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Abstract

We turn our attention to the role of money for determining nominal magnitudes. Using US data, we find that the aggregate "nominal output plus and stock market capitalisation" is closely related to the money stock, lending support to one of Milton Friedman's key monetarist propositions. This finding should be particularly important for ECB monetary policy: an inflation-free euro plays a crucial role for European economic and political integration. We conclude that monetary policy must keep a very close eye on money supply if it wants to prevent consumer and/or asset price inflation.

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Money and Inflation

Lessons from the US for ECB Monetary Policy

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Content

I. Introduction

Perhaps no other hypothesis in economics has been as strongly supported by theoretical reasoning and empirical evidence as Milton Friedman's famous dictum: "Money is always and everywhere a monetary phenomenon."[1] That said, it is surprising to see that today's monetary policies, which pursue the objective of maintaining price stability, pay rather little or no attention at all to money when setting interest rates.[2] [3] [4]

In view of the European Union (EU) celebrating the 50th anniversary of the Treaty of Rome, we would like to critically review the erosion of the role of money in international monetary policy making. From our viewpoint, such an undertaking appears to be all the more relevant as the "modern view" of "monetary policy without money" has started influencing euro area monetary policy.

In its strategy review on 8 May 2003, the European Central Bank (ECB) downgraded the role of money by making it an information variable rather than preserving it as the key indicator of its policy.[5] More recently, the stability of money demand in the euro area has been questioned, largely on the basis of empirical research.[6] However, the statistical results of conventionally specified money demand function tests cannot give a final answer as to whether the demand for money function is stable or not.[7]

It should be noted that with the fading out of money in monetary policy making, which set in around the early 1990s, many international asset markets have been experiencing strong price increases.[8] Most notably was the "New Economy" boom in the second half of the 1990s.[9] Overly confident investors bid up stock valuations to hitherto unseen levels, before markets came crashing down around the second half of 2000. Lately, the pronounced rise of property prices in many countries has caught attention among the public at large and policy makers alike.[10]

As history shows, swings in asset prices can have a highly important impact on output and employment.[11] In particular, there is plenty of evidence from around the world of the costs related to the formation and subsequent correction of pronounced asset price increases.[12] [13] [14] [15] [16]

Could it be that, following the fading out of money in today's monetary policy making, inflation comes along in a new disguise: that is "asset price inflation" rather than consumer price inflation? In "The Monetary History of the United States, 1867 – 1960", Milton Friedman and Anna Jacobson Schwartz concluded: "(...) the history of money will continue to have surprises in store for those who follow its future course – surprises that the student of money and the statesman alike will ignore at their peril."[17]

Using US data, we find that the aggregate "nominal output plus and stock market capitalisation" is closely related to the money stock, lending support to one of Milton Friedman's key monetarist propositions. In our view, the findings should be particularly important for ECB monetary policy, as an inflation-free euro plays a crucial role for European economic and political integration.[18] We conclude that monetary policy

should keep a close eye on money developments if it wants to prevent consumer and asset price inflation.

The paper has been structured as follows. First, we address some of the weak spots of monetary policies' widely accepted price stability objective (II.). Second, we briefly review the proposal of Alchian and Klein for including asset prices in the target price index (III.).[19] Third, we provide some empirical results for the relation of money and nominal magnitudes in the US (IV.). We give a summary and draw conclusions (V.).

II. Weak spots of the price stability concept

The idea of making price stability the primary objective of monetary policy is rooted in the view that "sound money" makes a positive contribution to improving growth and employment and raising living standards – a view that is confirmed by decades of experience and a substantial body of empirical and economic research. Following the "index regime" as proposed Irving Fisher,[20] central banks around the world have been identifying price stability with a small rise of a representative consumer price index over time, typically between 2 and 3% p.a.

The focus on consumer price indices might be explained by three factors. First, there is the notion that people want to preserve the purchasing power of their money holdings vis-à-vis a pre-defined set of consumption goods. Second, consumer prices, even though representing just a (small) fraction of all goods and services bought and sold, are assumed to "shadow" the economy's total price level. Third, there is a pragmatic reason: a price index for the total economy, including goods and services of final demand and wealth (that is goods produced in the past) is simply not available.

