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Milton Friedman, the Demand for Money and the ECB's Monetary-Policy Strategy

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Milton Friedman, the Demand for Money and the ECB's Monetary-Policy Strategy*

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ABSTRACT

The European Central Bank (ECB) assigns a greater weight to the role of money in its monetary-policy strategy than most, if not all, other major central banks. Nevertheless, reflecting the view that the demand for money became unstable in the early-2000s, some commentators in the press have reported that the ECB has "downgraded" the role of money-demand functions in its strategy. This paper explains the ECB's monetary-policy strategy and shows the considerable influence of Milton Friedman's contributions on the formulation of that strategy. The paper also provides new evidence on the stability of euro-area money-demand. Following a conjecture made by Friedman (1956), we assign a role to uncertainty in the money-demand function. We find that, although uncertainty is mean–reverting, it is none-the-less non-stationary, subject to wide swings, and has substantial effects on the demand for money.

Keywords: ECB's monetary-policy strategy, Milton Friedman, money demand,

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1. *Introduction*

The primary objective of the European Central Bank's (ECB's) monetary-policy strategy is to maintain price stability in the medium term.[1] In pursuing that objective, the ECB assigns more weight to the longer-term relationship between money growth and inflation than most, if not all, other major central banks. This emphasis reflects, in part, the ECB's views that (1) "inflation is ultimately a monetary phenomenon", and (2) "price stability enhances the potential for economic growth" (ECB, 2011, pp. 55-56). Effectively, the emphasis reflects the notion that longer-term growth is determined by real factors -- including an economy's resources, the growth of its population, and the technical skills of its labor force -- and that the most that monetary policy can do to help the economy reach its growth potential is to deliver a stable price level (ECB, 2011, p. 56).

In a number of important respects, the ECB's monetary-policy strategy reflects the substantial influence of the research carried out by Milton Friedman during the 1950s and 1960s.[2] One such respect concerns the stability of the demand for money, which helps underpin the idea that there exists a reliable, longer-term relationship between the growth in the money supply and inflation. Friedman (1959) found that demand for money in the United States was stable, a finding that was corroborated for the euro area in early work by the staff at the ECB (Calza, Gerdesmeier, Levy, 2001). However, beginning around 2003, most euro-area money-demand functions began exhibiting instability, leading some commentators in the press to infer that the role of money had been "downgraded" in the ECB's monetary-policy strategy (see Section 3).

In this paper, we explain the key linkages between Friedman's work, including the relevance of a stable money-demand function, and the strategy adopted by the ECB. We also provide new evidence on the stability of euro-area money demand based on a framework that captures the effect of uncertainty on the demand for money, an idea first proposed by Friedman (1956).

The remainder of this paper is structured as follows. To set the stage, Section 2 provides an overview of Friedman's earlier research findings, which, as we show, underpinned his famous policy proposal for a constant money-supply growth rate, first published in 1958. Section 3 describes the monetary-policy strategy of the ECB, including the role of the

[1] The ECB's definition of price stability is given in Section 3.
[2] Elements of Friedman's thinking can be found in the monetary-policy strategies of other central banks, including those that follow inflation targeting. For an acknowledgement of Friedman's views in influencing the Federal Reserve's policy, see Bernanke (2002).

demand for money in that strategy; that section also describes the influence of Friedman's work on the ECB's monetary-policy strategy. We show that, although the finding in the mid-2000s by ECB economists that the demand for money in the euro area was no longer stable led to what the press reported as a "downgrading" of the role of money in the ECB's strategy, the role of monetary analysis in the ECB's strategy remains pivotal in assessing the outlook for future price developments. Section 4 turns to our analysis of euro-area money-demand. That section provides the basic theoretical framework we use to estimate money-demand. Unlike previous empirical studies of money-demand, we include a measure of economic sentiment to capture the effect of uncertainty on money-demand. As pointed-out by Friedman (1956), and as reflected in the capital asset pricing model, at times of declining confidence (or increasing uncertainty), any asset should yield an increased rate of return in order to compensate for the increased risk. If the rate of return does not rise to mirror the increase in uncertainty, there will be a flight into liquid assets, such as money. This confidence effect can be extremely important during times of crises. The recent crisis in the euro area provides an apt setting to test that hypothesis. Section 5 describes the two empirical methodologies we use to estimate euro-area money demand: (1) the workhorse vector-error-correction (VEC) approach, and (2) a generalized cointegration approach, which is estimated on the basis of a time-varying-coefficient (TVC) technique. Section 6 presents the empirical findings. To anticipate briefly, both empirical methodologies suggest that, taking account of uncertainty, the long-run demand for money in the euro area has been stable. We find that, although uncertainty is mean–reverting, it is none-the-less non-stationary, subject to wide swings and has substantial effects on the demand for money. Section 7 concludes with the implications for the ECB's monetary-policy strategy.

2. *How the Constant Money-Supply Rule was Formed*

Friedman joined the University of Chicago faculty in 1946 and remained at that institution until his retirement from teaching (and his move to the Hoover Institution) in 1977. He began collaboration with Anna Schwartz in 1948 on U.S. monetary history; around the same time that he began conducting a Workshop in Money and Banking at the University of Chicago.[3] He first proposed the constant money-growth rule in a 1958 paper, "The Supply of Money and Changes in Prices and Output", submitted to the Congressional Joint

[3] The collaboration with Schwartz resulted in this classic, *A Monetary History of the United States, 1867-1960*, published in 1963. In his initial correspondence with Schwartz, Friedman estimated that their project would be completed in three years. See Tavlas (2012), upon which the discussion in this section draws.

Economic Committee.[4] Friedman (1958, p. 174) stated that his aim was to summarize "the preliminary results" of his work with Schwartz and the series of studies conducted in the Chicago Workshop in Money and Banking, conducted under Friedman's direction. A main implication of those results is the need to distinguish between long-run, or secular, empirical relationships and short-run, or cyclical, relationships; the former tend to show considerable stability whereas the latter are subject to large uncertainty. The money growth-rate rule was formulated on the basis of long-run relationships. The following discussion draws on three studies: (1) the 1958 study presented to the Joint Economic Committee; (2) a 1959 paper, "The Demand for Money: Some Theoretical and Empirical Results", published in the *Journal of Political Economy,* and (3) a 1960 book, *A Program for Monetary Stability*, which was based on a series of lectures Friedman gave at Fordham University in 1959. The discussion focuses on those empirical findings that underpinned the money growth-rule.[5]

2.1 *The long-run*

Money and prices. The historical evidence suggests that there is a strong empirical regularity between changes in the stock of money per unit of output and changes in prices in the same direction. Friedman (1958, p. 173) noted that this regularity "tells nothing about direction of influence". However, the variety of monetary arrangements - - for example, the gold standard, flexible exchange rates, regimes with and without a central bank, changes in the structure of the Federal Reserve System and commercial banking, shifts in leadership of the Fed - - over which this regularity has been observed "supports strongly… [the view] that substantial changes in the stock of money are both a necessary and sufficient condition for substantial changes in the general level of prices" (1958, p. 173).

Definition of money. How should the money supply be defined? Friedman argued that "there is a continuum of assets possessing in various degrees the qualities we attribute to the ideal construct of 'money' and hence there is no unique way to draw a line separating 'money' from 'near-moneys'" (1960, p. 90). The "most useful concept" is that corresponding to currency held by the public plus adjusted demand deposits plus time

[4] The paper was published as part of the collected essays in Friedman (1969).

[5] It should be kept in mind that the Friedman and Schwartz evidence to which Friedman referred in these studies was preliminary. Moreover, during the 1960s Friedman's views on some of the issues discussed below, including the Great Depression, would undergo refinement. The data periods to which Friedman referred in these studies alternated among either 1867-1954, 1867-1957, and 1870-1954.

deposits in commercial banks[6] "because it seems *more closely related empirically* to income and other economic magnitudes than other concepts" (1960, pp. 90-91, italics supplied).

Output and prices. Historical evidence indicates that there is no clear-cut relation between price changes and output changes. The "only conclusion" that can be drawn from this evidence is that "either rising prices or falling prices are consistent with rapid economic growth, provided that the price changes are fairly steady, moderate in size, and reasonably predictable" (1959, p. 184). The underpinnings to economic growth are to be found in such factors as "available resources, the industrial organization of a society, the growth of knowledge and technical skills, the growth of population, the accumulation of capital and so on" (1959, p. 182). On average, over a period of 90 years (from 1867-1957), the average annual growth in output has been "something over three percent" (1960, p. 91).

Income velocity. Friedman (1959) reported empirical findings of his work with Schwartz on *secular* changes in the real money stock per capita and secular changes in real income per capita over the period 1870 to 1954 for twenty reference cycles measured from trough to trough. The observations consisted of average values of the variables concerned over the *complete* cycle. The findings showed that "secular changes in the real stock of money per capita are highly correlated with secular changes in real income per capita" (1959, p.113). The correlation coefficient between the logarithm of the real stock of money per capita and the logarithm of real income per capita was found to be 0.99 and the computed elasticity was 1.80 (1959, p.113). Hence, a one per cent increase in income per capita was, on average, associated with a 0.80 decrease in income velocity. Friedman noted that the high correlation could be a reflection of trends in the data so that the results might "not justify much confidence that the statistical regression is a valid estimate of a demand relation rather that the result of an accidental difference in trends" (1959, p.113). He noted, however, that "additional evidence from other sources leads us to believe that it can be so regarded" (1959, p.113).

In the same paper (1959), Friedman's (log-linear) estimation of the demand for money *corroborated* the above findings. The specification of the money-demand function consisted of the following elements: (1) the dependent variable was nominal cash balances (i.e., M2) per capita; (2) the explanatory variables were measures of permanent income, permanent prices and population; and, (3) the estimation period was 1870 to 1954. Using average values

[6] Subsequently, this measure corresponded to what became known as M2.

of the variables over the cycle (measured from trough to trough),[7] Friedman (1959, pp. 126-27) estimated an income elasticity of nominal cash balances of 1.810 which implied a velocity elasticity of -0.810. He then used these parameters to compute annual estimates of velocity, which he compared with the actual figures. He found that the estimates accounted for "the bulk of the fluctuations of measured velocity" (1959, p. 130). "These results", he argued, "give strong support to the view that cyclical movements in velocity largely reflect movements along a stable demand curve for money" (1959, p. 130).[8]

2.2 *The short run*

The foregoing secular empirical relationships, Friedman found, do not hold tightly within the business cycle. In his paper for the joint Economic Committee, Friedman (1958, p. 179) reported that his research with Schwartz revealed that, although there is a close link between monetary changes and price changes within the business cycle, "the direction of influence between the money stock and income and prices is less clear-cut and more complex for the business cycle than for the longer movements". This circumstance, he argued, reflected three factors.

First, "the character of our monetary and banking system means that an expansion of income contributes to expansion in the money stock, partly through inducing banks to trim more closely their cash reserve position, partly through a tendency for currency in public hands to decline relative to deposits" (1958, p. 179). Thus, Friedman argued that, during the business cycle, changes in the money supply are "a consequence as well as an independent cause of changes in income and prices" (1958, p. 179). Moreover, once a cyclical expansion or contraction is started the process is self-generating: "once they [changes in money, income and prices] occur, they will in their turn produce further effects on income and prices" (1958, p. 179).

