# ECONOMETRIC MODELS OF INFLATION IN BRAZIL: STRUCTURALISTS, MONETARISTS AND RATIONAL EXPECTATIONS APPROACHS, 1995-2017

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**Abstract**
The present article seeks to demonstrate the evolution of the inflation rate in Brazil during the period between the era of President Vargas and the government of President Michel Temer, together with the determinants of inflation between 1995 and 2017. With the aid of structuralist, monetarist, and inertialist econometric models, we attempt to understand the factors that influenced the inflation rate during this period, based on the monetarist models of rational and adaptive expectations. Once the regressions have been completed, we reach certain conclusions on the statistical significance level of the model and whether its variables have the power to explain the inflation rates in Brazil during the period following the Real Plan. Finally, we conclude that there are reasons to reject the hypothesis that the trend variable is adequately formulated to capture the effect of financial innovations in the equation for the demand for money.
**Keywords:** Inflation; Rational Expectations; Adaptive Expectations; Regression; Monetarist.
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## 1. Introduction[1]

Inflation is a monetary phenomenon manifested by the generalized, continuous rise in prices, which causes the currency to lose its purchasing power. The general price index at a given moment measures the level of inflation and the variation of the general price index measures the inflation rate over a period of time. Therefore, sporadic high prices of certain goods and services do not characterize inflation.

For example, the prices of horticultural products rise and fall according to climatic conditions, and harvest and off-season periods do not constitute a tendency to increase the general level of prices. The market prices of goods and services may rise or fall, thus reflecting either shortages or an oversupply on demand. Prices may rise, but may return to a point of market equilibrium as soon as the quantities offered are restored to their previous levels. This does not characterize a rise in the rate of inflation because the inflation rate is a weighted mean of price hikes in a given period of time.

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The inflation rate may be broken down into two components: one due to shocks and the other caused by an inflationary trend (LOPES, 1985). Inflationary shocks are caused by new facts, for example: attempts by economic agents to increase their share of the economy, by changing the relative prices of goods and services, such as higher prices for goods and services due to an increase in oil prices; agricultural crop failures; an increase in tariffs or taxes; and exchange rate variations.

The shocks may be from supply or demand. Supply shocks are caused by rising prices resulting from increased production costs and a shortage of goods and services on the market. Demand shocks are caused by demand pressure on the market supply of the final goods and services. With the ocurrance of shocks, the inflation rate rises above the inflationary trend. The inflationary trend results from the actions of the economic agents to maintain their participation in the national product of the economy, which translates into maintaining the same rate of inflation from period to period.

MUTH (1981) defines rational expectations as informed predictions of future events that are essentially the same predictions of relevant economic theory. There are two types of inflation: demand-pull inflation, which occurs when the demand for goods and services is greater than the supply; and cost-push inflation, which is characterized by an increase in production costs due to an increase in the prices of raw materials and/or wages.

The objective of this article is to present the evolution of inflation and identify the determinants of the inflation rate in Brazil between 1995 and 2017. Thus, besides the introduction and conclusion, the present work has been organized into six sections, besides this introduction and the final considerations. In the second section, an analysis on the historical development of inflation, growth and unemployment in Brazil. In the third section, we analyse the evolution of the inflation rate in Brazil from the second term of President Vargas until the government of President Temer. In the fourth, we discuss the structuralist, monetarist and inertialist theories of inflation, and in the six thsection, we present the econometric models. Finally, the results are analyzed.

## 2. THE EVOLUTION OF THE INFLATION RATE IN BRAZIL: FROM THE GOVERNMENT OF PRESIDENT VARGAS UNTIL THAT OF PRESIDENT TEMER

The experience of inflation in Brazil goes back to the end of the monarchy and the beginning of the Republic, with the "encilhamento" crisis, an economic credit bubble that burst during the government of Marshal Deodoro da Fonseca between 1889-1892, thus triggering a financial crisis. The Finance Ministers of the time, Visconde de Ouro Preto and Ruy Barbosa, with the justification of stimulating industrialization, adopted a monetary policy based on unrestricted credit for industrial investments, guaranteed by a large amount of money. This led to financial speculation and the acceleration of high inflation caused by the mistrust of speculative practices on the financial market (Tannuri, 1991).

During the second term of President Getúlio Vargas, 1951-1954, the inflation rate was 20.8%; during Juscelino Kubischek's government, 1956-1961, inflation reached 25.6%; in Jânio Quadros' government, from 31/01/1961 to 25/08/1961, the inflation rate reached 50.8%; and during João Goulart's government, 1961-1964, inflation reached 92.12%. Between 1965 and 1968, during the period of Marechal Castelo Branco's military government, the inflation rate in Brazil dropped from 92.12% to 39.12%. In the years 1968 and 1969, during Costa e Silva's brief period in government, inflation rose from 25.01% to 25.49%.

During President Médici's period in office, 1969-1974, referred to as the Brazilian economic miracle, inflation decreased from 19.31% to 15.54%. Between 1974 and 1979, during the time of President Geisel, the inflation rate increased again from 26.90% to

77.25%. Between 1980 and 1984, during the government of President Figueiredo, the inflation rate jumped from 99.20% to 215.27%. With the end of the military dictatorship in 1985, a new cycle of democracy began in Brazil, and after the death of President Tancredo Neves, Vice-President Sarney took over the presidency.

The economic team of the New Republic of President José Sarney, from 1985 to 1990, began with a division between the orthodoxy of the Minister of Finance, Francisco Dornelles, and the heterodoxy of the Minister of Planning, João Sayad. However, the mediating actions of the economist and company consultant, Luís Paulo Rosemberg, finally favoured the appointment of the Minister of Finance, Dilson Funaro.

