Money and the Great Disinflation

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Abstract

Empirical studies that include the post-1980 period tend to reject a proportional (or any significant) influence of money growth on inflation. This paper argues that these results come from not accounting for changes in equilibrium velocity due to interest rates adjustments to different steady-state inflation rates. I first present consistent results for U.S. and euro area money demand estimates, with a unitary income elasticity, and show why different money demand specifications have resulted from empirical studies which include the disinflation period of the 1980s. I then present evidence of a significant and proportional influence of money growth on inflation when money demand adjustments to equilibrium changes in interest rates are accounted for.

JEL classification: E31; E41; E52

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1. INTRODUCTION

In the 1980s and 1990s, the consensus about the existence of a useful link between money and inflation and/or a stable money demand relationship broke down. For example, Friedman and Kuttner (1992) wrote: "[i]ncluding data from the 1980's sharply weakens the postwar time-series evidence indicating significant relationships between money (however defined) and nominal income or between money and either real income or prices separately. Focusing on data from 1970 onward destroys this evidence altogether", and further: "...before the 1980's, there was widespread agreement that fluctuations in money did contain at least potentially useful information about future income and price movements. In the 1980's, however, the empirical basis underlying that agreement disappeared." Other examples include DeLong (2000), who stated that "...the velocity of money turned unstable in the 1980s, but not in any manner simply correlated with the rate of money growth", and Mankiw (1997), who wrote: "[t]he deep recession that the United States experienced in 1982 is partly attributable to a large, unexpected, and still mostly unexplained decline in velocity".

Even though studies using data from the euro area have been relatively more supportive of monetary aggregates[1], the reported relationships between money and inflation as well as the estimated money demand specifications vary substantially from one study to another. Moreover, De Grauwe and Polan (2001) argue that "[t]he relationship between inflation and money growth for low inflation countries (on average less than 10% per annum over the last 30 years) is weak". Given that the debate has focused on data from the U.S. and the euro area, I will develop here my arguments

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[1]See, for example, Brand, Gerdesmeier and Roffia (2002) and references therein, Bruggeman, Donati and Warne (2003), Gerlach (2003, 2004), Gerlach and Svensson (2003), Neumann (2003), Neumann and Greiber (2004) and references therein, and von Hagen (2004).

using data from these economies in order to allow comparisons with the existing literature. This will also highlight the fact that there exists a clear link between money growth and inflation even in low inflation economies, e.g. in the U.S. and in the euro area during the 1990s. The conceptual analysis presented in this paper generalizes to other countries as well, and allows for cross-country comparisons.

This paper argues that the reported weak relationship between money growth and inflation in low inflation countries, in the forms of a non-significant or non-proportional influence of money growth on inflation, in cross-country or time series studies, is due to not appropriately accounting for interest rates equilibrium changes associated with disinflation. This is why issues appear when examining data from the 1980s and 1990s, a period characterized by disinflation in most industrialized countries. As Nelson (2003) reports, Friedman (1985) notes that "[a] break in the trend of velocity [...] has been observed whenever and wherever accelerating inflation has been succeeded by disinflation". Nelson (2003), in his review of empirical evidence on money and inflation, argues that falls in interest rates due to the Fisher effect can justify the negative correlation between money growth and velocity growth that puzzled De Grauwe and Polan (2001). Those changes in equilibrium velocity are central to the analysis presented in this paper. I also show that major discrepancies in money demand estimates, particularly regarding income elasticity, are linked with changes in steady-state inflation rates.

The paper first provides explanations of why different money demand specifications have resulted from empirical studies when changes in steady-state inflation have occurred. When monetary assets are chosen such as to correspond to the transaction concept of Baumol-Tobin, i.e. assets yielding transaction or monetary services, and

when the effects of disinflation on money demand are accounted for, money demand estimations result in a unitary aggregate income elasticity and a similar interest rate elasticity with both U.S. and euro area data. A unitary income elasticity corresponds to the prediction of the Baumol theory if we assume that "it is the *number* of cash flows to be managed that doubles whenever real GDP doubles, not their average size" (Lucas, 2000).

Different U.S. estimates emerge depending on whether substitutes to checking accounts, also yielding transaction services, are accounted for, and how the particularly eventful period of the 1970s is treated. As those substitutes were introduced in the early 1980s, i.e. at a time characterized by disinflation and a corresponding drop in interest rates, not accounting for these additional accounts creates the appearance of a weak money demand relative to the drop in opportunity cost. This, together with financial market events in the 1970s, made it difficult to interpret the changing behavior of M1 when interest rates and inflation were declining, and explain why recent income elasticity estimates of narrow monetary aggregates have been relatively low.

Euro area money demand studies have also resulted in different estimated money demand specifications. I argue that the key factor to account for, is that the opportunity cost of holding money balances has gone down dramatically during the past twenty-five years. Not accounting for this fact leads to money demand misspecifications, as the level of money balances has shifted up as a result of this development. Given that income has been increasing as well, not accounting for the drop in opportunity cost as a cause of the money level increase leads to an overestimation of income elasticity.

Moreover, given that the commonly used euro area data samples begin in the

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early 1980s and are thus dominated by the disinflation period, both combinations of higher income elasticity / lower interest rate elasticity and lower income elasticity / higher interest rate elasticity can coexist econometrically, depending on the exact sample period or estimation method, as income and money were trending upward while interest rates were trending downward, with all relatively smooth trends. The argument is similar to that of Lucas (1988), but in the opposite direction, i.e. in a disinflationary rather than an inflationary environment. Lucas showed that, as all three series of money, interest rate and income were increasing during the 1970s inflationary episode in the U.S., money demand estimations over the 1958-85 period can result in unitary income elasticity, confirming the pre-war specification of Meltzer (1963), or in both lower income and interest elasticities. When the sample is extended and include "stationary periods", a unitary income elasticity emerges.

The paper then addresses the issue of the influence of money growth on inflation. I use long-term money demand estimates to adjust for changes in equilibrium velocity in order to account for money demand adjustments to changes in steady-state inflation rates. Accounting for these equilibrium changes affects dramatically the estimated influence of money growth on inflation. I find a significant and proportional influence of money growth on inflation. In contrast, not accounting for equilibrium changes in interest rates leads to the non-significant or non-proportional influence of money growth on inflation that the literature has reported, for time series as well as cross-country studies of low inflation economies.

The basic idea is that, for example, when inflation persistently decreases, as it did in the past 25 years in most industrialized countries, money grows faster than inflation as the opportunity cost of money persistently decreases, which induces people

to hold additional money balances. Comparing money growth with inflation without accounting for that change in equilibrium velocity will thus lead to a weakened link between money growth and future inflation. Higher money growth resulting from declining interest rates via the Fisher effect is not associated with higher future inflation, and this biases empirical results on the relationship between money growth and inflation. This is what has led many observers to conclude that the link between money and inflation is weak in low inflation countries, as many industrialized countries experienced disinflation in the past two decades. The same argument (but in the opposite direction) applies in inflationary episodes, like in the 1970s in the U.S. for example. Moreover, when samples with accelerating inflation as well as disinflation are considered, the dynamic relationship between money growth and inflation is also affected and the result of a less than proportional effect of money growth on inflation emerges, as low-frequency movements in money growth and velocity growth are negatively correlated.

Thus, not accounting for changes in equilibrium velocity and interest rates results in biased coefficients in estimations of the influence of money growth and other variables on inflation. Moreover, results are dependant of the sample considered, as the underlying trend and fluctuations in velocity growth differ across samples.

The paper is organized as follows. Section 2 presents consistent results for both U.S. and euro area long-term money demand estimates, which will be used to compute equilibrium velocity in section 3, and suggests reasons why different money demand results coexist in the literature. Readers interested only in the paper findings regarding the estimated influence of money growth on inflation can skip section 2 and go directly to section 3. Section 3 presents the effects of changes in steady-state inflation

and equilibrium velocity on the long-term and dynamic influence of money growth on inflation, relates the results to the existing literature, and shows how previously established results are affected quantitatively. Finally, the last section concludes.

2. DISINFLATION AND MONEY DEMAND ESTIMATES

Discrepancies in money demand estimates have been due to different causes in the U.S. and the euro area. On one hand, U.S. data, analyzed in section 2.1, were affected by financial innovations and deregulation in the late 1970s and early 1980s, immediately following a major structural change in aggregate money demand due to an increase in financial market participation, and at a time when disinflation occurred. U.S. studies were thus mostly affected by issues of definitions and events interpretations. Euro area studies, on the other hand, considered mainly the post-1980 disinflation period, and section 2.2 explains why different results have turned out from empirical models due to characteristics linked to the disinflationary environment. This section overall shows that with a coherent treatment of monetary aggregates, similar outcomes emerge from U.S. and euro area data, with a unitary aggregate income elasticity.

2.1. NON-LINEARITIES, DEREGULATION AND FINANCIAL INNO-VATIONS - U.S. DATA

The first blow to the consensus that considered money as a useful indicator for monetary policy came in the early 1980s. At that time, the velocity of $M1$, the monetary aggregate officially considered by the Federal Reserve Board, started to exhibit fluctuations, as can be seen from Figure 1, after having grown smoothly for
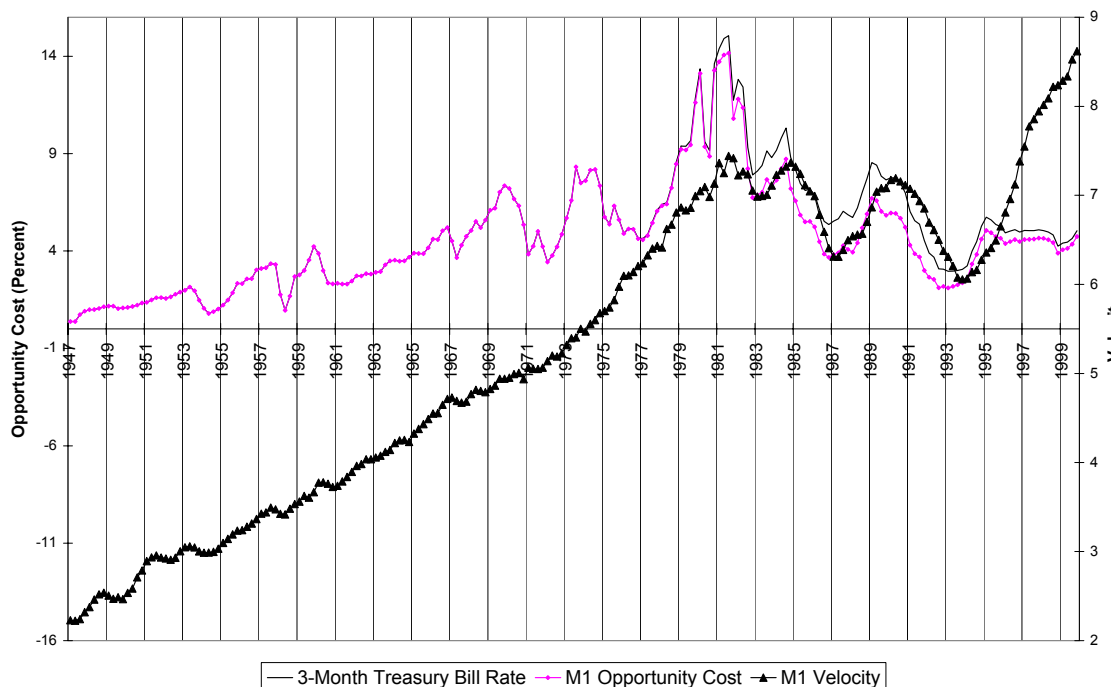
the prior three decades[2].

