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Inflation and Money Growth: Evidence from a Multi-Country Data-Set

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Abstract: Using a multi-country data set strong correlation are found between average growth rates of monetary aggregates and average inflation. The correlation remains strong when countries with higher average inflation rates are removed from the sample. These results confirm the strong correlation found in the traditional literature but contradict those in De Grauwe and Polan (2001) who, in a recent analysis, find that the strong link vanishes when higher inflation countries are excluded. Further analysis confirms the unit response and bears out the value of monetary aggregates as an input to the making of monetary policy.

I INTRODUCTION

Monetary theory predicts a strong long-run correlation between money growth and inflation. One strand of the empirical evidence for this assertion examines the correlation between average money growth and average inflation in a sample of countries. Calculated across a range of countries this correlation will be independent of various country specific effects and policies (e.g. the way in which monetary policy is implemented). The most quoted study of this kind is McCandless and Weber (1995). They examined data covering a 30-year period for 110 countries using three definitions of money (M0, M1 and M2). They also examined two subsamples of their data (their first subsample consisted of 21 OECD countries and their

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second contained 14 Latin America Countries). As regards money growth and inflation they concluded:

In the long run there is a high (almost unity) correlation between the rate of growth of the money supply and the rate of inflation. This holds across three definitions of money and across the full sample of countries and two subsamples.

McCandless and Weber give graphical evidence that the relationship between inflation and money growth is one-one but that the 45° line representing this relationship does not pass through the origin. They suggest that this implies that a central bank cannot generate a particular long-run inflation level by choosing an equal long-run growth rate for the money supply. Long-run inflation is also effected by the long-run growth rate of the economy and by changes in velocity. However, a central bank can be confident that, over the long run, a higher growth rate of the money supply will result in a proportionately higher inflation rate. Their results are broadly consistent with various other smaller studies.

De Grauwe and Polan complete a similar exercise but come to a different conclusion. From the International Financial Statistics (IFS) database of the International Monetary Fund they take samples of 165 and 159 countries to estimate the correlations between average percentage change in M1 and M2 and average inflation. For their entire sample of countries they find a high correlation for both definitions of money. However, on examining the sample of countries in more detail they conclude that this correlation is entirely due to the presence, in their sample, of high inflation countries. If these high inflation countries are excluded they found no evidence of correlation between inflation and money growth.

Their results have been quoted as evidence of the decreasing importance of monetary variables in monetary policy analysis. In particular this result, if robust, has serious implications for the conduct of monetary policy in a low inflation environment such as the euro area.¹ In view of the fundamental importance of the money price relationship in economic theory and policy it is important that the robustness of these results be examined.

This paper re-estimates the regressions using a later version of the same data set. The data set has been edited to remove discontinuities and countries with short spans of data. Also it may use a different method of averaging. Using this carefully constructed data set their results cannot be replicated. I find strong correlations between average growth rates of six monetary

¹ See Begg *et al.* (2002); de Grauwe (2003) and Svensson (2002). Nelson (2003) does not question their empirical findings but argues that they are not relevant.

variables and average inflation. The correlations remain strong even if high inflation countries are removed from the sample. For the lower inflation countries the response of average inflation to the monetary growth variables is less than one-one. When countries are arranged in order of increasing average inflation recursive regressions indicate that the response may not be constant. A variable coefficient model of the relationship is proposed and estimated. There is considerable variability in the estimate of the coefficient for individual countries but the resulting estimates are not inconsistent with a one-one response of average inflation to excess money growth even in low inflation countries.

These results say nothing about any short-run relationship between money growth and inflation. All the correlations estimated in this paper are long run. They do not establish any direction of causality between money and inflation even in the long run. The analysis shows that this data set and methodology cannot be used to deny the existence of a unit long-run relationship between money growth and inflation. Put simply, if in the long run money supply is growing faster even low inflation countries will experience greater inflation.

II EMPIRICAL RESULTS

2.1 Data Definitions and Sources

The data used are taken from the January 2003 International Financial Statistics CD-ROM (IFS) of the International Monetary Fund. IFS contains annual country data from 1948 for countries that have such data. For other countries data are included from the earliest year possible.

Inflation was measured as (100 times) the log difference of item 64 (CPI) for each country. Three definitions of the monetary aggregate were used. For M0² line 14 (Reserve money) was used when available. Where this was not available line 14a (Currency outside Banks) was used. Line 34 (Money) was used as an estimate of M1. M2 was estimated by the sum of lines 34 and 35 (quasi money). Line 99b (GDP at current prices) was used as an activity variable. Nominal growth rates of M0, M1, M3 and GDP were estimated as (100 times) the log difference of the variable in question. Where a real growth rate was required the nominal value was deflated by the price series. This choice of series was the only one that would give a set of consistent series for a reasonable sample of countries.

