indicator had been used to derive a rough indication of the importance of portfolio flows for monetary developments in times of heightened uncertainty. In deriving an estimate of the net purchase of non-monetary securities by the consolidated money holder sector, data from MFI balance sheet, from the annual monetary union financial accounts and from balance of payment had been combined on the basis of a number of additional assumptions. The rough direction of this indicator proved

25 In line with the view that close to market rates remunerated products in M3 are affected more by portfolio decisions than other components of M3, the analysis of Divisia indices for monetary aggregates played some role in analysing extraordinary portfolio shifts as well. Indeed, by giving less weight in the index to instruments remunerated close to market rates, growth rates of Divisia indices are considerably less affected by extraordinary portfolio decisions than simple sum aggregates.

in real-time to give relevant qualitative and quantitative indications of the importance of portfolio shifts on money demand patterns. A comprehensive list of indicators that have been used to assess the impact of uncertainty on monetary developments and a simple visualisation can be found in the annexed table.

7.3 THE QUANTIFICATION OF SPECIAL FACTORS WITH A REG-ARIMA MODEL

In case, a direct quantification of special factors in M3 developments that were assumed not to be related to risks to price stability was not available and the episodic nature of the type of event prevented the use of multivariate models in real time, judgemental corrections had been performed by designing intervention variables in a univariate reg-ARIMA model for the levels of M3. The use of a reg-ARIMA model offered the advantage of monthly availability, thus offering monitoring tools at higher frequency than the regular quarterly monetary assessment. Furthermore, such models can be theoretically understood as encompassing univariate models in a multivariate VECM money demand framework (see for example Maravall and Mathis, 1994). In addition, the residuals from this model had proved in the past to be very similar to the residuals of standard multivariate money demand models. The reg-ARIMA model for the log-levels (notional stocks) of M3 has been defined as:

$$\Delta\Delta^{12}\left(y_t - \sum_i \beta_i x_{it}\right) = \left(1-\theta_1 L\right)\left(1-\Theta L^{12}\right)a_t \qquad (7.7)$$

where Δ is the first difference, Δ^{12} the seasonal difference, y_t the log transformed index of adjusted stocks of M3, χ_{it} is the set of intervention variables and regressors, β_i the regression coefficients, θ_1 the regular moving average parameter and Θ the seasonal moving average parameter and a_t independently identical distributed (i.i.d.) white noise variable that is normally distributed with mean 0 and standard deviation σ_a. The appropriately identified intervention variables and regressors in the case of euro area M3 are calendar effects stemming from the fact that MFI balance sheet data are collected on the last day of the calendar month and that the day of the week of this date has a certain impact for the demand for banknotes and short-term deposits, the payment of taxes and salaries and other effects. The second group of regressors consists of seasonal level shifts in April 1998 and December 1997, stemming from the problems in backward extension of the time series. In addition, two temporary changes in March 1993 and September 1992 capture effects related to the ERM-II crisis modelled as additive outliers followed by an exponentially decaying effect with decay factor 0.7 in September 1992 and March 1993. In addition to the above-described intervention variables, three types of judgemental corrections between 1999 and today had been performed for M3 via the use of intervention variables in the reg-ARIMA model for M3, namely the correction for the impact of the introduction of a new reporting scheme for MFI balance sheet data and the introduction of a remunerated minimum reserve system both in January 1999, the impact of the extraordinary level of uncertainty on M3 between 2001 and 2003 and its unwinding between mid 2003 and late 2005 and finally the impact of financial innovation on M3 in 2005 Q2 and 2005 Q3. The distortion in M3 related to the introduction of a new reporting scheme for balance sheet data of Monetary Financial Institutions in 1999 and the impact of the introduction of a remunerated minimum reserve system in January 1999 was modelled as an intervention effect that combined a permanent level shift in January 1999 and an additive outlier in January 1999 followed by an exponentially decaying effect with a decay factor of 0.2. The decay factor had been chosen based on the minimisation of the out-of sample error in 1999 in real time.

For the intervention variables capturing the extraordinary portfolio shifts between 2001 and 2003 and the unwinding of those portfolio shifts in following periods, the following two variables had been designed (for a motivation of this design based on illustrative indicators, see Chart 11):

March 2001 to June 2002: Linear increasing effect between March and October 2001, then constant. In order to capture the impact of the significant inflows into money in September 2001 following the terrorist attack on September 11 2001, the increase in September was assumed to be twice as strong as during the other periods, whereas October was assumed to be only half as strong as the regular linear increase.

July 2002 to June 2004: Linear increasing effect between July 2002 and May 2003, followed by a linear decline with one fourth of the speed observed for the increase.

The following tables summarise the point estimates and the corresponding t-values for the stochastic and the regression variables integrated in the reg-ARIMA model up to 2004 Q2.

Table 7 **Summary of the coefficient estimates of the stochastic part of the univariate reg-ARIMA model as estimated for data up to June 2004 when including all intervention variables listed in Table 2b**

Parameter	Estimate	S.E.
Regular MA parameter	0.09	0.06
Seasonal MA parameter	-0.56	0.06
Variance of the error term	$8.60 * e^{-06}$	

All these parameters have a straightforward interpretation. Whereas the regular moving average parameter indicates, that the series displays a rather stochastic trend (close to a random walk plus drift), the seasonal moving average parameter indicates a medium stable seasonal component. Finally, the standard error of the error term indicates that the standard error of the one-step-ahead forecast is approximately equal to 0.29 percent of the level of the series.

Table 8 Summary of the coefficient estimates of the regression variables in the univariate reg-ARIMA model as estimated for data up to June 2004

Parameter	Estimate	t-value
Constant	-0.16	-1.7
Calendar Effect (Monday up to 1991)	1.4	4.4
Calendar Effect (Friday up to 1991)	-2.6	-9.2
Calendar Effect (Saturday up to 1991)	-1.1	-3.6
Calendar Effect (Friday from 1992)	-9.1	-3.8
Temporary change with decay factor 0.7 09/92 (ERM 2 crisis)	8.4	3.6
Temporary change with decay factor 0.7 03/93 (ERM 2 crisis)	9.0	3.8
Seasonal level shift 12/97	-8.0	-4.7
Seasonal level shift 04/98	3.4	2.1
Combination level shift and temp. change decay factor 0.2 01/99	4.8	4.0
Portfolio shift regressor phases 1 and 2	2.3	2.6
Portfolio shift regressor phases 3 and 4	2.6	3.3
Residual statistics	**Value**	**S.E.**
Skewness	0.25	0.15
Kurtosis	2.96	0.3

Notes: No signs of autocorrelation and non-linearities in residuals using the Ljung Box test statistics for residuals and squared residuals. Parameters in the Table are multiplied by 1000.

The parameter values of the intervention variables have again a straightforward interpretation. For example, the intervention variable dealing with the potential distortions linked with the start of Stage III have a permanent impact of around 0.5% on the level of M3. The parameter of the portfolio shift regressors indicate that the inflow into money had been more pronounced in phase 3 than in phase 1. Given that phase 1 lasted 8 months and phase 3 12 months, the overall maximum impact on the level of M3 due to portfolio shifts can be derived as having been around 5% (8*0.23% + 12*0.26%).