FIG. 1. M1 Velocity in the U.S.

Given the change in behavior of $M1$ velocity, it was argued that the demand for $M1$ had become unstable. DeLong (2000), by referring to a figure plotting the velocity of $M1$ against a pre-1980 trend line over the period 1960-2000, writes: "[t]he sharp swings in the velocity of money in the 1980s, as shown in Figure 1, led not to a renewed commitment to stable inflation and money growth to eliminate such swings, but instead to a distrust by central bankers of monetary aggregates as indicators." What was considered as a change in behavior of the velocity of $M1$ in the 1980s

[2]$M1$ consists of cash, demand and checking deposits. The opportunity cost is the 3-month Treasury bill rate minus the weighted average of interest rates paid on the different monetary assets. Figures 1 and 2 are taken from Reynard (2004), and updated with the FRED database. See appendix A for data sources.

coincided with financial deregulation, with the introduction of new accounts providing transactions services, and with the disinflation. Instead of recognizing the transaction properties of those newly introduced accounts, the change in the behavior of M1 was attributed to the fact that the distinction between what was traditionally considered as transactions and savings balances became difficult to draw, as checking accounts began to earn interest. Referring to graphs which compare the evolution of the velocity of $M1$ with its pre-1980 trend, economists sharing this view seem to have expected transaction balances not to react to their opportunity cost, and their velocity to keep increasing smoothly[3]. It is often suggested that an explanation for the upward trend in $M1$ velocity during the post-war period is that technical progress in credit cards and other advances would have allowed individuals to economize on money balances, justifying an income elasticity below unity.

Thus, the conventional view is to consider the swings in the velocity of $M1$ in the 1980s, and the fact that the velocity stopped its smooth ascension, as a puzzle, and as an argument that monetary aggregates should not be considered anymore as indicators for monetary policy. However, if we have in mind a model where people trade off real resources with monetary assets, in order to carry out transactions, the puzzle is rather the smooth behavior of the velocity of $M1$ during the 1970s, i.e. in particular the fact that velocity did not drop with the falls in nominal interest rates in 1970 and 1974, and the fact that velocity increased faster than interest rates over the 1950s, 60s and 70s. Moreover, instead of being surprised by the decline in velocity at the beginning of the 1980s, we would wonder why the velocity did not decrease

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[3]For example, Mankiw (1997) wrote: "[f]or reasons that are still not fully understood, the velocity of money (nominal GDP divided by M1) fell in the early 1980s substantially below its previous upward trend. This fall contributed to a reduction in aggregate demand, which in turn led to the 1982 recession, one of the deepest in recent history", and further: "[t]he experience of the early 1980s shows that the Fed cannot rely on the velocity of money remaining stable".

more sharply at that time, with the initial fall in nominal interest rates.

Indeed, if we compare the evolution of $M1$ with its opportunity cost, as shown in Figure 1, we notice that $M1$ velocity did not decline correspondingly to the strong decrease in opportunity cost in 1982 due to Volcker's disinflation. This actually just reflects the fact that, with financial deregulation and innovations, new types of accounts providing monetary services, thus substitutes to $M1$, were introduced. Those accounts generally yield rates close to checking accounts, below the 3-month T-bill rate, and are checkable. When those new accounts are included, as is the case in Figure 2, in an aggregate called M^{US} hereafter for comparisons with euro area data, then a clear drop in velocity occurs with the disinflation, i.e. a strong increase in money demand as interest rates dropped[4].

The swings in $M1$ velocity represented thus well the effect of disinflation and fluctuations in its opportunity cost. The reason why the sensitivity of $M1$ and M^{US} to interest rate fluctuations has increased since the late 1970s and velocity shifted upwards in the 1970s is due to an increase in financial market participation that took place mostly in the 1970s, as documented in Reynard (2004). Note that M^{US} seems to have grown faster than what would have been expected from the evolution of its opportunity cost towards the end of the sample; however, this apparent instability does not appear when the logarithms of those variables are considered, i.e. in a log-log money demand specification, as can be seen from Figure 3.

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[4] M^{US} corresponds to $M2$ minus small time deposits, or $M2$ Minus in the FRED database. It includes $M1$ plus savings accounts, money market deposit accounts, and retail money market funds. These assets correspond to what the Surveys of Consumer Finances group as "Transaction Accounts" (see Kennickell et al., 2000). For a study of monetary assets in the context of Divisia or Currency-Equivalent indexes, see Rotemberg et al. (1995). Analysis of this and broader aggregates can be found in Carlson, Hoffman, Keen and Rasche (2000), Carlson and Keen (1996), Motley (1988), Poole (1991), and Reynard (2004).
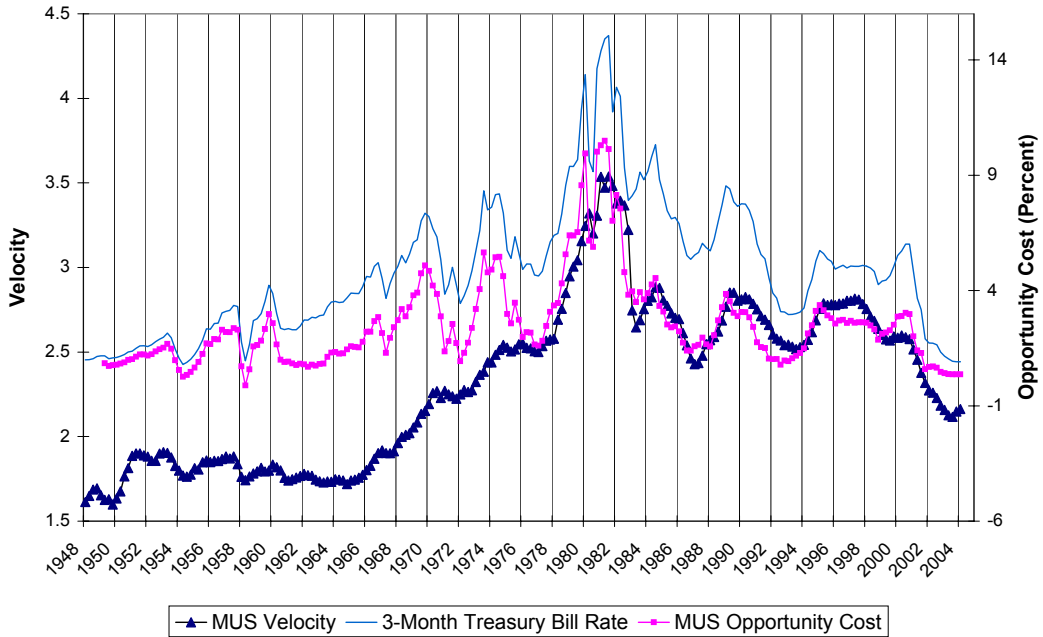
FIG. 2. M^{US} Velocity and Opportunity Cost, 1948-2003

Money demand estimations of M^{US} appear in Table 1[5]. We thus obtain a unitary

	1949-1969	1977-2003
Interest Rate Elasticity	-.065	-.128
	(.031)	(.021)
Income Elasticity	1.001	1.039
	(.074)	(.063)

DOLS standard errors in parenthesis.

Table 1. MUS Money Demand Estimates

income elasticity, and an increase in interest rate elasticity from -.065 before the

velocity shift, to -.128 after the shift.

The behavior of money in the 1980s, when correctly measured, was thus affected

by the disinflation in the way we expect money to react to a change in its opportunity

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[5]Table taken from Reynard (2004) and updated. DOLS regressions use one lead and lag of the first differences and an AR(2) process for the error.
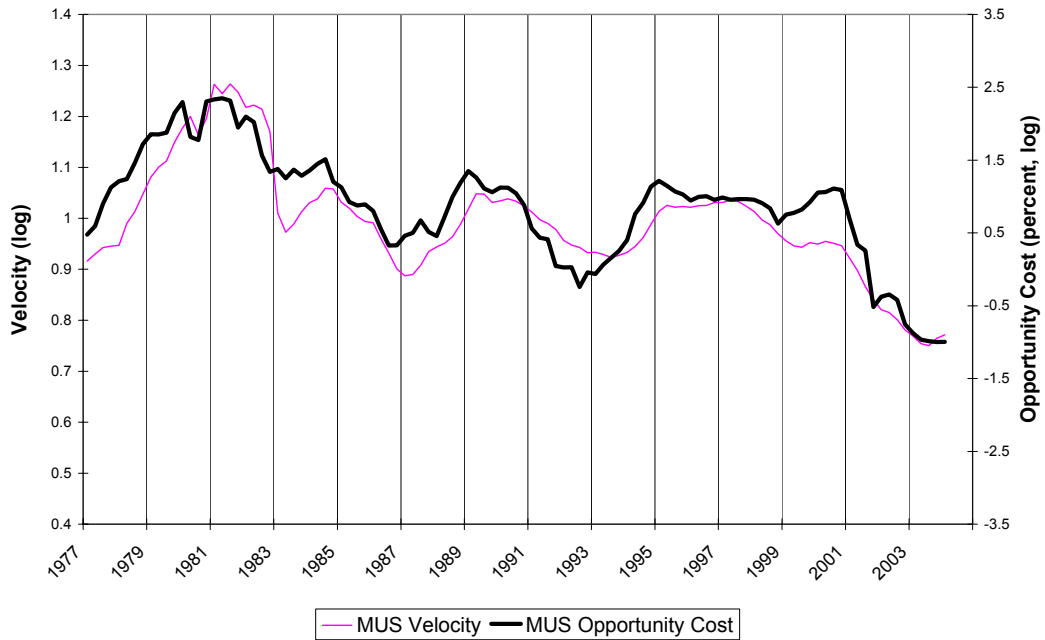
FIG. 3. U.S. Money Demand (log-log), 1977-2003

cost, i.e. with a strong increase in money balances reflecting the sharp fall in interest rates. But given the particular events that took place during the 1970s, i.e. the increase in financial market participation, the change in behavior of $M1$ was not correctly interpreted. People considered the smooth increase in the 1970s as normal and a large literature developed around modeling dynamic short-term money demand adjustments, where in fact those fluctuations were due to instability episodes.