² Variables in levels are represented by upper case characters while those in logarithms by lower.

All series were examined graphically. Some series appeared to have serious discontinuities. Where these discontinuities were confirmed by the country notes on the IFS CD-ROM, data before or after (whichever allowed the maximum sample) the discontinuities were removed. All euro area country data were truncated in 1998. As the analysis concentrated on the long run I decided to limit the analysis to countries that had at least 25 years of annual data. The total number of countries included (89, 88, and 87 for M0, M1 and M2 respectively) is less than that used by McCandless and Weber (1995) or by de Grauwe and Polan (2001). Appendix A gives a list of countries in the analysis after these adjustments.

2.2 Empirical Analyses of the Data Set

Six regressions of the form

$$\pi_i = \alpha_0 + \alpha_1 \Delta m_i + \varepsilon_i \quad (1)$$

were completed using data for all countries and for countries with lower inflation. Average inflation (π_i) in each country was regressed on the average percentage log differences of each of M0, M1 and M2 and three average excess monetary growth variables, $\Delta \hat{m}_0$ (average excess M0 growth), $\Delta \hat{m}_1$ (average excess M1 growth), and $\Delta \hat{m}_2$ (average excess M2 growth). Excess money growth is the excess of money growth over real output growth i.e.

$$\Delta \hat{m}_i = \Delta m_i - \Delta y + \Delta p, \quad i = 0, 1, 2$$

Figure 1 shows scatters of average inflation and average monetary growth rates. The scatters in the left hand column show the almost one-one relationship between average inflation and average money growth for all countries. There is a considerable concentration of data points in the lower left hand corner of each of these scatters. The scatters in the right hand column show a magnified version of the corresponding figure in the left hand column and cover countries with average inflation of less than 10 per cent. These show a weaker relationship which appears to be less than one-one. Figure 2 shows corresponding scatters for the average excess monetary variables. The results are broadly similar and the linear relationships would appear to be more concentrated.

Tables³ 1, 2, and 3 give regression estimates of Equation (1) and correspond to the data in the scatters. The regressions confirm the above comments. For the full samples the coefficient on the monetary growth variables is close to one (minimum .938 – maximum 1.074), and has low standard deviation. The constant terms in these regressions include

³ All standard errors in these tables and in the following recursive estimates have been adjusted for heteroscedasticity.

Figure 1: *Scatter Plots of Average Inflation and Average Growth Rates of M0, M1 and M2 for all Countries and for Lower Inflation Countries*