Other procedures to obtain an estimate for the impact of uncertainty on money demand between 2001 and 2003 were also produced for robustness reasons. The main alternative method was based on a simple structural Vector Autoregression model (SVAR) as described in Cassola and Morana (2002). This SVAR model comprised six key macroeconomic variables for the euro area: real M3, real GDP, the ten-year government bond yield, the three month money market rate, GDP deflator inflation and real stock market valuation. The system comprises four long-run relationships: (1) a long-run money demand function, (2) a constant yield spread, (3) a Fisher parity condition, (4) a relationship linking stock market valuation and output. One could obtain a model based estimate of the trend in M3 and identify a liquidity preference shock as a shock that negatively affect the stock market variable and positively the money variable (see Section 8.2.4 for further details). Those portfolio shifts had been very similar to those derived from the alternative judgemental approach. However, signs of instability in the model in late 2003 urged for caution when using this model and the model was thus not used as the main quantification approach.

A number of further methods to quantify portfolio shifts have also been proposed. However, such models are based on an ex post assessment of the data – they were not constructed in real time. The approach adopted in this literature has been to model the impact of uncertainties within money demand models directly, e.g.Carstensen (2003), ECB (2005b), Greiber and Lemke (2005) and Avouyi-Dovi, Brun, Dreyfus, Drumetz, Oung, and Sahuc (2006). The results of such models led to estimates of the impact of uncertainty on money demand that were broadly similar to those identified in the real time ECB analysis, both in terms of timing and magnitude. For the technical quantification of extraordinary portfolio shifts on M3, the period after June 2004 required a change in the estimation procedure within the univariate time series model. Upward shocks have been occurred to M3 that have less been related to extraordinary portfolio shifts but rather to the low level of interest rates. Indeed, the main sources of money creation during those phases have been the demand for loans rather than portfolio decisions. The impact of the low level of interest rates likely to be behind positive residuals in classical money demand equations and in univariate time series models. A straightforward estimation of portfolio effects with univariate time series, given the new type of shock, was therefore not possible. Thus, from July 2004 onwards, the parameter estimates of the intervention variables in the univariate time series model have been frozen and the portfolio shift regressor had been prolonged for the period July 2004 to July 2005 and for the period December 2005 to June 2006, assuming no extraordinary portfolio in- or outflows from M3, fully in line with the indications stemming from the list of variables that have been used to monitor the impact of uncertainty and risk on money demand (see Chart 11). For 2005 Q4, a large set of indicators signalled a clear reversal of portfolio shifts. In order to design a parsimonious intervention variable, the outflow of funds from M3 between August and November 2005 has been modelled in connection with the distortions in M3 between 2005 Q2 and 2005 Q3 as described below. Finally, intervention variables in the reg-ARIMA model have been used to quantify and eliminate the impact of specific security trading activities of security dealers, previously performed directly by credit institutions. Based on a detailed monetary analysis, signals from National Central Banks and the analysis of one-step-ahead forecast errors in the reg-ARIMA model for M3, in 2005 Q2 and 2005 Q3, significant other technical distortions within M3 had been identified. In several countries, repurchase operations that were previously undertaken between credit institutions, have been switched to electronic trading platforms operated by security dealers resident in the euro area. As such transactions switch from being interbank operations to transactions intermediated by OFIs, they may enter the definition of M3 and thus blur the evolution of underlying monetary dynamics. The elimination of those effects upwardly distorting M3 developments was estimated together with the downward influence of portfolio outflows from M3 in 2005 Q4 within one intervention variable, e.g. a linear upward sloping trend for 2005 Q2 and Q3, combined with a downward sloping trend for the reversal of portfolio shifts in 2005 Q4.

Chart 11 Illustrative indicators motivating design of intervention variables for quantifying extraordinary portfolio shifts into and out of M3