When changes in financial market participation and substitutes of monetary assets included in $M1$ are not taken into account, the effects of the disinflation period are not correctly assessed and this explains why different income elasticity estimates have emerged from econometric studies. Studies based on narrower aggregates not including checking accounts substitutes, like e.g. Ball (2001), find income elasticity

estimates below unity, whereas studies based on broader aggregates, e.g. Carlson, Hoffman, Keen and Rasche (2000) and Reynard (2004), find a higher and usually unitary income elasticity. This is due to the fact that when substitutes from checkable deposits and the increase in financial market participation are not taken into account, money does not appear to have increased as much as the decline in opportunity cost would have implied during the early 1980s disinflation, and the velocity of M1 appears to have increased faster than interest rates in the 1960s and 70s. As a result, the pre-1980 increase in velocity is not attributed to the increase in interest rate but to economies of scale, thus the estimated income elasticity is below unity.

Additional assets, like certificates of deposits or institutional money market mutual funds, have been used in broader U.S. monetary aggregates studies. Although it is difficult to know where to draw the line, I do not consider them as monetary assets, as their link to the transaction concept is less clear, and both of them are closely related to portfolio considerations. The switch from certificates of deposits to bonds and stocks mutual funds in the early 1990s caused instability in M2[6], and institutional money market funds grew abnormally fast from the mid-1990s on. The analysis in section 3, assessing the effects of money growth on inflation, will thus use money demand estimates from M^{US}, which includes assets usually yielding an interest rate close to the one paid on checkable accounts and below the 3-month risk-free rate, thus providing transaction or monetary services. The general idea is that households accept a lower yield, reflecting banks' resources to provide transaction services, in order to have assets available to buy goods and services. Moreover, the apparent instability and stability phases of M^{US} can be explained in terms of extensive/intensive margins

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[6]Several explanations for that event have been provided. See e.g. Carlson, Hoffman, Keen and Rasche (2000), and Collins and Edwards (1994).

of money demand: an upward velocity shift occurred in the 1970s as a larger fraction of U.S. households started to hold non-monetary assets as part of their financial portfolio, and money demand remained stable in the 1980s and 1990s as financial market participation remained constant as a fraction of U.S. households[7].

2.2. DISINFLATION, TERM STRUCTURE AND SHORT SAMPLES - EURO AREA DATA

Money demand studies using euro area data have also resulted in various outcomes regarding money demand specifications, particularly with respect to the income elasticity. Some euro area studies have found a unitary income elasticity, e.g. von Hagen (2004), whereas other studies find an income elasticity significantly greater than unity, e.g. Neumann and Greiber (2004) and references therein, Brand, Gerdesmeier and Roffia (2002) and references therein, Bruggeman, Donati and Warne (2003), and Gerlach and Svensson (2003), who find a unitary income elasticity but with a positive trend in money balances, which, as argued below, amounts to finding a higher income elasticity over the period considered. I will illustrate my arguments with both $M2$, the counterpart of M^{US} in the euro area, hereafter referred to as M^{2EA}, and $M3$, hereafter M^{3EA}, the aggregate usually used in euro area studies[8].

While my analysis applies to both $M2$ and $M3$, my preference for $M2$ over $M3$ is based on the following facts. Broader aggregates in general, like $M3$, include time deposits, which have a maturity over 3 months and up to many years. There are several issues in considering such assets. First, if we consider assets like time

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[7]See Reynard (2004).

[8]In the euro area, $M2$ does not include money market mutual funds, included in $M3$, but these assets are not checkable there. Some time deposits are included in $M2$. However, the main component that needs to be taken into account is saving accounts.

deposits with longer maturities, it would be natural then to include other assets, like e.g. bonds, with similar maturities. Not including those additional assets is likely to generate money demand instability due to portfolio considerations linked with financial market events, similar to what happened in the early 1990s in the U.S., which destabilized $M2$. Second, given their looser link with transactions, those aggregates are less likely to exhibit a stable relationship with GDP, i.e. a stable income elasticity. Different studies result in different values for income elasticity, usually significantly above unity, with no theory to restrict it, and those estimates are usually very sensitive to the sample period. And third, as assets included in those aggregates yield rates equal to or above the 3-month market rate, those aggregates are sometimes positively correlated with the 3-month rate, thus making their policy stance interpretation difficult.

2.2.1. THE CHOICE OF OPPORTUNITY COST

Studies which find an income elasticity significantly higher than unity usually use the spread between long- and short-term interest rates (i.e. 10-year and 3-month, respectively) as the opportunity cost of money balances. An important feature of that spread is that it does not exhibit a downward trend over the past 25 years, as shown in Figure 4. A major conceptual issue in using that spread as the opportunity cost is that the 3-month rate, supposed to reflect the own rate, is in fact the alternative rate of large parts of M^{2EA} and M^{3EA}. In contrast, own rates of monetary assets are lower than 3-month market rates, as those assets provide transaction services, and are relatively sticky.
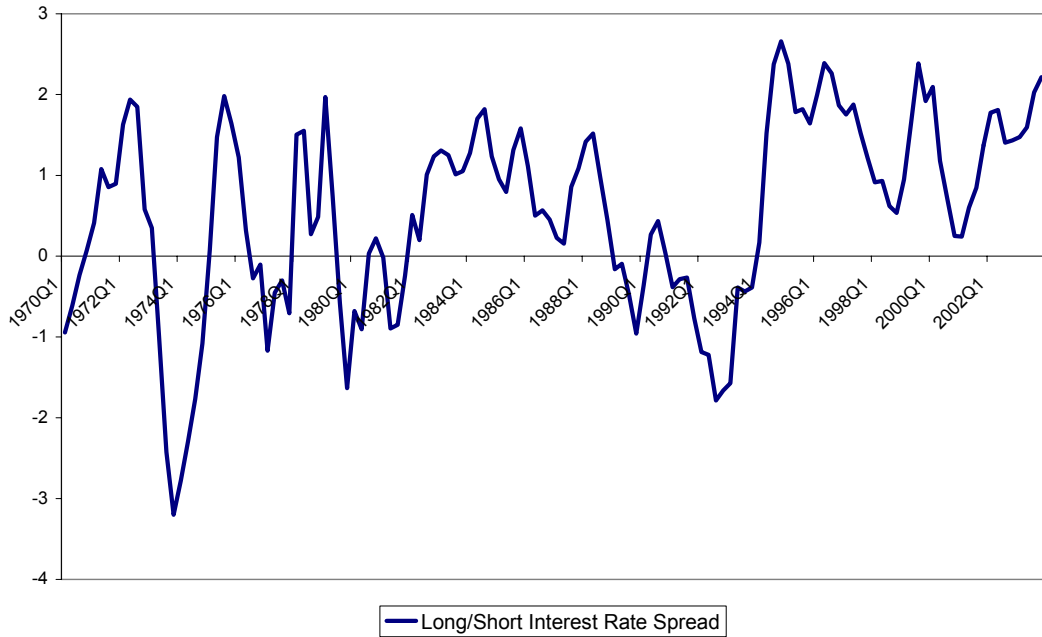
FIG. 4. Long/Short Interest Rate Spread

However, Figure 5, which displays the (log) velocity[9] of M^{2EA} together with the (log) 3-month interest rate, suggests that the velocity of money has been affected by the disinflation over the 1980s and 1990s. It is clear from Figure 5 that the strong (about 25 percent) decrease in velocity of the 1980s and 1990s was associated with the major disinflation that occurred during that same period in the euro area. A similar picture is obtained when velocity is plotted against the long-term interest rate, and available measures of opportunity costs, although particularly difficult to compute for the euro area, also show a downward trend[10], as retail rates are relatively sticky and

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[9] The HICP is used for the price level. Using the GDP deflator instead does not affect the analysis, but the fit with M^{2EA} deteriorates, particularly in the 1970s, whereas the fit with M^{3EA} improves in that earlier period. Over the 1975-2003 period, M^{3EA} income and interest elasticities are 1.01 and $-.13$, respectively.

[10] See Bruggeman, Donati and Warne (2003), who use the own rate of M3 to compute its opportunity cost. The latter trends downward during the period, similarly to the short- and long-term rates. The reason why those authors find an income elasticity higher than unity and an imprecise
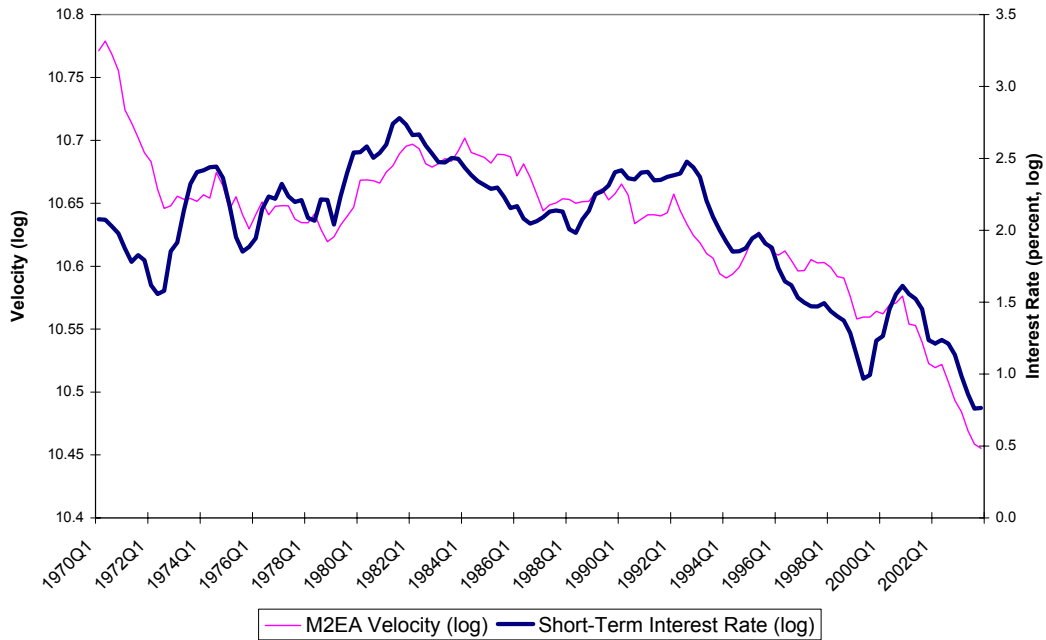
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FIG. 5. M2EA Velocity

did not decrease to the same extent as financial market rates did.

Thus the 1980s and 1990s were characterized by falling inflation and interest rates, through the Fisher effect, and real money balances reacted to that evolution by increasing strongly. Studies that consider the long/short interest rate spread as the opportunity cost are thus likely to overlook the effect of disinflation and find a higher income elasticity, as the increase in money balances is attributed to increasing income, given that the spread is not trending downwards. If, however, a trend is included in those money demand specifications, as in Gerlach and Svensson (2003) for example, the effect of disinflation, i.e. the fact that money increased by more than prices on average over the sample, appears in the trend instead of the income elasticity.

estimate of the interest rate elasticity might come from the particular sample used, as explained in section 2.2.2.