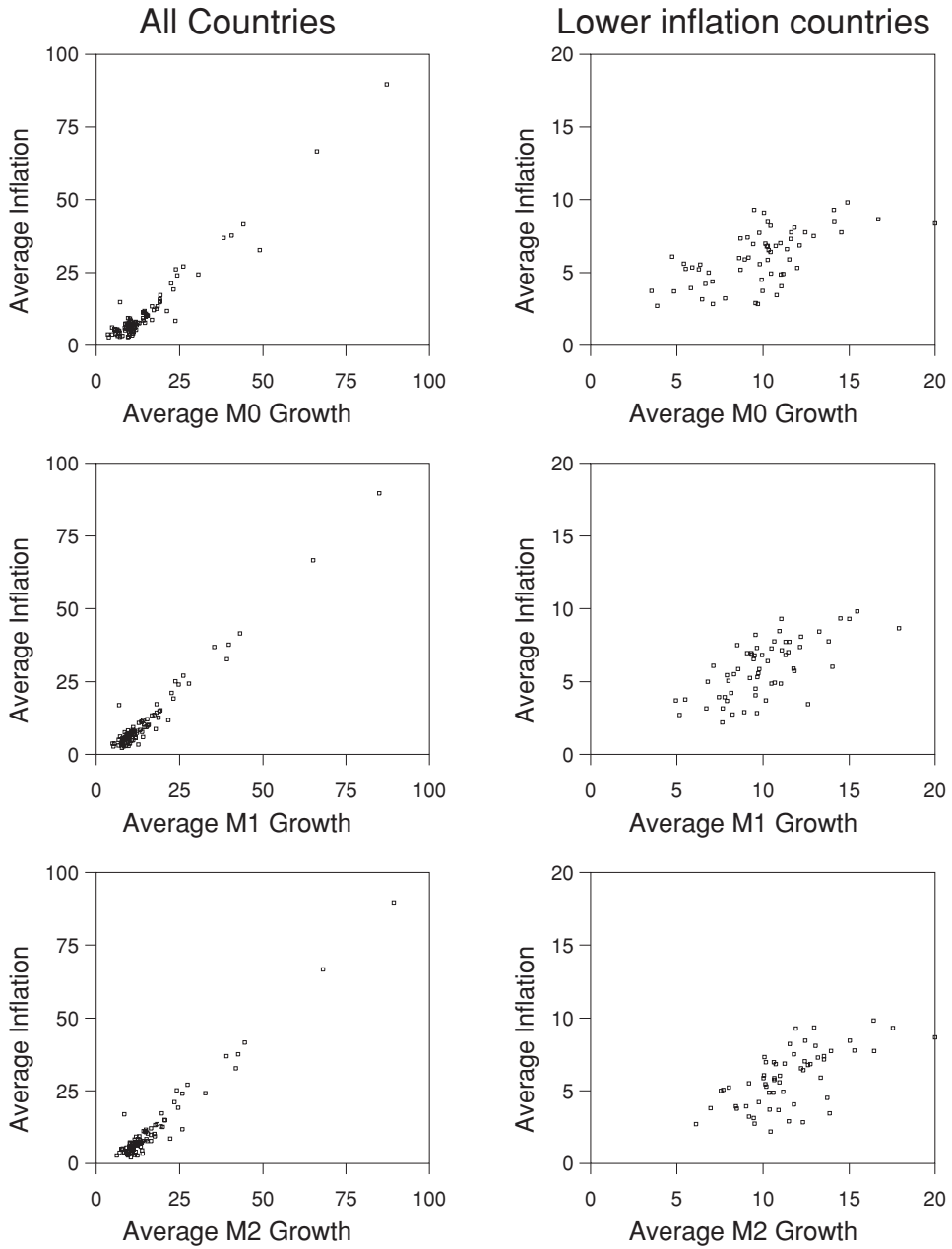
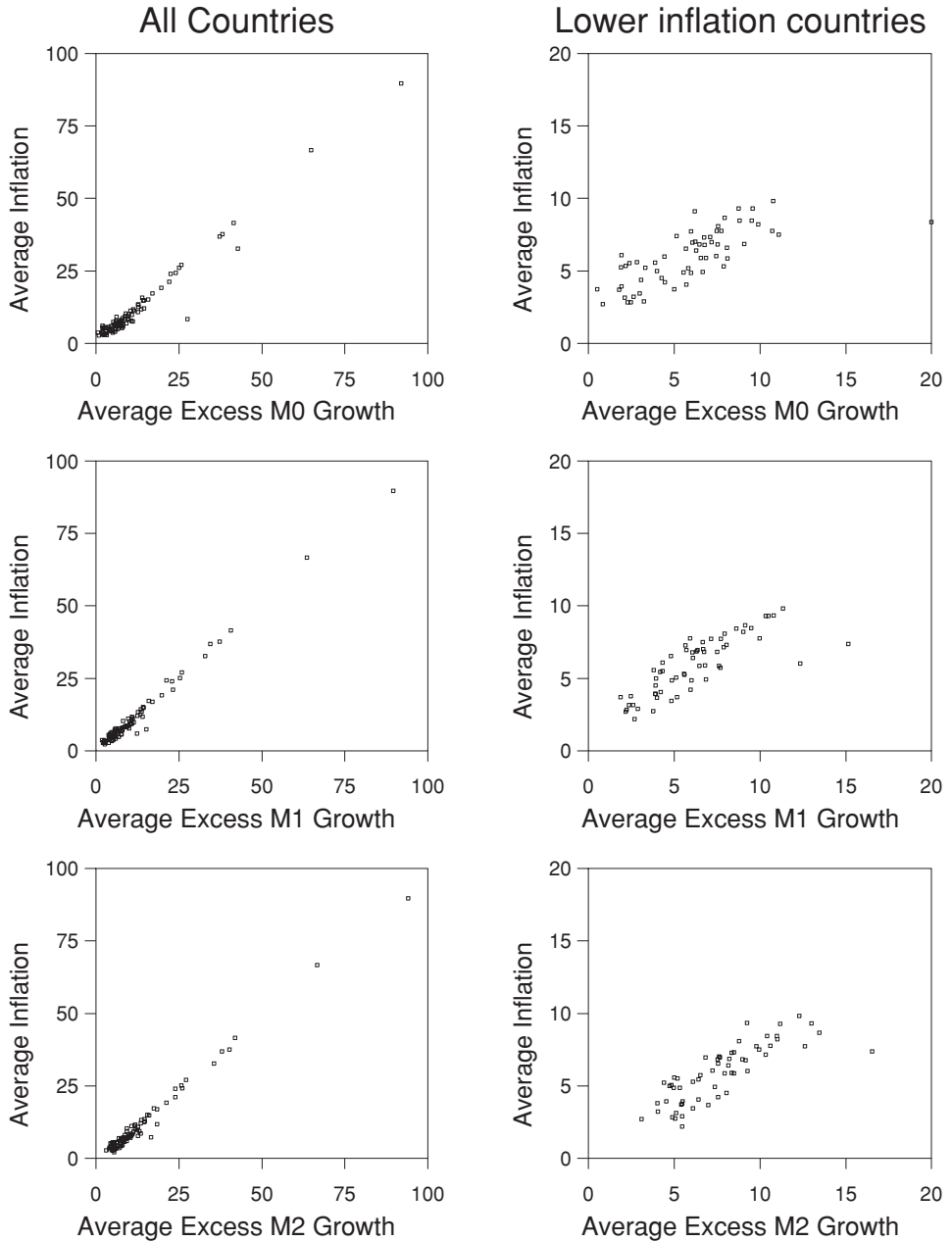


