Some Monetary Facts

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Abstract
This article describes three long-run monetary facts derived by examining data for 110 countries over a 30-year period, using three definitions of a country’s money supply and two subsamples of countries: (1) Growth rates of the money supply and the general price level are highly correlated for all three money definitions, for the full sample of countries, and for both subsamples. (2) The growth rates of money and real output are not correlated, except for a subsample of countries in the Organisation for Economic Co-operation and Development, where these growth rates are positively correlated. (3) The rate of inflation and the growth rate of real output are essentially uncorrelated.

The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.
There is no correlation between inflation and real output growth. This finding holds across the full sample and both subsamples.
able technology, education, and level of development of financial (and other) institutions. We consider the findings from these subsamples as a crude test of robustness of our full sample facts.

The data we use come from the CD-ROM version of the International Monetary Fund’s International Financial Statistics (IFS). The time period we consider is from 1960 to 1990. For each country with 10 or more years of data (110 countries), we calculate the geometric rate of growth for consumer prices (line 64 of the IFS tables); three definitions of money—M0, currency plus bank reserves (line 14); M1, money easily used in transactions (line 34); and M2, money easily used in or converted into use for transactions (the sum of lines 34 and 35)—and real GDP. The growth rate of real GDP is calculated by subtracting the growth rate of consumer prices from that of nominal GDP (line 99b).

The Facts

Now we will restate each of the three results of our study, describe each in detail, and discuss how our results compare with those of previous studies.

Money Growth and Inflation

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.

The evidence on the long-run relationship between the rate of money growth and the rate of inflation from our sample of 110 countries is presented in Table 1. It shows a high correlation between money growth and inflation for both narrow and broad definitions of money. For the full sample, for each of the three definitions of money we consider, the correlation coefficient between the rate of change of the money definition and the rate of change of consumer prices is 0.925 or higher.

The evidence from our sample also suggests that the growth rates of M1 and M2, which are broader definitions of money, are slightly more highly correlated with inflation rates than is the growth rate of M0, which is a narrow definition. The correlation coefficients for the broader definitions are both approximately 0.95, whereas that for the narrower definition is slightly lower, 0.925.

The evidence from the subsamples of OECD and Latin American countries, also shown in Table 1, confirms the robustness of the high correlation between money growth and inflation. For these subsamples, the correlation coefficients between money growth and inflation are always higher than 0.89, and the relation is always weaker for M0 than for the broader monetary aggregates.

The high correlation between money growth and inflation suggests that the relationship between these two variables is very close to linear. The natural question is, What is the slope of the relationship? Here the slope is very close to unity, as is illustrated in Chart 1, where we plot average rates of change of the M2 definition of the money supply and average rates of change of consumer prices for the full 110-country sample. Each point in the chart represents the observations on money growth and inflation for a particular country. In the chart we have also drawn a 45-degree line through the grand means of the observations. Inspect-

The finding that money growth and inflation have a linear relationship with a slope very close to unity brings to mind the quantity equation. The quantity equation is

\[ M \times V = P \times Y \]

where \( M \) is the money supply, \( V \) is the velocity of money (roughly, how many times each dollar in the money supply is spent each year), \( P \) is the price level, and \( Y \) is real output. Written in terms of growth rates, the quantity equation becomes

\[ m + v = p + y \]

where the lowercase letters in (2) refer to the growth rates of the variables represented by the uppercase letters in (1). The growth rate version of the quantity equation implies that there should be a linear relationship between money growth and inflation with a slope coefficient of unity when \( v \) and \( y \) are treated like constants.

The evidence in Chart 1 seems to support the quantity equation, at least as a long-run constraint on the effects of monetary policy. That the 45-degree line through the grand means does not go through the origin of the graph suggests that a central bank cannot generate a particular long-run rate of inflation by choosing an equal long-run growth rate for the money supply. The long-run inflation rate is influenced by the growth rates of real output and velocity as well as by the growth rate of money. However, a central bank can be confident that over the long run a higher growth rate of the money supply will result in a proportionally higher inflation rate.