Second, consideration of the timing of changes in the money supply, income and prices complicates the relationship among those variables, making it more difficult to infer an independent influence of monetary change within the cycle than for secular movements. Within the cycle, the relationship among these variables is subject to lags. His work with

[7] As Lothian (2008, p. 1089) pointed out: "By using reference-cycle averages as his basic units of observation, Friedman was able to focus on positions of long-run equilibrium. He, therefore, was able to get around to the problems of monetary endogeneity and the partially related econometric problems inherent in modelling short-run monetary adjustment."
[8] See, also, Friedman (1958, p. 175), which cited evidence on velocity behavior in papers by Cagan (1956) and Selden (1956), both of which were written for the Chicago Workshop in Money and Banking.

Schwartz provided quantitative estimates of the lags; the lags were found to be long - - on average, the rate of change in the money supply was found to have reached its peak nearly 16 months before the peak in economic activity and to have reached its trough over 12 months before the trough in economic activity - - and the lag lengths were found to have varied considerably from cycle to cycle (1958, p. 180; 1960, p. 88).

Third, and related to the previous factor, within the cycle, real shocks to velocity have been a source of economic fluctuations (1958, p. 89). Discretionary monetary policy in reaction to those shocks serves to amplify the effects of those real disturbances on the economy.[9] In the absence of the reaction of monetary policy, the shocks would merely constitute "the myriad of factors making for minor fluctuations in economic activity" (1959, p. 144).

2.3 *The policy rule*

The above evidence underpinned Friedman's proposal that the money supply - - defined as currency held by the public plus demand and time deposits in commercial banks (M2) - - should increase by between 3 to 5 per cent per year (1958, p. 184). The secular empirical relationships informed both the particular concept of money used and the numerical margins (*i.e.*, 3 to 5 per cent) of the growth range. Specifically, he chose M2 because of its close empirical relationship to "income and other economic magnitudes" (1960, p. 91).[10] During the period 1867-1957 output growth, Friedman noted, had averaged about 3 per cent a year, while velocity had exhibited a secular decrease of about 1 per cent a year (1958, pp. 184-85; 1960, pp. 90-91). Thus, "to judge from this evidence, a rate of increase [of M2] of 3 to 5 per cent per year might be expected to correspond with a roughly stable price level for this particular concept of money" (1960, p. 91).

Why conduct policy in terms of a rule instead of using discretion? In his 1960 *A Program for Monetary Stability*, Friedman (1960, p.86) argued that a rule would be easy to understand and would eliminate "the danger of instability and uncertainty of policy". Friedman (1960, p. 85) also argued that discretion absolves the policymakers of any criteria from which to judge their performance and leaves them vulnerable to political pressures (1960, p. 85). Finally, relying on the evidence of his work with Schwartz on short-term

[9] In a 1973 paper, Friedman argued that "if we knew about autonomous changes in the real demand for money, it would be right to adjust the money supply to them. However, we don't know about them" (Friedman 1973; quoted from Nelson, 2008, p. 101)

[10] Friedman (1960, p. 91) stated that "the evidence for this concept is certainly far from conclusive." In the early-1980s he switched to M1. Nelson (2007) provides a discussion of the reasons for the switch.

relationships, Friedman (1960, p. 85) argued that, in the past, discretion had led to "continual and unpredictable shifts in policy and in the content of policy as the persons and attitudes dominating the authorities had changed". A money growth rule, he believed, would have avoided the "excessive" mistakes of the past, including the collapse of money from 1929 to 1933, the discount-rate increases of 1931, and the resulting depression (1960, p. 93). It would not rule out mild cyclical fluctuations, but it "would almost certainly rule out…rapid and sizeable fluctuations" (1960, p. 92). Friedman (1960, p. 90) agued that the implementation of his money supply proposal has a further advantage; "it would largely separate the monetary problem from the fiscal [problem]". As discussed in the following section, the Friedman's empirical findings with regard to both the long-run and the short-run helped shape the monetary-strategy adopted by the ECB.

2.4 *The Phillips curve and expectations*

In addition to the above contributions made during the 1950s, another contribution by Friedman that would later have an impact on the ECB's monetary-policy strategy was Friedman's rebuttal of the traditional Phillips-curve notion that there exists a permanent trade-off between the unemployment rate and the inflation rate. Along with Phelps (1968), Friedman (1968) demonstrated that the steady-state unemployment rate is not related to the steady-state inflation rate when the Phillips relationship is augmented by a variable representing the expected inflation rate -- that is, labor negotiates on the basis of real, and not nominal, wages. Consequently, in the long run there can only be varying levels of the inflation rate – which, in turn, depend on the steady-state change in the money supply -- with the same "natural" level of the unemployment rate. This insight was a formalization of Friedman's earlier (1950s) research showing that, in the long-run, the monetary authorities can only control nominal values.

3. *The ECB's Monetary Policy Strategy*

As noted in the introduction, the primary objective of the ECB's monetary policy is to achieve price stability in the medium term.[11] The Governing Council[12] of the ECB defines

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[11] The meaning of medium term has not been precisely defined by the ECB.

[12] The ECB is governed by two main decision-making bodies - - the Governing Council and the Executive Board. The Governing Council is the main decision making body. It combines the six-member Executive Board (which includes the President and Vice President of the ECB) and the 17 governors of the National Central Banks of the Member States that have adopted the euro. The Governing Council usually meets twice a month in Frankfurt, Germany. At its first meeting each month, the Governing Council assesses economic and monetary developments and takes its monthly monetary policy decision. At its second meeting, the Council discusses issues mainly related to other tasks and responsibilities of the ECB.

price stability as a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the euro area of "below, but close to, 2 per cent in the medium term" (ECB, 2011, p. 64).[13] The ECB sees several advantages in this particular formulation of its policy objective (Issing and Tristani, 2005, pp. 62-64; Carboni, Hofmann and Zampoli, 2010; ECB, 2011, pp. 64-67). First, it is easy to understand, thereby contributing to the transparency of monetary policy. Second, it provides a yardstick with which to gauge the ECB's performance, thus providing accountability. Third, it provides an anchor for the formation of price expectations, under the assumption that expectations of inflation are a key determinant of actual inflation. Fourth, it provides a "safety margin" between the price-stability objective (below, but close to, 2 per cent) and zero inflation. Fifth, it helps deal with the issue of the possible presence of upward measurement-error bias in the HICP, whereby, the measured inflation rate may over-estimate the "true" inflation rate because the former does not adequately reflect such factors as improvements in the quality of products. Sixth, because the definition does not specify a precise numerical objective, it provides some allowance for inflation differentials within a monetary union comprised of heterogeneous countries.

3.1 *The influence of Friedman*

Many of the foregoing advantages attributed by the ECB to the formulation of its policy objective have been influenced, explicitly or implicitly, by Friedman's work.[14] In this regard, consider the following influences.

- As noted above, the main objective of Friedman's money-growth rule was to eliminate policy uncertainty. In explaining the rationale for the ECB's monetary policy strategy, Issing, Gaspar, Angeloni, and Tristani (2001, p. 99) stated: "the structure of any monetary policy strategy must reflect the extent and the nature of the uncertainties faced by the central bank. Different prevailing sources of uncertainty will normally require different strategies, i.e. differences in the way information is processed in order to attain policy decisions. The ECB strategy, in particular, was tailored having specifically in mind the uncertainties existing in the conduct of the single monetary policy…."

[13] The HICP is a weighted average of price indices of the member states of the euro area. Its coverage includes goods and services consumed. The index measures the change in expenditure necessary to maintain unchanged, with respect to a base period, the consumption pattern of households and the composition of the consumer population. See Issing, Gaspar, Angeloni, and Tristani (2001, pp. 51-53).

[14] It is important to note that the ECB's monetary-policy strategy reflects a broad range of contributions other than those of Friedman. For a good discussion, see Issing, Gaspar, Angeloni, and Tristani (2001, pp. 32-46).

- Friedman expressed the view that an advantage of his constant money-growth proposal was that it would be easy to understand, while holding policymakers accountable for their actions (Friedman, 1960, pp. 85-90). The ECB's medium-term price-stability objective is based, in part, on the criteria of transparency and accountability.
- The ECB's emphasis on the price level -- a nominal magnitude -- "echoes recommendations put forward by Milton Friedman" [that] the monetary authority can control nominal, but not real, variables (Issing and Tristani, 2005, p. 10)
- The medium-term orientation is an explicit acknowledgement "that Milton Friedman's assertion about the long and variable lags of the [monetary] transmission mechanism remains valid" (Issing and Tristani, 2005, p. 29). It is also an acknowledgement of "the possibility emphasized by Friedman… that counter-cyclical policy may actually increase instability in economic activity" (Issing, Gaspar and Vestin, 2005, p. 120).
- As mentioned above, Friedman wrote that it was important to maintain a clear separation of monetary policy from fiscal policy. Article 123 of the Treaty of the Functioning of the European Union (the Treaty), which is the legal basis of the ECB's setting of monetary policy, prohibits the monetary financing of fiscal actions, thereby drawing a clear line of separation between monetary policy and fiscal policy (ECB, 2011, p. 15).
- An objective of Friedman's (1960, p. 93) money-growth rule was to provide independence for the monetary authorities. Article 130 of the Treaty lays down an "institutional framework for the [ECB's] monetary policy [under which the] central bank … is independent from political influence" (ECB, 2011, p.14).[15]
- The idea that expectations of inflation are a key determinant of present inflation is directly related to Friedman's (1968) augmentation of the Phillips curve, under which the actual inflation rate was shown to be dependent on a variable representing the expected inflation rate.

[15] The ECB's monetary-policy strategy was, to a substantial extent, based on the earlier strategy of Germany's Bundesbank. Issing and Tristani (2005, p. 50) discussed the influence of Friedman on the Bundesbank's strategy.

3.2 *The two-pillar approach*

In pursuing its objective of price stability, the ECB's Governing Council regularly assesses risks to price stability on the basis of two organizing perspectives - - known as the "two pillars". The first pillar is the "economic analysis", which assesses the short-term to medium-term influences on price developments, with a focus on the real-activity and cost factors (e.g., wages, oil prices) driving prices over these horizons. The focus of this pillar is on the interplay of supply and demand in the goods, services and factor markets. The second pillar is the "monetary analysis". It exploits the long-run link between money and prices, and serves as a "cross-check, from a medium-term to long-term perspective, on the short-term to medium-term assessments derived from the economic analysis" (ECB, 2011, p. 69). This longer-run link between money and inflation was expressed by Issing (2008, p. 105) as follows: "The close relationship between the money supply and prices has been proven in countless studies all over the globe and all through history… Milton Friedman expressed this insight in a nutshell: inflation is always and everywhere a monetary phenomenon. In his analysis there is no case where a significant change in the quantity of money per unit of output has not been associated with a significant increase in the price level".