The cointegrating money demand relation, estimated by dynamic least squares (Stock and Watson, 1993) with M^{2EA} over the 1975-2003 period, is as follows[11]:

$$\ln\left(\frac{M_t^{2EA}}{P_t}\right) = -10.87 + 1.04 \cdot \ln(y_t) - 0.13 \cdot \ln(il_t),$$
$$(.71) \qquad (.05) \qquad\qquad (.03)$$

(1)

where P is HICP (Harmonized Index of Consumer Prices), y is real GDP, and il is the 10-year government bond rate[12]. An interesting finding is that the money demand function, using a comparable monetary aggregate, is very similar to the U.S. money demand: as in the U.S. case, income elasticity is not significantly different from unity, and the point estimate of interest rate elasticity is the same as the one obtained with U.S. data for the post-velocity shift period starting in 1977.

2.2.2. DISINFLATION SAMPLE

An additional fact, also linked to the disinflation, is responsible for generating different outcomes for the income elasticity, given that most euro area studies on money demand use data from 1980 only. During a disinflation, as was the case in the 1980s and 1990s, interest rates decrease. Given that, at the same time, output keeps increasing, different combinations of interest and income elasticities can emerge from money demand estimations, i.e. a lower income elasticity and a higher interest elasticity or vice versa, depending on the exact sample period and estimation method, i.e. how

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[11] Quarterly data. Regressions use two leads and lags of the first differences and an AR(2) process for the error. Standard errors in parentheses.

[12] I report here results with the long-term rate to ease comparison with the existing euro area literature. Similar results are obtained when the short (3-month) rate is used instead of the long rate, with an interest rate elasticity of .08. When income elasticity is constrained to unity, interest elasticity is .14 and .1 for long and short rates, respectively.

the dynamics are modeled. This is similar, although in the opposite direction, to the argument of Lucas (1988), who provided an explanation for the various estimates of income elasticity in the U.S. during the period including the inflation of the 1970s.

Equation (2) shows M^{2EA} demand results for the 1980-2003 period, i.e. the period usually considered in euro area money demand studies.

$$\ln\left(\frac{M_t^{2EA}}{P_t}\right) \quad = \quad -12.57 + 1.15 \cdot \ln(y_t) - 0.09 \cdot \ln(il_t). \tag{2}$$
$$(1.10) \qquad (.07) \qquad (.03)$$

The income elasticity is higher, significantly higher than unity, and the interest rate elasticity is lower than in equation (1), when the information preceding the disinflation period is not taken into account. However, when income elasticity is restricted to unity, we recover the same higher interest rate elasticity of .14 over both periods, i.e. 1975-2003 and 1980-2003. This thus explains why different money demand estimates coexist in euro area studies, as given data limitation the sample period is usually limited to the disinflation period, when the opportunity cost of money was trending downwards and income was trending upwards.

Results for M^{3EA} over the 1980-2003 period are as follows:

$$\ln\left(\frac{M_t^{3EA}}{P_t}\right) \quad = \quad -19.38 + 1.63 \cdot \ln(y_t) - 0.00 \cdot \ln(il_t). \tag{3}$$
$$(1.32) \qquad (.09) \qquad (.04)$$

Unlike von Hagen (2004), despite using the same sample, the estimated income elasticity here is much higher than unity. This reflects the previous argument, i.e. different

estimation results can emerge from a sample limited to the disinflation period. Indeed, when income elasticity is restricted to unity, a long-term interest rate semi-elasticity[13] of .029 is obtained, close to what was estimated by von Hagen (.034).

3. RECONSIDERING THE EFFECTS OF MONEY GROWTH ON IN-FLATION

This section argues that not accounting for changes in steady-state inflation and equilibrium velocity biases econometric results on the influence of money growth on inflation. The argument does not rely on short-term money demand econometric stability but uses the long-term elasticity estimates presented in the previous section to account for equilibrium changes in interest rates.

Accounting for equilibrium changes in interest rates dramatically affects the estimated influence of money growth on inflation. When accounting for equilibrium changes, money growth Granger-causes inflation with a clear proportional effect. In contrast, not adjusting for changes in equilibrium velocity results in money growth not Granger-causing inflation, seriously alters impulse-response functions and variance decompositions, and the long-term as well as short-term dynamic estimated relationships between money growth and inflation are affected.

I first present how I adjust money growth for changes in equilibrium velocity. Then I compare average money growth and inflation in the U.S. and the euro area, with and without adjustment for changes in equilibrium velocity, and relate the findings to cross-country studies results. Then I show how estimation results are affected if

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[13]Von Hagen uses the semi-log specification, so I report here the semi-elasticity. Using the $M3$ opportunity cost (3-month minus own rates) from Bruggeman, Donati and Warne (2003), yields an interest rate elasticity of .09 when income elasticity is restricted to unity.

the effects of interest rates equilibrium changes are not accounted for, and estimate a proportional influence of money growth on inflation. I further illustrate the reasons of the estimated bias by relating the velocity/money growth comovements with steady-state changes in inflation. Lastly, I relate the results with existing studies and present how some previously established results are affected.

3.1. ACCOUNTING FOR EQUILIBRIUM CHANGES

In order to account for changes in equilibrium velocity, the opportunity cost of money holdings is (HP) filtered, and then money growth over real potential output growth is adjusted by the change in that filtered series, as explained below. The filtered opportunity cost represents equilibrium opportunity cost and thus determines equilibrium velocity via the estimated money demand equation.

Three different growth rates are considered. First, π_t denotes inflation. Then, money growth corrected by real potential output growth is denoted by

$$\mu_t^X = \left(\frac{M_t^X}{M_{t-4}^X} - \frac{Y_t^p}{Y_{t-4}^p} \right) \cdot 100, \tag{4}$$

where M^X is a monetary aggregate and Y^p is real potential output. In equation (4), money growth is corrected by real potential output growth to account for the fact that variations in money growth and potential real output growth offset each others with respect to inflation developments. I correct by potential instead of actual real output as this allows me to assess the total effect of money growth on inflation rather than only the marginal effect of money given output evolution. Moreover, correcting money growth by actual output would cause μ^X to increase as output decreases after a contractionary policy for example, thus distorting the information of monetary

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aggregates and potentially resulting in an estimated reverse causality between money growth and inflation, as inflation usually responds to money with longer lags than output does.

Finally, money growth corrected by potential output and adjusted by changes in equilibrium velocity is denoted by

$$\widetilde{\mu}_t^X = \mu_t^X + 100\varepsilon_i \left(\ln\left(i_t^{HP}\right) - \ln\left(i_{t-4}^{HP}\right)\right), \tag{5}$$

which I will call net money growth. ε_i is the interest rate elasticity, estimated in section 2^{14}, and i_t^{HP} is the (HP) filtered opportunity cost. The X represents the different aggregates and countries considered, e.g. μ^{2EA} represents the growth rate of $M2$ (2) in the euro area (EA) corrected by potential output growth, and $\widetilde{\mu}^{US}$ represents net money growth in the U.S.

Thus, in equation (5), money growth is adjusted by the change in equilibrium velocity, e.g. if interest rates decrease as a result of disinflation, the second term on the right-hand side will be negative, thus money growth will be adjusted down as part of the increase in money balances reflects an adjustment of money demand to lower interest rates (Fisher effect) and should thus have no impact on future inflation developments.

3.2. EFFECTS ON LONG-TERM AVERAGES AND PROPORTIONALITY

For euro area data, Neumann (2003) presents sub-periods averages of inflation, money growth and real output growth, in his Table 1. A subtle feature of those

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[14] ε_i is a cointegrating vector estimate and is thus superconsistent.

numbers is that, for every of the three sub-samples considered, money in excess of real output growth grows faster than inflation, by about 1 percentage point per year on average, although this fact is not emphasized in his paper. For example, over the 1990s (1991-2002), μ^{3EA} averaged at 3.85% per year, but inflation averaged at 2.49%. However, when adjusted by changes in equilibrium velocity, i.e. using equation (5) above, money growth is close to inflation, i.e. $\widetilde{\mu}^{3EA}$ averaged at 2.32% per year. Not accounting for the effect of disinflation thus resulted in about 1.4% per year of money growth that does not reflect on inflation. Similarly, when the whole disinflation period (1980-2003) is considered, μ^{3EA} averaged at 5.15% per year, whereas $\widetilde{\mu}^{3EA}$ and inflation both averaged at 4.15% per year.

Thus, over the 1980s and 1990s disinflation, money grew in excess of real output growth by over 25 percentage points more than prices did. Estimates that do not account for the effects of changes in equilibrium velocity will thus find a weaker link between money and inflation, in the short as well as the long run.

Results are similar with U.S. data. Over the disinflation period (1982-1990), μ^{US} averaged at 6.3% per year, while $\widetilde{\mu}^{US}$ and inflation averaged at 4.5% per year and 4.1% per year, respectively. Thus, during the disinflation period in the U.S., the discrepancy was about 2 percentage points per year. During the 1990s however, when the opportunity cost of money was stationary, all measures coincide, i.e. μ^{US}, $\widetilde{\mu}^{US}$ as well as inflation all averaged at 3 percent per year.

Thus, comparing across these economies or over different periods, there is a clear proportional relationship between inflation and money growth when changes in equilibrium velocity are accounted for, i.e. there is a one-to-one relationship between $\widetilde{\mu}^{X}$ and inflation even for low inflation economies like the U.S. and the euro area.

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Cross-country studies of the money growth / inflation relationship, e.g. in De Grauwe and Polan (2001) and Gerlach (1995), have found a non-proportional link between these variables. Gerlach argues that one potential cause of non-proportionality comes from the omitted variable reasoning. Let's ν be velocity growth. Then, if we estimate equation (7) instead of equation (6), we obtain the OLS estimate in (8).

$$\pi_t = \beta + \beta_1 \mu_t + \beta_2 \nu_t + \epsilon_t \tag{6}$$

$$\pi_t = \gamma + \gamma_1 \mu_t + u_t \tag{7}$$

$$\gamma_1^{OLS} = \beta_1 + \beta_2 \frac{Cov\left(\mu_t, \nu_t\right)}{Var\left(\mu_t\right)} \tag{8}$$

As it is clear from the averages presented in this section, as well as from the time series results which will be presented in section 3.3, money growth is systematically negatively correlated with velocity growth driven by interest rate equilibrium changes. Thus, if systematic changes in velocity are not accounted for, by controlling for interest rates equilibrium movements, regressing cross-country inflation on money growth leads to a coefficient on money growth below unity as money growth is negatively correlated with velocity growth.

While De Grauwe and Polan argue that this negative correlation is difficult to interpret for low inflation countries in the sense that this cannot reflect a short run liquidity effect, and interpret it as exogenous (technological and institutional) velocity changes unrelated to growth rates of the money stock but to which money growth adjusts, Nelson (2003) argues that the negative correlation due to the Fisher effect, "could easily leave an imprint on long runs of annual data", which is confirmed here. This will be further confirmed in the analysis below, with a clear negative correlation

between time series of money growth and velocity growth as interest rates adjust to changes in inflationary environments.