Although 1986 witnessed the beginning of an era of stabilization plans with successive currency exchanges and several different approaches, unfortunately none proved successful in solving the problem of inflation. On February 26th, 1986, President Sarney and his finance minister Dilson Funaro adopted a set of measures in order to combat inflation. This set of measures became known as the Cruzado Plan because the new currency that was created - the Cruzado (Cz$) - replaced the currency of the time - the Cruzeiro (Cr$).

The Cruzado Plan, as an economic stabilization program, was based on two pillars: deindexation and price control. However, despite the complementary corrective measures, Cruzado Plan II was unable to prevent an increase in inflation [(CARNEIRO, 1987); (COSTA, 1987); BARBOSA e PEREIRA, 1989)]. With the failure of Cruzado Plans I and II, Minister Dilson Funaro was replaced by Bresser Pereira. On June 12th, 1986, the Bresser Plan was announced, and consisted of a set of measures that froze: peak prices, salaries at a set mean value and the exchange rate with 10% devaluation.

Nonetheless, the measures included in the Bresser Plan were insufficient to curb inflation. Minister Bresser was dismissed and Mailson da Nobrega was appointed Minister of Finance for the Sarney government. Mailson's stabilization plan, launched on January 15th, 1989, became known as the Summer Plan, which consisted of measures that froze prices and salaries, and the creation of the New Cruzado (NCZ $). However, the Summer Plan also failed to combat chronic inflation.

With the election of Fernando Collor as president of the republic, fresh measures were introduced to bring an end to inflation. President Collor's term of office was short-lived, from 1990 to 1992, during which, three stabilization plans were implemented. The Collor Plan I was announced on March 16th, 1990, and introduced the following measures: the New Cruzado was replaced by the Cruzeiro (Cr $); a tax on financial transactions was created (IOF); income from savings accounts was confiscated; prices and salaries were frozen; regional and sectoral tax incentives were eliminated; the fixed exchange rate was abolished and various government institutions were made extinct.

None of these measures however, brought an end to inflation (AMADEO, 1992). The Collor Plan II was announced on January 31st, 1991 and included several measures such a price freeze and replacing the overnight rates with fiscal measures to combat the public deficit, thereby reducing the high inflation rate in Brazil [(SIMONSEN , 1991); (CAMPOS, 1991). The Collor Plan II managed to reduce inflation for a short period of time. However, from May 1991, once again the rate of inflation began to rise sharply. On May 10th, 1991, the finance minister Zélia Cardoso, was replaced by Marcilio Marques Moreira.

The Marcílio Plan consisted of the following measures: interest rates were increased and a restrictive fiscal policy was introduced. Nevertheless, inflation rates, under Minister Marcílio's administration, reached levels of hyperinflation (BRESSER-PEREIRA and NAKANO, 1991); (BARBOSA, 1991)]. Because of this, Minister Marcílio was replaced by Gustavo Krause, on October 2nd, 1992.

However, by this time, President Collor had resigned as president due to a Congressional call from his impeachment, on September 29th, 1992. As a result, Collor's vice-president, Itamar Franco, began his term as president from 1992 to 1994. President Itamar appointed the Senator and Foreign Minister Fernando Henrique Cardoso (commonly known as FHC) as his finance minister in May 1993.

With the support of a mixed team of economists from UNICAMP and PUC in Rio de Janeiro, the president launched the Real Plan on December 7th, 1993. On March 1, 1994, Minister FHC changed the unit of account of the current currency to the real unit of value (UFV), approximately on a par with the dollar. The government set a conversion rate of R$ 1.00 to CRS 2,750.00 - which was the value in actual cruzeiros in URV.

Afterwards, the Real Cruzeiro (CZ$) was replaced by the Real (R$) as the official currency of Brazil, with all the functions of a national currency (means of exchange, means of payment, reserve price and full liquidity). Other important steps were also taken. As a result, the inflation rate fell from 2477.15% in 1993 to 916.43% in 1994. With a stable economy and inflation under control, Senator FHC was elected president of Brazil in January 1995.

During President FHC's first term, between 1995 and 1998, inflation fell from 14.5% to 1.7%, measured by the IGP-DI. During his second term, 1999-2002, the inflation rate rose from 8.9% to 12.5% per year. With the election of President Lula, a new stage of economic policy began in Brazil. The Minister of Finance continued the economic policy of high interest rates introduced by FHC's government. During President Lula's first term, 2003-2006, inflation fell from 9.3% to 3.1% per year. In his second term, between 2007 and 2010, the inflation rate rose again from 4.4% to 5.9% per year.

When President Dilma Roussef was elected in 2010, an economic policy was introduced aimed at the growth of the Brazilian economy. During President Dilma's first term, 2011-2014, the inflation rate rose again from 5.1% to 3.78% per year. President Dilma's second term however, between 2015 and 2018, was incomplete, as it was interrupted when Congress voted for her impeachment. Table 1 shows the evolution of the Brazilian inflation rate from 1985 to 2016 and the forecasts for 2017 and 2018.

