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# **A Reexamination of the Relationship Between Money Growth and Inflation Around the World: 1961-2022**

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# A Reexamination of the Relationship Between Money Growth and Inflation Around the World: 1961-2022

## Abstract

The main purpose of this paper is to reexamine the relationship between money growth and inflation using a large (unbalanced) panel of 133 countries for the period 1961-2022. The data is split into three subcategories of countries, three subperiods of time, and two intervals of the inflation rate. Applying panel data estimation techniques, I find that money growth continues to be a fundamental variable for understanding the behavior of inflation. Although the impact of money growth on inflation diminishes at lower inflation rates, it is still statistically significant at these lower levels, and it increases markedly when inflation moves beyond the 20 percent threshold. Additionally, there is not an evident reduction in the influence of money growth on inflation in the last thirty years in comparison with the preceding thirty-year period. Finally, I found some evidence that suggests that inflation and money growth might have a negative impact on output growth in the long run.

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## 1. Introduction

In 1995, the Federal Reserve Bank of Minneapolis Quarterly Review published an article by George T. McCandless Jr. and Warren E. Weber with the title Some Monetary Facts (Vol. 19, No. 3, Summer 1995, pp. 2-11). This interesting paper describes three long-term monetary facts derived by examining data for 110 countries over a 30-year period. The author's main findings as described in the abstract of the paper are the following:

- (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 Organization 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.

This research follows a similar approach to McCandless and Weber (1995) in the sense that I use data for a large cross-section of countries (133 countries) over a sixty-year period (1961-2022). However, I have introduced important elements that, hopefully, are an improvement with respect to McCandless and Weber's paper. Apart from the larger cross-section of countries and the time series update, this paper includes the following features:

- Instead of simple correlations applied to the cross-section data, I use panel data and estimate regressions using panel data estimation techniques.
- The use of panel data allows to divide the sample not only in the cross-section dimension, but also in the time series dimension.
- Apart from the division of the cross-section of countries in subsamples for the OECD and Latin American economies, I include a subsample of Emerging and Developments countries.
- The money growth – inflation relationship is initially examined for all values of inflation, but the analysis concentrates on two ranges that cap the rate of inflation at a low and a high level.

This is mainly an empirical research thus, I do not include a separate section devoted to theoretical issues. The theoretical foundation of this empirical work is the quantity theory of money and the Monetarist view (Cagan, 2010; Friedman, 2010). However, I examine the possibility that the long-run relationship between money growth and inflation is not linear, in the sense that the impact of money growth on inflation could be stronger (weaker) when the latter is higher (lower). Additionally, because I use

regressions to examine the link between money growth and inflation and not simple correlations, I adopt the assumption that causality runs from the money growth variable to the inflation rate. This assumption is based on Friedman's contention that in a relationship between two variables, the one that is potentially controllable by a policymaker can be considered as the causal variable (Hoover, 1989)<sup>1</sup>.

The paper is divided into five sections including this introduction. Section 2 describes the sources of the data used in the research, the way this data is portioned for analytical purposes, and the econometric methods used to estimate the relevant relationships. Section 3 presents the main results of the econometric estimations of the relationship between money growth and inflation for the complete sample and the different partitions of the data discussed in section 2. Section 4 presents the main results of the econometric estimates of the relationship between inflation and output growth, and money growth and output growth. Section 5 discusses the main conclusions obtained from the empirical econometric estimations and compared them to those of McCandless and Weber (1995).

## **2. The data and estimation methods**

Most of the data to build the panel used in the paper was obtained from the World Bank (WB) databases. I used WB data of the Broad Money measured in local currency, the CPI with base year 2010, and GDP at constant prices in local currency to calculate growth rates of these variables. The data includes information of 133 countries<sup>2</sup> for the period 1960-2022 for the variables in levels. I excluded some countries that have been involved in internal violent conflicts for long periods such as Lebanon, Somalia and Syria, and some very small economies (mainly island nations) such as Aruba and Curacao. For all economic series there are missing observations in different points, particularly at the beginning and end of the 1960-2022 period, and the WB data does not include CPI information for Argentina.

To the WB data, I added information for the growth rate of M1 and the CPI inflation rate for the period 1970-1998 for the main countries that today are part of the Euro Area. This information was obtained, mainly, from the International Monetary Fund International Financial Statistics (IMF-IFS)<sup>3</sup>. From 1999 to 2022, I included data for the

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<sup>1</sup> Friedman was generally reluctant to use the word causality in his research, but mainly when referring to the short run relationship between money and other variables. But his position regarding the role of money as the main determinant of inflation in the long run was clear (See, for example, Friedman, 1958). For thorough examinations of Friedman's methodological approach, see Hoover (1990) and Hammond (1996).

<sup>2</sup> A complete list of the countries included in the research is shown in Appendix A.

<sup>3</sup> Austria, Belgium, Finland, France (1979-1998; source: FRED), Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

M3 growth rate and the inflation rate for the Euro Area obtained from the FRED database.

Additionally, I completed the WB data for Venezuela with the CPI inflation for the periods 1961-2008 and 2017-2019, calculated the money growth rate using M1 for the period 2014-2019, and the growth rate of real GDP from 2015-2018. The source of all this information is the Central Bank of Venezuela (BCV).

a. Partition of the cross-section data

Econometric estimation techniques were applied to the complete sample of countries and to the following subsamples: 1) OECD countries (excluding Latin American countries members of the OECD<sup>4</sup> and Israel); 2) Emerging and Developing economies; 3) Latin American countries.

The OECD group contains 23 countries until 1998 and 13 afterwards; the Emerging and Developing Countries group includes 121 countries; Latin America comprises 18 countries.

For the Latin America group, I substituted the missing CPI data of Argentina with the GDP deflator reported by the WB to calculate the inflation rate.

b. Partition of the time-series data

In the time dimension, the data was split into three subperiods: 1961-1989; 1990-2019; 2019-2022.

The first long subperiod (1961-1989) is considered as one of accelerating inflation. Average inflation in the 1970s-decade increased in 98 percent of the countries in the sample with respect to the average inflation in the 1960s decade. In the 1980s-decade, average inflation increased in 46 percent of the countries in the sample in comparison with the 1970s-decade average inflation.

The second long subperiod (1990-2019) is considered as one of decelerating inflation. In the 1990s-decade, average inflation rose in 28 percent of the countries with respect to the 1980s-decade. Average inflation accelerated in the 2000s-decade in relation to the 1990s decade in 12 percent of the countries in the sample. In the 2010s-decade, average inflation increased in 15 percent of the countries with respect to the 2000s-decade.

The study of the short subperiod 2019-2022 attempts to examine the observed post Covid acceleration of inflation. In 2022, inflation was higher than the average inflation rate for the 2010-2020 period in 91percent of the countries in the sample. However,

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<sup>4</sup> These countries were included in the group of Emerging and Developing Economies.

due to the substantial reduction in the number of observations, the results for this subperiod should be taken with caution.

### c. Partition of the inflation data

As in Borio et al (2023) and Olivo (2023), this research explores the connection between money growth and inflation for different levels of the latter. Specifically, estimates are presented for a high inflation range that goes from zero to 100 percent, and a low inflation range from zero to 20 percent. The idea is to detect if the impact of money growth on inflation varies substantially between these two intervals, which would suggest that the relationship is not linear.

With respect to estimation methods, the relationships between money growth and inflation, inflation and output growth, and money growth and output growth were examined using two panel data regression techniques: a) standard random/fixed effects (RE/FE), and b) instrumental variables random/fixed effects (IV-RE/FE)<sup>5</sup>. In both cases, random effects were used when  $N > T$  and fixed effects when  $T > N$ . Random effects estimations were conducted using the Swamy-Arora approach modified by Baltagi and Chang.

