

Budget Deficit, Money Growth and
Inflation: Evidence from the
Colombian Case

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Budget Deficit, Money Growth and Inflation: Evidence from the Colombian Case

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Abstract

Evidence of the causal long-term relationship between budget deficit, money growth and inflation in Colombia is analyzed in this paper, considering the standard (M1), the narrowest (M0-Base) and the broadest (M3) definitions of money supply. Using a vector error correction (VEC) model with quarterly data over the last 25 years, the study found a close relationship between inflation and money growth on the one hand, and between money growth and fiscal deficit, on the other. The size of the long-term parameters looks acceptable, particularly when compared to what is seen in other countries, using analogous or different techniques. The conclusion, supported by several statistical tests, is that the Sargent and Wallace hypothesis would be the most appropriate approach to understanding the dynamics of these variables.

Keywords: Deficit, Money supply, Inflation, Hypothesis testing

JEL Classification: H62, E51, E31, C12

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1. Introduction

The relationship between budget deficit, money growth and inflation has acquired a prominent place in literature on monetary economics. From a theoretical perspective, both the monetarist hypothesis (MH), based originally on the quantitative theory of money, and the fiscal theory of the price level (FTPL), known as the quantitative theory of government debt, represent the two traditional approaches to understanding what links these macroeconomic variables. Recently, the new Keynesian (NK) theory, build on dynamic general macroeconomic models with imperfect competition, offers an alternative explanation of the dynamics of these variables.

The role of money in monetary-policy management has been relegated, in practice. While some analysts emphasize that money helps to explain the dynamics of inflation,¹ others suggest it should be considered a mere unit of account.² As recent textbooks point out, a discrepancy over the significance of money supply to modern monetary policy has emerged between the European Central Bank (ECB) and other central banks, such as the United States Federal Reserve or the Bank of England.³ At present, the ECB appears to be alone among the central banks in the importance it gives to the rate of money supply, while still trying to use this variable as the *second pillar* of its monetary policy. Conversely, the United States Federal Reserve is discontinuing the collection of statistical data on certain monetary aggregates and places relatively little emphasis on money. The discussion on the role of money has influenced policy-making at the central banks of emerging countries as well.

On an empirical basis, the connection between budget deficit, money growth and inflation has been explored extensively in both industrial and developing economies, with mixed results. In developing countries, it often has been argued that high inflation materializes when governments face large and persistent deficits that are financed through money creation. Hence, inflation emerges as a fiscal-driven monetary phenomenon. Nevertheless, if inflation is a consequence of non-fiscal disturbances, real tax revenues might decline and the budget deficit could end up being endogenous to the inflationary process. Thus, fiscal and monetary policies could exhibit a simple or a bi-directional causal-relationship: changes in inflation could influence the fiscal authority's decisions and (or), conversely, the budget deficit could have implications for money growth and inflation.

An endogeneity (exogeneity) analysis of budget deficit and money supply with respect to inflation appears as crucial to understanding the dynamics between these variables as well as to assessing the theoretical approaches. This tri-variate system has been proposed to test at least four alternative hypotheses. The first is the MH, which requires the definition of a long-run inflation equation as a function of money growth and budget deficit. The evidence supports this approach, if the last two variables are weakly exogenous in the system. The second is the Sargent and Wallace hypotheses (SW-H), which emphasizes that causality goes from deficit to money growth and, thereafter, from money growth to inflation. It also says the

¹ Nelson (2003); Gerlach (2004); and Nelson (2008)

² Woodford (2003); Woodford (2007); and Galí and Gertler (2007)

³ Wickens (2008)

fiscal deficit needs to be weakly exogenous especially in the long-term money growth equation. The third, which is the FTPL, requires the presence of a deficit-caused long-term inflation equation, with money playing no role. Finally, there is the NK hypothesis, which is supported empirically by a money growth equation conditioned to weakly exogenous inflation.

In Colombia, the system described previously has yet to be evaluated empirically, in its entirety, even though fiscal deficits have been interpreted as a possible cause of inflation. There are a number of papers that assess the empirical relationship between money growth and the price level, but none explicitly cites the fiscal deficit as a possible source of money creation and/or inflation. This paper attempts to provide evidence on the subject, using a vector error correction model (VECM), which is recommended in earlier empirical papers. Our analysis is relevant for Colombia, particularly as of the early nineties, when the autonomous central bank was restricted to making direct loans to the government and the banking system (included the central bank) became a major holder of Colombian government securities.

Apart from the introduction, this paper is organized as follows. The next section contains a summary of the foremost theoretical ideas on price level determination and the role of the budget deficit. It also offers a review of earlier empirical studies. The data and the tests of the main statistical properties required for the VECM (unit root and cointegration tests) are described in the third section. In the fourth, both the nature of the model and the results are presented and discussed. The paper ends with some concluding remarks.

2. Some Notes on Price Level Determination and the Budget Deficit Role

2.1 Review of Theory

The Monetarist Hypotheses (MH)

With the quantitative theory of money, the pattern of real economic activity requires a certain desired level of real money balances, and the price level is controlled by the nominal money supply. The reasoning is straightforward. Given the nominal money supply –exogenously determined by the monetary authority– the price level is determined as the unique level of prices that will make the purchasing power of the money supply equal to the desired level of real balances. From an operational point of view, it means the central bank seeks to ensure the quantity of money agents want for their transactions. Given a price level, if the nominal money supply differs from the desired real balances, it will translate into changes in that price level. Hence, the price level has to be fully flexible and determined exclusively by the exogenous nominal money supply.

With regard to fiscal policy, the nominal money supply could change due to the use of seigniorage as a main source of financing for public expenditure, or as the result of an open market operation in which the central bank purchases interest-bearing government debt. Since these two money-expansion mechanisms may have different repercussions for taxes and the stock of government debt, they may lead

to different effects on prices/or interest rates. While the monetarist hypothesis comments on the first mechanism, the second is analyzed extensively by the FTPL.

The budget deficit and its subsequent financing through money creation (seigniorage) are regarded as exogenous to the monetary authority. Hence, money growth would be dominated by the government's financing requirements, and the price level increases as result of that monetary expansion. From an empirical point of view, in terms of the deficit-money growth-inflation system, it means the first two variables in the system have to satisfy the weak exogeneity property, while the later has to be determined endogenously. Consequently, with a monetarist approach, there is expected to be a positive correlation between monetary growth and inflation. A regime of that nature is known as fiscal dominance, pursuant to the spirit of Sargent and Wallace's seminal paper (1981). Strictly speaking, they emphasized the causality runs from fiscal deficit to money growth and, subsequently, from money growth to inflation. Moreover, in the long-run money growth equation, the fiscal deficit needs to be weakly exogenous.⁴

In practice, the monetarist view founded on the quantitative theory of money faces serious difficulties when it comes to controlling inflation. One of those difficulties is the appropriate definition of nominal money supply, mainly due to the substitution between financial monetary and non-monetary assets. Asset substitution to conduct transactions has increased, given the rapid pace of financial innovations and global deregulation of the financial system. The effectiveness of influencing prices via the standard nominal money supply was questioned, because of the amount of financial non-monetary assets within the scope of the monetary authority's control. Instead, the nominal interest rate becomes the instrument used to control the price level, and the nominal quantitative supply of money ends up being determined endogenously in the money market.