**Table 1** – The evolution of the inflation rate in Brazil: 1985-2018

| Year | Inflation (%) | Year | Inflation (%) | Year | Inflation (%) | Year | Inflation (%) |
|---|---|---|---|---|---|---|---|
| 1985 | 242.24 | 1995 | 22.41 | 2005 | 5.69 | 2015 | 10.67 |
| 1986 | 79.7 | 1996 | 9.56 | 2006 | 3.14 | 2016 | 6.29 |
| 1987 | 3.634 | 1997 | 5.22 | 2007 | 4.45 | 2017 | 4.5(*) |
| 1988 | 9.802 | 1998 | 1.66 | 2008 | 5.9 | 2018 | 3.9(*) |
| 1989 | 19.729 | 1999 | 8.94 | 2009 | 4.31 | - | - |
| 1990 | 16.21 | 2000 | 5.97 | 2010 | 5.9 | - | - |
| 1991 | 4.727 | 2001 | 7.67 | 2011 | 6.5 | - | - |
| 1992 | 11.191 | 2002 | 12.53 | 2012 | 5.83 | - | - |
| 1993 | 2477.15 | 2003 | 9.3 | 2013 | 5.91 | - | - |
| 1994 | 916.43 | 2004 | 7.6 | 2014 | 6.41 | - | - |

**Source:** IGP-DI/FGV. (*) The Central Bank's forecast for the inflation rate.

Accordingly to Guisan and Cardim-Barata (2003), the Brazilian economy has experienced growth very prominent during the second half of the twentieth century, in of real GDP and of the population. Moreover, according to the authors (2003), population growth has been very high compared to the world average and this has determined that the

per capita GDP growth has been low during the two in the last decades of the twentieth century, despite the experienced by real GDP.

During President Dilma's second term between 2015 and 2016, inflation dropped from 10.7% to 7.8% per year. On August 31st, 2016, Congress found President Dilma guilty of breaking the fiscal responsibility law. With the departure of President Dilma, Vice President Temer assumed the presidency of Brazil. Moreover, In 2016, the inflation rate fell to 6.29% and between January 2017 and August 2017, the inflation rate fell from 0.43% to 0.24% per month.

## 3. THE STRUCTURALIST, MONETARIST AND RATIONAL EXPECTATIONS THEORIES

For PINTO (1978), the monetarist theories of inflation do not seek out the *causes* of inflation in Latin America. For the monetarists, inflation in Latin America countries is basically summarized as a problem of the National Treasury's fiscal budget and the Central Bank's financial behavior.

In other words, the origins of inflation lie in the mismatched monetary, exchange and salary fiscal measures, adopted by government authorities at certain conjunctures or in the long term. The structuralist theory of inflation has its origin in the Commission for Latin America and the Caribbean (CEPAL).

### 3.1. The structuralist theory

The Chilean economist, Anibal Pinto, formulated the structuralist theory of inflation. PINTO (1978) highlights five factors responsible for the rise and spread of inflation:

a) Growth and inflationary potential: a long period of product expansion implies an inflationary potential due to the need for changes in the productive structure and in the variation times between the levels of income and the demand for goods and services.

b) Full employment and oligopolies: demand-led growth exceeding full employment generates inflation; oligopolistic firms impose prices, by the mark-up rule, above competitive market prices. This generates sectoral misalignments, particularly between agricultural and industrial prices, that have acted to benefit industry.

However, more than an excessive, generalized global demand for resources, the key element of the inflationary process could be the sectoral misalignments derived from the rapid growth of the product and the delay or absence of decisions that would solve this structural problem in advance;

c) The internationalization of prices: the internationalization of prices is another basic element that leads to inflationary propensity linked to the process of world economic integration and particularly to what has occurred between central countries and between central and peripheral countries. The high prices of imported products are transmitted to the domestic goods and services market.

It should be added that the fruits of technical progress were achieved mainly through an increase in income rather than a fall in prices (PINTO, 1978). This is because underdeveloped countries in Latin America have a structural heterogeneity ranging from crafts to state-of-the-art industries with state-of-the-art technologies (PINTO, 1970).

With regard to determining salaries, structuralists declare that salaries are not determined on the labor market, as monetarists believe, but rather result from a process of

bargaining and dispute between bosses and employees for the participation of the product, in which government intervention is important as a judge (PREBISCH, 1961, 1982).

d) Propagation mechanisms: In the Latin American approach to inflation, the mechanisms and decisions in the fiscal, monetary and foreign trade areas constitute a second order of elements that influence the rise in inflation. These mechanisms were considered propagation mechanisms. PINTO (1978) highlights monetary policy, fiscal policy and the foreign trade deficit as mechanisms for the propagation of inflation.

e) Inflationary mentality: Economic agents usually hold expectations of price increases in the future and this inflationary psychology has contributed to the spread and acceleration of the inflationary process.

### 3.2. The monetarist theories

The monetarist theories of the inflationary process are based on three basic empirical propositions: a) first, the demand for money is a stable function and depends on the rate of income and nominal income; b) the money supply is controlled by the monetary authority; (c) market economies are stable in the sense that deviations in relation to full employment are always (or eventually) eliminated by the price system which always leads to the equilibrium of the various markets. This hypothesis corresponds, in the last instance, to the idea of the vertical line on the long-run Phillips curve.

Monetarists emphasize the formation of adaptive expectations – i.e., in view of the agents' expectations on prices, markets are usually assumed to be in equilibrium. With this, the excesses of market demand or supply, permanent or temporary, have a much smaller role in the monetarist models. In the Walrasian equilibrium hypothesis, a rise in inflation may be avoided by the Central Bank controlling the supply of money (Barbosa, 1983).

#### *3.2.1. Quantity Theory of Money: Fisher's Version*

In the system of classical economics, the price level is determined by the money supply with the rate of constant currency circulation. The quantity of money offered determines the level of demand which, in turn, determines the level of prices. This is the Quantity Theory of Money.