The use of instrumental variables attempts to avoid potential bias in OLS/GLS estimators due to correlation between the explanatory variable (contemporaneous money growth) and the regressions errors that can arise from different sources (Kennedy, 2008).

## 3. Money growth and inflation

In this section, the relationship between money growth and the inflation rate is first examined for the complete sample of countries and the entire period (1961-2022), and then the data is split into the different subsamples of countries and time periods defined in section 2.

### a. Money growth and inflation in the complete sample of countries

The results of the estimation of regressions of the inflation rate (CPIg) against broad money growth (Mg) for the complete sample of countries for the period 1961-2022 and using all observations of inflation are summarized in Table 1. The first column shows the estimation using random effects with standards errors robust to autocorrelation and heteroskedasticity. The second column presents the estimation using the method of instrumental variables and random effects (IV-RE), in which lags one and two of Mg are the instruments. In both methods, the inflation rate lagged one period is included when its coefficient is statistically significant in an equation.

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<sup>5</sup> Estimations were conducted using the GRETL econometric software.

Results with both estimation methods suggest a very strong and statistically significant effect of contemporaneous money growth (Mg) on inflation, with a coefficient above 2 in the RE estimation and close to 1 using the IV-RE method. The sum of the coefficients of Mg and Mg\_1 (money growth lagged one period) in the RE model is 1.89.

	Random-effects	IV-Random effects
N° Obs	6204	6105
Mg	2.75252 ***	1.04867***
Mg_1	-0.857844***	
Sum of coeff.	1.89468	
CPIg_1	0.287173***	0.390721***
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

This particularly strong contemporaneous effect of money growth on inflation is produced by the inclusion of relatively few observations of the inflation rate above 100 percent (See Appendix B). Thus, in the rest of the paper, the discussion is limited to the relationship between money growth and inflation in the two intervals described in the previous section: a) inflation rates equal to or below 100 percent; b) inflation rates equal to or less than 20percent.

Results of the estimation of the relationship between money growth and inflation for all countries in the sample for the period 1961-2022 and inflation rates equal to or under 100 percent are summarized in Table 2.

	Random-effects	IV-Random effects
N° Obs	5512	5714
Mg	0.17498 ***	0.87089 ***
Mg_1	0.113473 ***	
Mg_4	0.00245992 *	
Sum of coeff.	0.29091292	
CPIg_1		
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

The estimation with RE indicates that the coefficients of contemporaneous money growth (Mg) and lags one (Mg\_1) and four (Mg\_4) are statistically significant. The sum of the coefficients is 0.29 and the coefficient of Mg (0.17) is the highest of the group.

The estimation of the money growth-inflation relationship with IV-RE generates a statistically significant coefficient of 0.87 for Mg (Instruments: Mg\_1 and Mg\_2). This suggests a substantially larger impact of money growth on inflation than the one obtained with the standard RE method.

Results of the estimation of the relationship between money growth and inflation for all countries in the sample for the period 1961-2022 and inflation rates equal to or less than 20 percent are summarized in Table 3.

	Random-effects	IV-Random effects
N° Obs	4992	5074
Mg	0.0487356***	0.251966***
Mg_1	0.0481696***	
Mg_2	-0.0134424***	
Mg_3	0.000863508***	
Sum of coeff.	0.0969052	
CPIg_1	0.340068***	0.207626***
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

The estimation with RE indicates that the coefficients of contemporaneous money growth (Mg) and lags one (Mg\_1) to three (Mg\_3) are statistically significant. The sum of the coefficients is 0.1 and the coefficient of Mg is 0.05.

When the money growth-inflation relationship is estimated with IV-RE, it produces a statistically significant coefficient of 0.25 for Mg (Instruments: Mg\_1 and Mg\_2). This suggests a substantially larger impact of money growth on inflation than the one obtained with the RE method.

The previous results indicate that the impact of money growth on inflation decreases considerably as the inflation rate is lower, but in all cases the coefficients of money growth remain statistically significant in the different equations estimated. It is also interesting to note that with both estimation methods, the coefficient of CPIg lagged one period (CPIg\_1) is statistically significant when inflation is equal to or below 20 percent.

It is also evident that the IV-RE method estimates a substantially higher impact of money growth on inflation than the RE method. Additionally, the estimates obtained



using the standard RE method are not consistent according to the Hausman test, while it is expected that those obtained using the RE method with instrumental variables are consistent.

Summary results of the estimation of the money growth-inflation relationship for the three subperiods (1961-1989), (1990-2019), (2019-2022) are presented in Appendix C, tables 4 to 9.

Estimations with standard random effects (RE) show that the coefficients of contemporaneous money growth (Mg) and various lags are statistically significant in all three subperiods. The impact of money growth on inflation tends to be larger when the sample includes data on inflation below 100 percent than when inflation is capped at 20 percent. The sum of the coefficients in the three subperiods and two inflation intervals (0-100 and 0-20 percent, respectively) are: (1961-1989; 0.15/0.11), (1990-2019; 0.33/0.09), (2019-2022; 0.63/0.15).

Estimations with instrumental variables and random effects (IV-RE) show that the coefficients of the contemporaneous money growth rate (Mg) are statistically significant in the three subperiods under analysis. The coefficients in the three subperiods and two inflation intervals are: (1961-1989; 0.57/0.41), (1990-2019; 0.91/0.18), (2019-2022; 0.79/0.18).

#### b. Money growth and inflation in OECD countries

The results of estimating the money growth-inflation relationship for the sample of OECD countries for the period 1961-2022 are shown in Table 10. Because in this case  $T > N$ , fixed effects (FE) and instrumental variables with fixed effects (IV-FE) are employed in the estimations. Also, in this case, the 100 percent and 20 percent caps for the inflation rate are not applied as most observations are below 20 percent.

	Fixed-effects	IV-Fixed effects
N° Obs	957	900
Mg		0.254024***
Mg_1	0.0235198***	
Mg_2	0.0346699**	
Sum of coeff.	0.0581897	
CPIg_1	0.78154***	0.651461***
Instruments:	Mg_1, Mg_2, Mg_3, Mg_4	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

With FE, the coefficient of Mg is not statistically significant while the sum of the statistically significant coefficients of Mg<sub>1</sub> and Mg<sub>2</sub> is 0.06. Using IV-FE, the coefficient of Mg is 0.25 and it is statistically significant.

The summary of the results for the subperiods (1961-1989), (1990-2019), and (2019-2022) are presented in tables 11, 12, and 13 in Appendix C.

With standard FE, the coefficient of the contemporaneous money growth rate (Mg) is not statistically significant in any of the long subperiods. For the subperiod 1961-1989, the coefficient of Mg<sub>3</sub> is statistically significant with a value of 0.07. For the subperiod 1990-2019, the coefficient of Mg<sub>2</sub> is statistically significant with a relatively low value of 0.009. In the short subperiod 2019-2022, the standard RE method produces a coefficient of 0.38 for Mg<sub>2</sub> that is statistically significant and consistent according to the Hausman test.

With the IV-FE method, the coefficient of Mg is 0.21 and statistically significant in the subperiod 1961-1989, but it is not statistically significant in the subperiod 1990-2019. The IV-RE method suggests that the coefficient of Mg is not statistically significant in the short subperiod 2019-2022.

Under both estimation methods, the inflation rate exhibits substantial persistence in the complete period and subperiods. The coefficients of lagged inflation (CPIg<sub>1</sub>) are generally above 0.6 and statistically significant in all the regressions estimated.