The Fiscal Theory of the Price Level (FTPL)

The FTPL links fiscal and monetary policies through the government's inter-temporal budget constraint (GBC), which also is understood as a long-term solvency condition for public sector finances. The GBC is satisfied when the discounted value of the government's future primary surplus is larger than (or equal to) the current nominal value of the public debt. It is important to note that seigniorage is included in the government's primary surplus –as a revenue source–, while the nominal public debt takes into account the monetary base. This is why the relevant public sector is comprised of both the government and the central bank. Because the GBC is expressed, most often, as a percentage of nominal GDP, the discount rate is determined by the ratio of the real interest rate to the economic growth rate.

According to the FTPL, the GBC is assumed to be an equilibrium condition, and the future path of revenues and primary expenditures is decided exogenously by the fiscal authority. Therefore, given a discount rate, if the discounted value of the

⁴ With this regime, the central bank loses the ability to control inflation: i.e. monetary policy becomes "passive", even if fiscal policy is "active" to decide revenues and expenses autonomously.

primary surplus is lower than a pre-determined level of nominal debt (both as a percentage of nominal GDP), the price level has to “jump” to equalize the GBC condition: i.e. the price level becomes the exclusive adjustment variable to maintain that condition.

So as to be more explicit about how the price level is affected by fiscal actions, Woodford (1995) suggests first considering a positive and exogenous price shock that reduces the real value of the government’s liabilities and leads to a parallel a reduction in the real value of private portfolios invested in government securities. The lower real value of these private assets generates a negative wealth-effect, which will be reflected ultimately in less demand for goods. According to the FTPL, the agent’s expectations concerning the sustainability of fiscal policy would produce a similar wealth-effect.

If the market has a negative perception of the sustainability of public finances; that is, if the discounted value of the government’s primary surplus does not cover the nominal value of its liabilities, that perception will prompt an increase in the price level to the extent required to restore GBC equilibrium. The higher price level reduces the real value of private portfolios, thereby generating the aforementioned wealth effect. The higher the nominal government liabilities (nominal debt), the greater the adjustment required in the price level. Hence, the FTPL is also known as the quantitative theory of the public debt. As a result, the presence of a budget deficit-caused long-run inflation equation, with money growth playing no role, may constitute strong support for the FTPL.

The New Keynesian Approach (NK)

With the NK standard approach, the relationship between money growth, inflation and budget deficit can be derived from a system of two equations: aggregate-supply (or an inflation equation) and aggregate-demand. The system, which is well-substantiated for a closed economy, is obtained with a dynamic stochastic general equilibrium framework based on maximization of the agent’s behavior, with imperfect competition. The nature of the NK theory is, therefore, quite different from the approaches discussed earlier, as it does not constitute a quantitative theory on price determination, since money amount is conceived in a monetarist way or as the stock of debt in the FTPL.

The demand equation is a “special” IS-function. It is achieved on a micro-fundamental basis and is affected by both the output gap and real interest rate expectations (i.e. it is an expectational, forward-looking IS curve). The supply equation corresponds to a NK version of the Phillips curve, based on maximization of the firm’s profits, which adjust its prices temporarily, in a staggered way. This two-equation system represents the equilibrium conditions for a well-specified general equilibrium model, which is usually completed with an interest-rate rule used by the central bank to control inflation (when monetary policy is rule-based instead of discretion-based).

The output-gap (current and expected), inflation (current and expected) and the nominal interest rate are the variables to be solved in the system. Even though

money is not taken into account as an explicit variable of the standard model, its inclusion throughout the utility function poses no problem.⁵ More importantly, when solving the NK model with money, the quantity of money ends up being endogenous to the nominal interest rate (or inflation), and becomes an irrelevant variable for policy purposes. According to Woodford (2007), because the system is self-contained, the money-demand function is not required to solve the model for inflation (this function is redundant).

In an additional simplification of the NK standard model, output is consumed entirely by households (i.e. consumption is the unique demand component), while the role of private investment and that of government expenditure are ignored.⁶ Nevertheless, public expenditure shocks can be incorporated feasibly into the standard model in the same way the productivity shock is introduced. Specifically, the effects of fiscal policy on the real economy will depend on agents' expectations about the current (in t) and future (in $t+1$) level of government expenditure.

Given an output gap and inflation expectations for $t+1$, if individuals expect government expenditure to increase in $t+1$, with respect to its current level, it is reasonable to expect that private consumption will fall in $t+1$. Because families have to save, at present, to finance added public spending in $t+1$, consumption in t will have to be reduced. With a Keynesian multiplier, the lower current-consumption level implies a contemporary decline in output, the output gap and inflation. The contrary case could be interesting, because current output (as well as the output gap) would increase, thus forcing up the price level, if individuals believe current government expenditure (in t) is greater than its trend in long-term sustainability (in $t+1$). In short, individual expectations with respect to current and future fiscal action could affect inflation directly and induce money expansion through a higher price level.

2.2. Review of Previous Empirical Work

The inflationary effects of a budget deficit have been the object of extensive empirical evaluation at international level, with mixed results. There are some remarkable papers that found no significant relationship between budget deficit, money growth, and inflation. In principle, this could be consistent with the New Keynesian standard model with *ricardian* fiscal regimes. Several other papers found results to the contrary: namely, significant positive inflationary effects of budget deficit, which could be coherent with the MH, SW-H or FTPL approaches.

Using postwar data for the US and twelve other developed and developing countries, King and Plosser (1985) examined the connection between government deficit and factors that influence inflation in neoclassical macroeconomic models; i.e. factors affecting the supply of, or demand for money. With an unstructured approach (basic regularities in the data), they found little evidence that deficit played an important role in postwar inflation by exerting pressure on the central

⁵ For instance, if money is added as a non-separable argument of the utility function, the balance of real money affects both the marginal rate of substitution (between consumption and leisure) and the demand equation.

⁶ Because the economy is closed, the model also assumes that households have zero net assets.

bank to print money. Karras (1994) investigated the impact of budget deficit on money growth, inflation, investment and real output for a wider sample (32 countries), including developed and developing economies. He used annual data (1950-1989) to estimate reduced-form equations and found, among other things, that (i) deficits are generally not monetized and, therefore, do not produce inflation via monetary expansion; and (ii) deficits are not inflationary, even by virtue of their aggregate-demand effects.

Using a variety of indicators of central bank independence, Sikken and Haan (1998) found analogous outcomes for a group of 30 developing countries. Basically, they tested whether a relationship exists between central bank independence and the government budget deficit, and whether such independence affects monetization of the deficit. They concluded there is no relationship between central bank independence and the budget deficit level. Other findings that show fiscal deficit does not contribute significantly to money growth and inflation are reported by Protopapadakis and Siegel (1987) and by Barnhart and Darrat (1988) for samples that include developed economies, and by De Haan and Zelhorst (1990) for developing countries.