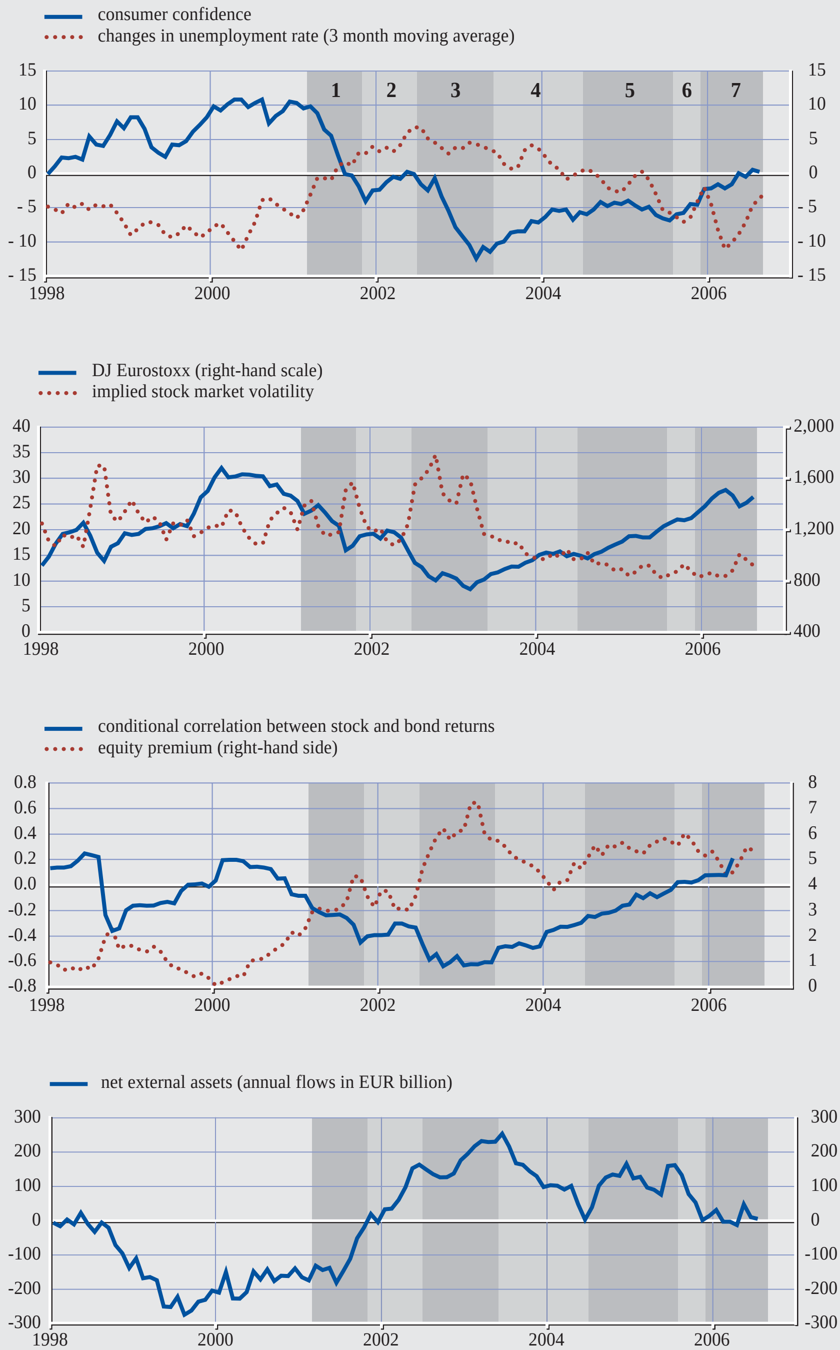
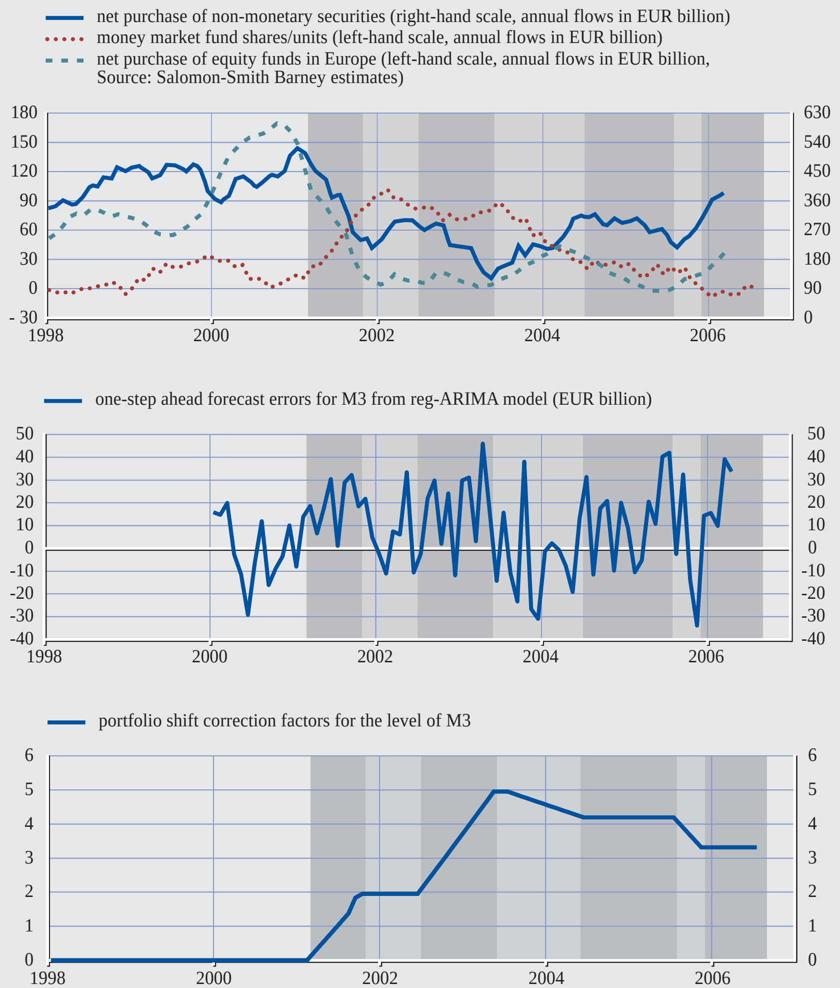


Chart 11 Illustrative indicators motivating design of intervention variables for quantifying extraordinary portfolio shifts into and out of M3 (cont'd)



Annex 1 Table of indicators used in real time to derive a judgemental adjustment of M3 for the extraordinary impact of portfolio shifts

Indicator	f	Available in	price/quantity	Motivation
Group 1: Measures of uncertainty				
Consumer confidence	m	t+1 WD	price	uncertainty measure
Changes in unemployment	m	t+23 WD		uncertainty measure
Group 2: Financial market indicators				
Exchange rate USD-euro	d	t+1 WD	price	rough capital flow indicator
DJ Eurostoxx index	d	t+1 WD	price	short term substitution effects with money/longer-term wealth effects on money
Implied stock market volatility	d	t+1 WD	price	immediate short term substitution between money and equity
Conditional correlation between stock and bond return	m	t+1 WD	price	risk aversion
Earnings yield premium	m	t+15 WD	price	risk premium, capturing asymmetric reaction to shocks, rapid to higher uncertainty, slow reversal due to time dependant risk aversion
Equity funds flows	m	t+28 WD	quantity	substitution equity/money
Group 3: Monetary indicators				
Money market fund shares/units	m	t+19 WD	quantity	money market funds are often used to park money in times of uncertainty due to low switching costs between equity/bond funds and money market funds
Loans to the private sector	m	t+19 WD	quantity	main factor for money creation
Net external assets	m	t+19 WD	quantity	captures main capital flows
Comparison US M2/euro area M3	m	t+19 WD	quantity	study of symmetric impact of global shocks on monetary aggregates
Divisia M3 index	m	t+28 WD		lower weight to components of M3 that are used mainly due to portfolio motives
Group 4: Financial account/ BOP indicators				
Monetary Presentation of BoP	m	t+36 WD	quantity	allows extraction of portfolio and direct investment flows from and into the euro area from net external assets
Net purchase of non-monetary securities	m	t+36 WD	quantity	Rough indicator to distinguish between portfolio considerations and money creation
Monitoring tools:				
One-step-ahead forecast error for M3 from reg-ARIMA model	m	t+19 WD	quantity	detection of specific "unusual events"
Standard money demand model	q	t+19 WD (now casts for real economic variables necessary)	quantity	analysis of new shocks
Liquidity preference shock derived from a small SVAR model	q	t+19 WD (now casts for real economic variables necessary)	quantity	alternative quantification of size of portfolio shifts via a historical decomposition of shocks

8 APPENDIX C: MONEY DEMAND EQUATIONS AND THEIR USE IN THE QUARTERLY MONETARY ASSESSMENT

This appendix draws on material prepared by ECB staff as background material for the QMA.

8.1 INTRODUCTION

For the ease of reading, the following conventions are taken throughout this annex:

- All coefficient estimates had been derived for the estimation period 1980 Q1 to 2001 Q2 if not indicated otherwise, as the parameters of the M3 money demand equations had been fixed at those values for period after 2001 in order to reflect the potential omitted variable problem that had been caused by high geopolitical and financial market uncertainties triggering an extraordinary flight to safe and liquid instruments that is not captured by the traditional determinants of money demand (ECB, 2004 and ECB, 2005b); see also the discussion in the main text).

- The naming of the different QMAs reflects the last available quarterly monetary data to which the note refers to. For example, the Quarterly Monetary Assessment that is delivered at the end of August 2006 to the Governing Council is named 2006 Q2.

- It is important to note the convention of the use of the term "levels" of monetary variables. The term "level" consistently refers to seasonally and end-of-month effect corrected notional stocks. The levels of monetary data (L_t) are affected by reclassifications (for example the enlargement of the euro area in January 2001 with Greece, the reunification of Germany in 1990, etc), exchange rate revaluations and other revaluations that do not reflect transactions by economic agents. Those "non-transaction-related factors" are reported by MFIs or are calculated at National Central Banks and the ECB and are used to derive monthly changes in levels (F_t) that are corrected for reclassifications and revaluations. Those changes are used to derive a chain index (I_t), called notional stocks (see equation 8.8 below).

$$I_t = I_{t-1}\left(1+\frac{F_t}{L_{t-1}}\right) \tag{8.8}$$

Such a method is for example used as well by the Bundesbank or underlies the calculation of growth rates for monetary variables in the Bank of England.