#### c. Money growth and inflation in emerging and developing countries

A summary of the results of the estimation of the money growth-inflation relationship for emerging and developing countries (E&D) for the period 1961-2022 are shown in tables 14 and 15.

In Table 14, when inflation is equal to or less than 100 percent, the RE method indicates that the coefficients of Mg, Mg<sub>1</sub>, and Mg<sub>4</sub> are statistically significant. The sum of these coefficients is 0.29. Using the IV-RE method the coefficient of Mg is statistically significant with a value of 0.9.

Table 14. Inflation equal or below 100% .		
Emerging & Developing Economies 1961-2022		
	Random-effects	IV-Random effects
N° Obs	4607	4759
Mg	0.178477 ***	0.895203***
Mg_1	0.113115 ***	
Mg_4	0.00228206 ***	
Sum of coeff.	0.29387406	
CPIg_1		
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

In Table 15, when inflation is capped at 20 percent, the RE method indicates that the coefficients of Mg and Mg\_1 are statistically significant. The sum of the coefficients is 0.1. With the IV-RE method the coefficient of Mg is statistically significant with a value of 0.26. Under both estimation methods, inflation exhibits some persistence with coefficients for CPIg\_1 close to 0.2 that are statistically significant.

Table 15. Inflation equal or below 20% .		
Emerging & Developing Economies 1961-2022		
	Random-effects	IV-Random effects
N° Obs	4215	4156
Mg	0.0515373***	0.2577***
Mg_1	0.0493682***	
Sum of coeff.	0.1009055	
CPIg_1	0.196597***	0.175515***
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Summaries of the results of the money growth-inflation relationship for the subperiods (1961-1989), (1990-2019), and (2019-2022), for inflation rates equal to or below 100 percent and 20 percent are presented in Appendix C, tables 16 to 21.

Estimations with random effects (RE) show that the coefficients of the contemporaneous money growth rate (Mg) are statistically significant in all regressions except for the period 2019-2022 when inflation is capped at 20 percent. Various lags of the money growth variable are statistically significant in all three subperiods. The effect of money growth on inflation tends to be larger when the sample includes data on inflation equal to or below 100 percent than when inflation is capped at 20 percent. Inflation persistence measured by the coefficient of CPIg\_1 is generally observed in the regressions in which inflation is capped at 20 percent. The sum of the coefficients

of the money growth variable for the three subperiods and two inflation intervals are: (1961-1989; 0.14/0.12), (1990-2019; 0.35/0.09), (2019-2022; 0.49/0.11).

Estimations using instrumental variables and random effects (IV-RE) show that the coefficients of the contemporaneous money growth rate (Mg) are statistically significant in the three subperiods. The coefficients of the contemporaneous money growth variable for the three subperiods and two inflation intervals are: (1961-1989; 0.5/0.4), (1990-2019; 0.97/0.19), (2019-2022; 0.78/0.18). Inflation persistence measured by the coefficient of CPIg\_1 is statistically significant when inflation is equal to or below 20 percent in the subperiod (1990-2019) and, more markedly, in the short subperiod (2019-2022).

d. Money growth and inflation in Latin American countries

Tables 22 and 23 summarize the results of the estimation of the money growth-inflation relationship for Latin American countries for the period 1961-2022.

For inflation rates equal to or below 100 percent (Table 22), the fixed effects (FE) method finds that the coefficients of Mg and Mg\_1 are statistically significant. The sum of the coefficients is 0.5. With the IV-FE method, the coefficient of Mg is statistically significant with a value of 0.89, if we ignore lagged inflation that has a coefficient with a value close to zero.

	Fixed-effects	IV-Fixed effects	IV-Fixed effects
N° Obs	928	912	910
Mg	0.423646 ***	0.887996***	0.519482***
Mg_1	0.0755016 ***		
Sum of coeff.	0.4991476		
CPIg_1			0.0380801***
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

For the 0-20 percent inflation range (Table 23), the FE method indicates that the coefficients of Mg, Mg\_1, and Mg\_2 are statistically significant. The sum of these coefficients is 0.11. When the estimation is conducted using IV-FE, the coefficient of Mg is 0.33 and is statistically significant, if we ignore the lagged value of inflation which is relatively low and negative (-0.17).

	Fixed-effects	IV-Fixed effects	IV-Fixed effects
N° Obs	714	715	714
Mg	0.0627583***	0.333658***	0.855309***
Mg_1	0.0477368**		
Mg_2	-0.0118840***		
Sum of coeff.	0.1104951		
CPIg_1	0.282625***		-0.167199**
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

The summary of the results for the three subperiods used in the research are presented in Appendix C (tables 24 to 29).

Estimations with FE (subperiods 1961-1989 / 1990-2019) and RE (2019-2022) show that the coefficients of the contemporaneous money growth rate (Mg) and various lags are statistically significant in all three subperiods when inflation is equal to or less than 100 percent. When inflation is equal to or below 20 percent, the coefficients of the contemporaneous money growth rate are statistically significant only in the long subperiods. The effect of money growth on inflation tends to be larger when the sample includes data on inflation equal to or below 100 percent than when inflation is capped at 20 percent. The sum of the coefficients of money growth variable for the three subperiods and two inflation caps are: (1961-1989; 0.51/0.08), (1990-2019; 0.31/0.1), (2019-2022; 0.46/0.24). The coefficients of CPIg\_1 are statistically significant in all the regressions in which inflation is capped at 20 percent.

Estimations with IV-FE for the long subperiods and IV-RE for the short subperiod show that the coefficients of the contemporaneous money growth rate (Mg) are statistically significant in all cases. The coefficients of the contemporaneous money growth variable for the three subperiods and two inflation intervals are: (1961-1989; 0.85/0.21), (1990-2019; 1.1/0.39), (2019-2022; 0.43/0.43). The coefficient of CPIg\_1 is statistically significant with a value well above zero, only in the regressions for the short subperiod (2019-2022).

#### 4. Inflation, money growth and output growth

Although the focus of this paper is on the relationship between money growth and inflation, this section follows McCandless and Weber (1995) in examining also the connection between inflation and output growth, and money growth and output growth. The link among these variables is first examined for the complete sample of

countries, and then the data is split in the different subsamples of countries defined in section 2. All estimations are for the complete time period 1961-2022.

- a. Inflation, money growth and output growth in the complete sample of countries

Estimations of the relationship between inflation and output growth using all inflation observations are shown in Table 30.

Both the RE and IV-RE methods indicate that inflation has a negative and statistically significant impact on GDP growth, even though the coefficients are rather small, particularly with the RE method. With both methods, the coefficient of the lagged GDP growth (GDPg\_1) is statistically significant, but its value with the IV-RE method is substantially larger.

	Random-effects	IV-Random effects
N° Obs	6180	6111
CPIg	-0.000114562***	-0.00115641***
GDPg_1	0.288094***	0.601774***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

The results of the estimation of the inflation-output growth relation when the inflation rate is capped at 100 percent and 20 percent, respectively, are shown in Appendix D (Tables 31 and 32).

When inflation is equal to or less than 100 percent, the RE estimation finds that the coefficient of the inflation rate is negative (-0.027) and statistically significant. Using the IV-RE method, the coefficient of inflation is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

When inflation is equal to or less than 20 percent, both RE and IV-RE indicate that the coefficient of the inflation rate is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

The results of estimating the relationship between the rate of money growth and output growth are shown in Table 33 (Appendix D). The estimation with RE shows a negative and statistically significant impact of money growth on GDP growth. With IV-RE, the coefficient of Mg is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

b. Inflation, money growth and output growth in OECD countries

Estimations of the relationship between inflation and GDP growth for OECD countries are shown in Table 34.