3.3. MONEY GROWTH AND INFLATION DYNAMICS RECONSIDERED

3.3.1. EURO AREA - THE DISINFLATION BIAS

We now turn to empirical estimates of the dynamic relationship between money growth and inflation. I will assess here the total effect of money growth on inflation, following Nelson (2003) use of money as "a "quantity-side" indicator of the monetary conditions induced by central-bank policy". The influence of the analysis for the estimated marginal effect of money on inflation will be presented in section 3.5. Regressing annual inflation on current and prior years' net money growth for the euro area (1975-2003, time units are quarters) yields[15]

$$
\begin{aligned}
\pi_t &= -0.32 + 0.20 \cdot \widetilde{\mu}_t^{2EA} + 0.32 \cdot \widetilde{\mu}_{t-4}^{2EA} + 0.20 \cdot \widetilde{\mu}_{t-8}^{2EA} \qquad (9) \\
&\quad\ (.40) \qquad (.10) \qquad\ (.09) \qquad\qquad (.09) \\
&\quad +0.25 \cdot \widetilde{\mu}_{t-12}^{2EA} + \epsilon_t, \\
&\quad\ (.12) \\
R^2 &= 0.86,
\end{aligned}
$$

with a coefficients sum of 0.97 on net money growth. This equation thus displays a proportional link between net money growth and inflation in the euro area, although

---

[15]In the following regressions, I used annual lags significant at the 5% level. Newey-West standard errors in parentheses.

it does not say anything about the "causality" issues, which will be addressed below with the VAR analysis.

If, instead, money growth is not adjusted by changes in equilibrium velocity, we obtain the following results:

$$\pi_t = -1.91 + 0.41 \cdot \mu_t^{2EA} + 0.51 \cdot \mu_{t-4}^{2EA} + 0.32 \cdot \mu_{t-8}^{2EA} + \epsilon_t, \qquad (10)$$

$$(.57) \qquad (.12) \qquad (.09) \qquad (.15)$$

$$R^2 = 0.79,$$

with a coefficients sum of 1.24 on money growth. A coefficient higher than unity on money growth means that, during the disinflation period, inflation decreased by more than money growth did. This is exactly what we would expect, as falling interest rates lowered the opportunity cost of money, which induced an additional increase in the level of money balances. Furthermore, the regression constant is negative and significant, further indicating a decline in inflation apparently independent from money growth, which in fact represents the decrease in velocity. In general, whether the bias is reflected in the constant, in the money growth coefficients or in other variables, depends on the relative variances of money growth and velocity and on the covariance between these variables.

These mechanisms, which bias the relationship between money and inflation, are present in other models as well. As interest rates decline as the result of the disinflation, inflation decreases by more than what money could explain if we do not account for interest rates equilibrium movements. This affects dynamic relationships between the variables considered.

Estimates from equations (9) and (10) might however be biased due to simultaneity issues and exogenous inflation persistence. The following analysis thus uses VARs and addresses the "causality" issue.

Figure 6 displays the impulse responses of a bivariate VAR, estimated over the 1975-2003 period, comprising inflation and net money growth (M2NG stands for $\widetilde{\mu}^{2EA}$) in the euro area, and Figure 7 displays the variance decomposition, with a 95% confidence interval[16].
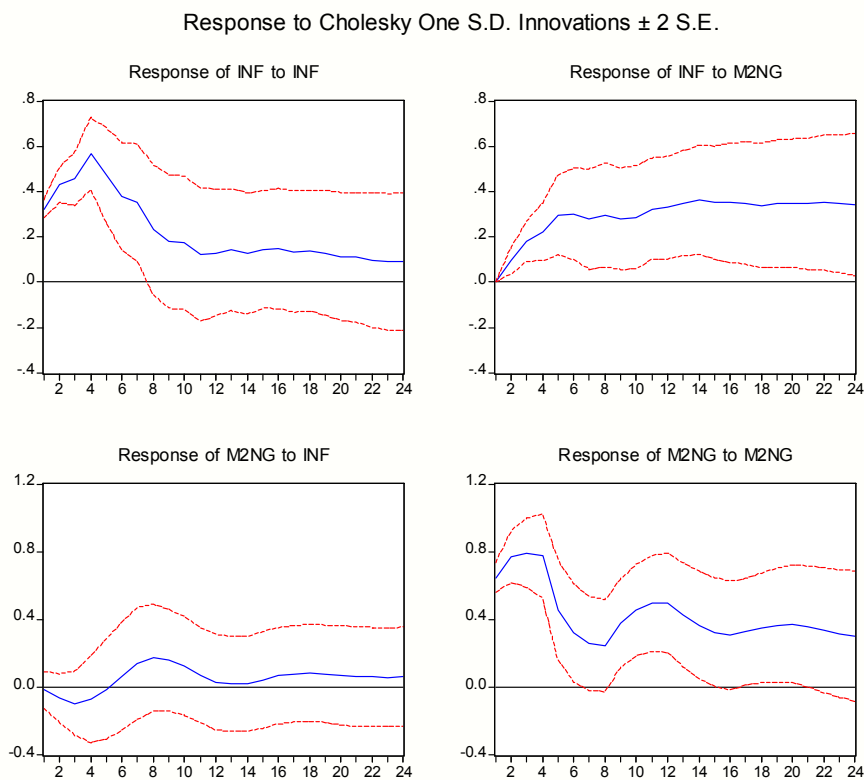

Fɪɢ. 6. Impulse responses of net money growth and inflation in the euro area (1975-2003)

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[16]Time units are quarters. The lag length is 5 quarters. The orthogonalization order is inflation first, which does not give an advantage to net money growth. Results are not significantly affected by the ordering. Monte Carlo confidence intervals with 100 draws are displayed.
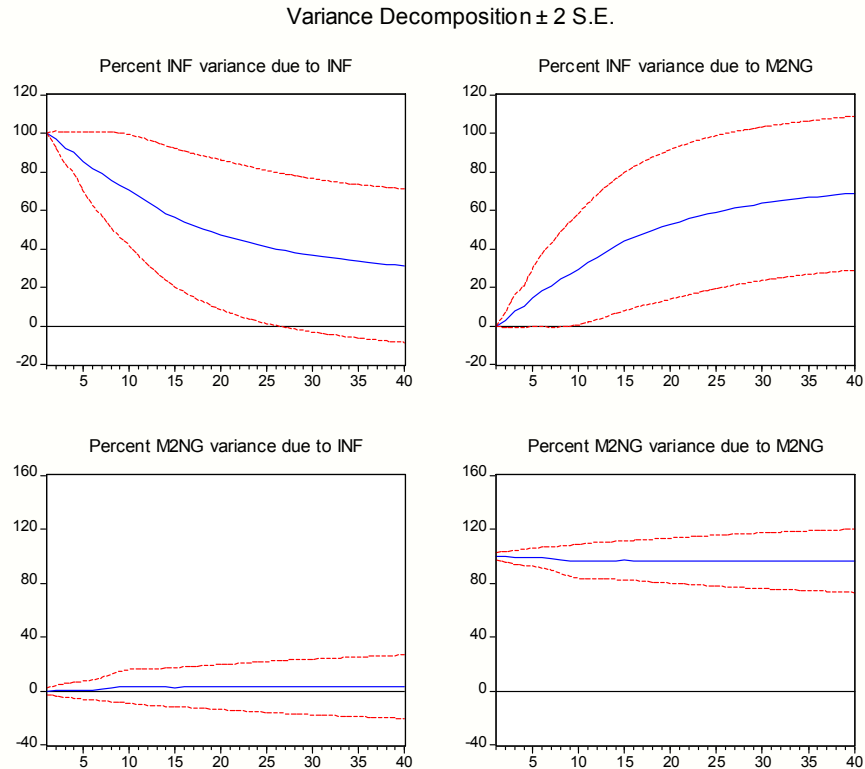
FIG. 7. Variance decomposition of net money growth and inflation in the euro area (1975-2003)

Granger causality tests indicate that net money growth Granger-causes inflation (p-value: 0.007) but that inflation does not Granger-cause net money growth (p-value: 0.673). Inflation responds significantly to a net money growth shock, but net money growth is not significantly affected by an inflation shock. Note that the shocks mentioned here do not have structural interpretations. They reflects, following Nelson (2003) terminology, a "quantity-side" measure of monetary conditions. Net money growth also accounts for 60 percent of the inflation forecast error variance, whereas inflation does not significantly account for net money growth forecast error variance.

However, when equilibrium changes in velocity are not taken into account, i.e. when

not-velocity-adjusted money growth, i.e. μ^{2EA}, is used instead of net money growth $\widetilde{\mu}^{2EA}$, the estimated influence of money growth on inflation deteriorates dramatically. Figures 8 and 9 display the impulse responses and the the variance decomposition of a bivariate VAR similar to the previous one, but with not-velocity-adjusted money growth (M2Y stands for μ^{2EA}) instead of net money growth $\widetilde{\mu}^{2EA}$.
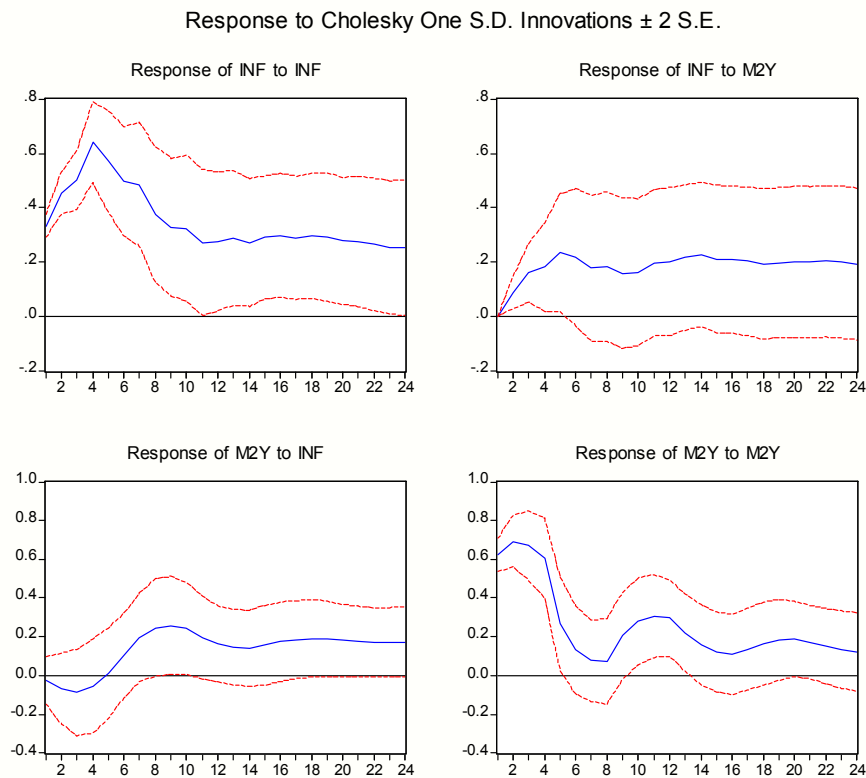