Our finding is consistent with what other studies have found. A sampling of them we summarize in Table 2. This table shows that the existence of a high correlation between money growth and inflation has been found in many studies, but these studies have focused almost exclusively on broad definitions of money. Lucas (1980), for example, applies filters that progressively emphasize the long-run relationship in U.S. data between M1 and the consumer price index. He finds that the relationship becomes more regular, with a coefficient closer to one, the more the filter stresses the low frequencies (the long-run relationships). Lucas (1980, p. 1005) claims that the low-frequency relationship he finds represents “one way in which the quantity-theoretic relationships can be uncovered via atheoretical methods from time-series which are subject to a variety of other forces.”

Other evidence for the long-run relationship between money growth and inflation has come from studies using cross-sectional data. In general, these studies include fewer countries and cover a shorter time period than does our study. For example, using a pooled time series–cross-sectional regression, Vogel (1974, p. 112) finds that “an increase in the rate of growth of the money supply causes a proportionate increase in the rate of inflation within two years.” The coefficients Vogel gets sum to close to one and behave like a filter that stresses low frequencies. These low-frequency results can be interpreted as representing long-run relationships. Dwyer and Hafer (1988, p. 9) find that “countries with higher money growth on average simi-
larly have higher rates of inflation.” However, we doubt that the five-year averages Dwyer and Hafer use are long enough to reflect the steady-state relationships as they claim. Studies by Barro (1990) and Poole (1994) are also consistent with the fact of a high correlation between money growth and inflation. Barro (1990, p. 155) finds a “strong positive association across countries between the average rates of price change and the average rates of monetary growth.” Poole finds a strong positive relationship between the rate of inflation and the average annual change in a broad measure of money per unit of real GDP. Pakko (1994) examines the relationship between money growth and inflation for 13 countries that were formerly Soviet republics. He finds that countries “with the highest rates of inflation tend to be those with the most rapid money growth rates.”

Rolnick and Weber (1994) use long-run average rates of growth to study the relationship between money and inflation under commodity and fiat monetary regimes. They find that the correlation between money growth and inflation is almost unity for fiat money regimes, but much lower, 0.61 or less, for commodity money regimes.

Sargent (1982) and Smith (1985) present some empirical evidence that seems inconsistent with the fact that money growth and inflation are highly correlated. Specifically, Sargent (1982) shows that in several European countries in the 1920s, inflation rates fell far more than did money growth rates after the monetary reforms that followed the end of four hyperinflations. Smith (1985) presents evidence that during the colonial period in the United States, prices did not increase at the same rate as did money. Taken together, the Sargent and Smith studies show that rates of money growth can exceed, perhaps significantly, rates of inflation.

On closer examination, however, their evidence is not inconsistent with that presented here. We find a few data points that do not lie close to the 45-degree line in Chart 1. Almost exclusively, these fall below the line—which is consistent with the Sargent and Smith observations.

Money Growth and Real Output Growth

In the long run, there is no correlation between the growth rates of money and real output. This holds across all definitions of money, but not for a subsample of OECD countries, where the correlation seems to be positive.

The evidence on the long-run relationship between money and real output growth from our sample of 110 countries is shown in Table 3. It shows no correlation between money growth and real output growth. Although the coefficients for the correlations between the growth of money, however defined, and real output are negative, all of the coefficients are lower than −0.05. Since the standard deviation away from zero is 0.097, none of these correlation coefficients is statistically different from zero at any reasonable significance level for the full sample.3 Chart 2 plots the average rates of change of the M2 definition of money and the average rates of change of real output for the full 110-country sample. The lack of any relationship between the two variables is also clearly shown here.