In a case study for the U.S., Joines (1985) empirically analyzed the relationship between government budget deficits and the growth of high-powered money during an extended period (1866-1983). Through reduced-form equations, he provides no evidence that growth in high-powered money is related to the non-war government deficit, after controlling for the level of overall economic activity. His results are consistent with the view that the government has set its real targets for the deficit and for high-powered money growth independently of one another.

Among the papers with opposite results, Edwards and Tabellini (1991) found that budget deficits are an important determinant of inflation. They used cross section techniques for a wide sample of developed countries. The remaining papers with similar findings are case studies of specific countries. For instance, Favero and Spinelli (1999) assessed the relationship among these variables for an extended period (1875-1975) in Italy. In doing so, they confirmed the positive long-term causal direction from budget deficit to money growth and from money growth to inflation, emphasizing the effects vary according to the degree of central banking independence and the type of monetary policy regime.

Metin (1998) evaluated annual fiscal and monetary data for Turkey (from 1950 to 1987) and found the budget deficit and government debt monetization affected the price level significantly. For the same country, Özata (2000) found the price level has been adjusted to the monetary imbalances caused by the Turkish government's fiscal imbalances. Tekin-Koru and Özmen (2003), on the other hand, confirmed the aforementioned results for Turkey, but used a vector error correction model. For the Democratic Republic of the Congo, Nachegea (2005) assessed the fiscal dominance (FD) hypothesis during the period 1981-2003, using a cointegration analysis. His empirical findings reveal a strong and statistically significant long-term relationship between fiscal deficit and money growth, and between money creation and inflation. This supports the assumption that the FD hypothesis applies throughout the period studied.

For Ghana, Sowa (1994) estimated an inflation equation for the period 1965-1991, carefully examining fiscal consistency under different regimes. On the whole, he found that inflation was influenced more by output volatility than by monetary factors induced by the government's deficit. However, inflation was on target during periods characterized by a fiscal discipline regime and exceeded the target during periods marked by fiscal incoherence. Later on, Ghartey (2001) found the fiscal deficit to be an inflationary factor in Ghana for the period 1972- 1992, because an important amount of financing came from printing money. He concludes that budget-deficit monetization generated inflationary pressures, which created, in turn, an adverse environment for economic growth. Accordingly, it is crucial to steer public finances along a balanced path.

For Colombia, there are no previous studies that empirically evaluate the relationship between budget deficit, money growth and inflation, as proposed in this paper. There are, of course, some remarkable papers assessing the bi-variate relationship between money growth and inflation, but none of them explicitly points to the fiscal deficit as a possible source of money expansion and/or inflation. For instance, Misas, López and Querubín (2002) evaluated the relationship between money and inflation through neuronal network models. They found that, although monetary aggregates have been used traditionally as explanatory variables of inflation, the presence of asymmetries between monetary policy and inflation explains the non-linear relationship between these variables. Jalil and Melo (1999) also found a non-linear relationship between inflation and money growth, which could be used to forecast inflation. Finally, Misas, Posada and Vásquez (2001) explore - for the period 1954-2000 - the statistical relevance of the permanent components of the nominal quantity of money and real output, as relative components for the price level (CPI).

3. The Data

3.1 Choice of Variables and the Sample Period

This paper proposes an evaluation of three systems, using the VEC model: $z_{1,t}=(\Delta P_t, \Delta M1_t, DEFY_t)$; $z_{2,t}=(\Delta P_t, \Delta M0_t, DEFY_t)$; and $z_{3,t}=(\Delta P_t, \Delta M3_t, DEFY_t)$. The first, represented by $z_{1,t}$, is the benchmark system and encompasses inflation (ΔP_t), the money supply growth rate ($\Delta M1_t$) and the budget deficit of the central government ($DEFY_t$). The second and third systems ($z_{2,t}$ and $z_{3,t}$), substitute only the standard money supply ($\Delta M1$) by its narrowest ($\Delta M0$) and broadest ($\Delta M3$) definition, respectively. The narrowest definition of money supply (using the monetary base) includes the total amount of reserves held by the banking system, plus the currency in the hands of the public, while the broadest definition consists of M1, plus saving accounts and other denomination time deposits easily used in, or converted to use for transactions.

The system $z_{2,t}$ is pertinent, since the government's domestic financing could be an important source of monetary base expansion (M0), while $z_{3,t}$ is relevant for the presumed high substitutability between monetary and non-monetary assets to conduct transactions. Inflation and the growth rate of money supply are derived, in practice, as the log-first-differences from the consumer price index (CPI) and from

the nominal monetary aggregates. The prices and money series are from the database at the Central Bank of Colombia (Banco de la República, BR).

An important question to emerge concerning the budget deficit-money growth-inflation relationship is whether fiscal data needs to be used; namely, central government or general government fiscal data. The choice is not a trivial one. Even if the central government deficit (and its financing) is related more to money expansion, the general government deficit could be related more to the inflation process. After analyzing the empirical results for both cases, we opted for the central government budget deficit ($DEFY_t$), which is defined as the difference between total expenditure and total revenue in cash bases, expressed as a percentage of GDP. The budget deficit is, therefore, a positive number.