The two pillars comprise complementary perspectives of the determinants of inflation (Carboni, Hofmann, and Zampoli, 2010, p. 57). As mentioned, the economic-analysis pillar seeks to identify risks to price stability at short to medium-term horizons. The monetary-analysis pillar seeks to identify risks to price stability at medium to long-run horizons. As is the case with the economic analysis, the monetary analysis is broad-based in that it takes into account information provided by a wide range of monetary indicators, including interest rates, asset prices, and various definitions of the money supply and their components and counterparts - - for example, credit and several measures of excess liquidity (Carboni, Hofmann, and Zampoli, 2010, p. 57). As the ECB's then-President Trichet (2006) put it: "the European experience - - both before and after the euro - - suggests that assigning an important role to money in monetary policy deliberations and communications in practice, helps to serve precisely those principles that modern monetary policy literature holds dear ... [when] the economic analysis is complex and its conclusions uncertain, cross-checks with the monetary analysis have proved extremely useful."[16]

At the inception of the ECB, that institution announced a "reference value" for monetary growth. An aim of the reference value was to help account for the long-run

[16] For a detailed discussion of the monetary-analysis pillar, see Drudi, Moutot and Vlassopoulos (2010).

relationship between money and prices. The construction of this reference value followed closely Friedman's construction of a money-growth rule. From the various definitions of money, that aggregate was chosen that has demonstrated the "best fit" with prices (Issing, 2008, p. 108). On the basis of the "best-fit" criterion, a broad measure of money, M3, was selected: M3 consists of currency in circulation plus overnight deposits (M1) plus deposits with agreed maturity of up to two years (M2), plus repurchase agreements plus money market fund shares plus debt securities up to two years[17]. The trend growth of real GDP was estimated by the ECB to be between 2 to 2.5 per cent per year and the trend (decline) in velocity was estimated to be 0.5 to 1.0 per cent per year. Based on these estimates, and the definition of price stability (annual inflation close to, but below, 2 per cent), the ECB set a reference value for M3 growth of 4 ½ per cent per year.

Several aspects of the M3 reference value are important to mention. First, the reference value is a medium-term *norm* rather than a monetary *target* (ECB, 1999; Issing, Gaspar, Angeloni, and Tristani, 2001); deviations of M3 growth from the reference value do not entail a commitment to correct the deviations (Issing, 2008, p. 108). Second, as noted, in addition to the reference value the monetary pillar is comprised of a broad array of monetary and financial-market data, including various credit aggregates and interest rates. Third, as discussed above, the M3 reference value is, in part, predicated on a stable M3 demand function. In this connection, for many years following the inception of the euro on January 1, 1999, euro-area consumer price inflation was close to 2 per cent, with little volatility, while M3 growth was almost always above its reference value, peaking at 12½ per cent (year-on-year) in late 2007 (Figure 1), implying that the relationship upon which the 4½ per cent reference value for M3 growth was based was no longer valid. Correspondingly, the consensus view that emerged from virtually all euro-area empirical money-demand studies beginning from the early 2000s was that of an unstable M3 demand function (e.g., Beyer, Fischer, and von Landesberger, 2007; Fischer, Lenza, Pill, and Reichlin, 2007; Fischer and Pill, 2010).

The impact of the finding of an unstable money-demand function for the ECB's monetary analysis was highlighted at an ECB conference on "The Role of Money: Money and Monetary Policy in the Twenty-First Century", in Frankfurt in November 2006. At that conference, ECB staff acknowledged that M3 demand functions had broken down,

[17] The sample period used by the ECB to estimate the "best-fit" criterion typically begins in 1980. Since euro-wide data were not available prior to the start of the euro area on January 1, 1999, data extending backward to 1980 were constructed "synthetically".

prompting some press commentators to infer that the role of money-demand had been downgraded. Thus, the German newspaper, *Handelsblatt* (November 10, 2006), reported on the conference proceedings as follows:

> The ECB managed to bring together most of the leading academic experts in monetary policy to present papers on and discuss the role of money in monetary policy….The ECB's [then] Director General for Research, Lucrezia Reichlin, presented a paper co-authored with three ECB colleagues, in which she presented some hitherto unpublished information about the development of monetary analysis within the ECB. The paper … contained a comparison of the accuracy, bias and volatility of inflation forecasts derived from monetary and other indicators….. Reichlin stressed that the ECB had found money demand not to be stable and had consequently downgraded the role of money demand functions in its analysis.

The *Financial Times* (November 10, 2006) reported on the same conference as follows:

> The ECB's "monetary pillar," largely inherited from Germany's Bundesbank, is controversial among economists because of confusion about the implications of money supply for inflation. At the ECB-hosted conference, prominent officials from the Frankfurt institution made clear that they saw significant scope for refinements….ECB research presented at the conference was open about the shortcomings of the bank's monetary analysis in its eight-year history (Atkins, 2006).[18]

Reflecting the above developments, with regard to money-demand during the past ten years or so the ECB has changed the role of the M3 reference value.

- From 1999 until 2003, the ECB conducted annual reviews of the reference value. Those reviews signaled that the ECB attached importance to the concept of a reference value.
- In order to highlight the medium-term context of the ECB's monetary-policy strategy, the annual reviews were discontinued in May 2003. This discontinuation implied that the M3 reference value was assigned a smaller role than previously under the monetary-analysis pillar.
- Subsequently, the role of the reference value was subsequently diminished further. As a result, the ECB presently uses deviations of M3 from the reference value as a "trigger" for "increased efforts to identify and assess the nature and persistence of

[18] The paper upon which Reichlin's presentation was based was a co-authored paper; the co-authors were Fischer, Lenza, Pill, and Reichlin (2006). The paper itself, while acknowledging the breakdown of euro-area money-demand relationships, stressed the importance of monetary factors and the need to develop new tools to assess the impact of monetary factors on the economy.

the forces responsible" (ECB, 2011, p. 80). Effectively, the reference value no longer has any direct impact on ECB decision-making.

In light of the importance attached to the finding of an unstable money-demand function in the developments described above, a question that arises is: How robust is that finding? To address this question, beginning in 2007, the ECB set-up a research program that created an organizational framework for the "enhancement of [the ECB's] monetary analysis" (Papademos and Stark, 2010, p. 8). Essentially, the enhancement involves (1) a *deepening* of monetary-analysis pillar through the development of new analytical tools that explore the relationship between monetary trends and underlying inflation dynamics, and (2) a *broadening* of the monetary-analysis pillar to assess the interaction of monetary variables with a wider set of economic and financial factors (Papademos and Stark, 2010, p. 9). In light of the role played by money-demand equations to the ECB's monetary-analysis pillar,[19] one of the major objectives of the enhancement program has been to provide a means for "improving models of euro area money demand" (Papademos and Stark, 2010, p. 8).[20] We provide our contribution to this issue in what follows.

4. *Theoretical Underpinning*

We consider euro-area money demand in the spirit of the framework proposed by Friedman (1956) and Brainard and Tobin (1968). Those authors postulated that money, like any asset, yields a flow of services to the agents who hold it. As under the usual theory of consumer choice, Friedman (1956, p. 4) argued that the demand for money depends on three major sets of factors: (1) total wealth - - the analogue of the budget constraint, and comprised of both non-human capital and human capital, (2) the price of, and return to, wealth[21], and (3) the tastes and preferences of the wealth-owning units. He also argued that the proportion of wealth held as money is likely to be affected by the level of uncertainty. Friedman (1956, pp. 8-9) wrote: "it seems reasonable that, other things the same, individuals want to hold a larger fraction of their wealth in the form of money when they are subject to

[19] Fischer and Pill (2010, p. 131) wrote: "Money-demand models are the workhorse of [the ECB's] monetary analysis, playing an unglamorous but crucial role in any comprehensive framework for the assessment of monetary conditions."

[20] Of the two press reports cited above on the November 2006 ECB conference - - those of *Handelsblatt* and the *Financial Times* - - the latter was more accurate about the implications of the conference for the ECB's monetary-analysis pillar. Although money-demand models had been found to have broken down, the ECB responded by attempting to improve those models.

[21] Friedman (1956) specified a money-demand function in which the real quantity of money demand is a function of a vector of returns on alternatives to holding money-bonds, equities, physical goods, and human capital.

unusual uncertainty than otherwise. This is one of the major factors explaining a frequent tendency for money holdings to rise relative to increases in income during wartime."

Brainard and Tobin (1968) and Tobin (1969) also stressed the role of wealth in the money demand function. Those authors argued that, in contrast to conceptual approaches that treat income and wealth interchangeably as determinants of money demand, an increase in wealth results in increases in the demand for all assets, whereas an increase in income increases the demand for money at the *expense* of other assets. Therefore, both income and wealth belong in the money-demand function. We follow the Brainard-Tobin approach in this paper.[22]

Specifically, we use a portfolio-balance model to estimate the demand for money. Assuming that the asset choices of investors involve money and equities, the demand for real money balances can be written as follows (where the symbols above the explanatory variables indicate the expected direction of influence on real money balances):

$$m - p = f(\overset{+}{y}, \overset{+}{w}, r^m \overset{+}{-} \dot{p}^e, r^e \overset{-}{-} \dot{p}^e, lesi) \qquad (1)$$

where m is the log of nominal M3, p is the log of the price level, y is the log of real income, w is the log of the real value of wealth, r^m is the own rate of return on money, $\dot{p}^e$ is the expected inflation rate, r^e is the opportunity cost of holding money balances, and, reflecting Friedman's (1956) emphasis on the role of uncertainty on money-demand, *lesi* represents investors' confidence (which we define below). In equation (1), real rates of return are approximated by nominal rates minus the expected inflation rate.

We also assume rate-of-return homogeneity of degree zero, implying that, if all rates of return change by *x* per cent, real quantities of assets in investors' portfolios relative to real income and real wealth will not change. Thus, only rates-of-return differentials affect money demand. Rate-of-return homogeneity implies that we can use interest differentials, selecting one of the assets as numeraire; we use *m* as a numeraire. Therefore, the money-demand function can be re-written as:

$$m - p = f(\overset{+}{y}, \overset{+}{w}, r^e \overset{-}{-} r^m, lesi) \qquad (2)$$

When *f* is semi-log linear, the money-demand function becomes:

[22] Friedman (1956, pp. 4-9; 1959) considered permanent income to be the relevant measure of wealth in the demand-for-money function. In addition to permanent income, he argued that a variable capturing the ratio of wealth-to-income should be included in the money-demand function. We use a wealth-to-income variable in what follows.

$$m - p = a_0 + a_1 y + a_2 w + a_3 (r^e - r^m) + a_4 lesi + u \qquad (3)$$

where u is an added error term.

We would expect this scale effect to have long-run unit elasticity. This would imply that the coefficients on income and wealth should sum to unity. By reparameterizing this into an income variable and a wealth to income ratio variable we make it easy to test or impose this effect, as now the coefficient on income is the scale effect (which should be unity), and the coefficient on the ratio of wealth to income captures the effect when income and wealth move separately. This reparameterization is not a restriction on the model until we impose the unit effect; it is simply an easier way of expressing the same thing. Thus, adding and subtracting $a_2 y_t$ on the right-hand side of (3) gives:

$$m - p = a_0 + a_1' y + a_2 (w - y) + a_3 (r^e - r^m) + a_4 lesi + u \qquad (4)$$

where $a_1' = a_1 + a_2$.[23]

5. *Methodology*

In the empirical analysis, we employ two quite distinct methodologies, one of which is now well-established in the literature and one of which is relatively novel. The first technique is the well-known vector error correction (VEC) approach, which involves testing for cointegration in the usual way and then building a dynamic system of cointegrated equations (Johansen, 1995; Davidson and Hall, 1991). The second approach uses the concepts of generalised cointegration (Hall, Swamy and Tavlas, 2012a) and time varying-coefficient (TVC) estimation (see Swamy, Tavlas, Hall and Hondroyiannis, 2010); this approach allows for consistent estimation of models in the presence of an unknown true functional form, omitted variables and measurement errors. We present intuitive descriptions of the two approaches in what follows.