The mainstream economic view about the objective, definition and desirability of price stability has not remained unchallenged, though. The free market oriented, libertarian Austrian School of economics has ever since been criticising that in a free market economy there would, and actually could, not be any stability as far as exchange ratios are concerned, including the exchange value of money.[21] And as the Austrian School yields rather rewarding insights into the relation between monetary policy and nominal magnitudes, some of their central views shall be briefly reviewed.

From the Austrian economics viewpoint, money is a means of exchange. Taking the standpoint of a methodological individualism and the law of diminishing marginal utility, changes in an individual's money holdings entail changes in the relative valuation of money.[22] That said, changes in credit and money supply, which are a characteristic feature of any monetary regime – be under a government controlled paper money or a commodity standard –, inevitably lead to changes in both subjective and objective valuations of money prices.

For Austrians, the objective of price stability, as heralded under an index regime, would therefore be a futile and illusory undertaking.[23] In fact, Austrians would fear that central bank induced changes in credit and money supply would cause distortions in the economy's relative price mechanism, leading to misallocations which, in turn, trigger economic crises. In particular in view of concerns about the fallibility of

government controlled money and the costs associated with it, Austrian economists have been arguing for returning to free market money.[24]

Austrian economists explicitly note that changes in credit and money supply affect individual prices at different times and to different extents, thereby bringing about changes in overall demand and supply, investment and consumption. So even if the central bank delivers a pro forma stable price index, there would be no protection against a misalignment of relative prices, or "imbalances". Austrians would therefore warn against the notion that price index stability would be compatible with equilibria in goods (and financial) markets.

Echoing this central aspect of the Austrian School of Economics, the Chief Economist of the Bank for International Settlement (BIS), William R. White noted that the Keynesian focus on aggregate measures in the economy like, for instance, price indices, provides an inadequate guidance for identifying potentially emerging macro-economic problems: "(...) achieving near-term price stability might sometimes not be sufficient to avoid serious macroeconomic downturns in the medium term."[25]

Price stability is usually measured as a change in the price index of final demand. Asset prices tend to be ignored (or are under-represented) in such measuring. However, since the middle of the 1980s, asset prices in many countries have been rising strongly, often exceeding consumer price inflation. In particular declines of asset prices – such as, for instance, the 1987 stock market crash, the property price collapses during the second half of the 1980s, the sharp decline in bond prices in 1994, and the deflation of the "New Economy" stock market hype setting in in late 2000 – have led to a growing interest in learning more about the relation between monetary policy and *asset price inflation*.[26]

III. Focussing on asset prices - the Alchian and Klein idea

When dealing with asset price inflation, some initial remarks appear to be in order. The term *inflation* is usually defined as an ongoing rise in the economy's overall price level. It refers to the *overall* upward drift of money prices, it does not refer to an increase in individual goods prices. Thus, inflation denotes the loss of purchasing power of money: as the price level rises, the purchasing power of money declines.

In a market economy, there are ever-changing relative prices of economic goods. Prices of some goods, services and assets may exhibit an ongoing rise over time. Such an observation, however, is not necessarily indicative of inflation, for price rises of one category of goods and services might be accompanied by price declines of others categories, thereby keeping the economy's total price level unchanged.

Clearly, assets such as stocks, bonds, housing etc., represent a specific category of goods being bought and sold in the market place. As a result, it might actually be misleading to speak of *asset price inflation*. This is because the latter would denote an ongoing increase in prices of a specific (tradable) item – namely assets –, thereby referring to a *relative* price change. However, it has become common practise to use the term asset price inflation for denoting an "unusually strong" increase in asset prices.

Indeed, there can be periods in which asset prices rise above what appears to be economically justified from the viewpoint of market observers.[27] However, in view of such a development one should better speak of *asset price bubbles* rather than asset price inflation. An asset price bubble denotes the difference between an asset's market price and the fundamentally, or: intrinsically, justified valuation[28]; asset price bubbles might not necessarily imply inflation in the sense that money loses its purchasing power, though.