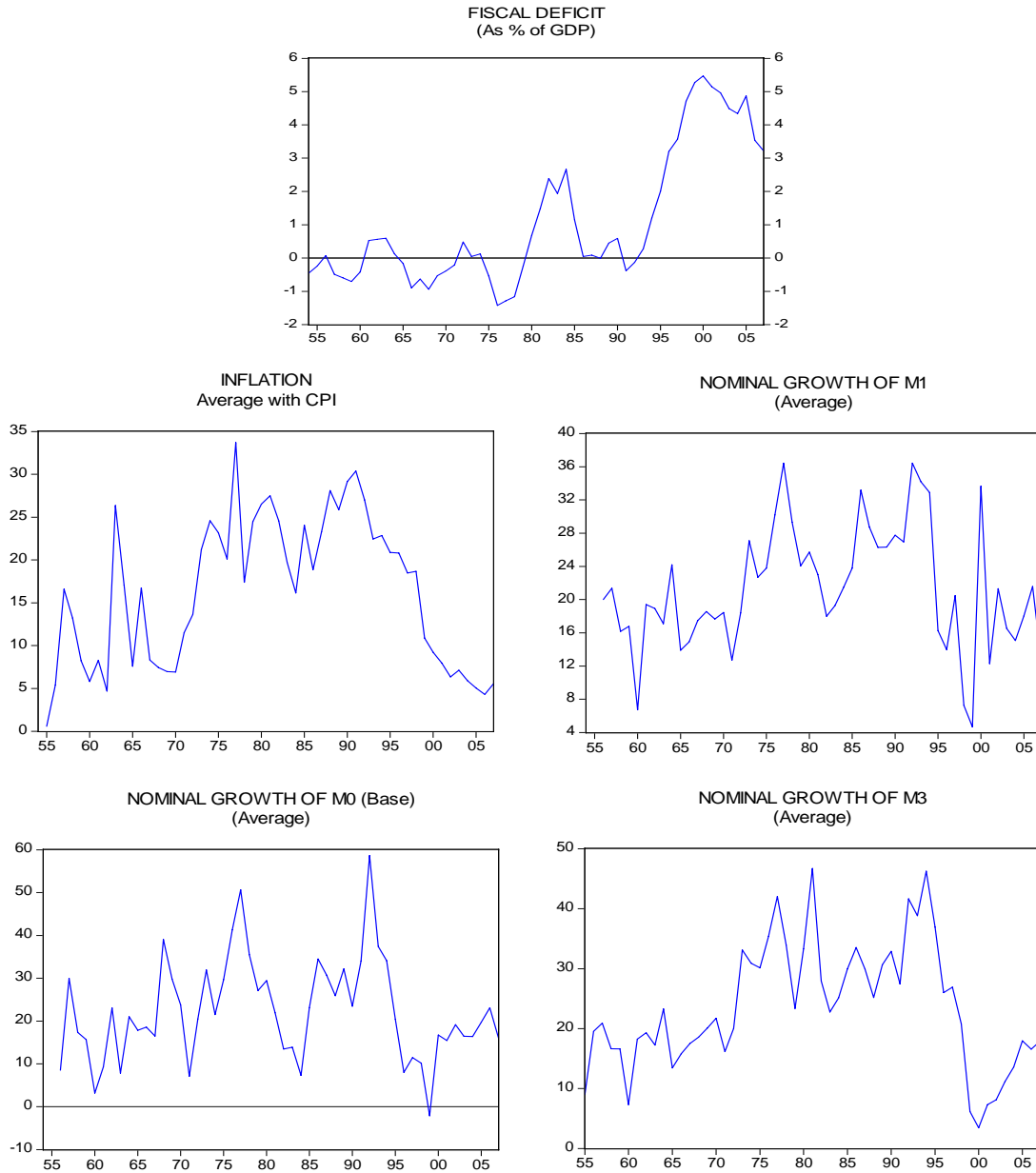
In as much as the VEC model makes it possible to establish the causal long-term relationship between a set of variables, this paper considers two samples in accordance with the availability of data. The first covers a 53-year period (from 1955 to 2007) and its management, employing annual data series. The fiscal budget is assembled by standardizing data from Junguito and Rincón (2004), Garcia and Guterman (1988) and the BR database. Nevertheless, because the VEC technique relies heavily on the existence of consistent quarterly data over a long period of time, we consider a second sample that covers the last 25 years (1982Q1 to 2007Q4). In this case, the fiscal budget is attained by homogenizing the databases of the National Planning Department (DNP) and the BR (Webside and the monthly review). The quarterly series are seasonally adjusted. Figures 1 and 2 show the data for these samples.

Two periods with important fiscal unbalances are clearly shown in the top panel of Figure 1: the first, at the beginning of the eighties, and the second, at the end of the nineties. However, the fiscal deficit grew extraordinary in the latter period, rising to 6% of GDP in 2000 (deficit in cash bases), partially as result of the severe economic slump at the end of the nineties, but also as a reflection of structural problems with central government finances.⁷ Even though the fiscal balance improved considerably during the final years (2004 to 2007), the government's fiscal position remains highly imbalanced (deficit equivalent to 4% of GDP).

Analyzing quarterly data (Figure 2), the minimum values for the fiscal deficit are recorded in the first quarters of 1985Q1 and 1990Q1, with -2.9% and -4.1% of GDP, respectively (by definition, negative numbers mean fiscal surplus). The maximum values are recorded in the fourth quarters of 2000Q4 and 2001Q4 (8.2% and 7.1% of GDP). The pattern of low-value deficits during the first quarters and high-value deficits during the fourths is repeated each year, reflecting a particular dynamic induced by the tax and budgetary institutions. Given the way the tax calendar is designed (especially for income tax), the major taxes are collected in first six months of each year; however, according to budgetary practices, a substantial share of payments is made in the second half of the year.

⁷ Lozano (2004) offers a complete analysis of the structural problems of public finances in Colombia.

Figure 1
BUDGET DEFICIT, MONEY GROWTH AND INFLATION IN COLOMBIA
Annual Data: 1955 to 2007



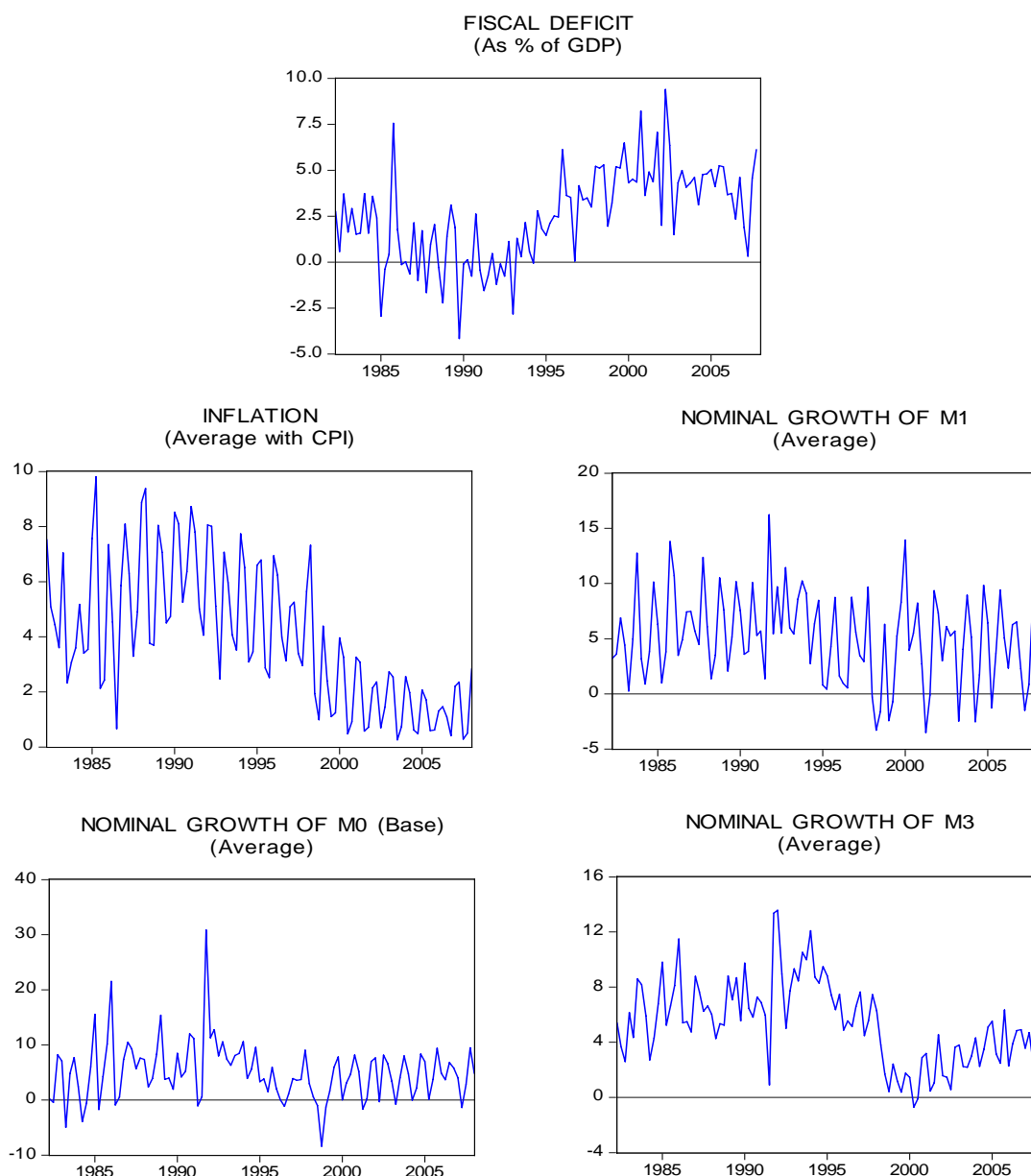
Source: Banco de la República, Junguito and Rincón (2004); and García and Guterman (1988)