The starting point of the quantity theory of money (QTM) is the exchange equation, an identity that relates the volume of transactions, valued at current prices, to the stock of money multiplied by the velocity of money circulation. The velocity of currency circulation measures the average number of times that each available monetary unit in the economy is used in transactions over a given period of time. The QTM is represented by Fisher's equation (1963):

$$MV_T = P_T T$$

Where M is the quantity of money, $V_T$ is the velocity of the circulation of money, $P_T$ is the price index of the transacted products, and T is the volume of transactions of goods produced in previous moments and of financial assets.

#### *3.2.2. Friedman's restatement of the quantity theory of money*

For Friedman (1956) money is stable and the elasticity of the demand for money in relation to the interest rate is not infinite, but only very small. With this, Friedman dismissed the idea of the liquidity trap of the old Keynesians. The Quantity Theory of Money (QTM) served as the basis for Friedman (1974) to develop his theoretical model for

monetary analysis. Friedman (1974) later developed the function of the demand for real money in equilibrium, and may be written as follows:

$$\frac{M_d}{P} = f(Y^P; r; P^e; u)$$

Where $Y^P$ is the permanent income that represents a proxy of wealth; the budget constraint; r is the rate of return on financial assets; $P^e$ is the expected rate of inflation; and u represents individual tastes and preferences. The analysis predicts that, ceteris paribus, the demand for money will be greater (i) the higher the level of wealth; (ii) the lower the yields of the assets; and (iii) the lower the expected inflation rate. The portfolio adjustment process is central to specifying the currency transmission mechanism through which changes in the currency stock affect the real sector of the economy.

### 3.3. The propagation mechanism of inflation

The inflationary process in Brazil presents unique historical characteristics. BRESSER-PEREIRA and NAKANO (1984) identified three propagation mechanisms, namely: 1) those that cause the acceleration of inflation; 2) those that cause the maintenance of the inflation rate; and 3) those that sanction a rise in inflation.

The accelerating factors of inflation in an open economy are: (a) an increase in real mean salary above productivity growth; 2) an increase in the profit margins on company sales; 3) currency devaluations; 4) an increase in the cost of imported goods; and 5) an increase in taxes.

Once the process of rising inflation has been initiated by any of these accelerating factors, maintenance mechanisms act to maintain the level of inflation. The maintaining factor of high inflation rates is the distributive conflict, i.e., the fact that both companies and unions possess the economic and political instruments to maintain their relative share of income. Finally, the sanctioning factors for the level of inflation, particularly an increase in the nominal quantity of money and in the public deficit, are aimed at keeping the level of inflation high, although they assume a character that is more effect than cause.

## 4. Econometric models of inflation

For structuralists, the inflation rate depends on the variables of economic policy that affect the aggregate demand for industrial and/or agricultural goods; the rate of price variations of imported inputs and price variations of exported products.

*4.1. The structuralist model of inflation*

The econometric model of the structuralists may be represented as:

$$p_t = p_{t-1} + \sum_{i=}^{\infty} \emptyset_{1,i} DZ_{t-i} + \sum_{i=0}^{\infty} \emptyset_{2,i} \pi_{x,t-1} + \sum_{i=0}^{\infty} \emptyset_{3,i}\, \pi_{m,t-i} + \sum_{i=0}^{\infty} \emptyset_{4,i} s_{m,1-i} \qquad (1)$$

Where $p_t$ is the present inflation rate; $p_{t-1}$ is the past inflation rate; D indicates growth rates; DZ indicates the growth rate of real government expenditure; $\pi$ e $s$ are variables that represent the prices of industrial goods and the prices of agricultural goods; the coefficients $\emptyset$ the structure of the economy, which signifies that structuralist economists emphasize that the basic cause of inflation lies in the fact that curbing inflation is a problem to be solved in the long run, since in the short term, it is practically impossible to change the structure of the economy.

Structuralists believe that there are several propagation mechanisms for inflation, which become relevant when explaining the occurrence of high inflation rates in Brazil. The equation for the demand for money is given by the following expression:

$$logm_t = \alpha_0 + \alpha_1 logy_1 + \alpha_2 p_t^e + \alpha_3 t \quad (2)$$

Where the coefficients $\alpha_1$, $\alpha_2$ e $\alpha_3$ are all positive. If there are economies of scale, the income elasticity of money, $\alpha_1$ will be less than unity. The coefficient of expectations, $\alpha_2$, will be less than one.

This is because the expected rate of inflation and the real quantity of money demanded move in opposite directions. The inclusion of time, t, as an explanatory variable in equation (1), with a constant coefficient, $\alpha_3$, presupposes that the effect of financial innovations on the demand for the quantity of money occurs uniformly over time.

The expansion rate of the real quantity of money, according to equation (1), depends on the growth rate of real income, on the acceleration of the expected rate of inflation and on the rate of financial innovations. The equation of this proposition may easily be encountered by subtracting the same lagged equation of one period from equation (1), the result of which is:

$$Dm_t = \alpha_1 Dy_t - \alpha_2 \Delta p_t^e - \alpha_3 \quad (3)$$

$Dm_t = log\, {m_t}/{m_{t-1}}$; $Dy_t = log\, {m_t}/{m_{t-1}}$; e $\Delta p_t^e = p_t^e - \alpha_3$

The inflation rate is equal to the difference between the expansion rate of the nominal quantity of money, , $\mu_t$, and the growth rate of the real quantity of money, $Dm_t$, so that:

$$p_t = \mu_t - Dm_t \quad (4)$$

*4.2. The monetarist model of inflation with rigid expectations*

The rigid inflation rate of the monetarists depends on the expansion rate of the quantity of money, the growth rate of real income, the acceleration of the expected rate of inflation, and the rate of financial innovations subject to the hypothesis that the acceleration of expected inflation is always equal to the inflation rate observed in the previous period. Hence:

$$p_t = \alpha_3 + \alpha_1 Dy_t + \alpha_2 \Delta p_t^e + u_t \quad (5)$$

Where $p_t$ is the monetarist rate of inflation with *rigid expectations*, i.e., expectations that are always repeated. The coefficients of the explanatory variables are positive, $\alpha_1 > 0$ e $\alpha_2 > 0$, respectively, and are the coefficients of the real income difference ($Dy_t$) and the lagged price variation of a period, ($\Delta p_{t-1}$), and $u_t$ is the stochastic term that represents the existence of uncertainty given by a shock or supply function disorder.