8.2 MONEY DEMAND EQUATIONS

8.2.1 SINGLE EQUATION MONEY DEMAND MODEL FOR M3 (CV)

The CV[26] money demand equation was the money demand equation first used within the QMA in 1999 Q3. The model can be estimated as a single equation, rather than within a system. The equation relates changes in real M3 to deviations from a long-run money demand relationship, changes in GDP growth, inflation, short and long-term interest rates. The long-run money demand relationship links the level of real M3 to that of real GDP, the difference between short-term and long-term rates and inflation. Both inflation and the yield curve spread are incorporated in order to capture opportunity costs of holding M3. The estimated equation has the following form:

$$\Delta(m_t - p_t) = k + 0.07\Delta^2 y_t + 0.16(\Delta s_t + \Delta s_{t-1})/2 - 0.33\Delta l_{t-1} - 0.21\Delta(\pi_t + \pi_{t-1})/2$$
$$-0.009DUM86 - 0.11\left[m_{t-1} - p_{t-1} - 1.28y_{t-1} + 0.44(l_{t-1} - s_{t-1}) + 1.12\pi_{t-1}\right]$$

where m is the log level of M3, p is the log level of the GDP deflator, y is the log level of real GDP, s is the short-term (3-month) nominal interest rate, l is the long-term (10-year) nominal interest rate, π is the annualized quarter-on-quarter inflation rate of the GDP deflator[27], DUM86 a dummy that is 1 in the second quarter of 1986 and 0.5 for the other quarters of 1986 and Δ is the difference operator. The CV model was based on the scarce data availability at that time. Improving data availability, data quality and further research improved the CV money demand framework in a number of directions, leading to a relative quick replacement as workhorse model.

8.2.2 STRUCTURAL VAR M3 MONEY DEMAND MODEL (BC)

The BC money demand system[28] for euro area M3 has been developed using a structural cointegrating VAR approach of order 2. The core of this model consists of the following long-run relationships:

$$m_t - p_t = const + 1.33y_t - 1.7l_t \quad (8.9)$$

$$l_t = const + 0.4\pi_t \quad (8.10)$$

$$l_t - s_t = const \quad (8.11)$$

where m is the log level of M3, p is the log level of the GDP deflator, y is the log level of real GDP, s is the short-term (3-month) nominal interest rate, l is the long-term (10-year) nominal interest rate, π_t is the inflation rate of the GDP

26 See Coenen and Vega (2001).
27 Notice that only in this appendix we define π_t as the quarterly growth rate of prices (GDP deflator or HICP). In the rest of the paper, π_t indicates the h-period annualized inflation rate.
28 See Brand and Cassola (2004).

deflator. Equation (8.9) represents a money demand relationship explaining real money balances with output as transaction variable and the long-term interest rate as opportunity cost variable, equation (8.10) a stable relationship between long-term interest rates and inflation and equation (8.11) a stable relationship between short and long-term interest rates. An important feature of this dynamic system framework is that these three relationships feed into changes of inflation, interest rates, money and income. Therefore, all the variables are simultaneously determined. From an economic perspective, the main features of the model can be summarised as follows:

- If M3 happens to grow faster than foreseen on the basis of the model this can together with higher GDP growth lead to higher inflation.

- M3 developments reflect current developments in GDP and help predict future GDP growth.

- In the long-term, higher short-term rates would lead to a decrease in money growth.

The BC model improved the CV money demand framework by answering the critique that a single equation model was inadequate given the fact, that on theoretical grounds, three cointegration vectors could be expected among the given set of variables. The BC model was the workhorse model for the QMA during 2000 and excess liquidity measures constructed on the basis of this model were reported until 2003 Q4 as a robustness check based on that model. It was felt, however, that opportunity costs of holding money had not been captured within this framework in a convenient way so that a third money demand equation was introduced after deriving historical estimates for the own rate of return of M3.

8.2.3 M3 MONEY DEMAND MODEL USING THE OWN RATE OF RETURN OF M3 (CGL)

The CGL model[29] has been the workhorse M3 money demand equation used in the QMA since 2001Q1 until today and is a Vector Error Correction (VEC) model of order 2 that includes only one stationary cointegration relation which specifies the long-run demand for real money (m-p) as a semi log-linear function of real GDP (y) and the spread between the short-term market interest rate (s_t) and the own rate of return of M3 (OWN).

$$m_t - p_t = k + 1.31 y_t - 1.1 (s_t - OWN_t) \qquad (8.12)$$

In the short-run equation for real money, it includes (one-quarter lagged) changes in oil prices as an exogenous variable in order to take account of the difficulty for the GDP deflator to fully capture the impact of external developments on domestic prices at times of rapidly changing import prices. In addition, in the short-run dynamics, one-quarter lagged changes in the yield spread (defined as the difference between the ten-year government bond yield

29 See Calza, Gerdesmeier, and Levy (2001).

and the short-term market interest rate) are included as an exogenous variable in order to enhance the dynamics of adjustment to equilibrium. This variable is expected to capture the shifts between short-term instruments included in M3 and long-term assets due to changes in their relative rate of return. From the QMA 2003 Q1 onwards, the originally imposed but theoretically not founded short-run price homogeneity had been relaxed by adding current changes in annualised quarterly inflation as exogenous variable in the dynamic equation. In addition to the baseline model, ad-hoc extensions of the CGL model had been used in the QMA from time to time to illustrate in a simplified way the potential impact of stock market developments on money holdings similar to the work of Carstensen (2003). The extension in the long-run relation included a smoothed version of the return on equity (combined with the ten-year government bond yield to give a broad measure of the returns available on non-monetary assets), and a smoothed version of a stock market volatility measure.[30]

Moreover, the short-term dynamics of the CGL money demand model have been extended by the introduction of a further risk measure related to the stock market, namely the first difference of the earnings-yield premium. Those ad-hoc extensions were always used as simplified ex-post robustness checks for the estimated impact of portfolio shifts on M3 derived in real time. There are two reasons not to modify the workhorse model on a permanent basis: First, the ex-post statistical exercise of including additional variables in order to capture certain episodic effects does not guarantee stability of money demand for future periods and second, the introduction of further asset prices and uncertainty measures does not solve the problem of how to assess the risks to price stability from money in a proper way in real time. Nevertheless, the identified portfolio shifts were assumed to distort estimates of the longer-run parameters in the money demand models, therefore from the QMA 2001 Q4 onwards, the CGL and the BC money demand equations had been used in all main applications by freezing the parameters as estimated for the time period between 1980 and 2001 Q2. Despite those signs of instabilities, potentially driven by an omitted variable problem, those models with fixed parameter estimates could still be used as a natural benchmark, consistent with the overall framework presented in Section 2.3(ii), given the assumption that a stable long-run money demand relation exists, however that the attempt to model both, short- and long-run links between money and economic variables might be problematic due to the complex relation between money and those variables in the shorter term. It is nevertheless fair to say that the importance of money demand models within the QMA has diminished over time, in particular during the period of extraordinary portfolio shifts triggered by geopolitical and financial market uncertainties.