Both the FE and the IV-FE methods indicate a negative and statistically significant impact of inflation on output growth. The estimated coefficients are -0.061 with FE, and -0.037 with IV-FE. The coefficient of GDPg\_1 is statistically significant in both estimations.

	Fixed-effects	IV-Fixed effects	
N° Obs	959	950	
CPIg	-0.0613474***	-0.0376315*	
GDPg_1	0.375182***	0.365784***	
Instruments:	CPIg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Regressions of the relationship between money growth and GDP growth for OECD countries are shown in Table 35 (Appendix D). The estimation with FE indicates that the coefficient of Mg is not statistically significant, while with the IV-FE method the coefficient of Mg is positive (0.15) and statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

c. Inflation, money growth and output growth in Emerging and Developing countries

Estimations of the relationship between inflation and output growth using all inflation observations are shown in Table 36.

Both methods, RE and IV-RE exhibit a negative and statistically significant impact of inflation on GDP growth. In both estimations, the coefficient of the lagged GDP growth (GDPg\_1) is statistically significant, but its value with the IV-RE method is substantially larger.

Tabla 36. Inflation and GDP growth		
Emerging & Developing Economies 1961-2022		
	Random-effects	IV-Random effects
N° Obs	5187	5127
CPIg	-0.000116939***	-0.00141299***
GDPg_1	0.277136***	0.571965***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

The results of the estimation of the inflation-output growth relation when the inflation rate is capped at 100 percent and 20 percent, respectively, are shown in Appendix D (Tables 37 and 38).

When inflation is equal to or less than 100 percent, the RE estimation finds that the coefficient of the inflation rate is negative (-0.032) and statistically significant. Using the IV-RE method, the coefficient of inflation is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

When inflation is equal to or less than 20 percent, both RE and IV-RE indicate that the coefficient of the inflation rate is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

The results of estimating the relationship between money growth and output growth are shown in Table 39 (Appendix D). The estimations with RE and IV-RE show a negative and statistically significant impact of money growth on GDP growth. The coefficient of GDPg\_1 is statistically significant in both estimations.

#### d. Inflation, money growth and output growth in Latin American countries

Estimations of the relationship between inflation and output growth using all inflation observations are shown in Table 40.

Using FE, the coefficient of CPIg is negative and statistically significant, while the estimation with IV-FE indicates that the coefficient of CPIg is not statistically significant. In both estimations, the coefficient of the lagged GDP growth rate (GDPg\_1) is statistically significant.



	Fixed-effects	IV-Fixed effects
N° Obs	1023	1020
CPIg	-0.000102718***	-0.000533226
GDPg_1	0.25442***	0.176693**
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

The results of the estimation of the inflation-output growth relation when the inflation rate is capped at 100 percent and 20 percent, respectively, are shown in Appendix D (Tables 41 and 42).

When inflation is equal to or less than 100 percent, the FE estimation suggests that the coefficient of the inflation rate is negative (-0.025) and statistically significant. Using the IV-FE method, the coefficient of inflation is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

When inflation is equal to or less than 20 percent, both FE and IV-FE indicate that the coefficient of CPIg is not statistically significant. The coefficient of GDPg\_1 is statistically significant with both methods.

The estimations of the relationship between money growth and output growth are shown in Table 43 (Appendix D). The estimation with FE presents a negative coefficient (-0.00032) that is statistically significant. In contrast, the IV-FE method indicates that the coefficient of Mg is not statistically significant. The coefficient of GDPg\_1 is statistically significant in both estimations.

## 5. Conclusion

This research confirms that the rate of growth of the money supply (using a broad concept of money) is key to understanding the behavior of the inflation rate all over the world for the period 1961-2022.

For the complete sample of countries, and subsamples of Emerging & Developing countries and Latin American countries, the estimates using instrumental variables look more robust and consistent than the ones obtained with standard OLS/GLS methods. These estimates with instrumental variables for panel data indicate that the coefficient of the contemporaneous growth rate of broad money is statistically significant in all the regressions run. However, the dynamics of the money growth-inflation relationship in the OECD countries presents some differences compare to that observed in E&D economies. Although for the complete period 1961-2022 and the subperiod 1961-1989 the IV-FE suggest that the coefficient of contemporaneous money growth is statistically significant, in advanced economies, money growth tends

to exhibit a lagged impact (between one to three years) on inflation in the subperiods 1990-2019 and 2019-2022. Additionally, the coefficients associated with the money growth variable tend to be markedly smaller than the ones reported for E&D countries, except for the short period 2019-2022.

Another clear pattern that emerges from the data is that the coefficients of the money growth variable tend to be smaller when the inflation rate is equal to or below 20 percent than when inflation is capped at 100 percent. Thus, as discussed in Borio et al (2023) and Olivo (2023), the money/money growth - price level/inflation relationship is not generally linear. This can be explained by the tendency of the velocity of circulation to increase rather rapidly (although not explosively) when money growth and inflation accelerate beyond certain rate values.

It is also observed that when the inflation rate is capped at 20 percent, the coefficients of the money growth variable are generally lower for the subperiod 1990-2019 compared to the subperiod 1961-1989, although this pattern is not detected in the case of Latin American countries. This reduced impact of money growth on inflation might be explained by the fact that the frequency distribution of the inflation data for the subperiod 1990-2019 shows a larger proportion of values of the inflation rate in the 0-10 percent range than in the frequency distribution for the 1961-1989 subperiod (see Appendix B). However, when the inflation rate is capped at 100 percent, there is no evidence of smaller coefficients of the money growth variable when the 1961-1989 and 1990-2019 subperiods are compared. On the contrary, in most cases the coefficients of the contemporaneous money growth variable are larger in the 1990-2019 subperiod than in the 1961-1989. These results contradict Borio's et al (2023) statement of a general weakening of the money growth inflation relationship in recent years.

Except for the case of OECD countries, there is no indication that the post-covid inflation surge affected substantially the money growth – inflation relationship when compared to the results obtained for the 1990-2019 subperiod. For OECD countries, there is a substantial increase in the coefficient of the money growth variable lagged two periods in the 2019-2022 subperiod (from 0.009 to 0.38). This might suggest that OECD countries implemented a more expansive monetary policy response during and immediately after the Covid-19 pandemic than E&D economies.

Regarding the relationship between inflation and GDP growth, the results using instrumental variables tend to indicate that rates of inflation equal to or below 100 percent have no impact on output growth. This result is more evident when the inflation rate is capped at 20 percent in the regressions. However, for the OECD countries, both the FE and IV-FE methods suggest a negative impact of inflation on output growth. Also, in the case of Latin America, the FE method indicates a negative effect of inflation on GDP growth when inflation rates equal to or below 100 percent are considered.

With respect to the broad money growth - GDP growth relationship, most of the estimations for E&D and Latin American economies suggest a relatively small but negative impact of money growth on output growth. Only in the case of advanced economies does contemporaneous money growth exert a positive and statistically significant impact on GDP growth according to the IV-FE method.

Compared to McCandless and Weber's (1995) paper, this research confirms the strong relationship between money growth and inflation. However, there are some key differences with respect to the main results reported by these authors:

- The coefficients for the growth rate of broad money closer to one are only obtained for the complete sample, Emerging and Development and Latin American economies when inflation rates above 20 percent are included in the estimations.
- The dynamics of the money growth-inflation relationship in the OECD countries exhibits some differences with respect to that of non-advanced economies. In OECD countries, at least during the subperiod 1990-2022, money growth impacts inflation with lags.
- This research finds evidence of a statistically significant negative impact of inflation and money growth on GDP growth in certain cases.