5.1 *The VEC methodology*

The VEC methodology has become a workhorse of empirical research (see Cuthbertson, Hall and Taylor, 1991; Greene, 2008 among others). This approach aims to identify a set of variables which, together, form a stable long-run relationship. If such a

[23] Our specification is identical to that derived by Tobin (1969, p. 20, equation (I.2)), except that Tobin included the ratio of income to wealth rather than the ratio of wealth to income.

relationship is found to exist, the variables are said to cointegrate.[24] This methodology is, therefore, of particular relevance to the task at hand here since the existence, or absence, of cointegration essentially determines the existence of a satisfactory and usable money-demand function. This methodology is, however, limited in certain ways by its basic set-up. Cointegration has been largely developed within a linear (or log-linear) framework and so it cannot easily allow for other (nonlinear) functional forms, unless the precise nonlinear functional form happens to be known. Moreover, if an important variable is missing from the set of variables under consideration, then the researcher may conclude that there is no cointegration. This finding, of course, may be true about the set of variables under consideration, but it may not be true of the real world. For example, a researcher may test to find whether cointegration exists among three variables - - say, real money balances, real income, and wealth - - and find that those three variables do not cointegrate. The researcher might then conclude that a stable relationship among these variables does not exist. In so far there may exist a fourth variable whose inclusion with the other three variables would have provided a cointegrating relationship, the researcher's inference on the basis of just the three variables would have been misleading. In other words, we might find no cointegration between a set of variables and conclude that there is no stable money-demand function. However, this finding may simply indicate that we have not found the appropriate set of variables and that, in fact, money demand is stable. Consequently, much of the work in the VEC tradition becomes a search for a suitable set of variables which both cointegrates and provides a good model of the relationship under consideration.

5.2 *Generalised cointegration and TVC estimation*

The other approach we use is less well-known and so we will provide an intuitive account of the ideas used; we will also provide references to a formal exposition. Both generalised cointegration and TVC estimation precede from an important theorem which was first established by Swamy and Mehta (1975), and, which has subsequently been confirmed by Granger (2008). This theorem states that any nonlinear functional form can be exactly represented by a model that is linear in variables but which has time-varying coefficients. The implication of this result is that, even if we do not know the correct

[24] Suppose that the variables - - say, real income, real money balances, and wealth - - in a money-demand equation are each non-stationary and integrated of order one. The finding of cointegration would mean that the error term in the money-demand equation is stationary.

functional form of a relationship, we can always represent this relationship as a time varying-parameter relationship and, hence, estimate it.

This theorem underlies the idea of the concept called generalised cointegration (Hall, Swamy and Tavlas, 2012b), which relaxes some of the stringent assumptions of standard cointegration analysis. In particular, generalized cointegration does two things. First, it allows for the possibility that we may have important omitted variables. Second, it allows for the possibility that we may have misspecified the functional form we are estimating. That is, under generalized cointegration we are able to estimate unbiased relationships among a set of variables even if we don't know the true, underlying functional form and even if there are missing variables. To go back to the previous example of a money-demand function comprised of just three variables (real money balances, an interest rate, and wealth), generalized cointegration works by estimating a relationship that does not contain specification errors (such as omitted-variable biases). Underlying generilized cointegration is a new way of thinking about, and testing for, cointegration that emphasises the properties of the real world rather than a particular model. If, in the real world, a causal cointegrating vector exists which determines a variable, say, money, then, obviously, if one of the variables (say X) in that relationship changes, money will also change. This implies that the partial derivative of money with respect to X is non-zero. Thus, if we had a way of obtaining consistent estimates of this partial derivative and testing to see if it is indeed non-zero, this would give us a way of testing for the presence of cointegration in the real world (rather than just between an arbitrary set of variables). So, we might be able to assert that there is a stable money-demand function in the real world, even though we do not know its exact functional form and/or all the variables that comprise that relationship. This would still be a very useful statement to make from a policy perspective, although, obviously, not as useful as knowing the complete form of that relationship.

Of course, this is asking a great deal of an estimation technique. However, that is precisely what TVC estimation aims to provide (Swamy, Tavlas, Hall and Hondroyiannis, 2010). This technique builds from the Swamy and Mehta theorem, mentioned above, where it turns out that the time-varying coefficients in a model without omitted variables or measurement error are consistent estimates of the partial derivatives of the unknown non-linear functional form. So, in the absence of other misspecification testing, the significance of the time-varying coefficients would be equivalent to testing for generalised cointegration.

Swamy, Tavlas Hall and Hondroyiannis (2010) show exactly what happens to the time-varying coefficients as other forms of misspecification are added to the model. If we allow for the presence of some omitted variables from the model, then the true time-varying coefficients get contaminated by a term which involves the relationship between the omitted and included variables. Also, if we allow for measurement error, then the time-varying-coefficient gets further contaminated by a term which allows for the relationship between the exogenous variables and the error terms. Thus, as one might expect, the estimated time-varying coefficient is no longer a consistent estimate of the true partial derivatives of the non-linear function, but is now biased due to the effects of omitted variables and measurement error. There are exact mathematical proofs provided for our statements up to this point.

To make TVC estimation fully operational, we now need to make some parametric assumptions. We make two key assumptions; first, we assume that the time-varying coefficients themselves are determined by a set of stochastic linear equations which makes them a function of a set of variables which we call driver (or coefficient-driver) variables. This is a relatively uncontroversial assumption. Second, we assume that some of these drivers are correlated with the misspecification in the model and some of them are correlated with the time-variation coming from the non-linear (true) functional form. Having made this assumption we can then simply remove the bias from the time-varying coefficients by removing the effect of the set of coefficient drivers which are correlated with the misspecification. This procedure, then, yields a consistent set of estimates of the true partial derivatives of the unknown nonlinear function, which may then be tested by constructing ‘t’ tests in the usual way. An important difference between coefficient drivers and instrumental variables is that for a valid instrument we require a variable which is uncorrelated with the misspecification. This often proves hard to find. For a valid driver we need variables which are correlated with the misspecification and we would argue that this is much easier to achieve.

These consistent (or bias-free) estimates may then be used to test for generalised cointegration, even in the presence of omitted variables. It is important to stress what is being claimed here, as well as what is not. This test aims to tell us whether or not there is cointegration in the real world, that is, whether there actually exists a stable function determining the variable of interest. It does not, however, tell us the complete form of that relationship or what the missing variables might be.

6. ***Estimation***

6.1 *Data*

The variables used include the following. Real money balances are broad money (M3) divided by the GDP deflator. Real income is proxied by real GDP. The opportunity cost of holding money is the long-term interest rate minus the own rate of return on M3. Because a long-run interest-rate series for the euro area as a whole does not exist for the entire estimation period, which begins with 1980:Q1, we used the rate on the ten year German sovereign bonds for the long-term rate. The series for the own rate of return on M3 was constructed by ECB staff, who provided us with that series. The source of the other above data is the ECB Statistical Data Warehouse, which contains (synthetic) euro-area data beginning with 1980:Q1. The estimation periods are the pre-crisis sample, 1980:Q1-2006:Q4, and the full sample, 1980:Q1-2009:Q4, the latter of which includes the initial stages of the international financial crisis. All variables other than the opportunity cost variable are in terms of logs.

We use two wealth series to capture the effect of wealth on money-demand -- financial wealth and housing wealth. Financial wealth is total financial assets (currency and deposits, debt securities, shares and mutual fund shares, and insurance reserves) held by households and non-profit institutions serving households. Original series are from the euro area quarterly sectoral accounts for the period since 1999 (these are available at a quarterly frequency), from the monetary union financial accounts for the period 1995-1998, and from national sources for the period 1980-1994. Housing wealth is total housing held by households and non-profit institutions serving households. Housing wealth data are at current replacement costs net of capital depreciation based on ECB estimates. Both series refer to the euro area at a fixed composition of 15 members. For the periods prior to the introduction of the euro, the respective irrevocable exchange rates have been used. The two wealth series and the opportunity cost series were provided to us by ECB staff; the two wealth measures are available only on an annual basis; we interpolated these data to a quarterly frequency using a cubic spine.

Why include the two measures of wealth separately rather than a composite wealth variable? After all, the money-demand theory described above includes only a single aggregate measure of wealth.[25] However, as we show below, financial wealth has been more volatile than housing wealth. Given that the volatility properties of the two measures of wealth have been quite different, it seems reasonable to hypothesize that the effects of the two components of wealth on money demand might be different. For example, if money demand responds to permanent income and wealth, then short-term movements in financial markets may have a very different impact on an individual's perceived wealth than short-term movements in the housing market. In any case, the issue is empirical and is addressed in the results presented below.

6.2 *VEC Results*

As a point of departure, we begin by specifying a general vector autoregressive model (VAR) and then reparameterise this into a vector error correction (VEC) model.[26] This allows us to both test and impose the appropriate cointegrating rank on the system[27]. A problem encountered in estimating euro-area money demand with the above data is illustrated in Figures 2 and 3. Figure 2 shows the velocity of M3 during 1980:Q1-2009:Q4; velocity shows a clear downward trend, which is normally explained by the growth in wealth (housing and financial) relative to total income. However, at the end of the period velocity clearly reverses course and moves upward. Figure 3 focuses on the period 2005:Q1-2010:Q4; the figure shows the annualized growth rates of real money, real GDP, and the ratios of housing wealth-to-GDP and financial wealth-to-GDP. As would be expected, GDP and the wealth ratios typically sum to around the same growth rate as real money, but from

[25] To our knowledge, the first empirical study to include wealth in a money demand specification for the euro area was by Hall, Hondroyiannis, Swamy and Tavlas (2007). Those authors used a single wealth variable. In the absence (at that time) of the availability of a wealth variable for the entire euro area, they constructed a wealth variable on the basis of stock-market valuation. They found that the demand for money was stable over the period 1980:Q2 – 2006:Q4.

[26] The time series properties of all the variables were evaluated employing standard unit-root tests - - the augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski et al. (KPSS) test. All these tests suggested that real money, real income, the ratio of real financial wealth to real income, the ratio of real housing wealth to real income and the confidence index were (unit-root) non-stationary, while their first differences were stationary. The spread between the interest rate variable and the own rate on M3 was I(0). Consequently, the interest rate spread was not included into the cointegrating relationship, although it was included with the VEC as part of the error-correction process. Because we focus on the I(1) analysis, real money balances, real income, the ratios of real financial and housing wealth to real income, and the confidence variables were included as I(1) variables in the vector autoregressive VAR specification. The interest rate spread was included as an exogenous variable, which was lagged so as to line up with the cointegrating vectors; since it is stationary, it cannot affect the cointegration among the other variables.

[27] This is done by setting up an unrestricted VAR estimation and testing this VAR for, misspecification and the co-integrating rank among the variables. To determine the lag length of the VAR model, alternate versions of the system were initially estimated using different lags. An Akaike information criterion, a Schwartz Bayesian criterion, and a Hannan-Quinn criterion were used to determine the lag length. Finally a VAR model of order two was used in the estimation procedure. For a discussion of these tests, see Maddala and Kim (1998, pp. 45-146).

the beginning of 2007 until the end of 2008 the growth rate of money exceeds the sum of the other variables, and by considerable amounts. Clearly, something else, besides wealth and income, is impacting on real money balances during the latter period.