Our finding of no correlation between money growth and real output growth appears to be robust across the subsample of Latin American countries (Table 3). While the correlation might seem to be more negative for this subsample than for the sample as a whole—the correlation coefficients for the subsample are between −0.17 and −0.25 for all three definitions of money—none of the correlation coefficients is significantly different from zero at any reasonable significance level.

However, the fact of no correlation between money growth and real output growth does not appear to be robust across the subsample of OECD countries (Table 3). For these countries, there is a positive and relatively high correlation between average rates of growth of money and real output. For these countries, the correlation coefficients between money and real output growth are always lower than 0.5 and range between 0.51 and 0.71. This indicates that within the group of OECD countries, those with higher rates of growth of the money supply tend to have higher rates of real output growth. The correlation is highest for M0 growth; the correlations for M1 and M2 growth are lower and approximately equal to each other, which is to be expected since they are so highly correlated themselves.3

While correlation coefficients indicate the direction of a relationship, they do not indicate its magnitude. That is, while the positive correlation coefficients for the OECD subsample indicate that increases in money growth tend to be associated with increases in real output growth for these countries, they do not tell whether the money growth increases are associated with real output growth increases that are large or small. To obtain some idea of the magnitudes involved, we regressed real output growth on money growth for the OECD countries and measured the slope of the regression line. We obtained slope coefficients approximately equal to 0.1 for all three definitions of money. These results indicate that increases in money growth are associated with increases in real output growth about one-tenth as large. The positive relationship between the growth rates of M0 and real output for OECD countries is shown in Chart 3. In that chart we have also drawn a line through the grand means with a slope of 0.1.

Some might be led to conclude from these results that the central banks of OECD countries should embark on rapid money growth in order to achieve high rates of long-term real output growth. This is not necessarily so. As was suggested above, the positive correlations in the data may reflect not a causal relationship, but rather a similarity in central bank policy; the central banks of the OECD countries may all be following similar feedback rules from real output growth to money growth, increasing or decreasing money growth as real output growth increases or decreases. Further investigation is required to determine what is going on.

Nonetheless, that qualification does not mean that the correlation for the OECD subsample of countries must be dismissed. It is a reminder that results based on select subsamples of the world’s countries cannot necessarily be interpreted as representing global relationships. Institutional or policy differences among countries may be an important feature in explaining how each country’s real output relates to its money supply process. For example, our finding may reflect the fact that the financial institutions of the OECD countries permit a separation of fiscal and monetary policies that is not seen in the rest of the world.
Table 4 summarizes some previous studies of the relationship between money growth and real output growth. The studies do not agree on what that relationship is. This is not surprising given our finding about the sensitivity of the results to the subsample chosen. Some studies find a negative relationship. For Kormendi and Meguire (1985), the average rate of growth of the money supply and the standard deviation of money supply shocks are both negatively correlated with real output growth. For Dwyer and Hafer (1988), the growth rate of money is negatively correlated with that of real output, but money growth is not statistically significant for explaining real output growth. Some studies get ambiguous results. Poirier (1991) finds that money is neutral in some countries and not in others. For Poirier (1991, p. 137), “the data provide little discrimination between neutrality . . . and nonneutrality.” Other studies find no relationship. Geweke (1986) finds money “superneutral,” implying no correlation between money growth and real output growth. His result is not consistent with our finding of a positive relationship between these variables for the subsample of OECD countries.

Inflation and Real Output Growth

In the long run, there is no correlation between inflation and real output growth. This finding holds across the full sample and both subsamples.

For the inflation–real output relationship, the evidence from our sample of 110 countries is shown in Table 5 and plotted in Chart 4. The correlation between inflation and real output growth is \(-0.243\). Since the standard deviation away from zero is 0.097, this correlation coefficient is significantly different from zero at a reasonable level for the full sample.