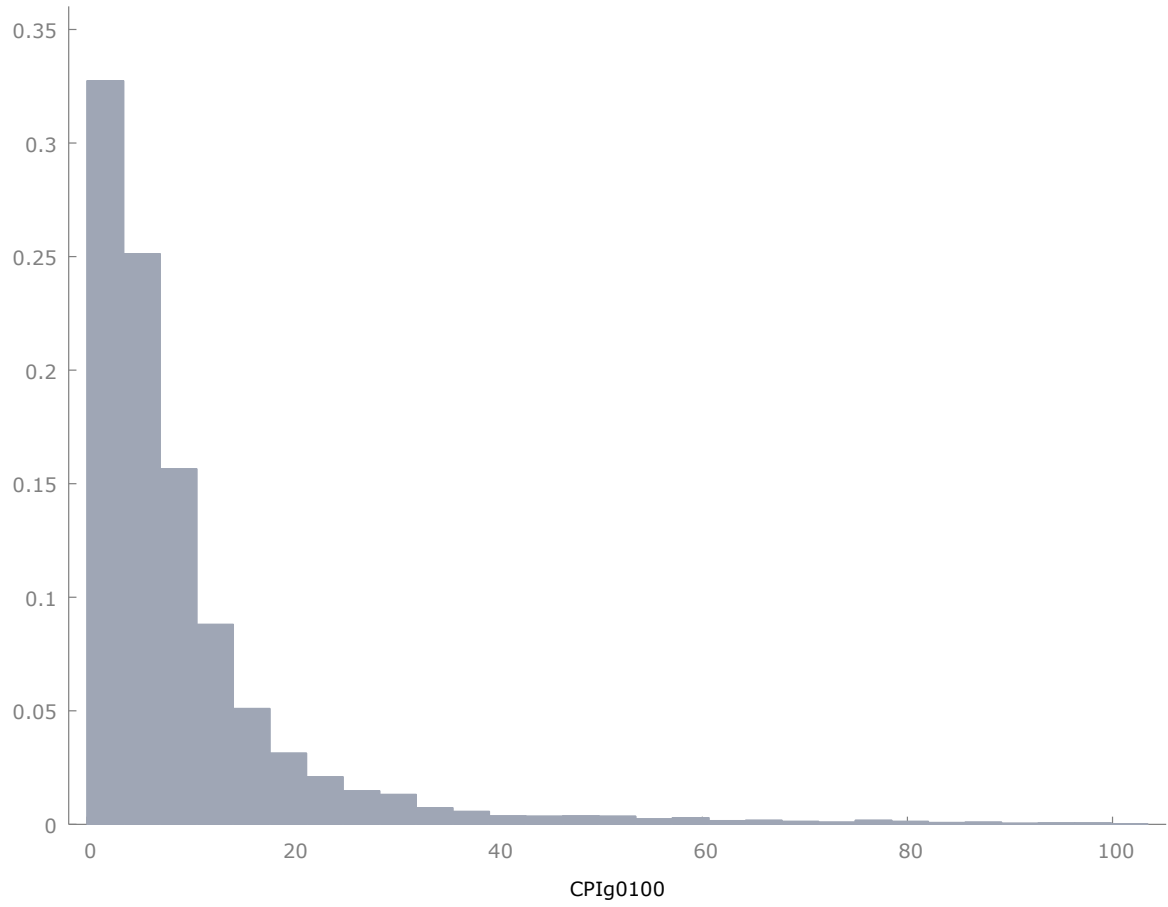
## Appendix A. List of countries included in the empirical analysis.

United States	Norway
Algeria	Oman
Argentina	Pakistan
Australia	Panama
Bangladesh	Papua New Guinea
Belize	Paraguay
Benin	Peru
Bolivia	Philippines
Brazil	Poland
Burkina Faso	Qatar
Cabo Verde	Romania
Cambodia	Russian Federation
Cameroon	Rwanda
Canada	Samoa
Central African Republic	Sao Tome and Principe
Chad	Saudi Arabia
Chile	Senegal
China	Serbia
Colombia	Seychelles
Comoros	Sierra Leone
Congo, Dem. Rep.	Singapore
Congo, Rep.	Solomon Islands
Costa Rica	South Africa
Cote d'Ivoire	Sri Lanka
Croatia	St. Kitts and Nevis
Denmark	St. Lucia
Dominican Republic	St. Vincent and the Grenadines
Ecuador	Sudan
Egypt, Arab Rep.	Suriname
El Salvador	Sweden
Equatorial Guinea	Switzerland
Eswatini	Tajikistan
Ethiopia	Tanzania
Fiji	Thailand
Gabon	Togo
Gambia, The	Tonga
Georgia	Trinidad and Tobago
Ghana	Tunisia
Grenada	Turkiye
Guatemala	Uganda
Guinea	Ukraine

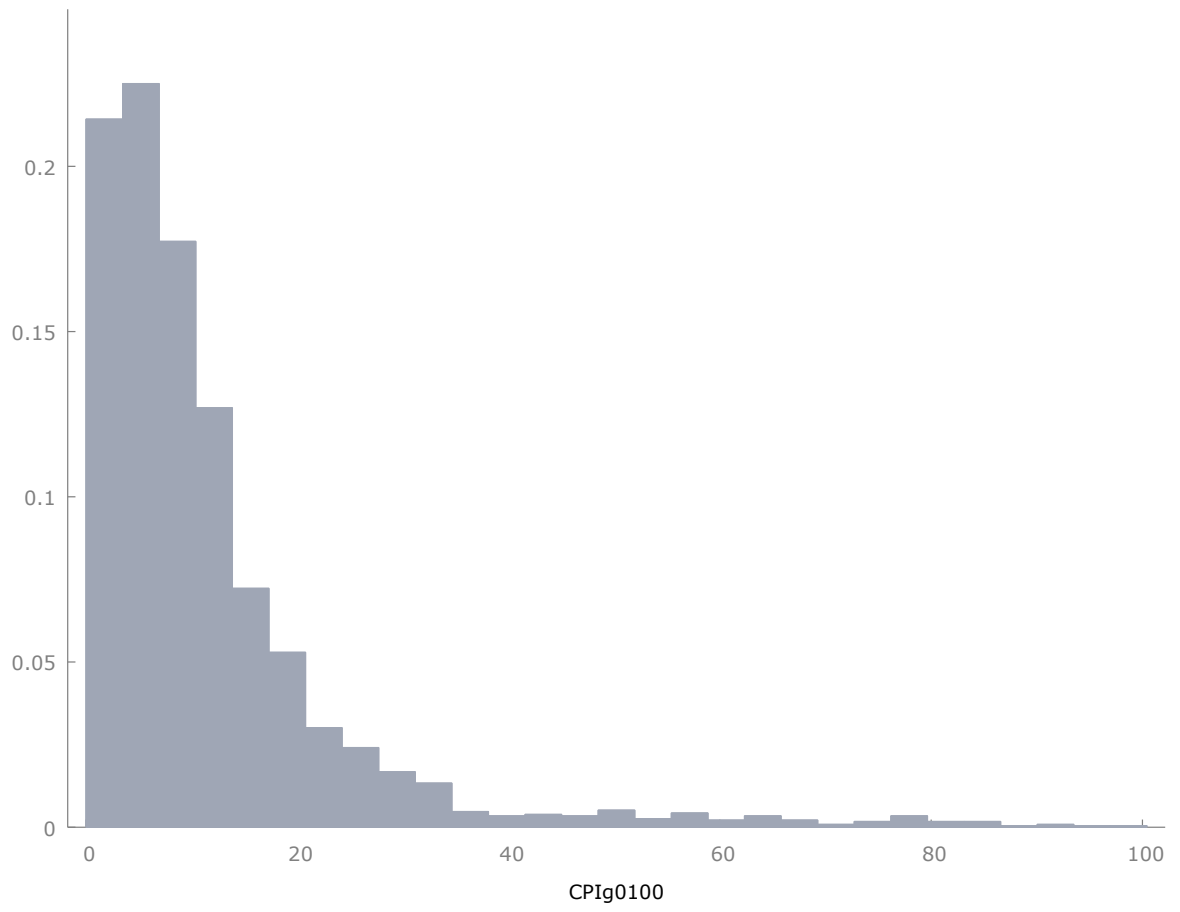
Guinea-Bissau	United Kingdom
Guyana	Uruguay
Haiti	Uzbekistan
Honduras	Vanuatu
Hong Kong SAR, China	Venezuela, RB
Hungary	Vietnam
Iceland	Zambia
India	Zimbabwe
Indonesia	Austria
Iran, Islamic Rep.	Belgium
Israel	Finland
Jamaica	France
Japan	Germany
Jordan	Greece
Kazakhstan	Ireland
Kenya	Italy
Korea, Rep.	Netherlands
Kosovo	Portugal
Kuwait	Spain
Kyrgyz Republic	Euro Area
Liberia	
Libya	
Madagascar	
Malawi	
Malaysia	
Maldives	
Mali	
Mauritania	
Mauritius	
Mexico	
Moldova	
Mongolia	
Montenegro	
Morocco	
Mozambique	
Myanmar	
Namibia	
Nepal	
New Zealand	
Nicaragua	
Niger	
Nigeria	
North Macedonia	