THE CONCEPT

After having addressed these definitorial issues, it's time to move on to the discussion about the role of asset prices in monetary policy making. Goodhart argued that monetary policy should assign an explicit role to asset prices in policy making, thereby preventing monetary policy from accentuating business cycles via affecting asset prices.[29] Rather than identifying asset prices as an element in the wider context of the transmission mechanism of monetary policy, Alchian and Klein (1973) pointed out that a monetary policy focus on consumer prices has the drawback that asset prices might be made irrelevant.[30]

The authors argued that a correct inflation measure should include asset prices, and that a "constant utility" price index should take account of current and future prices for all goods and services bought and sold. If future prices were not available, the Alchien and Klein wrote, asset prices could be used as substitutes, as these variables would be related to the current price of future consumption flows. Their idea thus amounts to stabilizing a cost-of-life index, with changes in asset prices reflecting future inflation. A consumer's life time budget constraint can be written as:

(1) $$p_t c_t + \sum_{j=1}^{T} p_{t+j} c_{t+j} ,$$

where p and c represent prices and consumption goods, respectively. Consumers allocate their wealth into current consumption and asset holdings ($p_A A_t$) in each time period. So the budget constraint can be also written as:

(2) $$p_t c_t + p_A A_t .$$

Subtracting the second equation from the first yields an expression that shows the link between asset prices and future prices:

(3) $$p_A A_t + \sum_{j=1}^{T} p_{t+j} c_{t+j} .$$

If A_t and future consumption choices were known, then changes in p_A would reflect changing future prices. Shibuya and Shiratsuka exploit this link and further simplify Alchian and Klein's abstract theory for practical purposes.[31] [32] The approach would define the economy's total price level as a weighted-sum of consumer and asset prices:

(4) $p_{total} = \alpha p_c + (1-\alpha) p_A$, or, when expressed in inflation terms,

$\pi_{total} = \alpha \pi_c + (1-\alpha) \pi_A$, with α (1 – α) and

with $0 \leq \alpha \leq 1$ $(1 - \alpha)$ representing the weight of consumer (assets) in the total price index.

THE CRITIQUE

One could indeed argue that asset prices – if the overall monetary policy objective is preserving the purchasing power of money – should be included in a price index measure because assets are, like any other goods and services of final demand, bought and sold by market agents. From this viewpoint, asset prices would actually be assigned the same status as goods and services of current production.

In view of the above one could think about broadening the policy objective of central banks to stabilize an index consisting of consumer and (financial) asset prices. However, it has been argued that such an approach, if put into practice, would create more difficulties for central banks than it solves (ECB (2005)):[33] [34]

— If the objective of monetary policy is broadened beyond purely stabilising consumer prices by focusing on an amalgamated price index that includes asset prices, this would presumably result in an index exhibiting higher volatility than the traditionally defined consumer price index. Targeting a broad index might thus lead to greater and more frequent changes in central bank rates compared with the status quo, which might have negative effects on output and employment.

— The foremost problem with asset price movements lies in the signal extraction problem.[35] Asset prices may be driven by a number of factors, namely expected returns, future short-term rates, time preferences, risk and liquidity premia, etc. It might thus be difficult, if not impossible, to identify the causes of the change in asset prices. If, for example, stock prices rise, no policy action would be required when prices move closer towards fundamentally justified valuations. In contrast, a case for policy intervention might be made if prices would move away from equilibrium values. The identification problem is thus twofold: firstly, in identifying to what degree asset prices reflect fundamentals and, secondly, in identifying as to whether new prices are in line with fundamentals.

— On a more technical level, there may be difficulties in constructing an index including all relevant asset markets. For instance, for some asset prices – housing might be a good example – it could be difficult to obtain price data on a timely basis. Also, heterogeneous product prices might be driven by relatively pronounced expenditure patterns which can be expected to exert a rather strong impact on prices, which should contribute to the volatility of the overall price index.

THE RESPONSE

Perhaps the concerns outlined above would be mitigated when we subject them to closer scrutiny. For instance, a more volatile price index – which might be the case if the central bank were to include consumer as well as asset prices in its target index – does not necessarily imply a more activist monetary policy. In view of the well-known time-lag problem, monetary policy should base its decisions on “leading” intermediate, or indicator, variables, rather than (consumer) prices themselves. Of

course, it is an open question whether the central banks can identify variables that have a predictable impact on future inflation of the total price level, and which can be influenced by the central bank accordingly; this question can only be properly answered by theoretical reasoning and empirical research.