Another way to illustrate the above argument is to test whether the variables real money, real GDP, and the two wealth-to-GDP ratios cointegrate. To determine whether there is cointegration, we have (1) used normalization restrictions on money and real GDP (i.e., we put real money balances on the left-hand-side of the first cointegrating vector, and we put real GDP on the left-hand-side of the second cointegrating vector), (2) imposed the income effect in the money equation to be unity, and (3) excluded money from the GDP equation (i.e., the second cointegrating equation). Consider, first, the period 1980:Q1 through 2006:Q4, i.e., the period ending just before the outbreak of the international financial crisis. As reported in Table 1, there are at least two cointegrating vectors over that period. However, extending the data sample by three years, i.e., 2007:Q1 through 2009:Q4, suggests that there is no cointegration among the same four variables.[28] The failure to cointegrate over the extended sample period is reflected in Figures 4 and 5, which show the recursive residuals and the standard CUSUM test. [29] Both tests clearly show that the model is stable up to around 2006, but then become highly unstable over the remainder of the period.

6.3 *The role of confidence*

What happened over this latter period? One possibility is that the crises in the international financial system caused a flight into money. Specifically, heightened uncertainty may have led to an increase in the precautionary demand for money, a safe asset. In this regard, an issue that arises is whether we can measure this uncertainty effect with reasonable accuracy.

Although earlier writers such as Friedman (1956) stressed the role of confidence in their discussions of money demand, those writers were not able to use measures of confidence in their applied work because relatively-long times series on measures of

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[28] We do not report these results for the period ending in 2009:Q4 in Table 1. The augmented Dickey-Fuller (ADF) test statistic is -2.95, compared with a 5 per cent critical value of -4.80. Therefore, we fail to reject the null hypothesis that there is no cointegration. For the ADF test, we included a split time trend starting in 2002 to proxy the change in behavior that occurred after the introduction of the euro, a dummy that takes a value of unity from 2002 to the end of the sample period, and the opportunity cost of holding M3 minus the own rate on M3 (which is stationary). These variables were included to make the results comparable with the VEC results reported in what follows.

[29] The CUSUM test will not have the standard critical values for a cointegrating regression but the instability is obvious.

confidence were unavailable to them. This situation has carried over - - to the best of our knowledge - - to all subsequent empirical work, despite the fact that time-series indicators of confidence have become available for most economies since the early 1990s, if not earlier. To capture the effect of confidence on euro-area money demand we used the euro-area economic sentiment indicator (ESI) compiled by European Commission service. The ESI is a composite indicator made up of five sectoral confidence indicators with different weights: industrial confidence (40 percent), services confidence (30 percent), consumer confidence (20 percent), construction confidence (5 percent), and retail-trade confidence (5 percent). The ESI is available on a monthly frequency from 1986:1. For this study, it was converted to a quarterly frequency. A plot of the level of ESI is shown in Figure 6. As shown in that figure, the series on confidence tends to exhibit wide swings; it is non-stationary, but none-the-less exhibits mean-reverting behaviour.[30] Of particular interest is the sharp decline in the ESI that began in early 2007 and lasted through the end of 2008. During the crises, the sentiment indicator fell from a peak of 110 to about 70, a fall of around 36 per cent.

We now turn to the formal VEC analysis with the confidence effect for the full sample period, 1980:Q1-2009:Q4. As above, we construct a VAR system with the I(1) variables forming a vector of four endogenous variables: real money balances (*m-p*), real GDP (*y*), the ratio of real housing wealth to real GDP (*wh-y*) and the ratio of real financial wealth to real GDP (*wf-y*). The log of the ESI index (*lesi*) was treated as an exogenous variable in the vector error correction system (VEC), under the (reasonable) presumption that confidence is typically affected by overall economic and financial conditions, and not by real money balances. The spread between the ten year German bond rate and the own rate on money (*r10-rm*) is not in the cointegrating vector, as it is stationary, but it is in the dynamics at lag minus 1 to line up with the cointegrating vector; it may be reinterpreted as part of the long-run solution. Following our previous procedure, we also included a split time trend and a shift dummy starting in 2002 to the end of the sample to proxy the change in behavior that occurred after the introduction of the euro; both dummy variables are lagged one period to line up with the error correction mechanism.

The number of co-integrating relationships in the system was tested using the Johansen procedure (Johansen, 1995). These results are reported in Table 2, which shows that at a 1 per cent significance level there are two cointegrating vectors; the table shows the just identified vectors where we have again (1) used normalization restrictions on money and real

[30] In technical terms, uncertainty acts as a fractionally-integrated process.

GDP (i.e., we put real money balances on the left-hand-side of the first cointegrating vector and we put real GDP on the left-hand-side of the second cointegrating vector), (2) imposed the income effect in the money equation to be unity, and (3) excluded money from the GDP equation (i.e., the second cointegrating equation). The finding of two cointegrating vectors is an important result in itself, as it illustrates that with the confidence variable we now have cointegration for the entire period. Thus, we do not get a breakdown in the model by including the crises period as we did when the confidence variable was not included. The error correction coefficient on the first cointegrating vector is both significant (the t-ratio is 4.7), correctly signed, and reasonably large (0.16), and the error correction equation for money is well specified.[31] In the full VEC system, we also find a fairly large role for the interest rate differential variable.

What about the role of confidence? The long run effect of the confidence variable is -0.037. Given the 36 per cent decline in the confidence indicator during 2007 and 2008, the estimated coefficient of the confidence variable in the cointegrating vector suggests that this would have caused an increase in the demand for money of around 1.3 per cent based on the precautionary effects discussed above. For much of the period from 2007:Q1 through 2008:Q4, the growth rates of income and the two wealth variables were negative, which acted to reduce the demand for money. Therefore, the confidence effect helps to explain why real money growth, which was falling during those two years, nevertheless remained positive. In 2009 the confidence index reversed course and increased from around 70 to about 90 (Figure 6). What happened to real money? As shown in Figure 2, income velocity rose in 2009; alternatively, real money balances declined (see, also, Figure 3). This is what we would expect - - a rise in confidence should decrease the demand for money. Moreover, the decline in real money took place during a time that both real income and financial wealth jumped upward, which, everything else held equal, should have increased real money-demand.

Figures 7 and 8 report the recursive residuals (from an OLS static regression) from the money cointegrating vector and the CUSUM test applied to this equation. These residuals should be contrasted with those reported in Figures 4 and 5, which show the corresponding residuals without the confidence variable. Both procedures illustrate that the money demand equation is now stable through the complete crises period.

[31] The complete results are available from the authors.

6.4 *TVC Results*

Next, we estimated the long-run money-demand equation using TVC estimation. The equation estimated is:

$$(m-p)_t = \alpha_{0t} + \alpha_{1t} y_t + \alpha_{2t}(wf-y)_t + \alpha_{3t}(wh-y)_t + \alpha_{4t} lesi_t + \alpha_{5t}(r10-rm) \qquad (5)$$

where the coefficients are time-varying. It is assumed that for j = 0, 1, 2, 3, 4, 5:

$$\alpha_{jt} = \pi_{j0} + \pi_{j1} z_{1t} + \pi_{j2} z_{2t} + \pi_{j3} z_{3t} + \varepsilon_{jt} \qquad (6)$$

where the π's are constants, the ε_{jt} are contemporaneously and serially correlated[32], and the z's are the coefficient drivers (in this case we use the lagged change in real money, the lagged change in GDP and the lagged opportunity cost variable). In light of the financial crisis beginning in 2007, we might expect that the total time varying coefficients could vary considerably at the end of the period, but that the biased free coefficients would remain stable.

Table 3 presents both the (average) total effects and the (average) bias-free coefficients. Recall, the bias-free estimates are those for which specification errors have been removed. In what follows, we focus on the bias-free estimates.[33] The (average) income elasticity is 1.17;[34] the null hypothesis that this elasticity equals unity cannot be rejected at the 1 per cent level. The coefficient on the opportunity cost variable is correctly signed and reasonably large; although somewhat smaller than the VEC estimate, it is significant at the 5 per cent level. The coefficient on the financial wealth-to-income ratio is positive and highly significant as is the coefficient on the housing wealth-to-income ratio. Specifically, the coefficient on financial wealth-to-income ratio is 0.09, compared with 0.38 under VEC; the TVC estimate of the bias-free coefficient on the housing wealth-to-income ratio is 0.43, compared with 0.44 under VEC. Thus, in contrast to the VEC results, the TVC results indicate that the demand for money responds quite differently to changes in financial wealth and to changes in housing wealth; changes in housing wealth have a much larger effect on the demand for money than do changes in financial wealth. The sum of the TVC coefficients on the two wealth-to-income ratios is 0.52, so that if the ratio of wealth-to-income were to

[32] See Swamy and Tavlas (2001, p. 419)

[33] With the exception of the confidence and the opportunity cost variables coefficient, the bias-free coefficients are on average very close to the total effect coefficients but, as we will show, much more stable.

[34] (1/T) $\sum_{t=1}^{T} \sum_{k \in A_{11t}} \hat{\pi}_{1k} z_{kt}$ = 1.17, where $\hat{\pi}_{1k}$ is an IRSGLS estimator of π_{1k} .

rise by 10 per cent, real money demand would be expected to rise by 5.2 per cent. Therefore, especially in periods of rapid rises in property values and/or equity prices, the omission of wealth variables in the money-demand specification can be a source of instability in that specification.

What about the effect of confidence on money demand? As reported in Table 3, the coefficient on the confidence variable is -0.29 and is significant; thus, a one per cent decline in confidence increases the demand for money by 0.29 per cent. An implication of this result is that the sharp decline in confidence observed during 2007-09, shown in Figure 6, contributed to an increase in the demand for money during that period. As mentioned above, the confidence index fell by about 36 per cent in 2007 and 2008. Everything else remaining the same, this decline in confidence would have led to about a 10 per cent increase in money demand, helping to explain why real money growth remained high during the crisis years. In 2009, the growth of real money balances declined sharply (Figure 3), and income velocity suddenly increased (Figure 2). Why did the growth of money demand decline? As shown in Figure 3, the growth of both real income and financial wealth turned sharply positive in 2009, while housing wealth was little changed. On balance, therefore, these factors should have caused a rise in the growth of real money balances. Yet, the growth of real money balances declined. The sharp rise in confidence explains this occurrence very well.

Figures 9 through 13 presents the time profiles of the total effect and the bias-free effect yielded by TVC estimation for the four variables, real GDP, the ratio of financial wealth to income, the ratio of housing wealth to income, and the confidence variable, respectively. A striking feature about these results is that the bias-free effect can be much more stable than the total effects, as illustrated in Figure 10, which reports the coefficients on the ratio of financial wealth-to-income. Another important feature is that some of the total time varying coefficients exhibit a strong instability in the last few years, which is completely eliminated in the bias free component. This again is consistent with the VEC result that confidence effects seem to have been very important over this period.

6.5 *Comparing the empirical methodologies*

The generalized, nonlinear cointegration technique by-and-large confirmed the results of the widely-used, linear VEC technique. Nevertheless, there are some differences.