## Appendix B. Frequency distributions

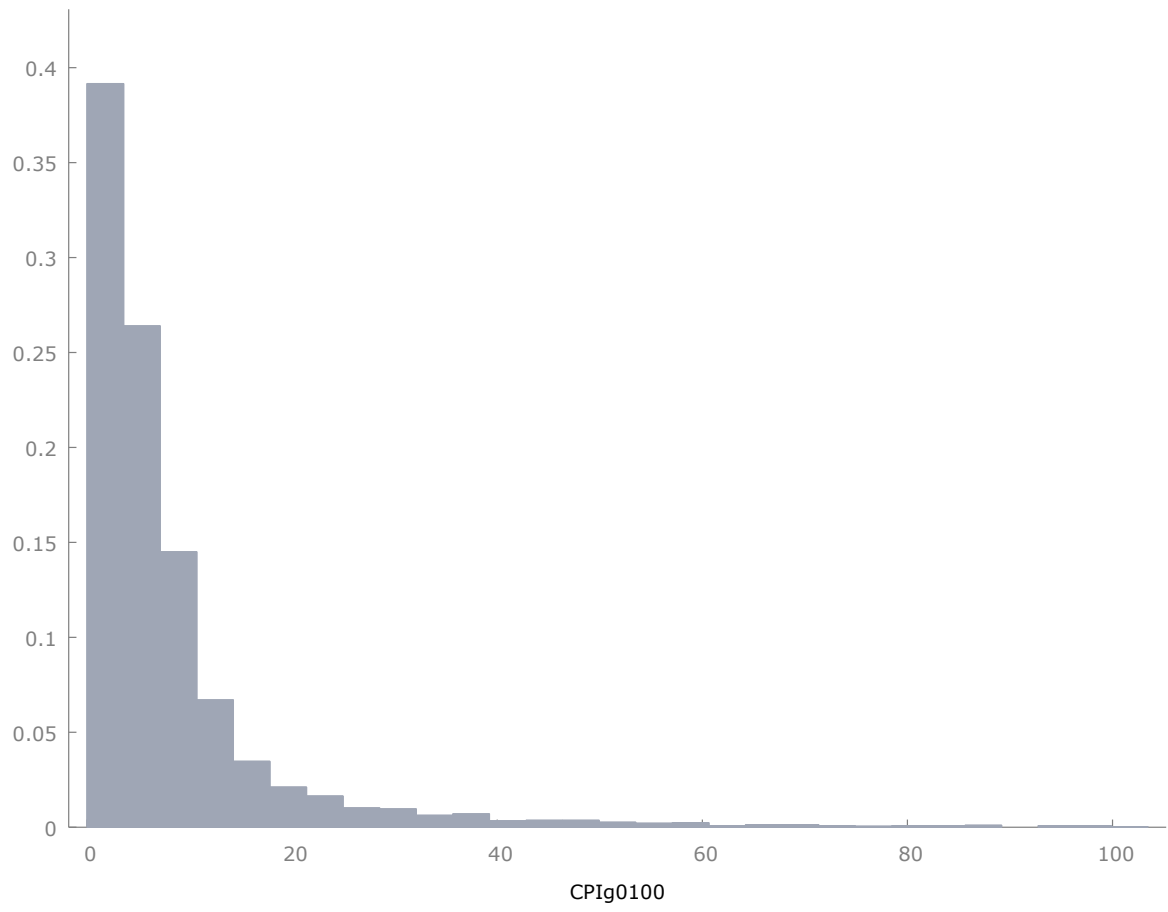
1961-2022



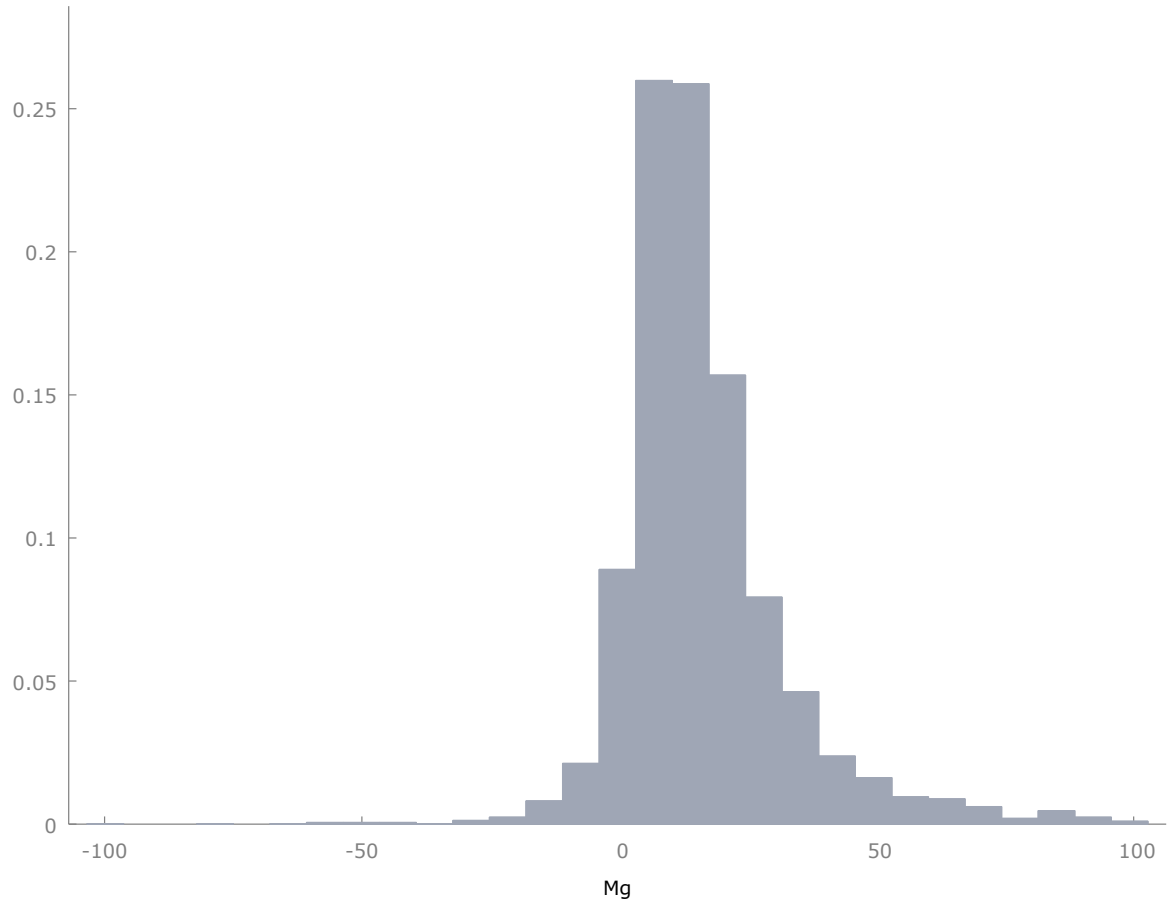
1961-1989

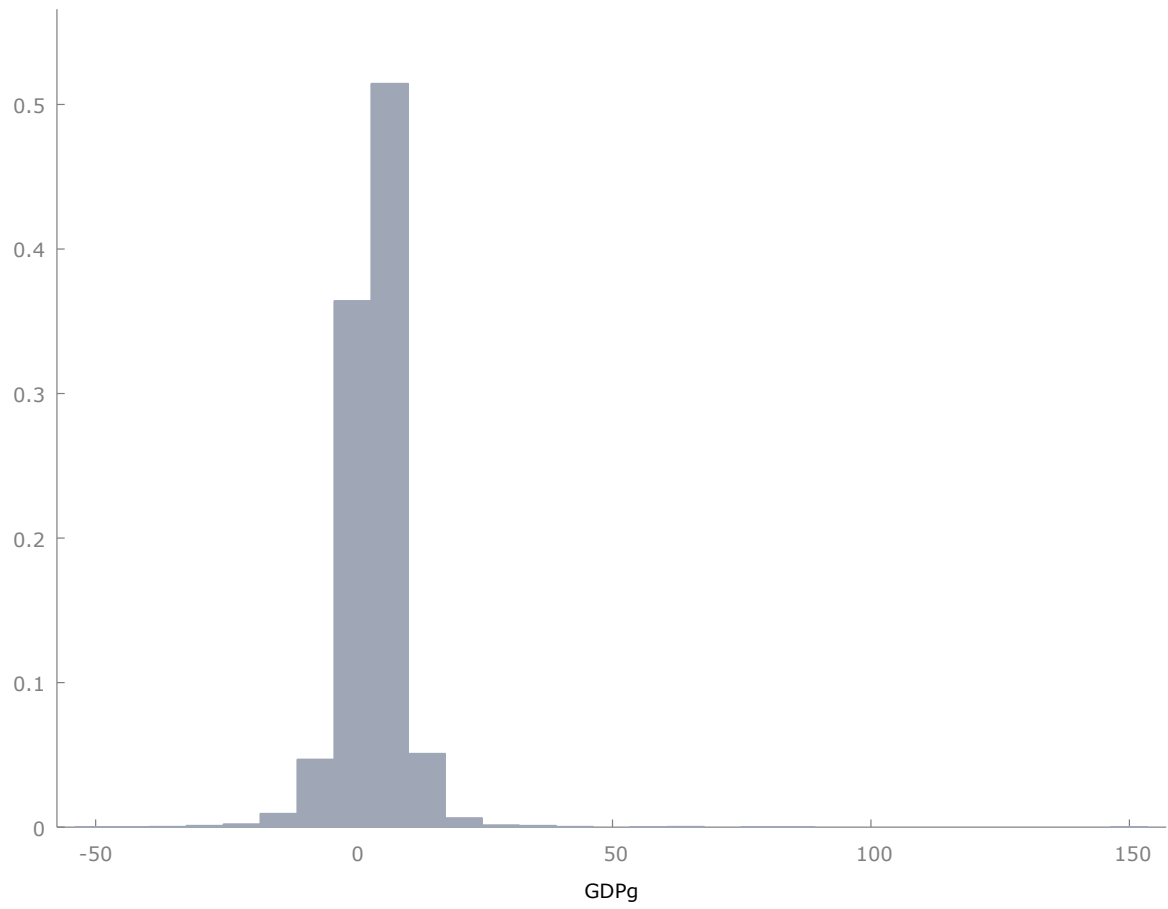


1990-2019









## Appendix C. Econometric results. Money growth and inflation

Table 4. Inflation equal or below 100%. All countries 1961-1989		
	Random-effects	IV-Random effects
N° Obs	2110	2067
Mg	0.10387***	0.565612***
Mg_1	0.0446445**	
Sum of coeff.	0.1485145	
CPIg_1	0.42301***	
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 5. Inflation equal or below 20%. All countries 1961-1989		
	Random-effects	IV-Random effects
N° Obs	1595	1731
Mg	0.0460564***	0.410419***
Mg_1	0.060658***	
Mg_2	-0.0144303***	
Mg_4	0.000913704***	
Sum of coeff.	0.107628104	
CPIg_1	0.351932***	0.0939099***
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 6. Inflation equal or below 100%. All countries 1990-2019		
	Random-effects	IV-Random effects
N° Obs	3336	3387
Mg	0.234518 ***	0.906326***
Mg_1	0.0930412 ***	
Mg_3	0.00340274 **	
Mg_4	0.00176687 **	
Sum of coeff.	0.33272881	
CPIg_1		
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 7. Inflation equal or below 20%. All countries 1990-2019		
	Random-effects	IV-Random effects
N° Obs	3108	3094
Mg	0.0412373***	0.183694***
Mg_1	0.0442191***	
Sum of coeff.	0.0854564	
CPIg_1	0.234777***	0.275283***