In fact, the signal extraction problem might not become relevant when using a broadly defined price index. The central bank could actually accept a strong rise in asset prices if it is compensated for by declines in prices of goods and services so that the total price index would remain unchanged. Furthermore, there could indeed be problems in providing data on all relevant asset classes in a reliable and timely manner. However, the latter might be solved by stepping up efforts to improve the availability and quality of price data for the economy's stock of wealth.

The broadening of the catalogue of monetary policy objectives would require a careful analysis of the costs and benefits of asset price inflation, actually in line with analyzing the costs and benefits of consumer price inflation. For instance, asset price inflation might be seen as being beneficial as it increases output and employment. However, asset price inflation may ultimately lead to costly consumer price inflation and/or financial crises and severe recessions Trichet (2005)).[36] [37] [38] For instance, a bursting asset price bubble, as a result of asset price inflation, could lead to a sharp drop in aggregate demand, undermine the stability of the financial system and ultimately end in "bad deflation".

If the primary objective is the maintance of price stability, asset price inflation has to be taken proper account of in the monetary policy making. To this end, monetary policy will have to learn more about the developments that attribute to, or can actually be held be responsible for, asset price inflation. As asset price inflation periods have usually been associated with excess credit and money creation it appears to be promising to review the link between money and nominal magnitudes.

IV. Long-run relation between money and nominal magnitudes

For deriving some basic relationships between money and nominal magnitudes, the well-known quantity equation relationship can serve as a starting point:

(5) $M \cdot V = Y \cdot P$,

where M denotes the stock of money, V represents the velocity of money, whereas Y and P stand for the real transaction volume and the price level, respectively. Equation (5) is simply an identity; it states that the stock of money, multiplied by the number of times a money unit is used for financing purposes, equals real output multiplied with the price level. In this sense, the monetary side of the economy is in line with the real side of the economy.

The quantity theory of money states that an increase in the stock of money translates in a (proportional) in increase in the economy's price level. Assuming a constant income velocity of money (or, alternatively stated, a constant demand for real money holdings), changes in money supply equal changes in the nominal transaction volume:

(6) $\Delta m = \Delta y + \Delta p$.

where Δ represents the change in natural logarithms of the levels of the variables under review. That said, money growth above (below) the growth of the real transaction volume could be interpreted as the loss (gain) of the purchasing power of money. In fact, equation (6) epitomises one of Milton Friedman's key monetarist proposition, namely that the growth rate of money determines changes in nominal magnitudes.

Unfortunately, data about an economy's total transaction volume and total price level are not available. In empirical work, the former is typically approximated by the gross domestic product (GDP), the latter by a consumer goods price indices or the GDP deflator. A method for approximating the economy's nominal transaction volume might be seen in combining the economy's nominal GDP and its stock market capitalisation.

DESCRIPTIVE STATISTICS

Figure 1 shows some descriptive statistics for various key variables of the US economy for various sample periods. Perhaps most strikingly, M2 expansion was 6.7% p.a. on average in 1959-Q1 to 2006-Q3, that is equal to the growth rate of the nominal transaction volume. The difference between the growth rate of the transaction volume and real GDP was 3.4%. The latter corresponded to the average annual increase in the GDP deflator, being somewhat below the average rise in the consumer price index of 4.0% p.a.

Figure 1. – Descriptive statistics

	CPI	Real GDP	Nominal GDP	Dow Jones	Transaction volume	M2	M2ST
I. 1959-Q1 to 2006-Q3 (195 observations)							
Mean	0.040	0.033	0.069	0.065	0.067	0.067	0.064
Maximum	0.137	0.090	0.136	0.409	0.207	0.127	0.326
Minimum	0.003	-0.031	-0.007	-0.443	-0.104	0.003	-0.037
Std. Dev.	0.027	0.023	0.027	0.153	0.063	0.028	0.051
II. 1959-Q1 to 1979-Q4 (80 observations)							
Mean	0.046	0.038	0.081	0.015	0.055	0.079	0.055
Maximum	0.118	0.082	0.136	0.324	0.170	0.127	0.115
Minimum	0.007	-0.023	0.002	-0.443	-0.097	0.022	-0.024
Std. Dev.	0.031	0.024	0.027	0.148	0.065	0.026	0.033
III. 1980-Q1 to 2006-Q3 (107 observations)							
Mean	0.038	0.029	0.061	0.096	0.073	0.058	0.072
Maximum	0.137	0.081	0.132	0.409	0.172	0.122	0.326
Minimum	0.012	-0.028	0.027	-0.264	-0.104	0.003	-0.037
Std. Dev.	0.025	0.019	0.021	0.147	0.057	0.026	0.060