Inflation has exhibited a great deal of fluctuation in the last fifty years. During the first half of the seventies, the inflation rate showed a remarkable degree of acceleration. Subsequently, and for a period of twenty years (between 1975 and 1995), the annual inflation rate fluctuated around 25%, with the highest rates occurring in 1977 and 1991 (33.7% and 30.4%, respectively). Inflation has been on a downward trend since the beginning of the nineties. At the present time, the annual rate of inflation oscillates around 6% (Figure 1).

Using quarterly data, the inflation rate (average) starts with a maximum-value of 8.9% in the first quarter of 1988 and recorded a minimum-value of 0.28% in the

third quarter of 2007. Contrary to what happens with the dynamics of the budget deficit, the highest inflation rate is recorded in the first quarter of each year, while the lowest rate is attained in the third quarter.

Figure 2
BUDGET DEFICIT, MONEY GROWTH AND INFLATION IN COLOMBIA
Quarterly Data: 1982Q1 to 2007Q4



Source: Banco de la República and National Planning Department (DNP)

Finally, the bottom panels in Figures 1 and 2 show the growth rate for the monetary aggregates: the standard money supply (M1), the monetary base (M0) and M3. A look at the quarterly series shows M1 and M0 exhibit similar time-behavior (stationary pattern), even though M1 is highly dispersed. Notice when the Colombian economy faced the lowest growth phase (between 1997 and 2002), the

variation in M1 was higher. As we mentioned previously, the inclusion of M0 and M3 could be interesting from an empirical standpoint. However, from a theoretical point of view, M1 is the candidate to explore the long-term relationship with inflation and budget deficit.

3.2 Properties of the Systems

Two statistical properties are required of the variables used in the VEC model: non-stationary and cointegrated. A time series is non-stationary, if its mean and variance are time-dependent, which is very common in the economic variables we chose for this paper. Furthermore, if the variables have a common stochastic trend, which means they move together in the long-term, they are cointegrated. The VEC model is one of the most recommended specifications for analyzing variables of that nature, since it offers more and better information compared to other data generation processes.

The analysis begins by testing the set of variables contained in $z_{1,t}$, $z_{2,t}$ and $z_{3,t}$ for the presence of unit roots and the possibility of a common stochastic trend among them. Three test statistics are used: the Augmented Dickey-Fuller test (ADF, 1979), the Phillips-Perron test (PP, 1988) and the GLS transformed Dickey-Fuller test (DFGLS, 1996). The most common is the ADF-test, which allows for series with a deterministic component. It also makes it possible to include a high number of lags, which is useful for high frequency series. The null-hypothesis (H_0) denotes the presence of a unit root in each variable. When H_0 is rejected, the variables are stationary.

The optimal lag-lengths are fixed on four variables with quarterly frequency (and two with annual frequency).⁸ The tests contain constant and exogenous linear trends. Table 1 reports the ADF unit root tests in which all the series are integrated of order one, $I(1)$, and robust across the other alternative tests (at 0.05 levels of significance). Although the tests for the annual frequency variables are not shown, their results are similar.

A system that involves non-stationary variables presents an equilibrium or long-term relationship, provided those variables do not move independently of one of another (i.e. are cointegrated). Initially, we explored this long-term relationship using the cointegration methodology developed by Johansen-Juselius (1990). The test provides two types of proof: the maximum eigenvalue (λ_{\max}) and trace statistical (λ_{trace}). The maximum eigenvalue and trace tests proceed sequentially from the first hypothesis –no cointegration– to an increasing number of cointegrating vectors. The λ_{\max} is based on the null hypothesis that the number of cointegrating vectors is r in contrast to the alternative $r+1$ cointegrating vectors, while the λ_{trace} is based on the null hypothesis that the number of cointegrating vectors is less than or equal to r in contrast to a general alternative. The results of these tests for $z_{1,t}$, $z_{2,t}$ and $z_{3,t}$, are reported in Table 1. Clearly, the null hypothesis of no-cointegration (i.e. $r=0$) is rejected with both λ_{\max} and λ_{trace} , but not the

⁸ According to Akaike's criterion (AIC), Schwarz's criterion (SC) and Hannan-Quinn's criterion (HQC).

alternative hypothesis of at least one cointegration vector ($r = 1$), at 0.01 level of significance.

Table 1. Unit Root and Cointegration Tests
(Using Quarterly Data)

Unit Root Test:

	ADF-t				
	P	M1	M0	M3	DEFY
Levels	-2.3841	-2.6698	-3.0741	-0.7692	-0.2685
First differences	-4.2418*	-3.8906*	-6.8053*	-12.034*	-7.422*

* Denotes rejection of the hypothesis at the 0.01 level.

Johansen Cointegration Test:

Hypotheses		$r = 0$	$r \leq 1$	$r \leq 2$
Z_1	Eigenvalue	0,2555	0,0373	0,0145
	λ trace	34.7792**	5,2677	1,4625
	λ max	29.5114**	3,8052	1,4625
Z_2	Eigenvalue	0,2250	0,0337	0,0163
	λ trace	30.5842**	5,0832	1,6467
	λ max	25.5009**	3,4365	1,6467
Z_3	Eigenvalue	0,1806	0,0392	0,0111
	λ trace	25.0458**	5,1247	1,1186
	λ max	19.9211**	4,0060	1,1186

** Denotes rejection of the hypothesis at the 0.01 level.

4. The Vector Error Correction Model: Nature and Results

4.1 The Model

The VEC model is used to establish the causal long-term or equilibrium relationship among a set of variables. In addition, when an unexpected shock results in any variable of the system deviating temporarily from the equilibrium path, the model also allows us to evaluate the short-term dynamic adjustment. To facilitate the VECM description, we redefine the variables of $z_{1,t}$ as $z_{1,t} = (x_{1t} \ x_{2t} \ x_{3t})'$, where $x_{1t} = \Delta P_t$; $x_{2t} = \Delta M1_t$ and $x_{3t} = \text{DEFY}_t$.

The equilibrium relationship between the variables of $z_{1,t}$ could be given by the equation $\beta' z_t = \beta_1 x_{1,t} + \beta_2 x_{2,t} + \beta_3 x_{3,t} = 0$, where $\beta = (\beta_1, \beta_2, \beta_3)'$ are the parameters to fix that relationship. For a particular period, the long-term relationship is not usually satisfied; that is, it could be that $\beta' z_t = y_t$, where y_t is a stochastic variable

representing deviations from the equilibrium level. If the equilibrium relationship actually exists, it is plausible to assume the $z_{1,t}$ variables move together and y_t is stable.