This seems to indicate that there is at least a weak negative relationship between the rate of inflation and the rate of growth of real output, but further investigation contradicts that. The correlation coefficients for the entire sample are distorted by one unusual country. The plot of the individual country observations in Chart 4 demonstrates that the data include a definite outlier, a data point that seems very different from the rest. This data point is for Nicaragua, which had real output growth of \(-12\) percent and an inflation rate of 52 percent. (Nicaragua was engaged in a civil war during much of the sample period.) With Nicaragua eliminated from the sample, the correlation coefficient (for the remaining 109 countries) is \(-0.101\), which is not significantly different from zero.

Further, although the inflation–real output growth results for the Latin American and OECD subsamples look different from those for the full sample, all the results are consistent. For the Latin American subsample, the correlation is negative, at \(-0.342\), but since the standard deviation from zero is 0.302, this not significantly different from zero at the 0.1 level. Rather interestingly, for the OECD subsample, the correlation is positive, but it is not significantly different from zero at the 0.1 level either.

Our finding about inflation and real output growth is somewhat different from much of what has already been reported in the literature. Table 6 summarizes some of the other studies. Kormendi and Meguire (1985) find that the average inflation rate is negatively correlated with average output growth. Fischer (1983, 1991); Altig and Bryan (1993); Ericsson, Irons, and Tryon (1993); and Barro (1995) all find a negative correlation between the inflation rate and the growth rate of output.

The difference between our results and those of the studies listed in Table 6 and the difference between our results for the full sample and the Latin American subsample and those for the OECD subsample suggest that the true relationship between inflation and real output growth is still uncertain. This conclusion is supported by the work of Levine and Renelt (1992). They find that the relationship between inflation and output is not robust to the inclusion of additional variables in regression equations explaining real output growth. The types of variables Levine and Renelt include are the average rate of inflation, the growth rate of domestic credit, and the standard deviations of both of those variables.

Conclusion

Here we present three principal long-run monetary facts derived from an examination of 110 countries over a 30-year period, using three definitions of a country’s money supply. First, growth rates of the money supply and the general price level are highly correlated, with a correlation coefficient close to one, for three money definitions. Second, the growth rates of money and real output are not correlated. This fact is not robust, however. For a subsample of OECD countries, growth rates of money and real output are positively correlated. Third, the rate of inflation and the growth rate of real output are essentially uncorrelated.

To the extent that we can interpret the long-run relationships we get here as causal relationships, what do they suggest about the ability of central banks to hit policy targets? First, the fact that the correlation between money growth and inflation is close to one implies that we can adjust long-run inflation by adjusting the growth rate of money. However, that does not mean that we can hit specific inflation targets. To do that requires accurately predicting the growth rates of real output and velocity, something that has not been done well. This should cause concern about the type of inflation targets that have been adopted by some countries recently. Further, our results do not argue either for or against a constant money growth rule. We find a relationship between long-run rates of money growth and inflation. On the short-run relationship between these variables, this study can say nothing.

Second, the fact that the growth rates of money and real output are not correlated suggests that monetary policy has no long-run effects on real output. Of course, this does not rule out the possibility that it might have short-run effects. On the ability of monetary policy to hit any short-run real output targets, this study, again, is silent. However, if the long-run effect of monetary policy on real economic activity is truly zero, then any short-run success in reducing downturns can only come about at the expense of reducing upturns.
from both sides yields the ratio of the standard deviation of \( x \) be zero as well. (†) implies that the correlation between the growth rates of money and velocity must relation between the growth rates of money and real output seems to be zero, equation two correlations must be equal up to the ratio of their standard deviations. Since the cor-