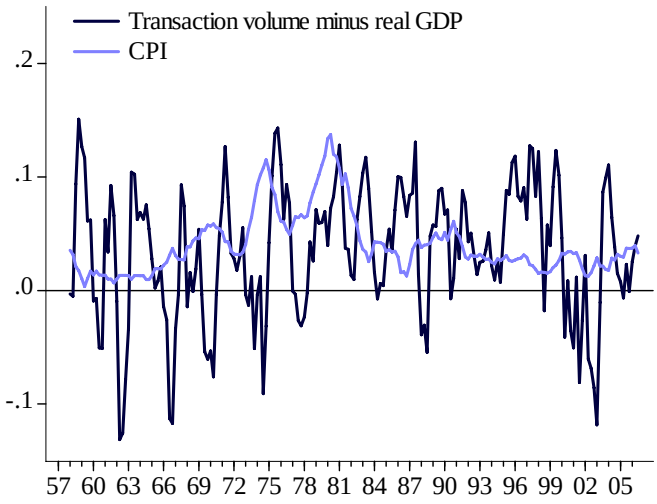
Source: Bloomberg, Thomson Financials, own calculations. – The transaction volume is defined as nominal GDP plus the stock market capitalisation of the US S&P 500 index. – 4th differences of log levels.

These findings might serve as a reminder of one of Milton Friedman's key monetarist propositions, namely that over the long-run money growth equals the growth rate of nominal magnitudes.[39] However, Friedman did not suggest that changes in money would have an immediate and predictable effect on nominal magnitudes. He explicitly suggested that it may take quite some time (which, in turn, could vary from

instance to instance) until the effects of changes in money supply would ultimately show up in nominal magnitudes.[40]

Fluctuations of the growth rate of the nominal transaction volume minus real GDP growth – which might be interpret as an approximation to the economy's total price level – were higher than the variability of consumer price inflation (see Figure 2). There were a number of instances in which the growth rate of the transaction volume minus GDP (representing an alternative measure of the economy's total price level) fell into negative territory – something consumer prices never did in the period under review.

Figure 2. – Transaction volume minus real GDP and CPI



Source: Bloomberg, Thomson Financials, own calculations. – Period: 1959-Q1 to 2006-Q3. – The transaction volume is defined as nominal GDP plus the stock market capitalisation of the S&P 500. – 4th differences of log levels.

MONEY DEMAND ESTIMATES

Monetary impulses are transmitted via the demand for money function. When using money as an indicator for price developments, a crucial assumption is that there exists a stable long-run money demand function (which is homogenous in terms of prices) such as:[41]

(7) $m_t = \beta_0 + \beta_1 tv_t + \beta_2 \ln(1+i_t^{long}) + \beta_3 \ln(1+i_t^{short}) + \varepsilon_t$,

where m_t is a money, tv the nominal transaction volume (that is, in our example, the sum of nominal GDP and the market capitalisation of the US stock market), i_t^{long} is the long-term interest rate (10-year US Treasury rate), i_t^{short} the short-term interest rate (US 3-months money market rate), and ε_t is the i.d.d. error term.

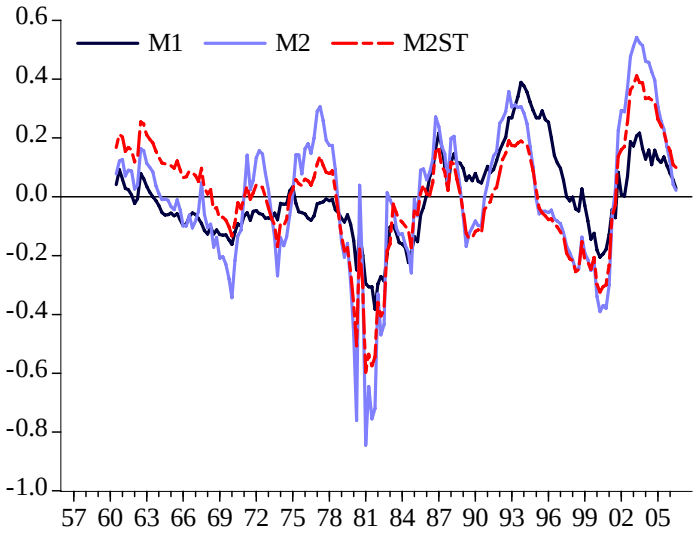
In economic terms, the error term in (7) can be interpreted as the "money overhang", a measure of "excess money supply",[42] [43] representing an indicator of disequilibria on the money market. If the money demand function forms a stable cointegra-