FIG. 8. Impulse responses of not-velocity-adjusted money growth and inflation in the euro area (1975-2003)

Granger causality tests in this case indicate that net money growth does not Granger-causes inflation (p-value: 0.057), and this worsens when the disinflation sample (1980-2003) only is considered (p-value: 0.096). In the latter case, the p-
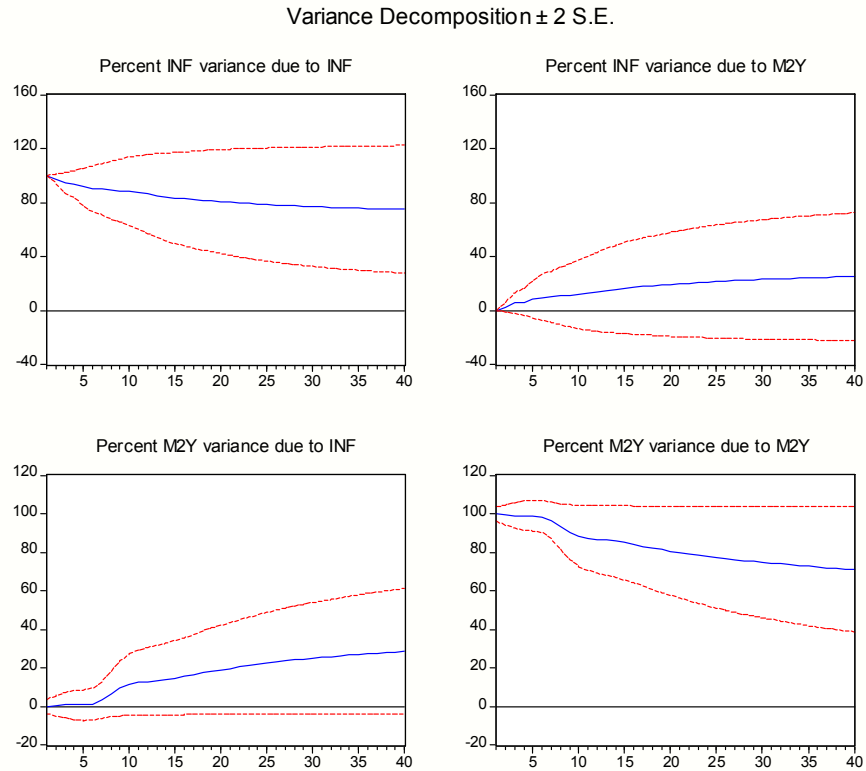
FIG. 9. Variance decomposition of not-velocity-adjusted money growth and inflation in the euro area (1975-2003)

value of the null hypothesis that inflation does not Granger cause money growth even drops to 0.145. Moreover, the response of inflation to money growth from the impulse response functions is insignificant and the response of money growth to infla-tion is significant. In addition, money growth now only accounts for a non-significant low percentage of the inflation forecast error variance, compared to 60 percent when changes in equilibrium velocity were accounted for.

3.3.2. U.S. - THE GENERAL TIME SERIES BIAS

U.S. regression results of inflation on net money growth over the 1949-2003 period are as follows[17]:

$$\pi_t = 0.45 + 0.17 \cdot \widetilde{\mu}_{t-8}^{US} + 0.17 \cdot \widetilde{\mu}_{t-12}^{US} + 0.19 \cdot \widetilde{\mu}_{t-16}^{US}$$
$$\quad (.64) \quad (.08) \quad\quad (.09) \quad\quad\quad (.07)$$

$$+0.13 \cdot \widetilde{\mu}_{t-20}^{US} + 0.11 \cdot \widetilde{\mu}_{t-24}^{US} + 0.13 \cdot \widetilde{\mu}_{t-28}^{US} + 0.10 \cdot \widetilde{\mu}_{t-32}^{US} + \epsilon_t, \qquad (11)$$
$$\quad (.06) \quad\quad (.04) \quad\quad\quad (.05) \quad\quad\quad (.05)$$

$$R^2 = 0.49,$$

with a coefficients sum of 1.00. We thus also find proportionality in the U.S. case. Note that the estimated impact of changes in money growth rates on inflation is more spread out, i.e. includes longer significant lags, in the U.S. than in the euro area.

However, when money growth is not adjusted by changes in velocity, we obtain

$$\pi_t = 1.96 + 0.08 \cdot \mu_{t-8}^{US} + 0.11 \cdot \mu_{t-12}^{US} + 0.13 \cdot \mu_{t-16}^{US}$$
$$\quad (.36) \quad (.04) \quad\quad (.04) \quad\quad\quad (.04)$$

---

[17]In order to account for the upward velocity shift that occured in the U.S. during the 1970s as a result of the increase in financial market participation (see Reynard, 2004), a time trend is introduced in the money demand equation, during the 1970-76 period, and then used to scale up M^{US} and obtain a counterfactual monetary aggregate. As an alternative, I introduced a time trend during the 1965-76 period and a trend dummy on interest rate elasticity during that period to account for the increase in interest rate elasticity. The main findings are similar in the two alternatives.

$$+0.07 \cdot \mu_{t-20}^{US} + 0.06 \cdot \mu_{t-24}^{US} + 0.09 \cdot \mu_{t-28}^{US} + 0.09 \cdot \mu_{t-32}^{US} + \epsilon_t, \qquad (12)$$

$$(.04) \qquad\qquad (.04) \qquad\qquad (.04) \qquad\qquad (.04)$$

$$R^2 \;=\; 0.25,$$

where the coefficients sum to 0.63, i.e. well below unity[18]. This below proportionality result can be attributed to the omitted variable argument discussed in section 3.2. When the omitted variable is negatively correlated with variables included in the right-hand side of the equation, coefficients will be biased downwards. This is further illustrated in section 3.3.3.

The following VAR analysis provides more precise information regarding the relationship between U.S. money growth and inflation. Figure 10 displays the impulse responses of a bivariate VAR, estimated over the 1949-2003 period, comprising inflation and net money growth (MUSNG stands for $\widetilde{\mu}^{US}$), and Figure 11 displays the variance decomposition, with a 95% confidence interval[19].

As in the euro area case, impulse responses display a significant influence of money growth "shocks" on inflation, and net money growth accounts for 60% of the inflation forecast error variance. A difference with the euro case is that there is an initial significative influence of inflation on net money growth. Granger causality tests indicate that both net money growth Granger-causes inflation (p-value: 0.015) and that inflation Granger-causes net money growth (p-value: 0.003). Appendix B presents results of a bivariate VAR with inflation and money growth not adjusted by velocity changes (MUSY stands for μ^{US}). As in the euro case, when interest rate changes

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[18]Note that, in this case, lags 20 and 24 are not significant either. When these non-significant lags are removed and the equation re-estimated, the coefficient sum drops even lower.

[19]The lag length is 11 quarters.
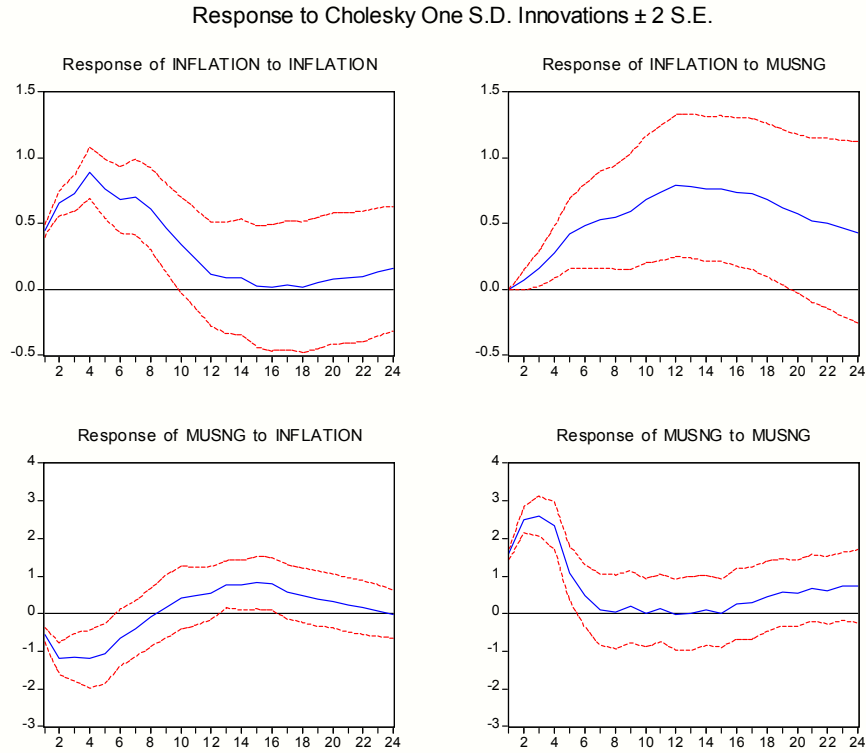
Response to Cholesky One S.D. Innovations ± 2 S.E.

FIG. 10. Impulse responses of net money growth and inflation in the U.S. (1949-2003)

are not accounted for, the response of inflation to money growth from the impulse response functions is insignificant, and the response of money growth to inflation is significant. Moreover, money growth now only accounts for a non-significant low percentage of the inflation forecast error variance, compared to 60 percent when changes in equilibrium velocity were accounted for.
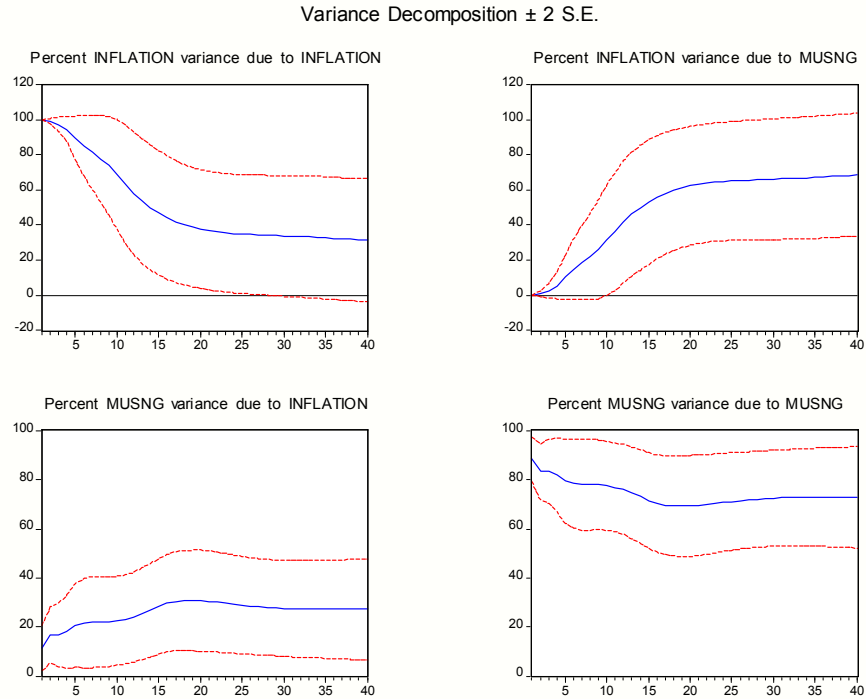
Fɪɢ. 11. Variance decomposition of net money growth and inflation in the U.S. (1949-2003)

3.3.3. VELOCITY/MONEY GROWTH COMOVEMENTS AND STEADY-STATE INFLATION

Figure 12 displays the (HP) filtered series of money growth, inflation, and the opportunity cost of money.