- Under the VEC technique, we found that the sum of the two wealth coefficients was 0.82, and that the individual coefficients - - 0.38 for financial wealth and 0.44

for housing wealth - - were similar. Under the TVC procedure, the sum of the wealth coefficients was 0.52, and the individuals coefficients were quite different - - 0.43 for housing wealth and 0.09 for financial wealth. Consequently, the TVC results support our earlier conjecture that, because changes in financial wealth tend to be more volatile - - or, less sustainable - - than housing wealth, the changes in the former have less of an impact on the demand for money than changes in housing wealth. Economic agents view given changes in housing wealth to be more permanent than the same changes in financial wealth.

- Using both the VEC and the TVC techniques, we found that confidence has had a significant impact on money-demand, and, in the case of VEC, we found that it produces cointegration during the extended sample period (*i.e.*, ending in 2009:Q4). Again, however, there were substantial differences in the estimated coefficients. The confidence variable accounted for an increase in money-demand during 2007 and 2008 of about 1.3 per cent, whereas, under the TVC technique, the confidence variable accounted for an increase in money-demand of around 10 per cent. As shown in Figure 3, real money-demand rose at rates in the range of 6 to 8 per cent during 2007 and 2008, while the growth rates of income and the two wealth variables were often negative during those years. Consequently, the TVC estimate of the effect of confidence helps explain better than the VEC estimate why growth in money-demand remained at such high levels during those two years. The growth of real money balances declined in 2009, despite rises in the growth rates of real income and financial wealth. However, confidence rose sharply, which acted to reduce money-demand. Again, the larger (in absolute value) TVC coefficient on confidence is more consistent with the behavior of real money demand than is the relatively-small coefficient on confidence estimated on the basis of the VEC procedure.

- Moreover, there were important differences in implementing the techniques. To achieve cointegration using VEC we had to do the following: (i) restrict the income coefficient to unity, (ii) assume that the I(1) confidence variable is exogenous in the cointegrating vector, and (iii) include a split trend and another dummy variable, both beginning in 2002, to capture a change in structure that appears to have occurred three years *after* the introduction of the euro (in 1999); effectively, the trends capture non-linearities in the cointegrating relationship. In contrast, using the TVC procedure we were able to estimate coefficients of all the explanatory variables without introducing restrictions and without the need of a split trend to capture nonlinearities; the TVC procedure generalizes cointegration to nonlinear relationships.

6.6 *Parallels with Friedman's work*

There are some clear parallels between our work on money demand and the work of Friedman (1956, 1959). (i) We previously noted that Friedman (1956) stressed the role of uncertainty, which could lead to prolonged departures from money-demand equilibrium. We used a time series on confidence to measure uncertainty and found that it plays an important role in the money-demand function. (ii) Cointegration is inherently about long-run relationships. Similarly, Friedman's (1959) empirical work on money demand was inherently long-run: the empirical specification did not include a lagged dependent variable to capture adjustment costs (or to correct for serial correlation and/or improve explanatory power), a device that became a standard feature of empirical work beginning in the 1960s, the times series used covered a long horizon (i.e. 1869-1956), and the data abstracted from the business cycle, using average values of variables *over* the cycle.[35] (iii) Friedman stressed the role of wealth in the money-demand function, using permanent income as a proxy for wealth in the absence of the availability of a long-run series on wealth at the time that he wrote. Our results confirm the crucial role of wealth in the money-demand function.

7. *Conclusions*

In this paper, we provided an overview of the ECB's monetary-analysis strategy and of the pivotal role that monetary factors play in the assessment of medium-to-longer term prospects for price stability in the euro area. The ECB's monetary analysis goes beyond focusing on developments in M3. It also involves an assessment of various measures of money, as well as credit and financial flows, and asset prices. We have also demonstrated the many, direct connections between the contributions of Milton Friedman and the monetary-policy strategy of the ECB.

[35] Friedman (1959, p. 119) wrote: "the long time period covered assures that movements in money are dominated by the movements in the permanent component of income." As mentioned above, Friedman (1959) did not include an interest rate in his money-demand function. Laidler (1966) carried out an exercise similar to that of Friedman, but included the rate of interest in his regressions. Laidler found that the inclusion of the interest rate improved the predictability of his regressions, confirming the importance of the interest rate as a determinant of the demand for money. Friedman (1966) acknowledged that the interest rate could have an effect on the demand for money.

A salient feature of the ECB’s strategy is that it has evolved over the years; the monetary-analysis pillar has been - - and continues to be - - broadened and deepened. While some emphasis was given to a reference value for M3 growth at the inception of the ECB, at the present time, the M3 reference value plays a relatively-minor role within the monetary-analysis pillar. One factor accounting for this development was the instability displayed by euro-area money-demand functions beginning around 2003. Our results, however, indicate that M3 demand, taking into account wealth and confidence, has been stable.

Since the stability of the money demand is crucial in assessing the longer-term relationship between money and prices, what are the policy implications of our results? To the extent that deviations in the equilibrium relationship between real money and its determinants are temporary, they can be expected to be self-correcting. In this connection, the international financial crisis of 2007 and 2008 led to a sharp drop in confidence, which contributed to a flight into money. The relatively-fast growth rate of euro-area real M3 during those two years was not indicative of an overly-expansionary monetary policy, but of the increase in the demand for money stemming mainly from the precipitous fall in confidence. Nevertheless, confidence tends to be mean-reverting; thus, the sharp rise in confidence in 2009 contributed to a decline in real M3 balances. Our findings, therefore, reinforce the importance of using money-demand analysis in a medium-to-longer term context.

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Table 1

Panel A: Test of cointegration , 1980:Q4-2006:Q4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.285051	72.79355	47.85613	0.0001
At most 1 *	0.202307	37.56147	29.79707	0.0052
At most 2 *	0.122488	13.82815	15.49471	0.0878
At most 3	0.001031	0.108303	3.841466	0.7421

Panel B: The two identified cointegrating vectors, 1980:Q4-2006:Q4

Cointegrating Eq:	CointEq1	CointEq2
m-p	-1.000000	0.000000
y	1.000000	-1.000000
wf-y	0.675699	1.002571
wh-y	0.013909	0.111447

Notes: m-p is M3 divided by the GDP deflator.
y is real GDP
wf-y is the ratio of financial wealth to real GDP.
wh-y is the ratio of housing wealth to real GDP.
All variables are in logarithms.

Table 2

Panel A: Test of cointegration using the confidence index, 1980:Q1-2009:Q4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.381902	97.02697	47.85613	0.0000
At most 1 *	0.187033	40.73725	29.79707	0.0019
At most 2 *	0.126006	16.51067	15.49471	0.0351
At most 3	0.006415	0.752930	3.841466	0.3855

Panel B: The two identified cointegrating vectors, 1980:Q1-2009:Q4

Cointegrating Eq:	CointEq1	CointEq2
m-p	-1.000000	0.000000
y	1.000000	-1.000000
wf-y	0.38	0.642
wh-y	0.44	0.53
lesi	-0.0337	0.00
R10-rm	-1.62	0.0
C	-1.437	17.24

Notes: m-p is M3 divided by the GDP deflator.
y is real GDP
wf-y is the ratio of financial wealth to real GDP.
wh-y is the ratio of housing wealth to real GDP.
lesi is the euro-area economic sentiment indicator.
R10-rm is the interest rate on 10-year German government bonds minus the own rate on money.
C is a constant term.
All variables except the interest rate are in logarithms.

Table 3

TVC Estimation of Long-Run Money Demand for Euro-Area

Variables	Total effects (1)	Bias-free effects (2)
Constant	-4.82	-4.8*** (-2.4)
y	1.21	1.17*** (2.1)
wf-y	0.08	0.09*** (2.2)
wh-y	0.41	0.43*** (2.8)
lesi	-0.12	-0.29*** (-2.3)
R10-rm	-0.1	-0.03** (1.8)
$\bar{R}^2$	0.99	0.99

Notes: m-p is M3 divided by the GDP deflator.
y is real GDP
wf-y is the ratio of financial wealth to real GDP.
wh-y is the ratio of housing wealth to real GDP.
lesi is the euro-area economic sentiment indicator.
R10-rm is the interest rate on 10-year German government bonds minus the own rate of return on money.
C is a constant term.
All variables except the interest rate are in logarithms.

Prob (F-stat) : 0.000

Figures in parentheses are t-ratios.

t-ratios are not presented for the total effects since the coefficients could be subject to specification error

***, **, * indicate significance at 1%, 5% levels, and 10% respectively. The estimates in columns (1) are obtained using the following coefficient drivers the: the constant, lagged change in real income, lagged change in real money, and change in the difference between the opportunity cost on holding money and the own rate on money. The bias-free effects are estimated using three coefficient drivers: the constant term, and lagged change in real income and the lagged change in real money.

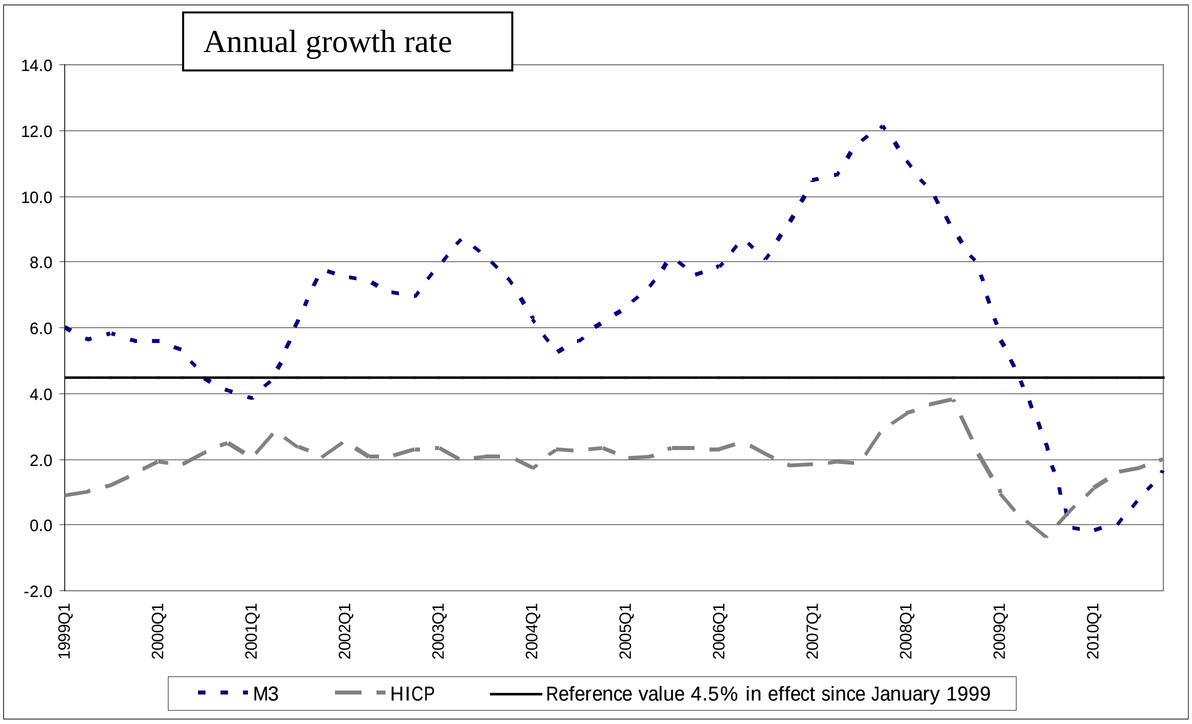

Figure 1: M3 and HICP annual growth rates

Note: HICP is the euro-area's harmonized index of consumer prices.