tion relationship, the monetary overhang is a stationary variable ($I(0)$) which contains information on the future development of money. Dynamic processes of adjustment ensure that, following a disturbance, the money holdings adjust to the path defined by the money demand.[44]

Using a cointegration framework as set out by Johansen,[45] we find a long-run relation between nominal monies (that is M1, M2 and M2ST), the transaction volume (as defined in this analysis) and long-and short-term interest rates in the US (see the Appendix) for the period 1959-Q1 to 2006-Q3.[46] The income elasticities have plausible magnitudes and the expected signs. The same holds true when long- and short-term interest rates are included in the cointegration vector. However, if just one interest rate is included, the interest rate elasticities become positive.[47]

Figure 3 shows the money overhangs of M1, M2 and M2ST, respectively, according to our cointegration results. High inflation and, most important, the restrictive US Fed policy in the early 1980s created a negative money overhang. In the second half of the 1990s, strong GDP growth and a strong increase in stock prices also resulted in a negative money overhang. The latter finding could suggest that the US Fed did (not fully) accommodate the increase in money demand towards the end of the New Economy episode.

Figure 3. – Money overhangs in the US



Source: Bloomberg, Thomson Financials, own calculations. – Period: 1959-Q1 to 2006-Q3. – The money overhang is defined as actual stock of money minus the equilibrium stock of money.

Following the slump in stock prices and the marked slowdown in US GDP growth as from 2001, the monetary overhang moved back into positive territory. In fact, it was the highest monetary overhang (at least when M2 and M2ST are used) in the period under review. This finding corresponds to Friedman's analysis in 2006: "The results strongly support Anna Schwartz's and my 1963 conjecture about the role of monetary policy in the Great Contraction. They also support the view that monetary

policy deserves much credit for the mildness of the recession that followed the collapse of the U.S. boom in late 2000."

Our cointegration results suggest that in the US there is a long-run relation between money and the nominal transaction volume in the period under review, as suggested by Milton Friedman. However, such a relation is far from being perfect in the short-term; there were periods in which deviations between the actual stock of money and the demanded quantify diverged substantially. Be that as it may, the results suggest that – and this is the important finding of our analysis – monetary policy does not only affect prices of current production but also stock (and presumably other asset) prices as well.

V. Summary and conclusions

In view of the role of money for nominal magnitudes in the US the question arises: What can be learned for ECB monetary policy? There is theoretical reasoning and empirical support for the hypothesis that money supply growth not only affects consumer but also asset prices. Against this background it would appear advisable for central banks to set rates in line with the signals provided by money supply if the objective is the maintenance of the purchasing power of money.

Such an insight is all the more relevant as money demand analyses for the euro area suggest that in the more recent past excess liquidity seems to have increasingly translated into asset price inflation rather than consumer price inflation.[4849] Headline euro area M3 growth might be much more closely related to the loss of purchasing of money power of the euro than may be widely believed. That said, for keeping inflation in check the ECB should set interest rates in line with the signals provided by money supply or, more to the point, measures of excess liquidity. [50]

Against this background it is hard to understand why the ECB de facto downgraded the role of money in its monetary policy strategy on 8 May 2003 to a mere information variable. In view of a long-run relation between money growth and inflation various economists, perhaps most prominently among them Nobel Price Laureate,[51] have concluded that the problem of controlling inflation could be successfully solved: choose the growth rate of money supply that corresponds to the desired long-run rate of inflation.[52]

Lucas' recommendation appears to be particularly important in view of the European integration process for which ECB monetary policy undeniably plays a crucial role. The euro, introduced at the beginning of 1999, is still a relatively new currency, and it has still to prove itself as a reliable means of payments. What is more, the European integration process is far from being accomplished, and new EU countries will have to be included in the single currency area in the years to come.