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 8. Inflation equal or below 100%. All countries 2019-2022		
	Random-effects	IV-Random effects
N° Obs	367	368
Mg	0.214921***	0.786651***
Mg_1	0.177968***	
Mg_2	0.239215***	
Sum of coeff.	0.632104	
CPIg_1	-0.118789*	
Instruments	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 9. Inflation equal or below 20%. All countries 2019-2022		
	Random-effects	IV-Random effects
N° Obs	389	IV-Random effects
Mg		356
Mg_1	0.102326***	0.180036***
Mg_2	0.0507775***	
Sum of coeff.	0.1531035	
CPIg_1	0.690001***	
Instruments	Mg_1, Mg_2	0.662727***
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 11. Inflation . Advanced Economies 1961-1989		
	Fixed-effects	IV-Fixed effects
N° Obs	363	451
Mg		0.212899***
Mg_3	0.0689453***	
Sum of coeff.		
CPIg_1	0.627802***	0.585951***
Instruments:	Mg_1, Mg_2, Mg_3, Mg_4	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 12. Inflation . Advanced Economies 1990-2019		
	Fixed-effects	IV-Fixed effects
N° Obs	416	426
Mg		-0.115693
Mg_1		
Mg_2	0.00878727**	
Sum of coeff.		
CPIg_1	0.650212***	0.695714***
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 13. Inflation . Advanced Economies 2019-2022		
	Random-effects	IV-Random effects
N° Obs	40	37
Mg		-0.0276308
Mg_2	0.382141***	
CPIg_1	0.660364***	1.49059***
Instruments:	Mg_1, Mg_2, Mg_3, Mg_4	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
\$Note: GLS estimates are consistent		