To make things easier, it is usually assumed the long-term relationship is given by $x_{1,t} = \beta_2 x_{2,t} + \beta_3 x_{3,t}$, where we normalized in β_1 ($\beta_1=1$). The VECM starts by emphasizing that changes in variables in period t depend on deviations from this equilibrium relationship in period t-1, which means:

$$\begin{aligned}\Delta x_{1,t} &= \alpha_1(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \mu_{1,t} \\ \Delta x_{2,t} &= \alpha_2(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \mu_{2,t} \\ \Delta x_{3,t} &= \alpha_3(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \mu_{3,t}\end{aligned}\tag{1}$$

where the α 's are parameters that measure the deviations and the μ 's represent the error terms. Moreover, the model assumes that changes in the variables in t depend not only on deviations from this equilibrium relationship, but also on changes in each of the variables in period t-1. Thus,

$$\begin{aligned}\Delta x_{1,t} &= \alpha_1(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \gamma_{11}\Delta x_{1,t-1} + \gamma_{12}\Delta x_{2,t-1} + \gamma_{13}\Delta x_{3,t-1} + \mu_{1,t} \\ \Delta x_{2,t} &= \alpha_2(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \gamma_{21}\Delta x_{1,t-1} + \gamma_{22}\Delta x_{2,t-1} + \gamma_{23}\Delta x_{3,t-1} + \mu_{2,t} \\ \Delta x_{3,t} &= \alpha_3(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) + \gamma_{31}\Delta x_{1,t-1} + \gamma_{32}\Delta x_{2,t-1} + \gamma_{33}\Delta x_{3,t-1} + \mu_{3,t}\end{aligned}\tag{2}$$

where the parameter γ 's denote the last effects. The close relationship between the VEC model –represented by (2)– and the cointegration relations can be checked by reordering any Δx_i equation,

$$\alpha_i(x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}) = \Delta x_{i,t} - \gamma_{i1}\Delta x_{1,t-1} - \gamma_{i2}\Delta x_{2,t-1} - \gamma_{i3}\Delta x_{3,t-1} - \mu_{i,t}\tag{3}$$

If we assume, for instance, that the cointegration order is I(1), as was found for the z 's in Section 3, the right side of (3) is stable, I(0), as long as the μ_i errors are white noise. If, moreover, $\alpha_i \neq 0$, then $x_{1,t-1} - \beta_2 x_{2,t-1} - \beta_3 x_{3,t-1}$ is also stable. Therefore, the β 's unambiguously represent a cointegration relation.

The system (2) can be represented, in a matrix shape, as:

$$\begin{aligned}\Delta z_t &= \alpha\beta' z_{t-1} + \Gamma_1 \Delta z_{t-1} + \mu_t \quad \text{or} \\ \Delta z_t &= \Pi z_{t-1} + \Gamma_1 \Delta z_{t-1} + \mu_t\end{aligned}\tag{4}$$

where, $z_t = (x_{1,t}, x_{2,t}, x_{3,t})'$; $\mu_t = (\mu_{1,t}, \mu_{2,t}, \mu_{3,t})'$; $\alpha = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix}$; $\beta' = (1, -\beta_2, -\beta_3)$; and

$$\Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix}$$

In (4) $\Pi = \alpha\beta'$, where α and β are matrices of order $K \times r$, the range of Π corresponds to a cointegration rank of the system (in our case $0 < r < 3$), while β represents the cointegration matrix.

Finally, the model is generalized to include two extensions. On the one side, the lag number of Δz is expanded up to period $t-\rho+1$ and, on the other, a deterministic term ε_t is included, which may be present in both the cointegration process and the VECM. The deterministic term (as an option extension) offers advantages to the model's estimation and could be a constant, $\varepsilon_t = \varepsilon_0$, a lineal trend, $\varepsilon_t = \varepsilon_0 + \varepsilon_1 t$, or simply a seasonal dummy variable (Lütkepohl, 2005). Notice that ε_0 and ε_1 are vectors of fixed parameters of dimension K . If we assume that $\varepsilon_t = \varepsilon_0$, then

$$\Delta z_t = \Pi z_{t-1} + \Gamma_1 \Delta z_{t-1} + \dots + \Gamma_{\rho-1} \Delta z_{t-\rho+1} + \varepsilon_0 + \mu_t \quad (5)$$

which is the final VECM model specification, where the Γ^j 's ($j=1, \dots, \rho-1$) represent the short-term parameters and Π denotes the long-term parameters of the model. More specifically, in $\Pi = \alpha\beta'$, α and β are $3 \times r$ matrices that represent, respectively, the short-term to long-term adjustment coefficients and the cointegration vector (or the long-term relationships among the set of variables).

4.2. Results

4.2.1 Results With Quarterly Data: Period 1982Q1 to 2007Q4

Table 2 contains the VECM estimates for the benchmark system $z_{1,t}$ and also for $z_{2,t}$ and $z_{3,t}$, using quarterly data for the last 25 years. The series are seasonally adjusted as a deterministic term option. Based on AIC, SC and HQC criteria (footnote 8), four were chosen as the optimum lag-lengths for the VAR in the VECM. The systems contain at least one cointegration relationship (Table 1).

The cointegration vectors are normalized in prices and money supply to obtain the long term equations of these variables. In the first case (when the system is normalized in prices, $\beta_1=1$), we find the long-term inflation equation is dependent upon money supply and fiscal deficits. In the second (when $\beta_2=1$), we obtain the long-term money growth equation dependent on inflation and fiscal deficits. Since we are particularly interested in the effects of the fiscal deficit, we do not normalize in this variable. The two-equation system provides economically and statistically significant information, as long as both systems are supported by tests for

exclusion, stationarity and weak exogeneity, which are usual in VEC modeling. Equations and tests are used together for an empirical assessment of the theoretical approaches described in Section 2.

Table 2. Cointegration Analysis for z_1, z_2 and z_3

(With Quarterly Data: 1982Q2-2007Q4)

Benchmark System z_1 ($\Delta P, \Delta M1, DEFY$):			
Standardized Eigenvectors (β 's)			
	ΔP	ΔMI	$DEFY$
First vector	1.000000	-0.957048**	0.437089
Second vector	-1.044880**	1.000000	-0.456705*
Standardized Adjustment Coefficients (α 's)			
	$\alpha 1$	$\alpha 2$	$\alpha 3$
$\Delta^2 P$	-0.166146**	0.159010**	-0.072621**
$\Delta^2 M1$	0.408708*	-0.39115*	0.178642*
$\Delta^2 DEFY$	0.029584	-0.028313	0.012931
Test for Exclusion: $LR \sim X^2(r)$			
	ΔP	ΔMI	$DEFY$
	47.89*	53.45*	6.00*
Multivariate Statistics for Testing Stationary: $LR \sim X^2(p-r)$			
	ΔP	ΔMI	$DEFY$
	57.29*	53.88*	57.01*
Test for Weak Exogeneity: $LR \sim X^2(r)$			
	ΔP	ΔMI	$DEFY$
	39.53*	25.95*	0.00
System z_2 ($\Delta P, \Delta M0, DEFY$):			
Standardized Eigenvectors (β 's)			
	ΔP	$\Delta M0$	$DEFY$
First vector	1.000000	-0.885107**	0.172814
Second vector	-1.129807**	1.000000	-0.195246
System z_3 ($\Delta P, \Delta M3, DEFY$):			
Standardized Eigenvectors (β 's)			
	ΔP	$\Delta M3$	$DEFY$
First vector	1.000000	-0.764105**	0.083620
Second vector	-1.308721**	1.000000	-0.109435