30 The annualised three-year log differences of the quarterly Dow Jones Euro Stoxx index have been used as an equity return variable. A two-year average of conditional variances from a GARCH(1,1) model derived from the yields of the daily Dow Jones Euro Stoxx index has been used as a stock market volatility measure.

8.2.4 A STRUCTURAL VECM MODEL TO INTEGRATE STOCK MARKET VARIABLES INTO MONETARY POLICY (CM)

This structural Vector Auto Regression[31] model was derived to study the role of the stock market in the monetary transmission mechanism and had been used in the QMA between 2002 Q1 and 2004 Q1. It comprises six key macroeconomic variables for the euro area: real M3 (rm) (in log levels), real GDP (y) (in log levels), the ten-year government bond yield (l), the three-month money market rate (s), GDP deflator inflation (π), and real stock market valuation (f) (in log-levels, deflated with the GDP deflator). Hence, in the context of the model, deviations of M3 from trend can be regarded as a temporary, or "cyclical", phenomenon. The system comprises four long-run relationships: (1) a long-run money demand function, (2) a constant yield spread, (3) a Fisher parity condition, (4) a relationship linking stock market valuation and output (see table below).

Table 9 Estimated cointegration relations in the CM model

N	Y	f	rm	i	l	π
1	-1.43	0	1	0	0	0
2	0	0	0	-1	1	0
3	0	0	0	1	0	-1.59
4	-4.69	1	0	0	0	0

Further structural analysis of the model allows analysing how different economic shocks affect the dynamics of the variables. The following six shocks have been identified: (1) a permanent productivity shock; (2) a permanent nominal shock; (3) a temporary shock to the term structure; (4) a temporary liquidity preference shock; (5) a temporary aggregate demand shock; and (6) a temporary shock to the Fisher parity/real interest rates.

The stylised interactions between money and stock prices under different shocks demonstrates that, on the basis of this model, different types of shocks lead to different reactions of money and stock prices. Only the permanent real output shock has a permanent positively correlated impact on real monetary balances and the stock prices. This correlation is due to the fact that on the one hand money balances react positively to higher output and at the same time the stock prices incorporate higher productivity and therefore higher corporate earnings. By contrast, the transitory liquidity preference shock leads to a negatively correlated but only temporary impact on money and stock prices. The estimation of this temporary shock allowed a robustness check for the estimation of extraordinary portfolio shifts into M3. However, due to signs of instability, the model had been used with caution and was dropped after 2004 Q1.

Other money demand models

Within the broad monetary analysis of the ECB, not only the demand for the monetary aggregate M3 but also the demand for the narrow monetary aggregate M1 (comprising currency and overnight deposits) and the demand for loans

31 See Cassola and Morana (2002).

were monitored within a Vector Error Correction Mechanism framework. The monetary aggregate M1 has played an important role, as it contains those components of M3 that are very interest rate sensitive and are therefore in particular adequate in monitoring the importance of the low level of interest rates on money demand. Finally, in order to monitor the impact of the euro cash changeover on the demand for currency, a currency demand model had been regularly used in the QMA.

8.2.5 M1 DEMAND MODEL

The money demand equation for M1[32] that had been used in the QMA from 2000 Q4 onwards, reflects the expected non-linear long-run link between interest rates and real M1 balances driven by the fact that the reaction to changes in the opportunity costs of holding real M1 balances when they are at low levels are likely to be stronger than the reaction to similar opportunity cost changes in case of higher levels of opportunity costs. The functional form for the long-run demand is as follows:

$$m1_t - p_t = k + 0.67 y_t + \frac{1.38}{(S_t - OWN_t)} \qquad (8.13)$$

where $m1$, p and y denote (logs of) the stock of M1, the price level (as measured by the GDP deflator) and real GDP, respectively; while the inverse of (S-OWN) stands for the opportunity cost of holding M1 as measured by the difference between the short-term market interest rate and the own rate of return on the instruments included in M1. Following the general-to-specific approach, the cointegrated VAR-system is subsequently reduced to a single equation. This equation includes two dummies: (1) dumJan99 to account for an exceptionally large jump in the demand for M1 in January 1999; and (2) dum2K for the temporary rise in the demand for M1 prompted by the possible "Y2K" effects between late 1999 and early 2000.[33]

8.2.6 CURRENCY DEMAND MODEL

In order to be able to monitor whether the euro cash changeover has triggered a structural change in the use of currency, a simple Vector Error Correction model of order two for the demand for real currency in the euro area estimated over the period 1980 to 2000 had been used in the QMA[34]. This model explains real currency balances (cur-p) as a function of a transaction variable and a measure of the opportunity cost of holding cash. As a transaction variable, real private consumption (c_t) is used. As a proxy for the opportunity costs, the three-month money market rate (s_t) for the euro area is used (the EURIBOR from January 1999 onwards and an M3-weighted short-term money market rate for the euro area countries for the period before). In addition, as a proxy for the non-resident demand, the real effective exchange rate (e_t) of the euro is

32 See Stracca (2003).

33 On the basis of a monthly regARIMA(0,1,1)(0,1,1)12 model for M1, the original dummies have been re-designed as follows: dumJan99 takes the value 0 before 1999, 1 in 1999 Q1 and 0.7 afterwards, while dum2K is an impulse dummy taking the value of 1 in the first quarter of 2000 and 0 elsewhere.

34 See Fischer, Köhler, and Seitz (2004).

introduced in the model[35]. Finally, the change in the unemployment rate is included as an exogenous variable to approximate business cycle developments that might influence the precautionary holdings of currency. All variables are in logarithms (including the interest rate), except the change in unemployment. The long-run equilibrium relationship reads as:

$$cur_t - p_t = -k + 1.08c_t + 0.39e_t - 0.033s_t \tag{8.14}$$

The variables show the signs expected on the basis of standard economic theory. Increased opportunity costs lead to a reduction in real currency holdings. The restriction that the transaction elasticity is one cannot be rejected. Finally, an appreciation of the euro by one percent leads to an increase in currency holdings by 0.4 percent reflecting foreign influence on the demand for euro area currencies in the form of "currency substitution". The coefficient of the error correction term of -0.11 shows that overhangs are corrected relatively slowly. A modification and simplification of the above-described currency demand equation has been used in the Quarterly Monetary Assessment to allow monitoring better the potential re-optimisation of currency holdings after the euro cash changeover given the availability of large denomination banknotes[36]. The following long-run equation has been estimated for the period from 1980 to 2000 (all variables were taken in logarithms except interest rates):

$$cur_t - p_t = k + y_t + 0.599e_t - 0.747s_t \tag{8.15}$$

where k is a constant, y real output, e the real effective exchange rate of the euro against a basket of currencies of major trade partners and s the three month money market interest rate. In order to estimate an error correction model for the demand for currency for periods including the euro cash changeover, it is necessary to include a number of deterministic dummy variables that intend to capture the extraordinary character of the year before the euro cash changeover and the period after the euro cash changeover. Developments during this period can obviously not be explained solely by the macroeconomic determinants of currency demand. In detail, the following dummy variables have been introduced: A first dummy (dprecc) tries to capture the strong decline in 2001 during the run-up to the euro cash changeover. It is defined as a logistic function of the period of time remaining until the cash changeover (timetocc):

$$dprecc = \frac{1}{1 + exp(-timetocc)} \tag{8.16}$$

where timetocc equals, before 2002, the number of months or quarters until the cash changeover, and zero from 2002 onwards. A second dummy variable (dpostcc) tries to capture the catching-up process of banknote developments