Money growth is adjusted by potential output growth, which affects the level but not the fluctuations. The variables have been filtered on this graph for illustrative reasons, as it is sometimes argued that a negative correlation between money growth and velocity growth occurs in the short run as a result of exogenous velocity shocks[20].

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[20]Note that there are issues in interpreting beginning- and end-of-sample HP filter movements.
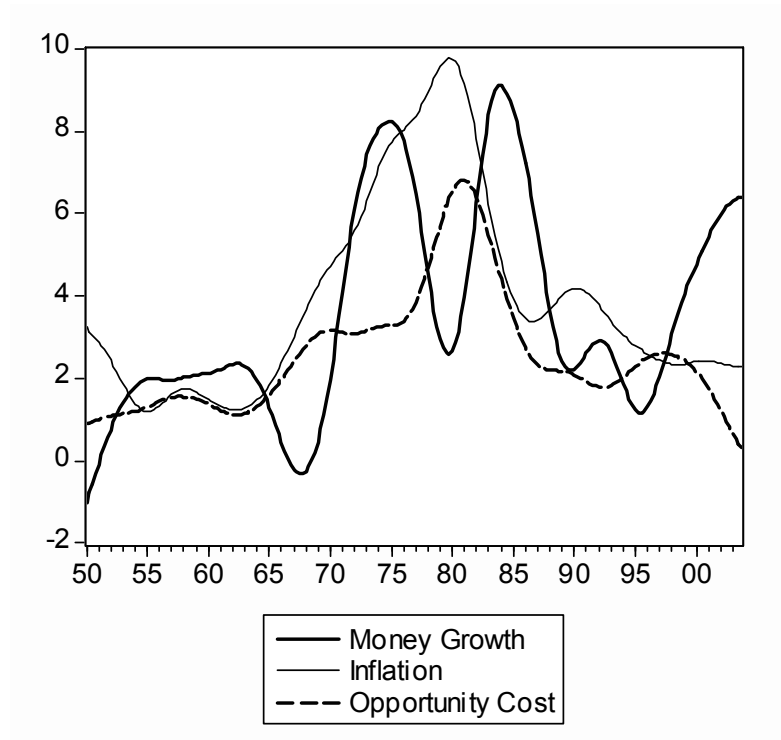
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FIG. 12. U.S. money growth, inflation and opportunity cost (HP filtered)

We clearly see from Figure 12 that the major discrepancies between money growth and inflation occured when changes in inflationary environments and low-frequency movements in interest rates occured, i.e. in the late 1960s (initial inflation increase), late 1970s (inflation burst) and early 1980s (disinflation). By definition, velocity growth is the difference between inflation and money growth, thus velocity growth is clearly negatively correlated with money growth, with the negative comovements occuring when interest rates move as a result of changes in inflationary environments: velocity growth increased in the late 1960s and late 1970s, as interest rates increased and money growth decreased, and velocity growth decreased in the early 1980s, as interest rates decreased and money growth increased. As a result, dynamic esti-

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mations underestimate the influence of money growth on inflation and do not find proportionality when interest rates equilibrium movements are not taken into account. Moreover, a reverse causality can appear in estimation results, as for example in the early 1980s, when following the great inflation, money holdings grew strongly as a response to the disinflationary decline in interest rates.

Figure 13 shows the low frequency movements of euro area variables. In the euro
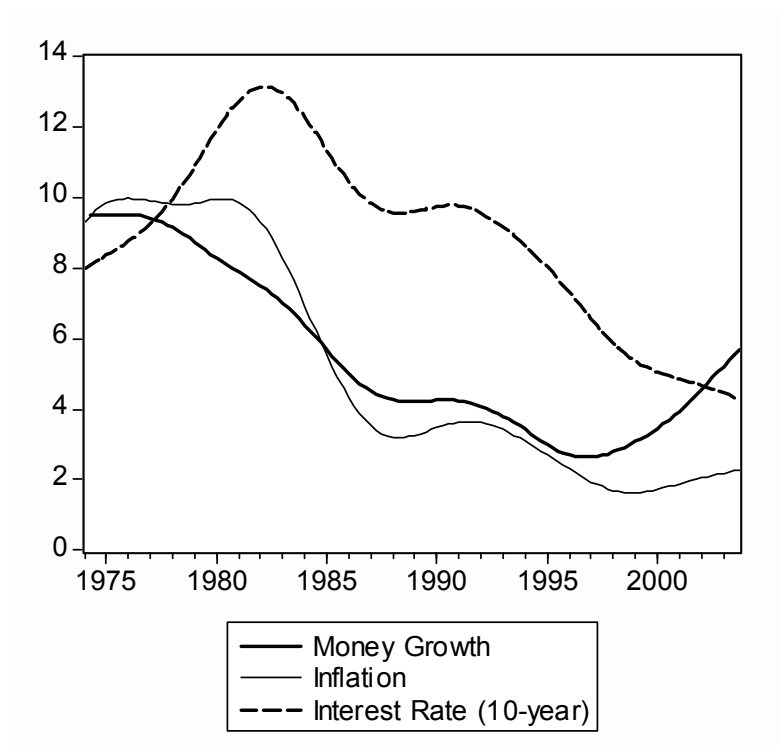

FIG. 13. Euro area money growth, inflation and interest rates (HP filtered)

case, regression (10) results shown above displayed a coefficient sum higher than unity, and the coefficient sum is even higher when only the disinflation sample is considered (1980-2003), as inflation decreased by more than inflation did, as a result of the Fisherian decline in interest rates. But in general, i.e. over a longer sample

period, not accounting for changes in equilibrium velocity weakens the estimated link between money and inflation, and results in a less than proportional link. When changes in interest rates are not accounted for, a proportional link would thus only occur by accident, due to a particular sample choice.

3.4. RELATING THE FINDINGS TO EXISTING STUDIES

[INCOMPLETE]

Not taking into account changes in equilibrium velocity affects results on the relationship between monetary aggregates and inflation, and many conclusions of a weak relationship between money and prices or a non-proportional link between money growth and inflation have been caused by that omission.

Regarding the claim made, among others, by Friedman and Kuttner (1992), that including the post-1980 period destroys evidence of a link between money and nominal income in the U.S., consider Figure 14, which displays the (log) level of M^{US} together with the after-1985 trend (6% per year) in nominal output. After 1985, the opportunity cost of U.S. money balances was stationary (see Figure 2), real output grew at an average of 3 percent, and inflation was relatively stable at around 3 percent as well, with a temporary increase around 1990 and a temporary drop in the late 1990s. Figure 14 displays a clear relationship between nominal income growth and money growth during that period. Moreover, the two inflation fluctuations of the early and late 1990s followed, with a lag, deviations of money from its trend[21].

Claims that the link between money and inflation has disappeared since the early 1980s are thus misleading. Various conceptual as well as methodological issues are

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[21]Note that the latest increase in M^{US} reflects a strong fall in the opportunity cost, as interest rates reached historily low levels (see Figure 3).
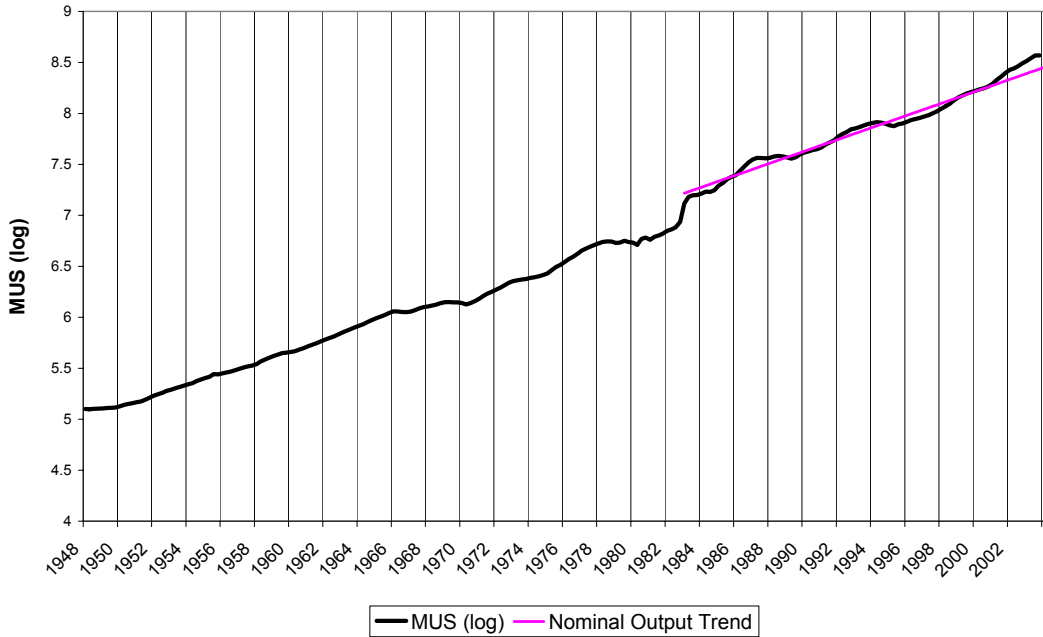
Fɪɢ. 14. MUS and Nominal Output Trend

responsible for those claims. A first issue is that sample periods including both the

1970s and the 1980s are affected by the upward velocity shift in the 1970s, due to the

change in financial market participation, and thus includes a period when aggregate

money demand was unstable, i.e. in the 1970s, with a period when aggregate money

demand was stable, i.e. in the 1980s. Then, some studies look at the marginal

effect of money growth on inflation, given GDP growth or other variables. Nelson

(2003) argues that including other variables should yield to no effect of money growth

on inflation, as the quantity theory does not claim a direct channel linking money

growth and inflation. I will assess the effects of the analysis of this paper on the

estimated marginal effects of money on prices in section 3.5. Some studies (e.g.

Carlson, Hoffman, Keen and Rasche, 2000) find significant short-term marginal effects

of money on prices within cointegrating money demand relationships.