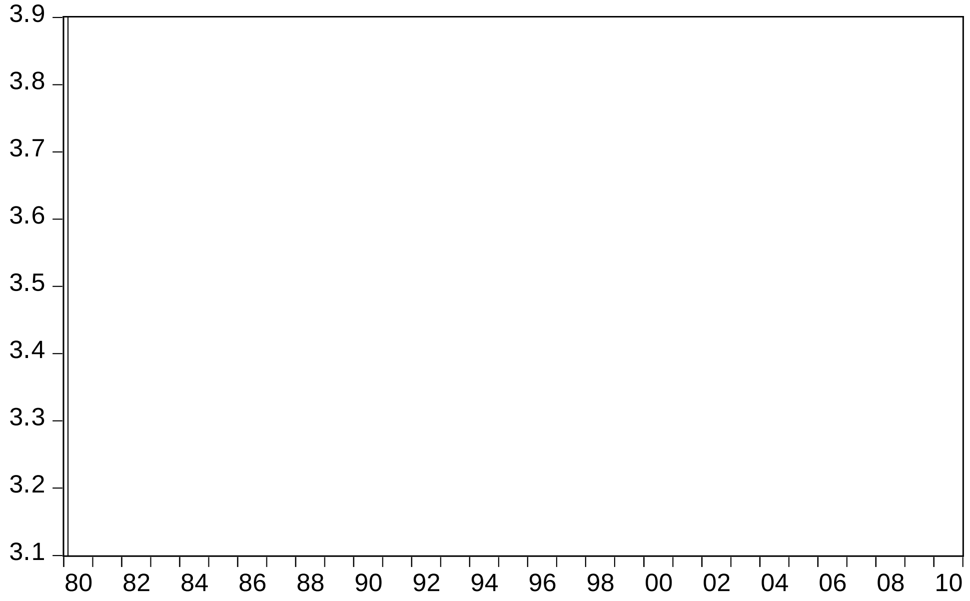

Figure 2 Log of Income Velocity

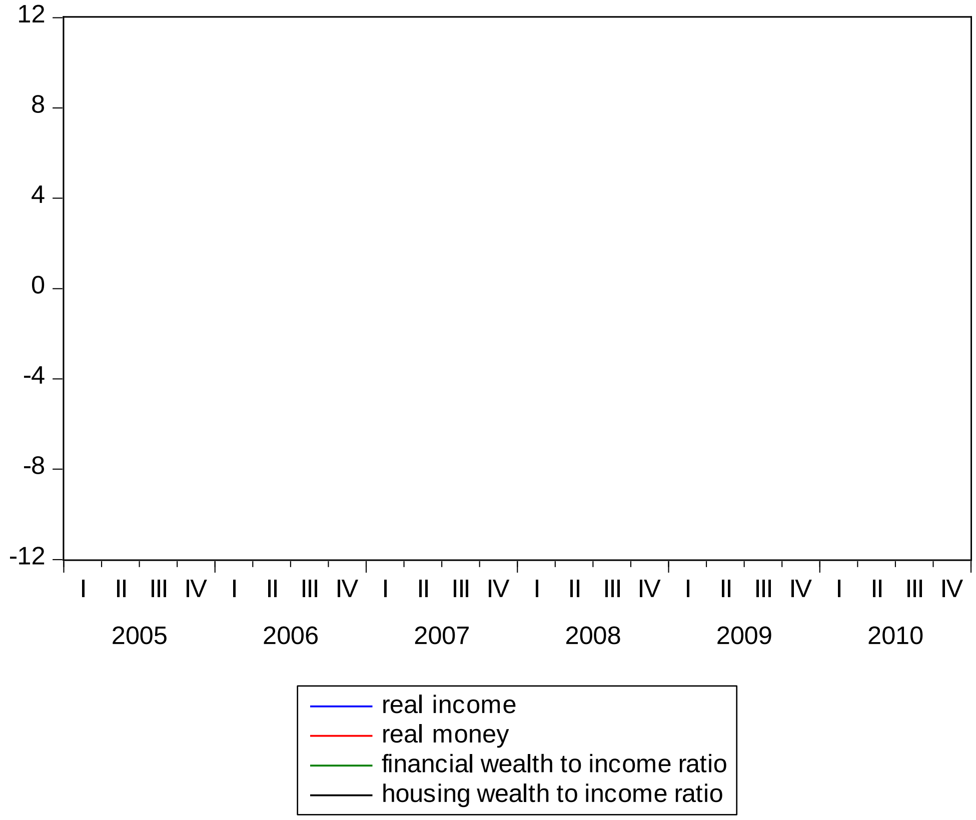

Figure 3: Growth rates of M3, wealth and real income

Figure 4: recursive residuals of the cointegrating vector

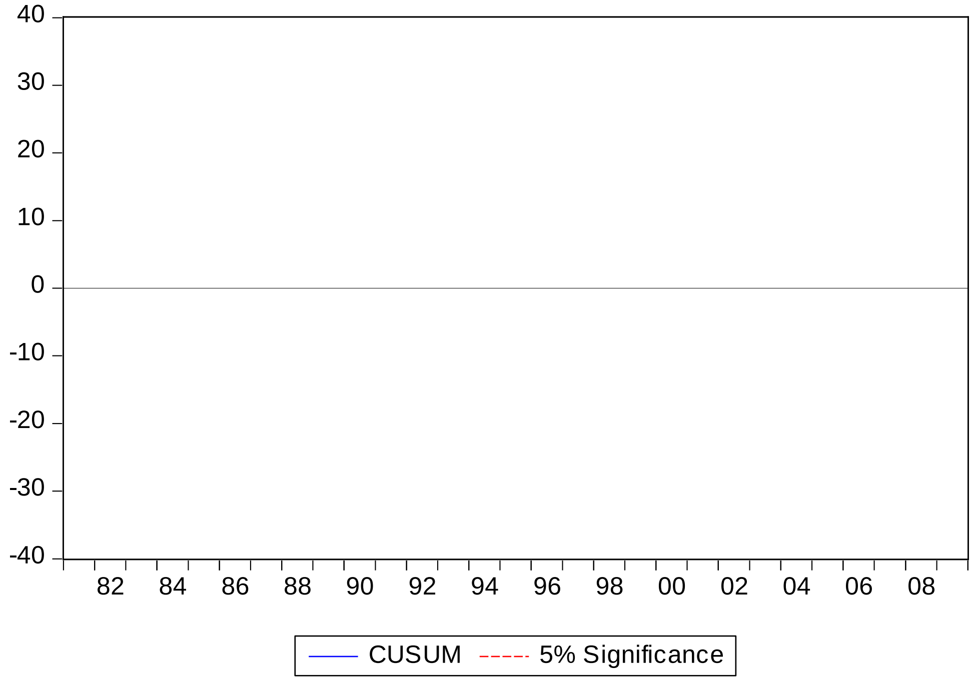

Figure 5: stability test

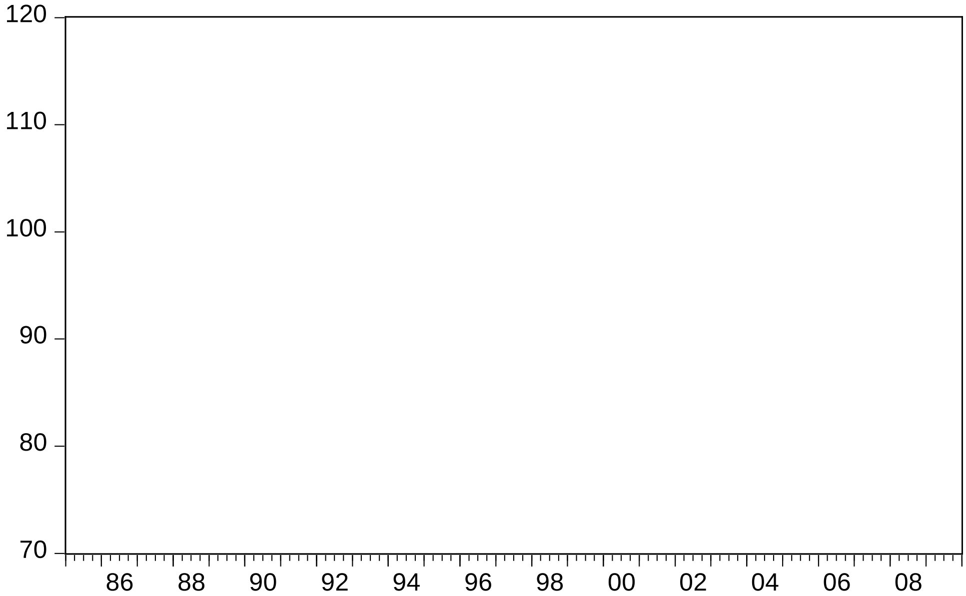

Figure 6: Euro Area Economic Sentiment Indicator

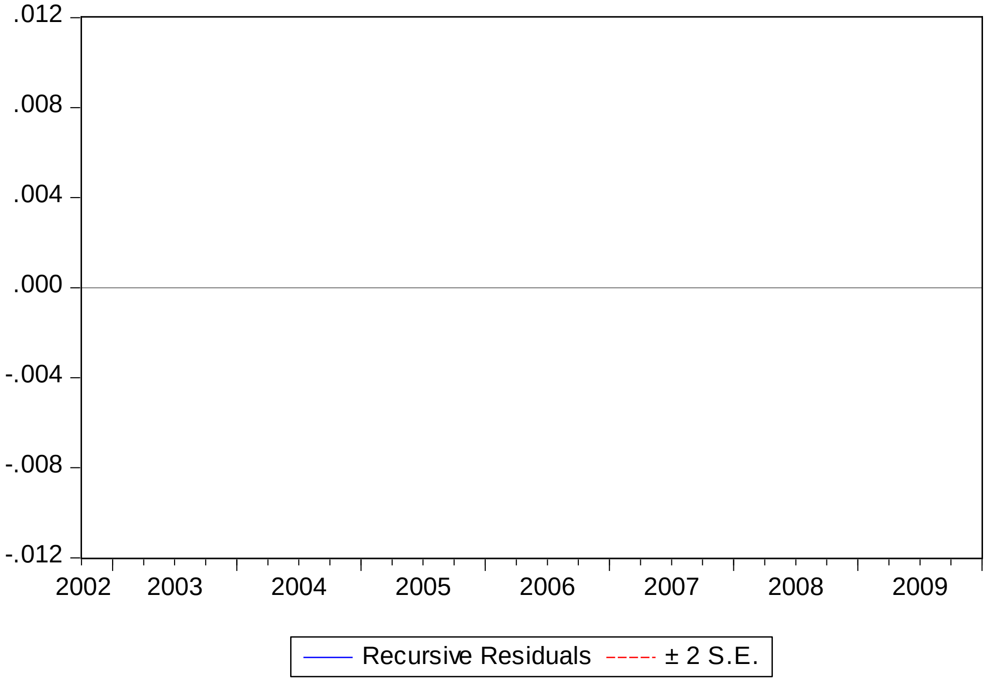

Figure 7: Stability of the enlarged model

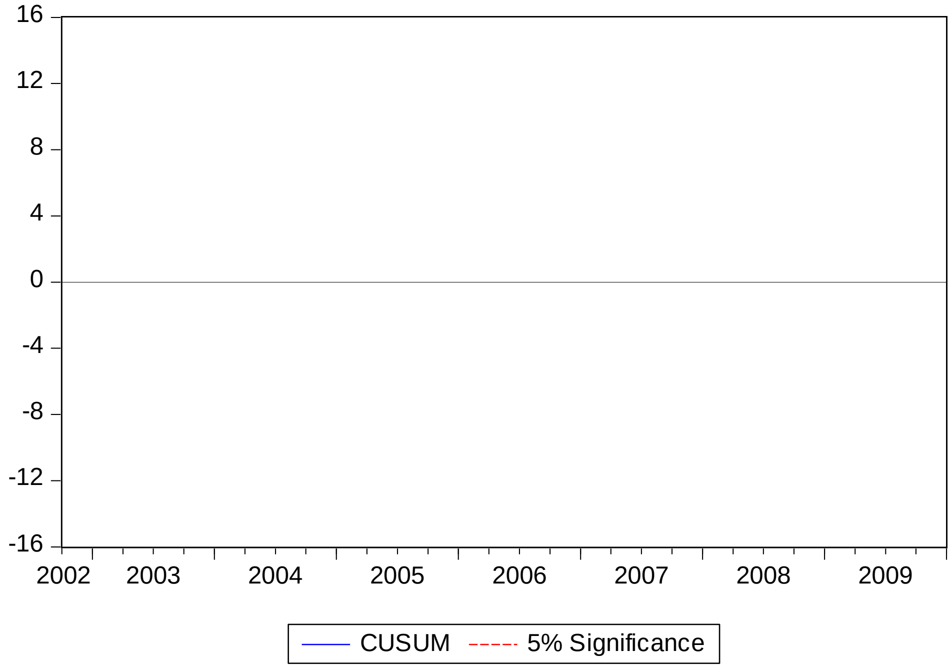