According to equation (†), once the correlation between money growth and real output growth have implications for the relationship between money growth and velocity growth. This is because the quantity equation restricts the pairwise correlations between the four variables that appear in it. Specifically, if we take the pairwise correlations of the variables in equation (2) with respect to the growth rate of money, we obtain

\[
1 + \rho(x,y)\rho(m,v) = \rho(m,p)\rho(m,p) + \rho(m,y)\rho(m,y)
\]

where \( \rho(x,y) \) denotes the correlation between the variables \( x \) and \( y \) and \( \rho(x,y) \) denotes the ratio of the standard deviation of \( x \) to the standard deviation of \( y \). Since we showed above that the relationship between \( m \) and \( p \) is linear with a slope coefficient of unity, we know that \( \rho(m,p)\rho(m,p) = 1 \). Substituting that into equation (†) and subtracting 1 from both sides yields

\[
\rho(x,y)\rho(m,v) = \rho(m,y)\rho(m,y)
\]

According to equation (†), once the correlation between money growth and real output growth is known, so is the correlation between money growth and velocity growth. The two correlations must be equal up to the ratio of their standard deviations. Since the correlation between the growth rates of money and real output seems to be zero, equation (†) implies that the correlation between the growth rates of money and velocity must be zero as well.

References


<table>
<thead>
<tr>
<th>Sample</th>
<th>Coefficient for Each Definition of Money</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M0</td>
</tr>
<tr>
<td>All 110 Countries</td>
<td>.925</td>
</tr>
<tr>
<td>Subsamples</td>
<td></td>
</tr>
<tr>
<td>21 OECD Countries</td>
<td>.894</td>
</tr>
<tr>
<td>14 Latin American Countries</td>
<td>.973</td>
</tr>
</tbody>
</table>

*Inflation is defined as changes in a measure of consumer prices.
Source of basic data: International Monetary Fund
Table 2
Previous Studies of the Relationship Between Money Growth and Inflation

<table>
<thead>
<tr>
<th>Author (and Year Published)</th>
<th>Time Series</th>
<th>Countries</th>
<th>Time Period</th>
<th>Data Frequency</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vogel (1974)</td>
<td>Currency + Demand deposits</td>
<td>16 Latin American countries</td>
<td>1950–69</td>
<td>Annual</td>
<td>Proportionate changes in inflation rate within two years of changes in money growth</td>
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<td>Lucas (1980)</td>
<td>M1</td>
<td>United States</td>
<td>1955–75</td>
<td>Annual</td>
<td>Strong positive correlation: Coefficient closer to one the more filter stresses low frequencies</td>
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<tr>
<td>Dwyer and Hafer (1988)</td>
<td>n.a.</td>
<td>62 countries</td>
<td>1979–84</td>
<td>Five-year averages</td>
<td>Strong positive correlation</td>
</tr>
<tr>
<td>Barro (1990)</td>
<td>Hand-to-hand currency</td>
<td>83 countries</td>
<td>1950–87</td>
<td>Full-period averages</td>
<td>Strong positive association</td>
</tr>
<tr>
<td>Rolnick and Weber (1994)</td>
<td>Various</td>
<td>9 countries</td>
<td>Various</td>
<td>Long-period averages</td>
<td>Strong positive correlation for fiat money regimes</td>
</tr>
</tbody>
</table>

n.a. = not available
Table 3
\begin{center}
\textbf{Correlation Coefficients for Money Growth and Real Output Growth*}
\end{center}
Based on Data From 1960 to 1990

<table>
<thead>
<tr>
<th>Sample</th>
<th>M0</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 110 Countries</td>
<td>-0.027</td>
<td>-0.050</td>
<td>-0.014</td>
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<td>Subsamples</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>21 OECD Countries</td>
<td>0.707</td>
<td>0.511</td>
<td>0.518</td>
</tr>
<tr>
<td>14 Latin American Countries</td>
<td>-0.171</td>
<td>-0.239</td>
<td>-0.243</td>
</tr>
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*Real output growth is calculated by subtracting changes in a measure of consumer prices from changes in nominal gross domestic product.
Source of basic data: International Monetary Fund
Table 4
Previous Studies of the Relationship Between Money Growth and Real Output Growth