It should be noted that, given the presupposition of the money illusion, the coefficient of the rate of monetary expansion is equal to 1. This hypothesis must be tested from the data. Monetarists assume that monetary policy does not affect the expansion of real income and that, for a given rate of monetary expansion, the expected rate of inflation acceleration is zero.

Thus, changes in the expansion rate of the currency are transmitted in full in the long term to prices, so that:

$$p_t = \alpha_3 + \mu_t - \alpha_1 D\bar{y}_t \quad (6)$$

Where:

$D\bar{y}_t = log\, \bar{y}_t/\bar{y}_{t-1}$ e,

$\bar{y}_t$ = represents the potential of the product.

*4.3. The monetarist model of inflation with adaptive expectations*

From a monetarist perspective, the short-term inflationary process can only be understood from the knowledge of the interrelationships between monetary policy, the rate of income growth, and the acceleration of the expected rate of inflation, since the last two variables are endogenous to the model. One important advance in relation to the rigid expectations model was the development of the adaptive expectations model in the 1950s and then widely used in the 1970s (Friedman, 1956).

The hypothesis of Friedman's model of adaptive expectations is that agents correct their expected expectations of inflation by a fraction of forecast error committed in the previous period, i.e.:

$$p_{t-1}^{e} = \theta(p_{t-1} - p_{t-1}^{e}), \text{where: } \theta < 1 \quad (7)$$

Or in an equivalent form:

$$p_{t}^{e} = \theta p_{t-1} + (1-\theta)p_{t-1}^{e} \quad (8)$$

Or, in econometric terms, in the following expression:

$$p_{t}^{e} = \theta p_{t-1} + (1-\theta)p_{t-1}^{e} + \mu_t \quad (9)$$

In which equation (9) demonstrates that the expected price at time t is a weighted mean by $\theta$, between the market price at t - 1 and the expected price at t - 1. The inflation expectations are formed if the acceleration rate of the expected inflation in period t is equal to the acceleration rate observed in period t - 1, such that:

$$\Delta p_{t}^{e} = \Delta p_{t-1} \quad (10)$$

By replacing $\Delta p_{t}^{e}$ por $\Delta p_{t-1}$ in equation (5) we obtain:

$$p_t = \alpha_3 + \mu_t - \alpha_1 Dy_t + \alpha_2 \Delta p_{t-1} + \varepsilon_t \quad (11)$$

*4.4. The monetarist model of inflation with rational expectations*

The monetarist econometric model with rational expectations presumes that the expected inflation rate in the present to the future is equal to the inflation rate observed in the past. The hypothesis that providing forecasts for the inflation rate may be interpreted in the context of rational expectations whenever the observed inflation rate differs from the inflation rate expected only by random fluctuations, according to the following equation:

$$p_t = p_{t}^{e} + \xi_t \quad (12)$$

The stochastic variable, $\xi_t \sim N(0,\sigma^2)$, has mean zero, constant variance and is serially independent. The observed acceleration of the inflation rate is a measure with an expected acceleration error of the inflation rate (8), so that:

$$\Delta p_{t}^{e} = \Delta p_t - (\xi_t - \xi_{t-1}) \quad (13)$$

By replacing (9) with (4) it may be concluded that the rate of inflation depends on the rate of monetary expansion, the growth rate of real income, the acceleration of the expected inflation rate and the rate of financial innovations, which is:

$$p_t = \alpha_3 + \mu_t - \alpha_1 Dy_t + \alpha_2 \Delta p_t + \varepsilon_t - \alpha_2(\xi_t - \xi_{t-1}) \quad (14)$$

It is possible to verify that the observed acceleration in the inflation rate is correlated with the term of error. Since the inflation rate is equal to the difference between the inflation rates in periods t and t - 1, equation (14) may be rewritten after some algebraic manipulations of the following:

$$p_t = \frac{\alpha_3}{1-\alpha_2} + \frac{1}{1-\alpha_2}\mu_t - \frac{\alpha_1}{1-\alpha_2} Dy_t - \frac{\alpha_2}{1-\alpha_2} p_{t-1} + \mu_t \quad (15)$$

Where: $\mu_t = \varepsilon_t - \alpha_2(\xi_t - \xi_{t-1})$ (16)

There by producing:

$$\alpha_0 = \frac{\alpha_3}{1-\alpha_2};\ \ \alpha_1 = \frac{1}{1-\alpha_2}; \alpha_2 = \frac{\alpha_1}{1-\alpha_2}; \alpha_3 = \frac{\alpha_2}{1-\alpha_2};$$

We may obtain:

$$p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 p_{t-1} + u_t \quad (17)$$

Where the coefficients of $Dy_t$ and $p_{t-1}$ are positive. In any situation, if there is no monetary illusion, the sum of the coefficients of the expansion rate of the money and of the lagged inflation rate will be equal to unity. The alternative to equation (11) implies the inclusion of the rational expectations hypothesis represented by $p_{t+1}$. Thus, equation (16) may be expressed as follows:

$$p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 p_{t+1} + u_t \quad (18)$$

## 5. DATA, MODELS ESTIMATION AND ANALYSIS OF THE RESULTS

The database used has as main source the General Price Index, also known as IGP-DI, which is calculated monthly by the Getúlio Vargas Foundation (FGV). The approach adopted combines a (brief) historical-institutional analysis of the inflation problem in the country, as well as a quantitative investigation of these indicators and their relationship with economic growth in multiple theoretical perspectives. The econometric models of the structuralist, monetarist and inertialist type will be extremely important for understanding the main factors that influence the variation of the inflation rate in Brazil.