* Indicates significance at the 0.05 level

** Indicates significance at the 0.01 level

The exclusion test evaluates the relevance (or significance) of each variable within the long-term equations, while the stationarity test verifies this statistical property for time series data. If the null hypothesis is rejected in the first case, the tested variable has not been excluded from the system. The weak exogeneity test is used

to verify whether or not the variables employed as explanatory variables (usually located on the right-hand side of the equation) are exogenous to the system and, in turn, if the variable chosen to be explained (located on the left-hand side) is endogenous to the system. In this case, if the null hypothesis is not rejected, the tested variable satisfies weak exogeneity. Consequently, proof of weak exogeneity becomes in one of the most relevant tests for empirically validating the causal relationship between fiscal deficit, monetary growth and inflation.

- Price and Money Supply Equations in the Benchmark System (z_1)

By normalizing cointegration vectors in both price ($\beta_1=1$) and money supply ($\beta_2=1$), on the one side, and taking into account the significance level of the long-term parameters, on the other, we obtain the following long-term equations (z_1 from Table 2)

$$\Delta P = 0,957 \Delta M1 \quad (6)$$

$$\Delta M1 = 1,044 \Delta P + 0,456 DEFY \quad (7)$$

The money supply coefficient of the inflation equation (6) has the expected sign. The value of 0.96 suggests that a one percentage point increase in the M1 growth rate induces, on average, an increase of about 0.96 percentage points in the inflation rate. The magnitude of this effect (close to one) is similar to the evidence found in other countries, using analogous or different techniques. McCandless and Weber (1995), for instance, found a long-term correlation coefficient of 0.958 among these variables for a period of 30 years in 110 countries. Because the parameter of the budget deficit has significance problems, that variable is not included.

Equation (7) shows that M1 grows with inflation and fiscal deficit. Intuitively, this seems realistic. In particular, a one percentage point increase in the fiscal deficit (as a share of GDP) leads to an increase of about 0.46 percentage points in the M1 growth rate. The size of this parameter looks acceptable, above all when compared to what is found in other countries. For instance, Tekin-Koru et al. (2003) found a β of 0.434 for Turkey. The standardizing adjustment coefficients (α 's) indicate a relatively rapid adjustment in inflation and money growth to disequilibrium (between two and six quarters).

The expected sign and the significance level of the coefficients are not enough to conclude the existence of a causal long-term relationship among the variables of z_1 . As previously mentioned, it requires further analysis of the exclusion, stationarity and weak exogeneity tests, the results of which are presented in Table 2. According to the exclusion test ($X^2(r)$), the null hypothesis is rejected for the three variables, at 95% confidence; in other words, all the variables are pertinent (significant) to the system. Hence, equations (6) and (7) reveal valuable information, in principle. Equally satisfactory results are obtained with the stationarity tests ($X^2(p-r)$), which corroborate the previous unit root test (Section 3.2), at 95% confidence.

The weak exogeneity test provides surprising results. The null hypothesis is not rejected at 5% significance, only in the case of the budget deficit. Consequently, the evidence supports the idea that fiscal deficit is actually the only exogenous variable in systems (6) and (7), while money growth and inflation are jointly (endogenously) determined. These empirical findings are crucial to establishing the scope of the theoretical approaches, in the following sense.

First, because money supply does not satisfy the weak exogeneity test, it is difficult to validate the orthodox monetarist hypothesis (MH) whereby one-time proportional changes in the nominal quantity of money lead to equal proportional changes in the prices level. Our results merely confirm the long-run inflation rate is linked closely to growth in money supply. Secondly, as we found no evidence that fiscal deficit is a direct cause of long-run inflation, with money supply playing no role, equation (6) offers no support to the fiscal theory of the price level (FTPL). In a recent paper, Lozano and Herrera (2008) found no evidence to support a fiscal dominance relationship between fiscal and monetary policies in Colombia for the period 1990 to 2007. These two empirical results are coherent, since the FTPL and fiscal dominance are proximate concepts. Thirdly, because the results presented in Table 2 clearly offer no evidence of a money growth equation conditioned by weakly exogenous inflation, the new Keynesian (NK) endogenous money hypothesis is difficult to corroborate.

Consequently, we conclude that the most appropriated approach to understanding the relationship between budget deficit, monetary growth and inflation in Colombia is given by the Sargent and Wallace hypothesis (SW-H). Previously, we mentioned this hypothesis consists of two parts. One concerns causality and calls for the budget deficit to cause money growth and, subsequently, money growth to cause inflation. The other is exogenously, in which fiscal deficit is required to be weakly exogenous, particularly in the long-term money growth equation. Even if, up to now, the first requirement is not entirely proved in this paper, the second is.

The close long-term relationship between inflation and money supply shown in (6) has been explored empirically, particularly through correlation analysis. As McCandless et. al., point out, even though correlations are not direct evidence of causality, they do lend support to causal hypotheses that yield predictions consistent with the correlations. We end this section with the results of a pair-wise granger-causality test for z_1 variables (Table 3).

Table 3. Results of Pair-Wise Granger Causality Test
(F-Statistic)

Pair-Variables	Quarterly: 1982Q1-2007Q4		Annual: 1955 -2007	
	Causal direction		Causal direction	
	⇒	⇐	⇒	⇐
$\Delta M1, \Delta P$	31.834**	19.126**	3,551	6.179*
DEF, ΔP	13.125**	4.083*	3,042	0,579
DEF, $\Delta M1$	5.670**	2,487	2,083	0,206

*denotes significance at a 0.05 level;

**denotes significance at a 0.01 level

Using the highest significance level (denoted by **), we find evidence, first, of fiscal deficit granger-cause money supply growth (which is consistent with SW-H) and, secondly, money supply growth granger-cause inflation (albeit the opposite is also true; that is, inflation granger-cause money supply growth). Notice that these conclusions do not hold when annual data for a longer period are used.

- Price and the Narrowest and the Broadest Money Supply Equations (z_2 and z_3)

The long-term coefficients (β 's) for systems z_2 and z_3 are presented in the lower part of Table 2. These systems use the narrowest and the broadest definitions of money supply growth, respectively. In Section 3.1 we noted the empirical valuation of z_2 could be relevant, since government borrowing (deficit) might be an important source of monetary base expansion ($\Delta M0$), while z_3 could corroborate the high substitutability conjecture between monetary and non-monetary assets to conduct transactions.