35 The choice of real versus nominal effective exchange rates has no major impact of the results of the model.

36 This model has been derived by an ad-hoc Task Force of the Banknote Committee (ESCB committee) on forecasting the banknote developments.

and the re-optimisation of currency holdings after 1 January 2002. It is defined as a logistic function of the time which has elapsed since the cash changeover (timeaftercc):

$$dpostcc = \frac{1}{1 + exp(-timeaftercc)} \quad (8.17)$$

where timeaftercc equals zero before 2002 and the number of months or quarters after the cash changeover from 2002 onwards. In addition, impulse dummies for the second and third quarters of 2002 have been introduced.

8.2.7 LOAN DEMAND MODEL (CMS)

The demand equation for loans to the private sector[37] used in the QMA since 2001 Q4 is a Vector Error Correction (VEC) model of order five in levels comprising real loans (deflated by the GDP deflator), real GDP, the nominal composite lending rate and the annualised quarterly inflation rate (based on the GDP deflator). One cointegrating vector links the variables in the system. This vector is interpreted as a long-run demand function explaining real loans (loan - p) in terms of real GDP (y) and the real lending rate (CLR - π):

$$loan_t - p_t = \alpha + 1.5y_t - 3.1(CLR_t - \pi_t) \quad (8.18)$$

The short-run dynamics of the model contain a dummy in 2000 Q2 and 2000 Q4 to capture M&A activities and the financing of the UMTS auctions at that period.

8.3 THE USE OF MONEY DEMAND MODELS WITHIN THE QUARTERLY MONETARY ASSESSMENT

Within the QMA and ECB's monetary analysis more generally, money demand models have been used for a number of purposes. The main uses are presented below:

8.3.1 DERIVATION OF THE REFERENCE VALUE FOR M3

The ECB has defined price stability as an annual increase in the HICP for the euro area of below 2%[38]. In December 1998, when the Governing Council of the ECB derived the first reference value, in addition to the definition of price stability, the following assumptions had been used:

- Trend growth rate of real GDP in the range of 2 to 2½%
- Trend decline in M3 income velocity in the range of ½% and 1%

Those assumptions let to the definition of the first reference value of 4½%. The money demand equations offered a further tool to verify those assumptions, as

37 See Calza, Manrique, and Sousa (2003).
38 In the Governing Council's evaluation of the that the ECB aims at annual HICP inflation "below, but close to" 2% over the medium term (ECB, 2003b).

the reference value can be derived s the steady-state rate of monetary growth that is consistent with price stability and the assumed trend behaviour of real GDP. Taking first differences of the long-run money demand equations of BC or CGL and substituting observed inflation with inflation in line with price stability and output with trend real GDP growth one gets

$$\Delta m_t^{ref} = \pi_t^* + \beta_y \Delta y_t^{pot} \tag{8.19}$$

8.3.2 DECOMPOSITION OF MONEY GROWTH BASED ON MONEY DEMAND MODELS

The money demand equations had been used in the monetary analysis to study the impact of the different determinants to money demand on current monetary developments, allowing a better understanding and analysis of the potential risks to price stability in the medium term. Indeed, for example the information that high monetary growth was caused by high current output or lower interest rates may be a clear signal of increasing risks to future price stability. The decomposition of monetary growth into its main determinants is done by first rewriting the money demand equation in terms of the levels of each variable:

$$\phi(L)m_t = \psi_1(L)p_t + \psi_2(L)y_t + \psi_3(L)opp_t + \psi_4(L)x_t + u_t$$

where $\phi(L)$ and $\psi_i(L)$ i=1 to 4, are polynomials in the lag operator L, m is the monetary aggregate, p is the price index, y is real GDP, opp is the opportunity cost measure and x is a vector of exogenous variables. It is then possible to rewrite the level of money (m) as a function of the several explanatory variables:

$$m_t = \frac{1}{\phi(L)}\left[\psi_1(L)p_t + \psi_2(L)y_t + \psi_3(L)opp_t + \psi_4 x_t + u_t\right]$$

The polynomials $\alpha_i(L)=\frac{\psi_i(L)}{\phi(L)}$, i=1 to 4, are used to compute the contribution of each variable to the level of money. For instance, the contribution of the price level to the level of money is: $\alpha_i(L)p_t$. Given that the annual growth rate of money is approximately equal to $m_t - m_{t-4} = \Delta_4 m_t$, the contributions of the explanatory variables to monetary growth can be obtained from the following expression:

$$\Delta_4 m_t = \frac{1}{\phi(L)}\Delta_4\left[\psi_1(L)p_t + \psi_2(L)y_t + \psi_3(L)opp_t + \psi_4(L)x_t + u_t\right]$$

These contributions are shown in the table for the annual growth rate. The part not explained by fundamentals $(\Delta_4 \frac{1}{\phi(L)} u_t)$ is further broken down in terms of the "new shock" (u_t) and the effect of lagged shocks $(\Delta_4 \frac{1}{\phi(L)} u_t - u_t)$. This is important, as the innovation in money growth, the "new shock" offers important information on potential special monetary developments in a certain quarter.

8.3.3 DERIVING MEASURES OF EXCESS LIQUIDITY

Excess liquidity can be measured in a variety of ways, each with its own strengths and weaknesses. One approach is to focus on the nominal and real money gaps, defined as cumulative deviations of M3 growth from the reference value. This is regularly done in the QMA (and is published in the Monthly Bulletin). The nominal money gap refers to the difference between the actual level of M3 and the level of M3, which would have resulted from M3 growth at its reference value. The real money gap measure shows the difference between the actual level of M3 deflated by the HICP and the level of M3 in real terms which would have resulted from nominal M3 growth at the reference value and HICP inflation in line with the definition of price stability. For both measures, a base period of December 1998 is used. The latter indicator takes into account the fact that part of the excess liquidity which has accumulated over the past few years has in the meantime been absorbed by higher prices, reflecting upward deviations of inflation rates from the price stability objective. For this reason, the measure of the real money gap shows a lower amount of excess liquidity. When analysing money gaps, some caveats have to be taken into account:

- The level of the money gaps will depend on the choice of the base period (for the money gaps based on the reference value) or the estimate of the constant in the long-run relationship (for the model-based money gaps).