Another issue, which is the main point of the analysis presented above, is that money growth increased significantly with the disinflation of the early 1980s as a result of decreasing interest rates, without a corresponding subsequent increase in inflation. Not accounting for changes in equilibrium velocity thus biases the results of studies that include the 1980s period. The corresponding increase in the money level can clearly be seen on Figure 14 in the U.S. case. The issue of a constant steady-state velocity growth assumption has been pointed out by Batini and Nelson (2001) as a weakness in Friedman and Kuttner's (1992) analysis, for example.

Studies using euro area data have usually been more supportive of monetary aggregates, but equilibrium movements in velocity are usually not accounted for. Papers by Neumann (2003), Neumann and Greiber (2004) and Gerlach (2003, 2004) have been looking for a distinct low-frequency role for money growth, and these authors report a prominent role for monetary aggregates in the inflation process. However, they do not account for interest rates equilibrium fluctuations; in these studies, measures of core money growth (i.e. money growth adjusted by real output growth, μ in my notation - but adjusted by actual instead of potential output, with the potential reverse causality effects discussed in section 3.1) thus grow faster than inflation over the whole sample period, i.e. in the 1980s and 1990s. This latter fact does not appear explicitly in their analysis for different reasons. Neumann explicitly disregards the early 1980s period in its estimation. Neumann and Greiber estimate income elasticity to be 1.5. As discussed in section 2.2, this estimate (or in general an estimate biased upwards) can turn out of a model of the 1980s and 1990s or where the opportunity cost is modeled as the long/short interest rate spread. Such an income elasticity

compensates for the fact that inflation decreased by more than money growth did over the 1980s and 1990s, but only on average, i.e. output fluctuations do not necessarily always compensate for money responses to opportunity cost changes, and this model specification would probably not fit the data if the sample were extended to include the pre-1980s period. Gerlach, in his graphical analysis, normalizes the data, which removes the relatively higher average growth rate of money but affects the money/inflation relationship if velocity does not follow a deterministic time trend. Velocity is assumed to follow a deterministic time trend in his econometric analysis as well, which, even if it were the case, affects the estimated coefficients depending on how money growth fluctuates and comoves with equilibrium velocity. This fact is recognized by Gerlach (2003), who argues that there should be no presumption of proportionality between core money growth and inflation, from the standard omitted variables reasoning discussed in section 3.2. Kugler and Kaufmann (2005) present a cointegrating relationship between money growth and inflation, with M3-growth shocks accounting for about 40 percent of the inflation forecast error variance in the long run. They have different orders of integration for money and prices ($I(2)$) than for interest rates ($I(1)$), thus their estimated long run relationship is not affected by interest rate changes. They however allow for a trend in real money balances, and find evidence for a second regime when inflation and interest rates were increasing in the late 1970s / early 1980s, with decreasing rates in real money growth. The second regime thus corresponds to the period when velocity growth was positive and increasing, before becoming negative and relatively stationary since the mid-1980s.

In general, not accounting for changes in equilibrium velocity and interest rates when assessing the influence of money growth on inflation results in biased coeffi-

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cients on money growth and on the other variables considered. Moreover, results are dependant of the sample considered: as explained above, the bias in accelerating inflation or disinflation samples are different than periods including both episodes, as the underlying trend and fluctuations in velocity growth differ. The next session reexamines some previously established results accounting for changes in equilibrium velocity.

3.5. PREVIOUSLY ESTABLISHED RESULTS RECONSIDERED

This section shows how previous results established in the literature, using different approaches and models, are affected quantitatively by the analysis above.

3.5.1. TIME SERIES EVIDENCE

[INCOMPLETE]

3.5.2. CROSS-COUNTRY EVIDENCE

[INCOMPLETE]

4. CONCLUSION

Less attention has been paid to monetary aggregates in the past 20 years, as many different money demand specifications or instability results have emerged from econometric studies, and the reported estimated influence of money growth on inflation has usually been non-significant, or at least non-proportional, in time series as well as cross-countries studies.

This paper has on the contrary found significant and proportional effects of money

growth on inflation, as equilibrium changes in velocity have been accounted for. I have shown that not accounting for interest rates equilibrium movements biases the estimated influence of money growth and other variables on inflation, and in particular weakens the estimated influence of money growth on inflation. Furthermore, I have suggested reasons why different money demand relationships have coexisted in the literature, particularly with respect to the income elasticity, which turns out to be unity when the Baumol-Tobin transaction concept is considered.

The current low inflation rates in industrialized countries can thus be explained by much lower money growth rates nowadays - and preceding the current low inflation period - than in the 1970s and 1980s. Relative price shocks like an increase in international competition, a commonly used argument to explain the current low inflation environment, or an oil price shock, cannot affect growth rates of the general price level without a corresponding change in monetary conditions.

While money demand relationships have been remarkably stable in the past 30 years, the dramatic increase in financial market participation in the U.S. during the 1970s, as documented in Reynard (2004), caused a decline in aggregate money holdings and biased aggregate money demand relationships. Similarly, but in the opposite direction, very low interest rates can generate non-linearities due to changes in financial market participation, which would induce relatively high growth rates in monetary aggregates not followed by high inflation. Part of the recent relatively high growth rates in monetary aggregates, particularly in the euro area, are likely to be related to that phenomenon. Those facts act as warning signals when interpreting short-term monetary aggregates growth rate fluctuations and call for more research on those potential non-linearities.

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APPENDIX A: DATA SOURCES

U.S. data were downloaded from the Federal Reserve Bank of St. Louis FRED (internet) database, and are released by the Federal Reserve Board, the Bureau of Economic Analysis and the Bureau of Labor Statistics. Monetary series prior to 1959 are from Rasche (1987, 1990). Interest rates paid on the various monetary assets were provided to me by Ruth Judson and Robert Rasche.

Euro area data (all series except monetary aggregates and own rates) from the euro Area Wide Model (AWM; see Fagan, Henry, and Mestre, 2005) were provided by Alistair Dieppe. Monetary aggregates were downloaded from the ECB internet site. Own rates series were provided to me by Paola Donati, Adriana Lojschova and Rolf Strauch, and are from Bruggeman, Donati, and Warne (2003).

All series except interest rates are seasonally adjusted.

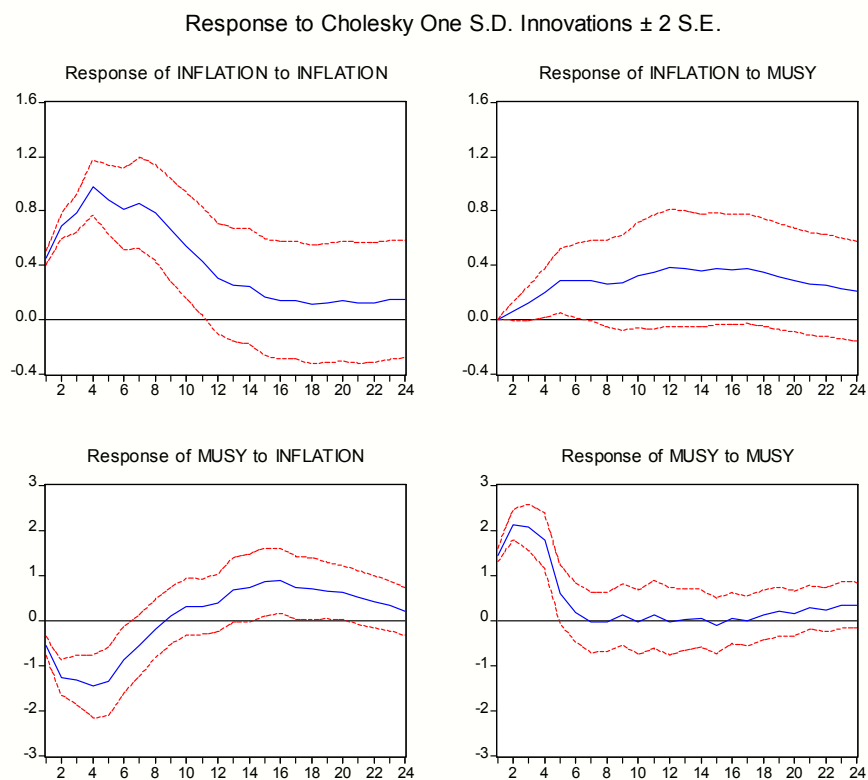# APPENDIX B: U.S. VAR WITHOUT INTEREST RATE ADJUSTMENT

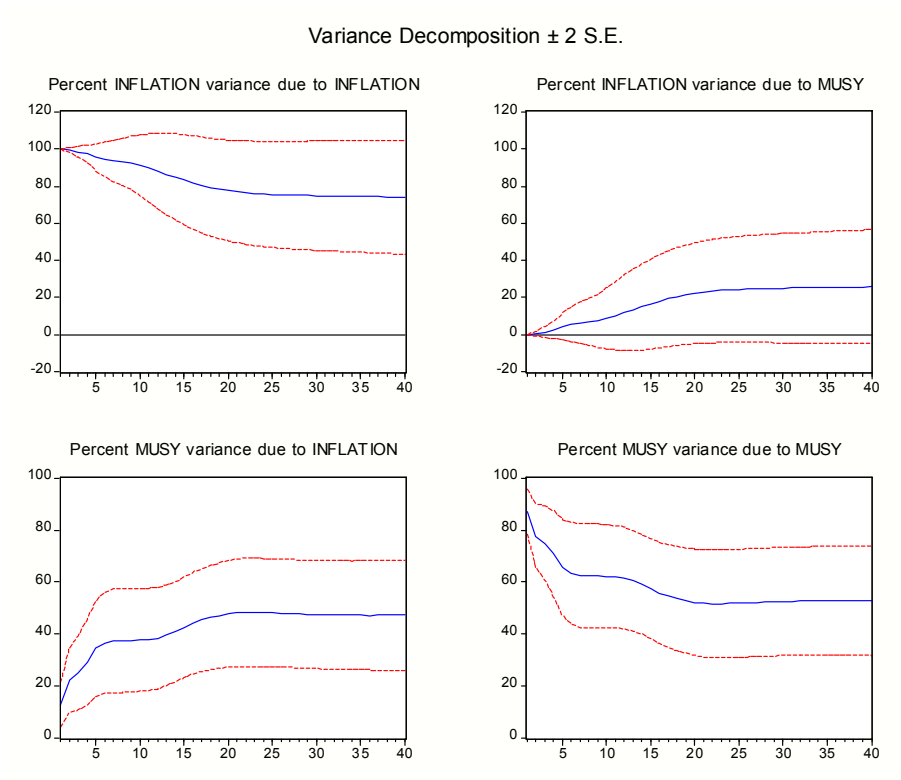FIG. 15. Impulse responses of not-velocity-adjusted money growth and inflation in the U.S. (1949-2003)

FIG. 16. Variance decomposition of not-velocity-adjusted money growth and inflation in the U.S. (1949-2003)