The emergence of a unified and peaceful of Europe is currently one of the most astonishing, even revolutionary, developments in the western hemisphere.[53] Historically speaking, though, the relation between European nation states has usually been associated with a deliberate balancing of rewards against costs. European societies

have not been formed by a concept of conceptual goodwill; even though they have been shaped by uniform, and intertwined, historical experience.

A peaceful societal cooperation under property rights and the division of labour in Europe requires a reliable means of exchange. That said, the idea of sound money plays a crucial role for allowing Europe to reap the full potential of economic and political integration.[54] A European monetary policy setting interest rates in line with the signals provided by money supply would actually be compatible with the objective of safeguarding the purchasing power of money. Inflation is, at the end of the day, always and everywhere a monetary phenomenon; and under a government controlled money monopoly it is made by central banks, even though this proposition is still often denied.

Growing insights into the contribution of asset prices to the economies' overall inflation rate might, as Otmar Issing put it,[55] add "(...) to the renewed role assigned to money in economic research and the revival of interest in money and its counterparts by other central banks (...). It should be obvious therefore that the burden of proof is indeed on the side of those who suggest that we should neglect the information stemming from monetary analysis."

Endnotes

[1] According to Milton Friedman, he first published the statement in these words in (1963). See Friedman ((1994), p. 262).
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Appendix

Figure A1. – Tests for unit roots

	Null hypothesis	Alternative hypothesis	Test statistics	
			ADF[a,b]	PP[a,b]
lnM1	stationary	I(1)	-1.27	-0.845
	I(1)	I(2)	-3.23**	-8.59***
lnM2	stationary	I(1)	-0.29	-2.37
	I(1)	I(2)	-3.22**	-6.71***
lnM2ST	stationary	I(1)	-0.04	-0.26
	I(1)	I(2)	-4.65***	-8.37***
lnGDP	stationary	I(1)	-2.24	-1.37
	I(1)	I(2)	-5.13***	-9.59***
lnGDPS&P	stationary	I(1)	-0.13	-0.19
	I(1)	I(2)	-7.44***	-13.73***
$\ln(1+i_t^{long})$	stationary	I(1)	-2.01	-1.85
	I(1)	I(2)	-7.20***	-14.91***
$\ln(1+i_t^{short})$	stationary	I(1)	-2.53	-2.61*
	I(1)	I(2)	-5.71***	-16.07***

Legend: * / ** /*** rejection of the null at the 10, 5 and 1 percent level (McKinnon (1991) values). – a ADF is the Augmented Dickey Fuller (1981) test (including up to the highest lag statistically significant at the 5% level); PP is the Phillips Perron (1988) test (with 3 truncation lags, as suggested by the Newey West criterion). – b Constant included in all the auxiliary test regressions, deterministic trend only if statistically significant at the 5% level.

Figure A2. – Cointegration of US M1, nominal transactions and interest rates

	Specifications:		
	- 1 -	- 2 -	- 3 -
AIC	7	7	7
SC	2	2	2
Chosen lags (quarters)	2	5	5
Johansen tests:			
Trace statistic r =0	57.48*	34.71*	34.06*
Critical value 0.05	47.86	29.79	29.79
Max-Eigen statistic r= 0	37.13*	17.63	19.42
Critical value 0.05	27.58	21.12	21.13
Long-run relation:			
tv_t	0.651 (0.05)	0.758 (0.08)	0.710 (0.03)
$\ln(1+i_t^{long})$	38.922 (5.33)	...	5.484 (1.48)
$\ln(1+i_t^{short})$	-31.178 (-6.49)	14.656 (3.47)	...
Constant	0.348	1.122	0.285
Error correction model:			
$\Delta m1_t$	-0.0058 [-2.17]	-0.0046 [-2.09]	-0.0210 [-3.69]
Δtv_t	-0.0045 [-0.48]	0.0043 [0.55]	0.0374 [1.86]
$\Delta \ln(1+i_t^{long})$	0.0073 [4.89]	...	0.0029 [0.86]
$\Delta \ln(1+i_t^{short})$	0.0026 [1.01]	0.0072 [3.57]	...
Autocorrelation tests:			
LM(2)	24.44 (0.08)	11.81 (0.22)	15.07 (0.09)
LM(4)	22.91 (0.11)	8.47 (0.49)	8.16 (0.52)
LM(5)	14.18 (0.58)	10.77 (0.29)	9.92 (0.36)