- Whether the nominal or the real money gap gives the more reliable signal in terms of risks to price stability depends on the specific economic situation. If the development of the nominal money gap is mainly driven by high inflation due to one-off factors and it is unlikely that there are second round effects, the development of the real money gap may be a better indicator to assess inflationary risks arising from excess liquidity. However, when the absence of second-round effects cannot be taken for granted, one may consider focusing on the development of the nominal money gap.

The QMA contains two further measures of excess liquidity that are linked with money demand equations, namely the “monetary overhang” and model based real money gaps. The monetary overhang is defined as the difference between the actual level of real M3 and the “equilibrium” or “desired” level of real M3 given by the long-run relation from a money demand model. In order to check the robustness of the results, two versions of monetary overhangs had been used in the Quarterly Monetary Assessment based on the two money demand equations BC and CGL. These imply the following equilibrium values for M3:

$$OverhangBC = m3 - p - c_1 + \beta_1 y + \gamma_1 LT \qquad (8.20)$$

$$OverhangCGL = m3 - p - c_2 + \beta_2 y + \gamma_2 (ST - OWN) \qquad (8.21)$$

where $m3$ is the stock of M3, p the price level, y real GDP, LT the long-term interest rate and (ST-OWN) the opportunity cost of M3 defined as the difference between the three-month market interest rate and the own rate of return on M3. All variables are in logs except interest rates. The constants c1 and c2 are chosen so that the overhangs average to zero over the sample period. The main problem with the interpretation of overhang/shortfall measures is that in principle a zero overhang/shortfall could be compatible with any level of inflation. For example, a low level of this indicator does not necessarily imply absence of risks to future price stability since it would be compatible with strong economic growth that might be translated into subsequent inflation. As a consequence, the overhang/ shortfall level might give under several circumstances false signals when assessing whether the medium-term inflation outlook is compatible with the ECB's definition of price stability. Nevertheless, it provides some indication of the extent to which the actual money demand is in line with the equilibrium values of the underlying economic model.

The money demand model-based real money gaps used in the QMA was derived from the BC or the CGL money demand equations for euro area M3. These model-based real money gaps (RMG) are defined as

$$RMG_t = (m3_t - p_t) - (c + \beta y_t^* + \gamma i_t^*) \tag{8.22}$$

where p is the price level (in logs), i^* is the equilibrium value of the opportunity costs variable, y^* the equilibrium level of real output and β and γ are the estimated coefficients of a long-run money demand equation. This model-based method has the advantage that it can take into account more detailed information on opportunity costs instead of assuming a deterministic trend in velocity, as is done for the gap measures based on the reference value. A further interesting feature of the money demand model based real money gap (RMG) is that it can be decomposed into the monetary overhang OH, the output gap YG (multiplied by the long-run income elasticity β) and the opportunity cost gap IG (multiplied by their long-run semi-elasticity γ):

$$RMG_t = OH_t + \beta YG_t + \gamma IG_t \tag{8.23}$$

where the monetary overhang is defined as the difference between the actual level of real M3 and the equilibrium level of real M3 given by the long-run relation from a money demand model. Furthermore, YG = y-y* and IG = i-i*. This decomposition allows analysing, if the information content of the real money gap for future inflation is stemming exclusively from the information of the output gap, or if the monetary overhang has additional information content.

An interesting feature of the real money gap is that it can be related to the P-star model of inflation, which is based on the quantity theory of money. The P-star model defines the (logarithm of the) price level pstar as the price level that is consistent with the current level of the nominal money stock M3 and the long run or equilibrium levels of both the income velocity of the nominal money stock and real output

$$p_t^* = m3_t + v_t^* - y_t^* \tag{8.24}$$

where $v_t^* = p_t^* + y_t^* - m3_t^*$ denotes the logarithm of the equilibrium level of the income velocity of the nominal money stock and y^* denotes the equilibrium level of real output. Relying on the quantity theory of money, the equilibrium level of the real money stock can be written as $m3_t^* - p_t^* = y_t^* - v_t^*$. The link between the real money gap and *p** is then evident:

$$RMG_t = (m3_t - p_t) - (y_t^* - v_t^*) = -(p_t - p_t^*) \tag{8.25}$$

The real money gap can, thus, be written as the negative of the price gap, which is, in turn, defined as the difference between the actual price level (in logs) and the P-star measure of the equilibrium price level. Equation (8.25) seems to imply that a real money gap measure may have leading indicator properties with regard to future inflation. Assuming that the actual price level moves towards the P-star measure of the equilibrium price level, according to a partial adjustment mechanism, the emergence of a positive real money gap would be associated with an increase in future inflation bringing the price level back in line with the equilibrium level *p**:

$$\Delta p_t = c + \alpha(L)\Delta p_t + \beta(L)\Delta p_t^* + \lambda(p_{t-1} - p_{t-1}^*) \tag{8.26}$$

where *c* denotes a constant and α(L) and β(L) denote lag polynomials[39].

This hypothesis is confirmed by the results of empirical studies, not only for individual euro area countries[40] but as well for the euro area itself. More specifically, for the euro area Trecoci and Vega (2000) find that their real money gap measures lead inflation by one to one and a half years. Gerlach and Svensson (2000) come to a similar conclusion: their real money gap measure is positively linked to inflation one and four quarters ahead. The latter model has been used in the Quarterly Monetary Assessment to derive inflation forecasts assuming different scenarios for the future use of excess liquidity in the euro area. The Gerlach-Svensson approach (henceforth GS) consists of a model for forecasting inflation in the euro area on the basis of a measure of the real money gap. The model consists of two building blocks: one for inflation determination and another for money demand estimation. In the most general formulation of the GS model, the inflation block can be represented in terms of three equations:

$$\pi_{t-1} = \pi_{t+1,t}^e + \alpha_m RMG_{t-j} + \alpha_m Z + u_{t+1} \tag{8.27}$$

$$\pi_{t+1,t}^e = \alpha_\pi(L)(\pi_t - \pi_t^{obj}) \tag{8.28}$$

$$\pi_{t+1}^{obj} - \pi_{t+1}^{obj,B} = \gamma(\pi_t^{obj} - \pi_t^{obj,B}) \tag{8.29}$$

The first equation specifies inflation at time t+1 (π_{t+1}) as a function of inflation expectations for the same period ($\pi_{t+1,t}^e$) made at time *t*, the lagged real money

39 Tödter (2002) proposes a more general formulation of the price adjustment mechanism based on an extended Philips curve, where the output gap is replaced by the price gap. The rationale for this extension is the hypothesis that in their price-setting behaviour firms take account not only of microeconomic variables such as marginal production costs, but also of the deviations of money balances from their equilibrium level. This extension allows Tödter (2002) to incorporate the P-star model in a new-Keynesian type model.