Figure 2: *Scatter Plots of Average Inflation and Average Growth Rates of Excess M0, M1 and M2 for all Countries and for Low Inflation Countries*



adjustments for real income growth, where appropriate, and for changes in velocity. Their estimated values are in accordance with expectations.

The regressions involving the excess monetary variables are stronger, in most cases, than those based on the ordinary monetary variables. In particular the standard errors of the coefficients on excess money growth are approximately half those on money growth. For all countries the constant are of an order consistent with changes in velocity.

For the lower inflation countries (with less than 10 per cent average inflation) the coefficients of the monetary growth variables remain significant (adjusted t-statistics vary from 2.87 to 8.22) but all are significantly less than one.

Table 1: *Regression of Average Inflation on Average M0 and Excess M0 Growth*

<i>Independent Variable : Average M0 Growth</i>							
<i>Full Sample (89)</i>				<i>Low Inflation Cos. (61)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-3.466	0.676	-5.13	α_0	2.696	0.610	4.42
α_1	0.993	0.050	19.90	α_1	0.330	0.062	5.46
	St. Error 3.21, R ² 0.94				St. Error 1.50, R ² 0.36		
<i>Independent Variable : Average Excess M0 Growth</i>							
<i>Full Sample (89)</i>				<i>Low Inflation Cos. (61)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	0.613	0.287	2.13	α_0	4.110	0.625	6.57
α_1	0.938	0.033	28.27	α_1	0.317	0.111	2.87
	St. Error 2.65, R ² 0.96				St. Error 1.42, R ² 0.43		

Table 2: *Regression of Average Inflation on Average M1 and Excess M1 Growth*

<i>Independent Variable : Average M1 Growth</i>							
<i>Full Sample (88)</i>				<i>Low Inflation Cos. (60)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-4.570	0.462	-9.90	α_0	0.577	0.653	0.88
α_1	1.074	0.024	43.59	α_1	0.532	0.065	8.22
	St. Error 2.63, R ² 0.96				St. Error 1.64, R ² 0.46		
<i>Independent Variable : Average Excess M1 Growth</i>							
<i>Full Sample (88)</i>				<i>Low Inflation Cos. (60)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-0.166	0.191	-0.87	α_0	2.369	0.532	4.45
α_1	1.012	0.012	84.53	α_1	0.571	0.094	6.08
	St. Error 1.59, R ² 0.99				St. Error 1.54, R ² 0.64		

Table 3: *Regression of Average Inflation on Average M2 and Excess M2 Growth*

<i>Independent Variable : Average M2 Growth</i>							
<i>Full Sample (87)</i>				<i>Low Inflation Cos. (59)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-5.604	0.499	11.22	α_0	0.677	0.781	1.78
α_1	1.031	0.026	39.18	α_1	0.452	0.069	6.51
St. Error 2.93, R ² 0.95				St. Error 1.60, R ² 0.39			
<i>Independent Variable : Average Excess M2 Growth</i>							
<i>Full Sample (87)</i>				<i>Low Inflation Cos. (59)</i>			
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>		<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-1.436	0.218	-6.59	α_0	1.413	0.624	2.27
α_1	0.983	0.013	74.26	α_1	0.581	0.085	6.87
St. Error 1.55, R ² 0.99				St. Error 1.16, R ² 0.66			

If countries are sorted in increasing order of average inflation Equation (1) can be estimated recursively. Figures⁴ 3, 4, and 5 show the recursive estimates of the coefficient of excess M0, M1 and M2 growth and their two standard deviation bands. These recursive estimates of the excess money growth variables are statistically significant even for small samples. A minimum sample size of 15 is used in the recursive estimates. This sample size corresponds to an inflation rate of about 4 per cent.