Source: Thomson Financial, Bloomberg, Federal Reserve Bank of St. Louis, own calculations. – *Legend*: AIC = Akaike information criterion, SC = Schwarz information criterion, as determined by an unrestricted VAR model. – *Denotes rejection of the null hypothesis at the 0.05 level (p-values according to MacKinnon-Haug-Michelis (1999)), with r = the number of cointegration ranks. We allowed for a linear deterministic trend in data, intercept, no trend in cointegration equation. – M1 = stock of M1, tv_t = nominal transaction volume (US nominal GDP plus market capitalisation of the S&P 500 index), i_t^{long} = 10-year US treasury yield, i_t^{short} = 3-months money market rate, Δ = first difference; standard errors below the coefficients. – The results of the error correction model refer to the one-period lagged error correction term, t-values in [.].

Figure A3. – Cointegration of US M2, nominal transactions and interest rates

	Specifications:		
	[1]	[2]	[3]
AIC	7	7	2
SC	7	2	2
Chosen lags (quarters)	5	5	5
Johnsen tests: Trace statistic r =0 Critical value 0.05	 68.55* 47.86	 32.09* 29.79	 22.13 (29.79
Max-Eigen statistic r= 0 Critical value 0.05	41.06* 27.58	21.34* 21.13	12.79 21.13
Long-run relation: tv_t	 0.836 (0.08)	 0.923 (0.05)	 0.883 (0.03)
$\ln(1+i_t^{long})$	60.146 (9.23)	...	8.001 (1.52)
$\ln(1+i_t^{short})$	-59.69 (-8.76)	11.068 (1.91)	...
Constant	0.570	1.087	0.678
Error correction model:			
$\Delta m2_t$	0.0019 [1.79]	-0.0055 [-2.27]	-0.0097 [-2.39]
Δtv_t	-0.0025 [-0.42]	0.0132 [1.04]	0.0295 [1.32]
$\Delta \ln(1+i_t^{long})$	0.0017 [1.80]	...	0.0079 [2.20]
$\Delta \ln(1+i_t^{short})$	-.00041 [-2.62)	0.0132 [4.05]	...
Autocorrelation tests: LM(2)	 0.05	 0.10	 0.07
LM(4)	0.19	0.29	0.94
LM(5)	0.39	0.43	0.43

For explanations, see text below Figure A2. – M2 = stock of M2.

Figure A4. – Cointegration of US M2ST, nominal transactions and interest rates

	Specifications:		
	[1]	[2]	[3]
AIC	7	4	2
SC	2	2	2
Chosen lags (quarters)	5	4	5
Johansen tests: Trace statistic r =0 Critical value 0.05	75.85* 47.86	18.82 29.79	32.33* 29.79
Max-Eigen statistic r= 0 Critical value 0.05	51.31* 27.58	13.81 21.13	24.75* 21.13
Long-run relation: tv_t	0.801 (0.06)	0.932 (0.03)	0.882 (0.02)
$\ln(1+i_t^{long})$	53.49 (8.06)	...	3.096 (1.06)
$\ln(1+i_t^{short})$	-59.66 (-7.64)	3.275 (1.59)	...
Constant	0.123	1.038	0.642
Error correction model:			
$\Delta m2ST_t$	0.0078 [3.21]	-0.0177 [-2.29]	-0.0427 [-4.76]
Δtv_t	-0.0026 [-0.41]	0.0229 [1.27]	0.0199 [0.86]
$\Delta \ln(1+i_t^{long})$	0.0018 [1.73]	...	0.0047 [1.12]
$\Delta \ln(1+i_t^{short})$	-0.0049 [-2.93]	0.0137 [2.85]	...
Autocorrelation tests: LM(2)	19.99 (0.22)	28.03 (0.00)	10.14 (0.33)
LM(4)	41.35 (0.00)	21.78 (0.01)	4.61 (0.86)
LM(5)	15.45 (0.49)	13.19 (0.15)	8.61 (0.47)

For explanations, see text below Figure A2. – M2ST = stock of M2 minus short-term deposits.

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