Table 2 contains the estimates of the parameters of equation (11), using the ordinary least squares (OLS) method, with annual data for the period 1995-2016. In the first line of the table the estimates of the constant, of the coefficient of the monetary expansion rate and of income elasticity are significant; while the coefficient of expectation presents a high standard error.

**Table 2** – Estimates of the parameters of equation (11) using the ordinary least squares (OLS) method. Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 \Delta p_{t-1} + \varepsilon_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_3$ | $R^2$ | $DW^*$ |
|---|---|---|---|---|---|
| 8.615 | 0.075 | -0.223 | -0.067 | 32.00 | 1.934 |
| (2.853) | (0.624) | (-0.434) | (-0.287) | - | |
| - | 0.232 | 0.449 | 0.369 | 43.00 | 2.278 |
| - | (1.849) | (0.075) | (1.763) | - | - |
| 8.358 | 1.0 | -0.129 | 0.492 | 53.50 | 0.996 |
| (5.243) | (-1) | (0.431) | (4.334) | - | - |

**Source:** own elaboration. *DW= The Durbin-Watson test.

When the regression was estimated without a constant, the value of the income elasticity decreased from 0.067 to 0.001; the coefficient of the monetary expansion rate rose from 0.075 to 0.210; the coefficient of expectation remained insignificant; and the income elasticity was 0.217.

These results from Table 2 lead to the following conclusions: the first is that the hypothesis that there is no monetary illusion is not rejected; the second is that if the hypothesis of the positive rate of financial innovations is accepted, the income elasticity of the money will be greater than 1 and, in the opposite case, the income elasticity of the

money will be less than 1; and the third is that, with static expectations, the hypothesis regarding the expectation coefficient being equal to zero is not rejected.

The inflationary experience in Brazil is so old that it is difficult to believe, a priori, that the inflation expectations process may be based on the extrapolation of the past without taking into account the facts in the present that may influence the future, especially when taking account of the annual data. Table 3 presents the estimates of the inflation regression parameters based on equation (11).

**Table 3** – estimates of the inflation regression parameters based on equation (11). Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3\Delta p_{t-1} + \varepsilon_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_2$ | $R^2$ | $DW$ |
|---|---|---|---|---|---|
| 8.495 | 0.029 | 0.165 | 0.185 | 25.73 | 1.401 |
| -4.087 | -0.262 | -0.185 | -0.356 | - | - |
| - | 0.301 | 0.435 | 0.152 | 51.81 | 0.906 |
| - | -2.459 | -0.711 | -1.325 | - | - |
| 8.358 | 1 | -0.129 | 0.049 | 53.5 | 0.996 |
| -5.243 | (-) | (-0.300) | -0.555 | - | - |
| - | 1 | -0.014 | 1.737 | 10.43 | 1.122 |
| - | (-) | (-0.127) | -3.383 | - | - |
| - | 0.286 | 0.621 | 0.416 | 21.7 | 0.925 |
| - | -2.372 | -0.971 | -2.35 | - | - |

**Source:** own elaboration. *DW= The Durbin-Watson test.

The alternative hypothesis is that the acceleration forecasts of the inflation rate are so precise that the expected acceleration is exactly equal to the observed inflation, as demonstrated in equation (7). With this hypothesis, the specification of the money demand equation is represented by the adjusted equation (11).

Table 4 contains the various econometric estimates of the parameters and coefficients of equation (17). The first two rows of the table present the estimates through the ordinary least squares (OLS) method. The coefficient of income changes substantially when the intercept is excluded; the coefficient of the rate of monetary expansion, contrary to expectations, is less than one; the hypothesis that the sum of the coefficients of $\mu_t$ e $p_{t-1}$ is equal to unity, is not rejected; the coefficient of the lagged inflation rate, instead of being negative, is positive.

**Table 4** – Estimates of the parameters and coefficients of equation (17). Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 p_{t-1} + u_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_3$ | $\alpha_1 + \alpha_3$ | $R^2$ | DW | Method |
|---|---|---|---|---|---|---|---|
| 8.079 | 0.045 | 0.168 | -0.065 | 0.283 | 2.54 | 1.904 | OLS |
| (2.543) | (0.346) | (0.268) | (-0.274) | (0.072) | 34.52 | 2.137 | - |
| - | 0.142 | 0.721 | 0.354 | 0.496 | - | - | OLS |
| - | (1.003) | (1.078) | (1.812) | (2.815) | - | - | - |
| 8.568 | -0.160 | 0.341 | 1.124 | 0.964 | 88.72 | 2.209 | IVM* |
| - | (-0.681) | (0.404) | (2.333) | (1.652) | - | - | - |
| - | -0.029 | 2.971 | -4.162 | -4.191 | 45.95 | 2.992 | IVM* |
| - | (-0.032) | (0.505) | (-0.486) | (0.518) | - | - | - |

**Source:** own elaboration. *IVM= Instrumental Variables Method.

The OLS method is inadequate to estimate the parameters of equation (14), since the estimators of this equation are inconsistent because the lagged inflation rate is correlated as the term of error of the referred equation. The third and fourth lines of Table 4 contain the estimates of the parameters of equation (16) with the instrumental variables method.