There are two possible interpretations of the recursive estimates. First there is a significant relationship between average inflation and average excess money growth. This relationship is less than one-one in lower inflation countries the volume of transactions or wealth may be growing faster than income. Lower estimates of excess money growth would arise if it were possible to use such data in their calculation. This would increase the coefficient on the excess money variable in the regressions. One cannot determine if the increase would be large enough to change the relationship to one-one.

Alternatively, the recursive regressions indicate that the α_1 coefficient is not constant in different countries. In this case the basic model underlying the regressions is not correctly specified. In such a case it is not clear how the α_1 coefficients and their error bands should be interpreted.

A better procedure would be to adopt a model and estimation method that allows the coefficients to vary between countries. The variable coefficient model (2) provides for such an outcome.

$$\begin{aligned}\pi_{i,j} &= \alpha_{i0} + \alpha_{i1,j} \Delta \hat{m}_{i,j} + \varepsilon_{i,j} \\ \alpha_{i1,j} &= \alpha_{i1,j-1} + \eta_{i,j}\end{aligned}\quad (2)$$

⁴ Data for Uruguay have been excluded from the recursive estimates.

Figure 3: *Recursive Estimates of Coefficient on Excess M0 and Two Standard Deviation Bands*

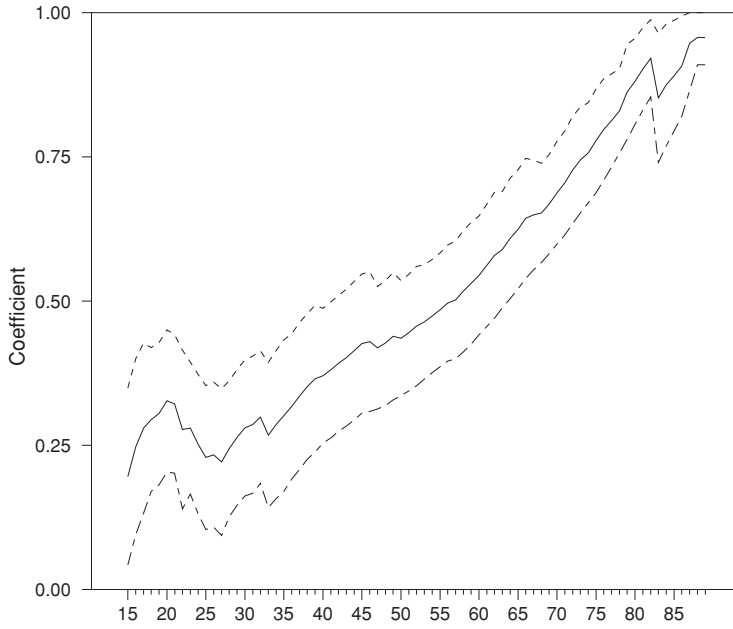


Figure 4: *Recursive Estimates of Coefficient on Excess M1 and Two Standard Deviation Bands*

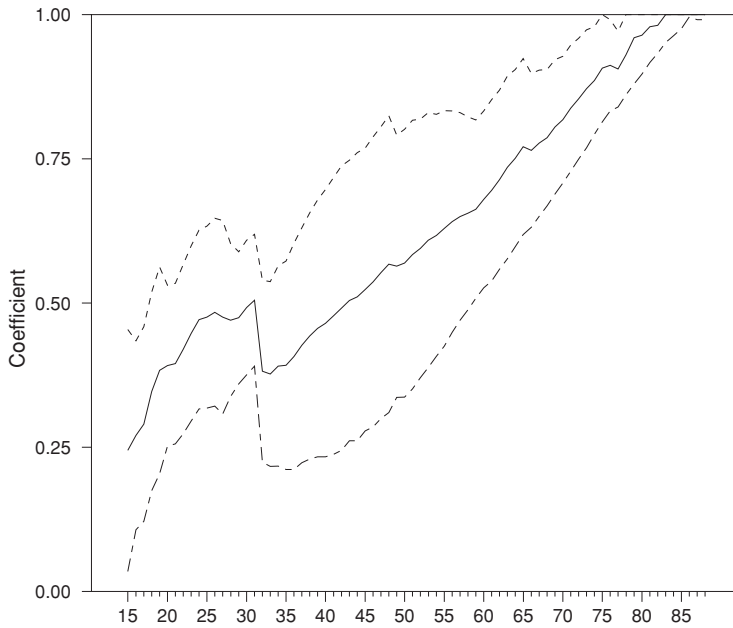
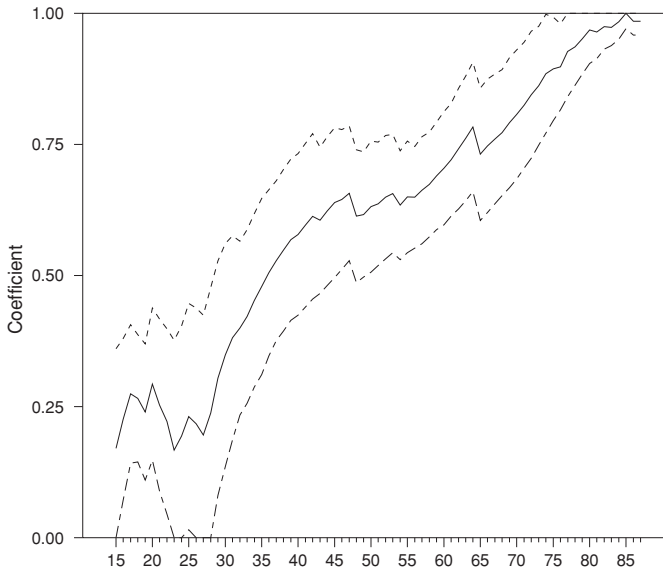