Table 16. Inflation equal or below 100% .		
Emerging & Developing Economies 1961-1989		
	Random-effects	IV-Random effects
N° Obs	1583	1562
Mg	0.0951062***	0.504684***
Mg_1	0.0403357*	
Sum of coeff.	0.1354419	
CPIg_1	0.466315***	
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 17. Inflation equal or below 20%		
Emerging & Developing Economies 1961-1989		
	Random-effects	IV-Random effects
N° Obs	1170	1285
Mg	0.057406***	0.397782***
Mg_1	0.0662359***	
Mg_2	-0.0125165***	
Mg_4	0.000884958***	
Sum of coeff.	0.124526858	
CPIg_1	0.29459***	
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		
Table 18. Inflation equal or below 100%		
Emerging & Developing Economies 1990-2019		
	Random-effects	IV-Random effects
N° Obs	2915	1962
Mg	0.255889 ***	0.966607***
Mg_1	0.093188 ***	
Mg_3	0.00307478 **	
Mg_4	0.00163018 **	
Sum of coeff.	0.35378196	
CPIg_1		
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 19. Inflation equal or below 20%			
Emerging & Developing Economies 1990-2019			
	Random-effects	IV-Random effects	IV-Random effects
N° Obs	2682	2682	2670
Mg	0.0420938***	0.353536***	0.189942***
Mg_1	0.0467485***		
Sum of coeff.	0.0888423		
CPIg_1	0.216827***		0.247164***
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Table 20. Inflation equal or below 100%			
Emerging & Developing Economies 2019-2022			
	Random-effects	IV-Random effects	
N° Obs	332	332	
Mg	0.242571 ***	0.784842***	
Mg_1	0.0769722 **		
Mg_2	0.171487 ***		
Sum of coeff.	0.4910302		
CPIg_1			
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Table 21. Inflation equal or below 20%			
Emerging & Developing Economies 2019-2022			
	Random-effects	IV-Random effects	
N° Obs	350	320	
Mg		0.181203***	
Mg_1	0.114538***		
Sum of coeff.			
CPIg_1	0.721546***	0.654073***	
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			
Note: GLS estimates are consistent			

Table 24. Inflation equal or below 100% . Latin America 1961-1989			
	Fixed-effects	IV-Fixed effects	
N° Obs	364	378	
Mg	0.357604 ***	0.847986***	
Mg_1	0.14786 ***		
Mg_2	-0.00717885 ***		
Mg_3	-0.00158838 ***		
Sum of coeff.	0.505464		
CPIg_1			
Instruments:	Mg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			
Table 25. Inflation equal or below 20% . Latin America 1961-1989			
	Fixed-effects	IV-Fixed effects	
N° Obs	246	268	
Mg		0.214808***	
Mg_1	0.0755988***		
Mg_2	-0.0119360***		
Mg_4	0.0010922***		
Sum of coeff.	0.076691		
CPIg_1	0.294713***		
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			
Table 26. Inflation equal or below 100% . Latin America 1990-2019			
	Fixed-effects	IV-Fixed effects	IV-Fixed effects
N° Obs	491	491	490
Mg	0.261552 ***	1.06009***	0.320014***
Mg_1	0.0398555 ***		
Mg_2	0.00532925 ***		
Sum of coeff.	0.30673675		
CPIg_1			0.0349579***
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			



Table 27. Inflation equal or below 20% . Latin America 1990-2019			
	Fixed-effects	IV-Fixed effects	
N° Obs	406	407	
Mg	0.0642255***	0.385663***	
Mg_1	0.0310969*		
Sum of coeff.	0.0953224		
CPIg_1	0.140879*		
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			
Table 28. Inflation equal or below 100% . Latin America 2019-2022			
	Random-effects	IV-Random effects	
N° Obs	62	59	
Mg		0.425567***	
Mg_1	0.246059**		
Mg_2	0.138963***		
Mg_3	0.073329**		
Sum of coeff.	0.458351		
CPIg_1	0.748776***	0.668722***	
Instruments:	Mg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			
Table 29. Inflation equal or below 20% . Latin America 2019-2022			
	Random-effects	IV-Random effects	
N° Obs	58	55	
Mg		0.426076***	
Mg_1	0.105122**		
Mg_2	0.137085***		
Sum of coeff.	0.242207		
CPIg_1	0.685579***	0.527639***	
Instruments:	Mg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

## Appendix D. Econometric results. Inflation, money growth, and output growth

Table 31. Inflation equal or below 100% and GDP growth. All countries 1961-2022

	Random-effects	IV-Random effects	
N° Obs	5723	5668	
CPIg0100	-0.02716***	0.00647213	
GDPg_1	0.27253***	0.398518***	
Instruments:	CPIg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Table 32. Inflation equal or below 20% and GDP growth. All countries 1961-2022

	Random-effects	IV-Random effects	
N° Obs	5133	5088	
CPIg020	0.000954753	0.0210122	
GDPg_1	0.266365***	0.356407***	
CPIg_1			
Instruments:	CPIg_1		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Table 33. Money growth and GDP growth. All countries 1961-2022

	Random-effects	IV-Random effects	
N° Obs	6585	6396	
Mg	-0.000369413***	-0.000444792	
GDPg_1	0.270593***	0.607747***	
Instruments:	Mg_1, Mg_2		
*** p-value <= 0.01			
** 0.01 < p-value <= 0.05			
* 0.05 < p-value <= 0.1			

Table 35. Money growth and GDP growth. OECD countries 1961-2022

	Fixed-effects	IV-Fixed effects
N° Obs	930	900
Mg	0.00815994	0.148204***
GDPg_1	0.361858***	0.225964***
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 37. Inflation equal or below 100% and GDP growth .

Emerging &amp; Developing Economies 1961-2022

	Random-effects	IV-Random effects
N° Obs	4769	4723
CPIg0100	-0.0316764***	-0.000485397
GDPg_1	0.257832***	0.377784***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 38. Inflation equal or below 20% and GDP growth .

Emerging &amp; Developing Economies 1961-2022

	Random-effects	IV-Random effects
N° Obs	4207	3938
CPIg020	-0.0101185	-0.0026004
GDPg_1	0.250378***	0.340299***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 39. Money growth and GDP growth .

Emerging &amp; Developing Economies 1961-2022

	Random-effects	IV-Random effects
N° Obs	5702	5473
Mg	-0.000378461***	-0.000746504*
GDPg_1	0.260177***	0.575773***
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 41. Inflation equal or below 100% and GDP growth .		
Latin America 1961-2022		
	Fixed-effects	IV-Fixed effects
N° Obs	945	943
CPIg0100	-0.0247599*	0.0178577
GDPg_1	0.20508***	0.215831***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 42. Inflation equal or below 20% and GDP growth .		
Latin America 1961-2022		
	Fixed-effects	IV-Fixed effects
N° Obs	741	740
CPIg020	0.031469	0.0190664
GDPg_1	0.162166***	0.16327***
Instruments:	CPIg_1	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

Table 43. Money growth and GDP growth . Latin America 1961-2022		
	Fixed-effects	IV-Fixed effects
N° Obs	1068	1047
Mg	-0.000316166***	-0.000618552
GDPg_1	0.289797***	0.269823***
Instruments:	Mg_1, Mg_2	
*** p-value <= 0.01		
** 0.01 < p-value <= 0.05		
* 0.05 < p-value <= 0.1		

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