Figure 8: The CUSUM test for the enlarged model

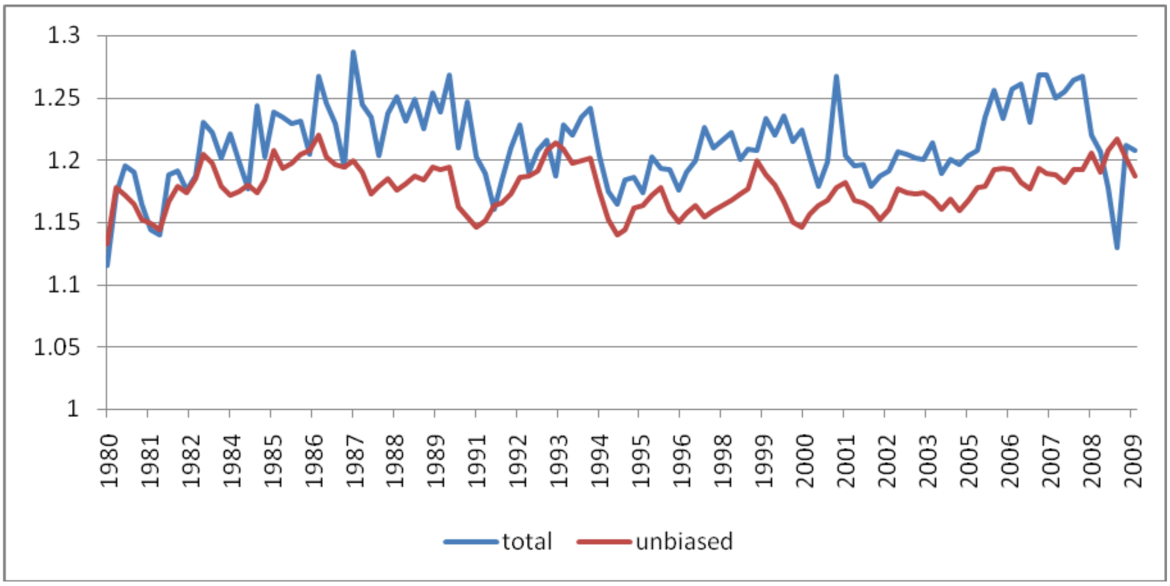

Figure 9: TVC estimation of the GDP coefficient

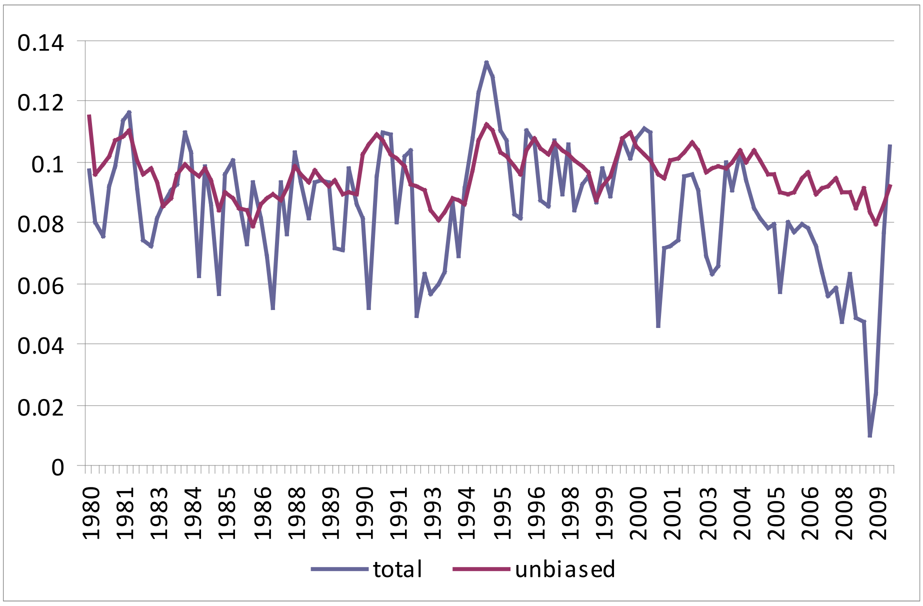

Figure 10: TVC estimation of the financial wealth to income ratio

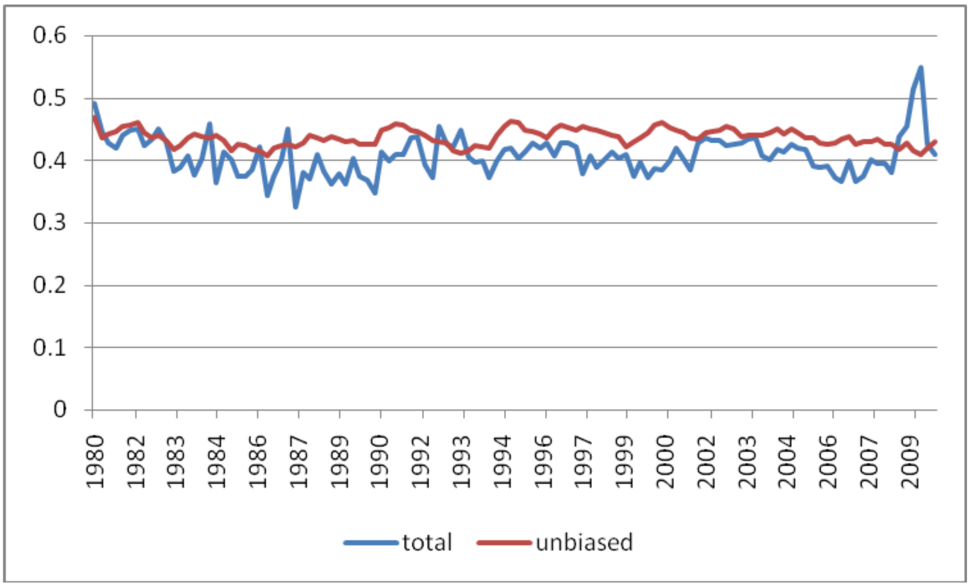

Figure 11: TVC estimation of the housing wealth to income ratio.

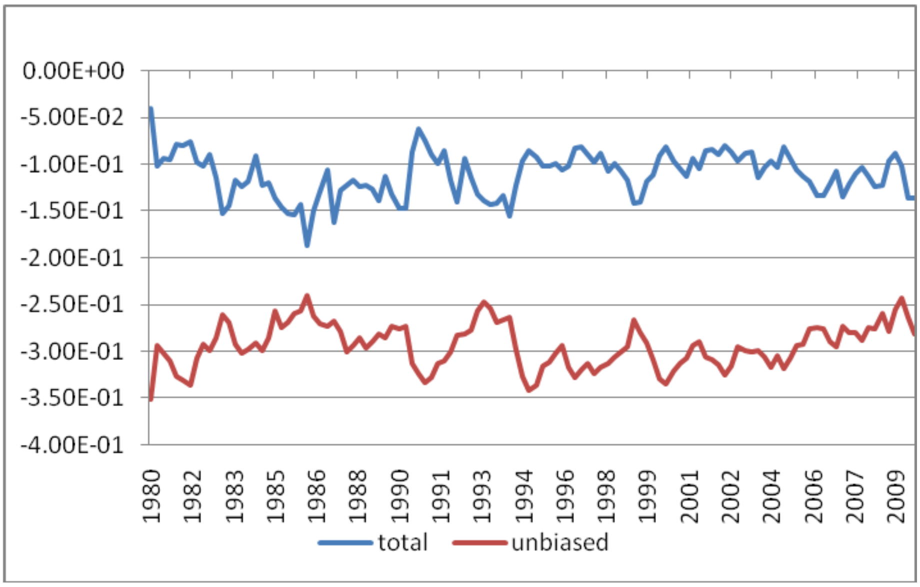

Figure 12: TVC estimation of the confidence effect

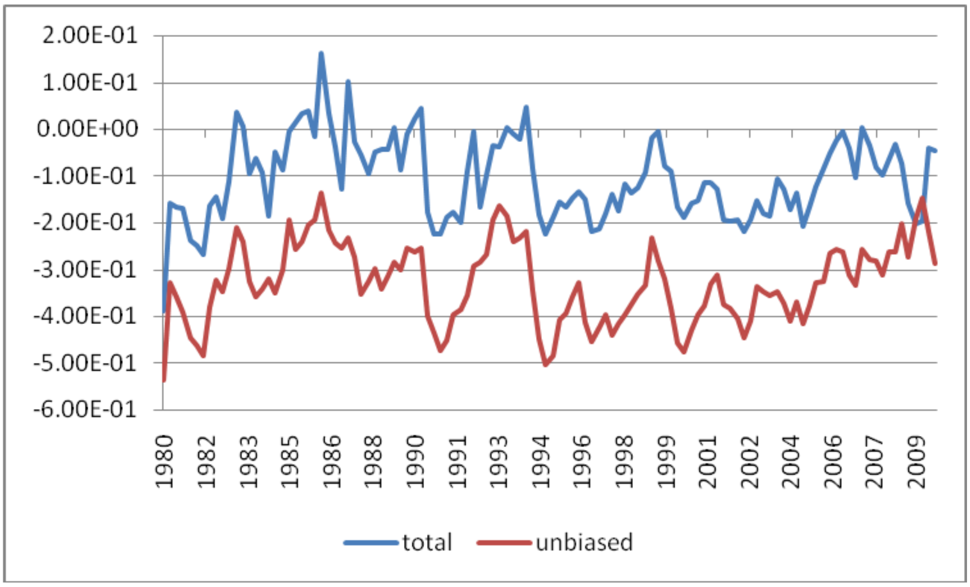

Figure 13 TVC estimation of the interest rate effect