The lagged inflation rate of two periods serves as an instrument of the above equation. Although the changes in the parameter values are related to the estimates of the OLS method, the conclusions persist: indeed, the coefficient of the lagged inflation rate is negative; the coefficient of expansion rate is less than one; and the hypothesis that the sum of these two coefficients is equal to 1 is rejected.

However, the coefficient of the expansion rate of the lagged money is not significant at 1% and the values of the estimates change when estimating the regression without intercept, despite the statistical significance. In these situations, the hypothesis of no monetary illusion is not rejected.

The results of Table 4 allow us to conclude that estimating the parameters of equation (16) by a method that takes into account the error of measurement and the simultaneity that exists in the explanatory variables changes the values of the estimates considerably. The estimation of the coefficient of expectation, despite presenting the expected signal, demonstrated a high standard error.

Table 5 presents the estimates of the parameters of equation (16) by several estimation methods. The first two rows of the table report the estimates by the OLS method; all of them are significant, when the intercept of the model is excluded, and the income elasticity decreases in value; and the hypothesis of no monetary illusion is not rejected. However, given the correlation between the expected inflation rate and the stochastic term, the ordinary least squares estimators are inconsistent. The expected inflation rate of two periods is then used as an instrumental variable.

**Table 5** – Estimates of the parameters of equation (16) by several estimation methods. Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 p_{t-1} + u_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_3$ | $\alpha_1 + \alpha_3$ | $R^2$ | $DW$ | Methods |
|---|---|---|---|---|---|---|---|
| 6.937 | 0.276 | 0.197 | -0.012 | 0.264 | 8.19 | 1.748 | OLS |
| (1.654) | 1.076 | 0.26 | -0.043 | 1.033 | | | |
| - | 0.369 | 1.091 | 0.349 | 0.718 | 6.57 | 1.954 | OLS |
| | 1.407 | 1.962 | 2.046 | 3.453 | | | |
| 8.419 | 0.310 | -0.401 | -0.022 | 0.288 | 10.65 | 1.755 | IVM |
| 2.756 | 1.248 | -0.733 | -0.401 | 0.847 | | | |
| - | 0.641 | 0.072 | 0.414 | 1.055 | 29.25 | 2.161 | IVM |
| - | 2.523 | 0.118 | 1.983 | 4.506 | | | |
| 5.402 | 0.301 | 0.364 | 0.666 | 0.966 | 11.41 | 1.674 | IVM |
| 1.660 | 1.090 | 0.516 | 0.265 | 1.355 | | | |
| - | 0.057 | 0.262 | 0.902 | 0.959 | 50.25 | 2.138 | IVM |
| - | 0.132 | 0.279 | 1.620 | 1.752 | - | - | - |

**Source:** own elaboration.

The third and fourth rows of Table 5 record such estimates. The coefficients of the explanatory variables are all significant in equation (15), although small changes occur

in the magnitude of the coefficients regarding the estimates and the ordinary least squares estimates. The hypothesis of no monetary illusion is rejected and the elimination of the intercept decreases the value of the income elasticity of the money.

As the rate of monetary expansion is an endogenous variable, it is quite plausible that previous estimates have been biased. Hence, the equation (16) is again estimated using the expansion rate of the monetary base and the expected inflation rate of two periods as instrumental variables.

The first two rows of Table 5 report the estimates using the OLS method. The coefficients of the variation of the monetary base and of the income variation are positive and the coefficient of the general index of prices is negative.

The intercept is positive. When the intercept is excluded, the income elasticity decreases substantially in value; and the hypothesis of the inexistence of monetary illusion is not rejected. But due to the correlation between the expected inflation rate and the stochastic term, by applying the OLS method the estimators are inconsistent.

The expected inflation rate of two periods is used as the instrumental variable. The third and fourth rows of Table 4 present the estimates of the coefficients of the endogenous variables of equation (16).

The coefficients of monetary base variation and income variation, by the instrumental method, are significant. The hypothesis of the inexistence of monetary illusion is rejected and the elimination of the intercept decreases the income elasticity of the money.

Table 6 reproduces the estimates for the coefficients of equation (18). The intercept is not significant, but if the equation is estimated without intercept, a substantial change occurs in the coefficient of the expansion rate of the expected income of a period. In any situation, the monetary illusion hypothesis is not rejected.

**Table 6** – Estimates for the coefficients of equation (18). Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_{t+1} + \alpha_3 p_{t+1} + u_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_3$ | $R^2$ | $DW$ | Method |
|---|---|---|---|---|---|---|
| 6.937 | 0.276 | 0.197 | -0.012 | 8.19 | 1.748 | OLS |
| (1.654) | (1.076) | (0.261) | (-0.043) | - | - | - |
| - | 0.369 | 1.091 | 0.349 | 6.57 | 1.954 | OLS |
| - | (1.407) | (1.962) | (2.046) | - | - | - |
| 8.419 | 0.311 | -0.401 | -0.022 | 10.65 | 1.755 | IVM |
| (2.756) | (1.248) | (-0.733) | (-0.092) | - | - | - |
| - | 0.369 | 1.091 | 0.349 | 6.57 | 1.954 | IVM |
| - | (1.408) | (0.119) | (0.413) | - | - | - |

**Source:** own elaboration.

The coefficient of the expansion rate of the money, although sensitive to the estimation method employed, is significant in all cases. Again, the OLS estimates of the coefficients of the rates of money expansion and the rate of income growth are lower; while the coefficient of rational expectations is higher than those obtained by the instrumental variables method.