Figure 5: *Recursive Estimates of Coefficient on Excess M2 and Two Standard Deviation Bands*



where

- i refers to the money variable – excess M0, M1 or M2
- j refers to the county rank ordered by increasing inflation
- $\varepsilon_{i,j}$ and $\eta_{i,j}$ are i.i.d. $N(0, \sigma_\varepsilon^2)$ and i.i.d. $N(0, \sigma_\eta^2)$ respectively.

The constant α_{i0} and the error term $\varepsilon_{i,j}$ represent the effects of changes in velocity and non-modelled effects on inflation. It is assumed that the α_{i0} take the relevant values in the regressions in Tables 1, 2, and 3. The following results are not sensitive to reasonable changes in this assumption. Maximum likelihood estimates of the hyper-parameters, σ_ε^2 and σ_η^2 may be obtained using Kalman filter techniques, assuming a diffuse initialisation of the filter (see Koopman (1997); Durbin and Koopman (2001)). Kalman filtering techniques may then be used to produce smoothed estimates of the coefficient for each country. Results for M0 and M1 and their two standard deviation bands are presented in Figures 6 and 7.

In almost all countries the coefficients are not significantly different from one. These estimates are consistent with the usual monetary model that relates inflation one-one to money growth in the long run. For low inflation countries the standard deviation of the estimates are large. The corresponding estimates for excess M2 show a much greater dispersion but the hypothesis of a unit coefficient cannot be rejected.

Figure 6: *Smoothed Estimates of Coefficient on Excess M0 and Two Standard Deviation Bands for Countries Ranked by Average Inflation*

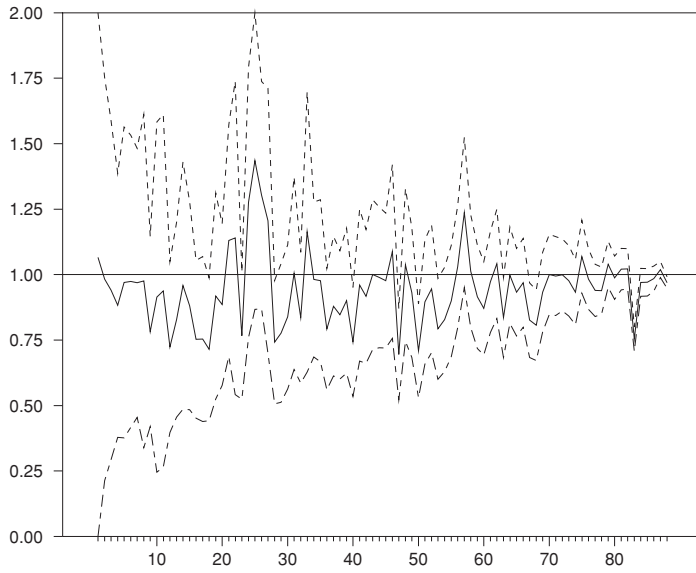
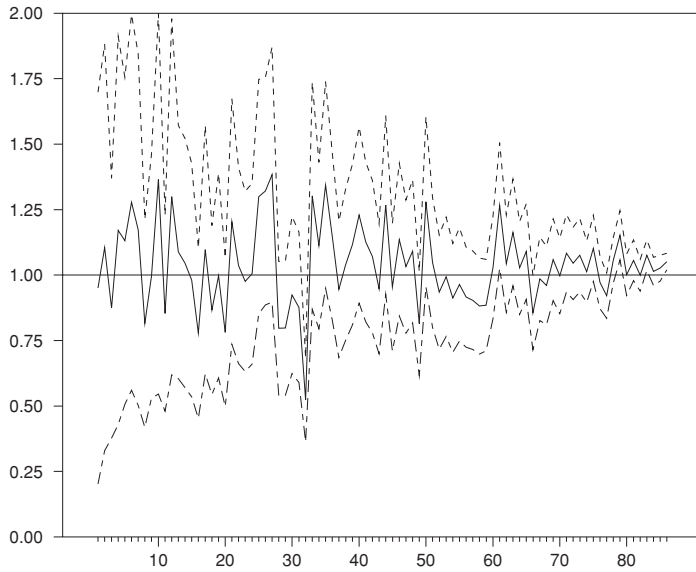