40 See e.g. Hoeller and Poret (1991), Kool and Tatom (1994) and Tödter and Reimers (1994).

gap (RMG_{t-j}) and some exogenous variables (Z, for instance energy prices). The second equation specifies the behaviour of inflation expectations. Inflation expectations in each period are a function of the euro area central banks' implicit inflation objective for the following period (π_{t+1}^{obj}) and of the current and lagged deviations of inflation (π_{t-i}) from the average implicit inflation objective of the euro area central banks (π_{t-i}^{obj}). Finally, the third equation defines how the average implicit inflation target of the euro area central banks is computed before 1999 Q1. Namely, it assumes that the average inflation objective of the euro area central banks converged to the Bundesbank's inflation objective $(\pi_t^{obj,B})$ at a rate γ. Following GS, the Bundesbank's inflation objective was set equal to the Bundesbank's normative inflation assumption for its monetary targets. Unlike in GS, the inflation objective of the euro area (π_t^{obj}) since the start of Stage Three of EMU is assumed to be 1.5% in the QMA[41].

In the QMA, the estimated inflation equation is the reduced form of equations (8.27 to 8.29). In addition, the decomposition of the real money gap into the output gap[42], the overhang and the interest rate gap is used, following equation (8.23). The oil price in EUR was included as exogenous variable in the model. A parsimonious equation for the euro area for the period 1981 Q4-2006 Q2 can then be estimated as (standard errors in parenthesis, overhang derived for M3 corrected):

$$\underset{}{\pi_t - \pi_t^{obj}} = \underset{(0.007)}{0.0019} + \underset{(0.08)}{0.3}(\pi_{t-3} - \pi_{t-3}^{obj}) + \underset{(0.05)}{0.34}YG_{t-4} + \underset{(0.04)}{0.1}OH_{t-4} + (\underset{(0.005)}{0.03} + \underset{(0.005)}{0.02}L + \underset{(0.005)}{0.01}L^3)\Delta oilp_t + u_t \quad (8.30)$$

The coefficients have the expected signs and the monetary overhang is significant in addition to the impact of the output gap measure. The real money gap thus contains additional useful information concerning future inflation as compared to the output gap. When forecasting inflation in the reduced form equation (8.30), it is necessary to supply the forecasts for the variables different from inflation. Assumptions and projections from the Broad Macroeconomic Projection exercise are used in the Quarterly Monetary Assessment to derive these forecasts. In order to illustrate the impact of excess liquidity on future inflation using the GS approach, the Quarterly Monetary Assessment presents inflation forecasts based on three scenarios: Scenario one assumes that excess liquidity impacts inflation in line with past regularities[43]. Scenario two assumes that the correction of the monetary overhang occurs slower than expected from past regularities, based on a possibly increased risk aversion of euro area economic agents after the prolonged period of stock market declines[44]. Finally, scenario three studies the impact of excess liquidity on inflation, assuming that

41 Gerlach and Svensson (2002) extend the series of the constant 1.5% inflation rate from the first quarter of 1999 onwards and then estimate the implicit inflation target of the euro area central banks as converging to this extended series.

42 This output gap is estimated by means of a multivariate unobservable components model (used to decompose the variables into a permanent and a cyclical component) implementing the production function approach, see Proietti, Musso, and Westermann (2002) for details.

43 Developments of the overhang are forecast with a money demand model estimated for the period 1980-2001 Q2.

44 Developments of the overhang are forecast with a money demand model estimated for the period 1980-2004 Q1.

past portfolio shifts between 2001 and 2003 do not impact inflation, as they are assumed not be used for spending. Overall, it has to be kept in mind that the inflation forecast equation presented above captures more the cyclical developments in inflation and money based measures. In that sense it does not use the full potential of the information contained in money concerning risks to future price stability, which is more geared towards the information contained in the longer-term trend components.

8.3.4 INFLATION FORECAST SCENARIOS

During 2000 and early 2001, money demand equations had been used in addition to simple bivariate forecasting models to derive forecasts for the GDP deflator, the HICP and for real GDP. The simultaneous determination of all model variables in the system money demand model (BC) (see Section 8.2.2) allows producing simultaneous predictions of all variables involved in the money demand framework, e.g. in this case short- and long-term interest rates, the GDP deflator, money and output. However, the experience with this framework was negative, mainly based on the fact that the empirical properties of inflation in the period 1980 to 1999, in particular due to the disinflation periods (inflation was integrated of order 1) weighted too much on the forecasts derived with such a system.

8.3.5 PARAMETER CONSTANCY

At the time of writing the QMA 2001 Q2, no signs of instability in the long-run or short-run relations of the workhorse money demand equation could be detected using conventional stability measures. Nevertheless, given the potential risks stemming from the extraordinary portfolio shifts triggered by heightened financial market and geopolitical uncertainties, at the end of 2001, it was decided to freeze the parameter estimates from the workhorse money demand models at their values estimated for the period 1980 to 2001 Q2. Such a measure was taken in order to protect against an assumed omitted variable problem that would otherwise affect the parameter values of the money demand equation, including the long-run parameter values and would at the same time signal instabilities. In addition to the above-described permanent measures that recognised in real-time the potential risks for the stability of the workhorse money demand specification, a number of parameter constancy tests have been applied regularly in order to monitor the progressive deterioration. It is important to note that those tests cannot answer the important question whether money demand instability is stemming from omitted variable problem, shifts in the demand and importance of certain sectors of money holders or from a general breakdown of the money demand relation. The test procedure relied heavily on the work by Bruggeman, Donati and Warne (2003) and can be separated in a number of steps:

Step 1:

Since the stability analysis is based on a given number of long-run relations, as a fist step, the long-run properties of the money demand systems need to be investigated. In particular, the results obtained from stability tests are conditional on the correct choice of the number of long-run relations. It is therefore crucial that a correct assessment on the number of these relations be made. In that respect it is important to estimate the probability that a sequence of tests for the number of long-run relations (based on critical values from the asymptotic distribution) incorrectly selects too few relations. This probability is zero for large samples, but it need not even be close to zero in smaller samples. Formally, the cointegration rank is analysed by studying the non-zero eigenvalues used in the cointegraion rank analysis, based on fluctuation tests as proposed by Hansen and Johansen (1999). In order to assess the properties of the stability tests in a small-sample setting with respect to test size and power, bootstrap-based distributions are generated. Bootstrapping is a method to construct artificial samples based on the estimated behaviour of the actual data. One benefit of applying bootstraps is that it allows accounting for the small-sample behaviour of the tests. While the theory on bootstrapping in a non-stationary framework, such as the cointegrated VAR, is still largely undiscovered, the usual theoretical properties form models with stationary variables seem to apply in this setting as well. Hence, the bootstrap distribution can be assumed to provide more reliable guidance for inference than when asymptotic distributions are used.

Step 2:

After studying the constancy of the cointegration rank, the parameter constancy of the long-run parameters is tested using the Nyblom type test (supremum and mean) (see Bruggeman, Donati and Warne (2003) for details).

Step 3:

In a third step, the constancy of the short-term parameters is studied based on fluctuation tests proposed by Ploberger, Kramer, and Kontrus (1999). It has to be noted that such formal tests can of course not answer the important questions on the sources of potential non-constancies in the parameter estimates and are in general not conclusive when non-constancy issues occur at the current end of the time series.