When normalizing cointegration vectors in prices ($\beta_1=1$), we find the expected sign for both the narrowest and the broadest definitions of money supply in price equations (at the highest level of significance). In the first case, the parameter β_2 suggests that a one percentage point increase in the monetary base (M0) growth rate has induced, on average, an increase of about 0.88 percentage points in the inflation rate. Once again, the lower size of this parameter (with respect to M1) is comparable to what is found in other studies (i.e. McCandless et. al (1995), who found a long-term correlation coefficient of 0.925 among these variables. In the second case (price equation with the broadest definition of money supply), the coefficient is 0.76.

As to the role of the fiscal deficit, our estimates do not proffer conclusive results in these systems, as the parameters do not present a suitable significance. Moreover, contrary what is showed for the benchmark system (z_1), the null hypothesis of the exclusion test is not rejected for fiscal deficit in z_2 and z_3 ($X^2(r)=0.07$ and $X^2 (r)=0.05$, respectively),⁹ which means this variable is not relevant to the systems. Nonetheless, the results of the stationarity and weak exogeneity tests for z_2 and z_3 are analogous with what is found for z_1 . Although the results of these tests are not presented in Table 2, they are available from the author upon request.

4.2.3. Results With Annual Data: Period 1955 to 2007

The empirical procedure described in Section 4.2.1, is conducted with annual data for the period 1955 to 2007. Essentially, the idea is to corroborate the results obtained with the benchmark system, using quarterly data, but for a longer period and with annual series. To begin with, we ensure the statistical properties of the variables are met (unit root and cointegration test). Afterward, we do the VECM estimates for similar systems: z_1 , z_2 and z_3 . Finally, the tests for exclusion, weak

⁹ The critical value for the exclusion test is 3.84, at a 0.05 confidence level.

exogeneity, and stationarity are provided on each one. The new results are shown in Table 4.

Table 4. Cointegration Analysis for z_1 , z_2 and z_3
(With Annual Data: 1955 -2007)

Benchmark System z_1 (ΔP, $\Delta M1$, $DEFY$):			
	Standardized Eigenvectors (β 's)		
	ΔP	$\Delta M1$	$DEFY$
First vector	1.000000	-0.837684**	0.722976
Second vector	-1.193768**	1.000000	-0.863066
	Standardized Adjustment Coefficients (α 's)		
	$\alpha 1$	$\alpha 2$	$\alpha 3$
$\Delta^2 P$	-0.388369**	0.325330**	-0.280781**
$\Delta^2 M1$	0.418193**	-0.350314**	0.302344**
$\Delta^2 DEFY$	0.011906	-0.009974	0.008608
	Test for Exclusion: $LR \sim X^2(r)$		
	ΔP	$\Delta M1$	$DEFY$
	14.98*	16.56*	3.83
	Multivariate Statistics for Testing Stationary: $LR \sim X^2(p-r)$		
	ΔP	$\Delta M1$	$DEFY$
	18.45*	18.85*	17.75*
	Test for Weak Exogeneity: $LR \sim X^2(r)$		
	ΔP	$\Delta M1$	$DEFY$
	10.64*	5.16*	0.09
System z_2 (ΔP, $\Delta M0$, $DEFY$):			
	Standardized Eigenvectors (β 's)		
	ΔP	$\Delta M0$	$DEFY$
First vector	1.000000	-0.730609**	-0.153536
Second vector	-1.368721**	1.000000	0.210148
System z_3 (ΔP, $\Delta M3$, $DEFY$):			
	Standardized Eigenvectors (β 's)		
	ΔP	$\Delta M3$	$DEFY$
First vector	1.000000	-0.714958**	0.036401
Second vector	-1.398684**	1.000000	-0.050914

* Indicates significance at the 0.05 level

** Indicates significance at the 0.01 level

Both the size and the sign of the long-term parameters (β 's) in all the systems are close to those obtained with quarterly data. The long-term ample relationship between money growth and inflation is corroborated with the three money definitions: 0.84 with M1; 0.73 with M0 (base); and 0.71 with M3. The results of the stationarity, weak exogeneity and exclusion tests are analogous to the previous

case.¹⁰ Once again, the budget deficit continues to be the only exogenous variable in the benchmark system, while money growth and inflation are determined jointly (endogenously).

Regarding the fiscal deficit, the VEC-new-sample model provides no results to support the role assigned in the previous case. The size of the budget deficit parameter in the money supply equation is larger than what is included in equation 7. Nonetheless, its significance level is below 0.1. In addition, when examining the pair-wise granger causality test (Table 3), we found no evidence that the fiscal deficit caused growth in money supply during this longer period. Hence, we cannot conclude that the fiscal deficit had inflationary effects for the period 1955 to 2007 as, in fact, we did conclude for a shorter period (from 1982 to 2007).

5. Concluding Remarks

This paper attempts to offer evidence on the causal long-term relationship between budget deficit, money growth and inflation in Colombia, considering the standard (M1), the narrowest (M0-Base) and the broadest (M3) definitions of money supply. The Johansen cointegration test suggests there is at least one cointegration vector among these variables. Under such circumstances, we employed a vector error correction (VEC) model, since it offers more and better information compared to other data generation processes. The VEC model was estimated for two samples according to data availability. The first covers a period of 53 years (from 1955 to 2007) and is done with annual series. Nevertheless, as the VEC technique relies heavily on the existence of consistent quarterly data over an amply long period of time, we considered a second sample from 1982Q1 to 2007Q4.

The results point to a close long-term relationship between inflation and money supply, comparable to what is found in other countries with analogous or different techniques (the long-term coefficient is 0.96 for the shorter period). As expected, this coefficient is lower with the narrowest and the broadest definition of the monetary aggregate (0.88 and 0.76, respectively). With regard to the role of the fiscal deficit, the VEC estimates provide evidence that a one percentage point increase in the fiscal deficit (as a share of GDP) leads an increase of almost 0.46 percentage points in the M1 growth rate. The size of this parameter looks also acceptable, above all when compared to what is found in other emerging countries. The causal long-term relationship between budget deficit, money growth and inflation could vary depending on the degree of independence of the central bank and the type of monetary-policy regime, as it has been explored in other studies. However, these subjects are beyond the scope of this paper and should be the subject of further research.

Based on (i) the sign of the long-term parameters and their significance level; (ii) the tests for exclusion, stationarity and weak exogeneity; and (iii) the pair-wise granger-causality test for the benchmark system variables, we conclude that the

¹⁰ Surprisingly, for the exclusion test, the null hypothesis is not rejected lightly for the fiscal deficit at the 0.05 level of significance: $X^2(r)=3.83$ versus a critical value of $X^2(r)_{C-0.05}=3.84$. Nevertheless, this hypotheses is rejected at the 0.1 level of significance $X^2(r)_{C-0.1}=2.705$.

Sargent and Wallace hypothesis (SW-H) could be the most appropriate approach to understanding the dynamics among this set of variables in Colombia as of 1980. The SW-H has two parts. One concerns causality and calls for the budget deficit to cause money growth and, subsequently, money growth to cause inflation. The other is exogenous, in which fiscal deficit is required to be weakly exogenous, particularly in the long-term money growth equation. Our findings do not uphold the orthodox monetarist hypothesis (MH), the fiscal theory of the price level (FTPL) or the new Keynesian (NK) endogenous money hypothesis.

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