Figure 7: *Smoothed Estimates of Coefficient on Excess M1 and Two Standard Deviation Bands for Countries Ranked by Average Inflation*



2.3 Comparison with De Grauwe and Polan (2001)

De Grauwe and Polan base their analysis on an earlier version of IFS database. They choose the largest available sample of countries (165 and 159 for the regressions of inflation on the growth rates of M1 and M2 respectively) covering the years 1969 to 1999. They do no regressions involving M0. The version of the IFS databank used here included only 88 countries with data for M1 covering the 31 years 1969-1999 as opposed to the 159 mentioned in de Grauwe and Polan (page 6). The version of the data-base used here contained 120 countries with 20 or more observations, 132 with 10 or more and 160 with 5 or more.

De Grauwe and Polan's full sample regressions are summarised in Table 4. The money growth coefficient of about 2 is considerably higher than that which might be implied from a quantity theory of money and the value found here. Using the data set used here higher estimates of these coefficients can be found if growth rates estimated as averages of the first differences of the logarithms of levels (multiplied by 100) are replaced by averages of the percentage change in the variables. Using averages of percentage changes leads to some points that have high leverage in the regressions.

Table 4: *Regression of Inflation on M1 and M2 Growth (de Grauwe and Polan (2000))*

	<i>M1 Regression (165)</i>			<i>M2 Regression (159)</i>		
	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>	<i>Value</i>	<i>St.Err.</i>	<i>t-Statistic</i>
α_0	-19.745	5.8758	-3.36	α_0 -22.2485	6.5191	-3.41
α_1	2.1018	0.1161	18.11	α_1 2.00	0.117	17.06

A second finding in their analysis is that this correlation is almost wholly due to the presence of high or hyperinflation countries in their sample. Sorting countries in order of increasing average inflation they estimate the M1 and M2 growth coefficients recursively. They find that these coefficients are insignificant unless high inflation countries are included.

In the recursive estimates here we use average excess money growth. The coefficients of the excess money growth variables used here remain significant at low average inflation levels. If money growth variables are used money growth caused by growth in real output will appear as noise in the system and reduce the significance of the regressions. The calculation of averages as averages of percentage changes will also add noise to the estimation and will contribute to the lack of significance.

Frain (2003) gives the results of similar regressions to those reported in

Tables 1, 2, and 3. These regressions cover countries in the IFS data-base at least 10 observations of each of the relevant variables. Otherwise they use the same data set and methods described here. While there is some greater dispersion (larger standard errors) in the results for the extended sample the results for the restricted sample presented here are confirmed.

III IMPLICATIONS FOR ECB MONETARY POLICY

The monetary policy strategy of the European Central Bank is set out in European Central Bank (2004). The primary objective of this strategy is to maintain price stability. Price stability in this context is defined as “a year-on-year increase in the Harmonised Index of Consumer prices for the euro area of below 2 per cent. Price stability is to be maintained over the medium term”. Following an evaluation of its strategy in 2003 the ECB Governing Council clarified that, within the definition, it aims to maintain rates below or close to 2 per cent over the medium term.

In its analysis of risks to price stability in its monetary policy strategy the ECB uses a two-pillar framework for organising its analyses. These pillars are based on two different perspectives. The first perspective is aimed at assessing the short to medium-term determinants of price developments with a focus on real activity and conditions in the economy. It is based on an analysis of conditions in the goods, services and labour markets and is referred to as the **economic analysis**. The second perspective referred to as the **monetary analysis** focuses on the longer term and exploits the long-run link between money and prices. Monetary analysis is to take into account a wide range of monetary indicators, including M3 and its components, notably credit and various measures of excess liquidity. The regressions in this paper verify the long-run correlation between money and prices that are the foundation of this **monetary analysis**.