Monetarists argue that changes in monetary policy take time to affect prices, i.e., there is a time lag between the formulation and execution of monetary policy. In the meantime, the effects of monetary policy are felt more intensely on production and employment. If this is the case, it is possible that the annual growth rate of money is a more reliable variable to explain the annual inflation rate.

Thus, the estimates of Tables 5 and 6 obtained from the data of the annual rates of December were recalculated using the rate of monetary expansion measured in the middle of each year. The Table 7 contains estimates of the parameters of equation (18) with and without the intercept by the OLS and IVM methods with the income elasticities of the currency and the coefficients of rational expectations. The results of the Durbin-Watson (DW) test indicate an absence of serial correlation.

**Table 7** – Estimates of the parameters of equation (18) with and without the intercept by the OLS and IVM methods. Regression: $p_t = \alpha_0 + \alpha_1\mu_t + \alpha_2 Dy_t + \alpha_3 p_{t+1} + u_t$

| $\alpha_0$ | $\alpha_1$ | $\alpha_2$ | $\alpha_3$ | $R^2$ | $DW$ | $E_R$ | $C_{Exp}$ |
|---|---|---|---|---|---|---|---|
| 7.837 | 0.008 | 0.360 | -0.009 | 19.76 | 1.898734 | 0.0130 | 0.149633 |
| (1.773) | (0.069) | (0.453) | (-0.032) | - | - | - | - |
| - | 0.074 | 1.283 | 0.387 | 16.14 | 2.146482 | 2.547 | 0.386714 |
| - | (0.578) | (2.019) | (2.138) | - | - | - | - |
| 6.255 | -0.012 | 0.490 | 0.149 | 4.87 | 1.880894 | 2.997 | 0.149633 |
| (1.865) | (-0.08) | (0.065) | (0.531) | - | - | - | - |
| - | 0.043 | 1.241 | 0.370 | 15.80 | 1.804950 | 0.0130 | 0.37027 |
| - | (0.279) | (1.854) | (1.352) | - | - | - | - |

**Source:** own elaboration.

## 6. Conclusions

After the regressions, it is essential to comment on the results obtained from the empirical evidence of the currency demand equation:

1) the coefficient estimates of the rates of monetary expansion and of income growth and of the rational expectations variable are, in general, significant;

2) the ordinary least squares estimatations underestimate the coefficients of the rates of monetary expansion and the growth of real income and overestimate the coefficient of the expected inflation;

3) the hypothesis regarding the inexistence of any monetary illusion is not rejected in any of the experiments;

4) in most cases, the constant presents high standard errors, but when regressions are estimated without the intercept, there is a substantial change in the coefficients of real income.

In Brazil, this kind of problem is somewhat analogous to that which is encountered in the consumption function when current income is used instead of permanent real income, since the intercept in the consumption function estimated with current income is positive, due to the error of the income variable. Here, these variable errors, especially with the expected inflation rate, must be causing this type of result. Finally, it is concluded that there are a priori reasons of a theoretical nature to discard the hypothesis that the trend variable is adequately formulated to capture the effect of financial innovations on the equation of the demand for money.

Brazil has experimented with its exchange rate regime: fixed exchange rate, dirty floating exchange rate, mini devaluations and maximum devaluation. Brazil's current floating exchange rate regime was instituted in January 1999, replacing the exchange rate regime administered by "exchange bands" since 1995. The managed exchange rate policies reduced exchange rate volatility - one of the most important of the four prices exchange rate, interest rate, wage rates and public tariffs.

The crises of the 1990s, meanwhile, contributed to exchange-rate regimes administered by the Central Banks being replaced by dirty floating exchange rates. But the subprime financial crisis in the US real estate industry - which broke out in 2008 - has contaminated the US real economy and has spread as a systemic financial crisis on a global scale, including giving rise to the sovereign debt crisis of the peripheral countries of the Euro.

The Brazilian government's response to the financial crisis was initially the adoption of the policy of reducing the basic interest rate, but without an expansionary fiscal policy, accompanied by the depreciation of the exchange rate. However, with the depreciation of the dollar, the Central Bank decided to operate in the market appreciating the domestic currency. Moreover, this appreciation of the real (Brazilian currency) contributed to reduce the competitiveness of exportable industrial goods and this facilitated the increase of imports of foreign industrial products.

Regarding the relationship between inflation and economic growth, some findings of the international research show that a healthy economy usually presents moderate increases of prices but moderation in prices not always imply a positive evolution of the economy. Inflation is more a consequence of disequilibrium between monetary and real variables, than an explanation of the real GDP.

In the research developed by Carvalho and Carvalho (2019), for example, is presented an analysis of economic performance in Brazil. The main conclusion of these authors is that Brazil urgently needs to improve its current economic performance. The trivial must therefore be done: the federal government must foster public and private investment so that all sectors of the economy can break with this current recession; strengthening mechanisms to control inflation; among other important economic actions.

The appreciation of the real and the loss of competitiveness of manufactured goods led to the risk of the process of deindustrialization in Brazil. In addition, the increase in government spending and administered prices implied a new trajectory of growth in the rate of inflation. The late response of the Central Bank was to initiate the increase of the interest rate as the main weapon against the rise of inflation. But this high interest rate policy is not having the necessary efficiency to reverse the rise in the rate of inflation. Interest-rate monetary policy needs to be accompanied by a fiscal austerity policy to reduce spending by central government and sub-national governments.

When the inflation rate increases, monetary policy reacts with an increase in the real interest rate. The impact of inflation on the real interest rate depends on the monetary policy rule of the central bank. In general, raising the interest rate alone is not able to reverse the rise in the rate of inflation if it is not accompanied by a fiscal policy of reducing public spending and / or raising tax revenue.

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