<table>
<thead>
<tr>
<th>Author and Year Published</th>
<th>Time Series</th>
<th>Money</th>
<th>Output</th>
<th>Countries</th>
<th>Time Period</th>
<th>Data Frequency</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kormendi and Muguire (1985)</td>
<td>M1</td>
<td>Real GDP</td>
<td>47 countries</td>
<td>1950–77</td>
<td>Period averages</td>
<td>Negative correlation</td>
<td></td>
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<tr>
<td>Dwyer and Hafer (1988)</td>
<td>n.a.</td>
<td>Real GDP and GNP</td>
<td>62 countries</td>
<td>1979–84</td>
<td>Five-year averages</td>
<td>Slight negative correlation (not statistically significant)</td>
<td></td>
</tr>
<tr>
<td>Poirier (1991)</td>
<td>M1</td>
<td>Real GDP</td>
<td>47 countries</td>
<td>1873</td>
<td>Annual</td>
<td>Money neutral in some countries, not in others</td>
<td></td>
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</table>

n.a. = not available
<table>
<thead>
<tr>
<th>Sample</th>
<th>Coefficient With Outlier**</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Included</td>
</tr>
<tr>
<td>All 110 Countries</td>
<td>-0.243</td>
</tr>
<tr>
<td>Subsamples</td>
<td></td>
</tr>
<tr>
<td>21 OECD Countries</td>
<td>0.390</td>
</tr>
<tr>
<td>14 Latin American Countries</td>
<td>—</td>
</tr>
</tbody>
</table>

*Inflation is defined as changes in a measure of consumer prices. Real output growth is calculated by subtracting those inflation rates from changes in nominal gross domestic product.

**The outlier is Nicaragua.

Source of basic data: International Monetary Fund
<table>
<thead>
<tr>
<th>Author (and Year Published)</th>
<th>Time Series</th>
<th>Number of Countries</th>
<th>Time Period</th>
<th>Data Frequency</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fischer (1983)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>53</td>
<td>Annual</td>
<td>Negative contemporaneous relationship; positive correlation with one lag</td>
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<tr>
<td>Fischer (1991)</td>
<td>GDP deflator</td>
<td>GDP</td>
<td>73</td>
<td>1970–85</td>
<td>Annual</td>
</tr>
<tr>
<td>Alig and Bryan (1993)</td>
<td>GDP deflator</td>
<td>Per capita GDP</td>
<td>54 and 73</td>
<td>1960–88</td>
<td>Annual</td>
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<tr>
<td>Ericsson, Irans, and Tryon (1993)</td>
<td>GDP deflator</td>
<td>GDP</td>
<td>102</td>
<td>1960–89</td>
<td>Annual</td>
</tr>
<tr>
<td>Barro (1995)</td>
<td>Consumer prices</td>
<td>Per capita real GDP</td>
<td>78, 89, and 84</td>
<td>1965–90</td>
<td>Five- or ten-year averages</td>
</tr>
</tbody>
</table>

n.a. = not available
Chart 1

Money Growth and Inflation:
A High, Positive Correlation

Average Annual Rates of Growth in M2 and in Consumer Prices
During 1960–90 in 110 Countries

Source: International Monetary Fund
Chart 2

Money and Real Output Growth: No Correlation in the Full Sample . . .

Average Annual Rates of Growth in M2 and in Nominal Gross Domestic Product, Deflated by Consumer Prices During 1960–90 in 110 Countries

Source: International Monetary Fund
Chart 3

... But a Positive Correlation in the OECD Subsample

Average Annual Rates of Growth in M0 and in Nominal Gross Domestic Product, Deflated by Consumer Prices During 1960–90 in 21 Countries

Source: International Monetary Fund
Chart 4
Inflation and Real Output Growth: No Correlation
Average Annual Rates of Growth in Consumer Prices
and in Nominal Gross Domestic Product, Deflated by Consumer Prices
During 1960–90 in 110 Countries

Source: International Monetary Fund