This correlation does not contradict the basic tenets of a quantity theory of money. They do not imply any direction of causation between money and inflation and are consistent with a variety of operating procedures and economic environments:

- if a central bank controls the money supply prices are endogenous and any causation is from money to prices,
- if prices are determined by the private sector and the central bank allows money to adjust to prices the direction of any causation is from prices to money,

- if the central bank uses an interest rate to control prices or inflation money will be determined by the private sector, money and prices are both endogenous and there may be no causation or questions of causation are irrelevant.

The results in this paper are long run. There is no support here for a view that fine tuning adjustments should be made in response to short-run fluctuations in monetary variables. Meyer (2001) argues that, given its particular knowledge and experience, a central bank should be in a position to identify and understand financial market innovations and shocks and extract long-run signals from monetary data. Thus, short-run variability and occasional breaks in velocity should not mislead it.

Money market data is often available in real time or after a short delay. Reliable real economy data are available only after a considerable delay. In particular, estimates of output gaps are notoriously unreliable and are available only after a considerable delay. In this sense it is essential to analyse monetary data and exploit the money/price correlation in the data.

The analysis in this paper confirms that deviations of a monetary aggregate from target, after account has been taken of the estimated effects of financial market innovations and shocks, may provide evidence of long-run inconsistencies between policies and targets and give rise to a reassessment of policy.

IV CONCLUSIONS

This paper has re-examined the correlations between average inflation and average growth rates of various monetary variables. A careful construction of the data set, excluding countries with short data spans, removing documented discontinuities and using appropriate methods of calculating averages confirm the earlier analysis of McCandless and Weber (1995) and question the robustness of some of the results in de Grauwe and Polan (2001). When countries are arranged in order of increasing average inflation recursive regressions indicate that the response may not be constant over countries. In such a case standard OLS produces results that are difficult to interpret and standard regression theory does not apply. For this reason a variable coefficient model is proposed and estimated. There is considerable variability in the estimates of the coefficients for individual countries but they are consistent with a one-one response of average inflation to excess money growth even in low inflation countries.

These results in this paper say nothing about any short-run relationship

between money growth and inflation. All the correlations estimated in this paper are long run. Also they do not establish any direction of causality between money and inflation even in the long run. The analysis shows that this data set and methodology cannot be used to deny the existence of a long-run relationship between money growth and inflation. Put simply, if money supply is growing faster in the long run in a country that country will have greater inflation even if that country is a low inflation country.

The analysis provides a measure of empirical justification of the “monetary analysis” of the European Central Bank. This assesses medium to long-term trends in inflation, paying particular attention to the close relationship between money and prices over extended horizons.

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APPENDIX A – LIST OF COUNTRIES INCLUDED IN ANALYSIS

The countries included in the regressions are as follows:

Panama (0), Switzerland, Germany, Singapore, Malaysia, Bahrain Kingdom of, Malta, Saudi Arabia, United States, Japan, Belgium, Canada, Netherlands (0), Cyprus, Kuwait, Austria, Thailand, St. Vincent & Grens., St. Lucia, Morocco, Niger, Denmark, Sweden (1,2), Norway, Dominica, France, Australia, Gabon, United Kingdom (1 2), Finland (0), Togo, Senegal, Seychelles, Ireland (1 2), Ethiopia, New Zealand, India, Sri Lanka, Honduras, Jordan, Fiji, Guatemala, Trinidad and Tobago, Cameroon, Barbados, Pakistan, Egypt, Papua New Guinea, South Africa, El Salvador, Italy (2), Philippines, Nepal, Mauritius, Spain, Haiti, Samoa, Dominican Republic, Rwanda, Korea, Portugal (1), Burundi, Greece, Syrian Arab Republic, Costa Rica, Algeria, Kenya, Swaziland, Madagascar, Myanmar, Indonesia, Jamaica, Iran, Venezuela, Paraguay, Ecuador, Colombia, Nigeria, Iceland, Tanzania, Mexico, Suriname, Sudan, Israel, Sierra Leone, Ghana, Chile, Uruguay, Bolivia, Peru, Argentina and Nicaragua

The notation 0, 1 or 2 included in brackets after each country name indicates that the country was not included in the M0, M1 and M2 regressions respectively. Countries included in the M0 recursive regressions are given in the order that they enter the regression. Where a country was not included in the M0 regressions their place in the list is determined by average inflation in the M1 or M2 regressions. Compared to the M0 recursions there are some minor transpositions in the order in which the countries entered the M1 and M2 analysis. These transpositions are due to different monetary aggregates being available for different periods in different countries.