Hyperinflation in Venezuela. An Analysis Based on Cagan's Conceptual Framework

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Abstract

The purpose of this work is to provide a detailed descriptive analysis of the hyperinflationary process that affected Venezuela between December 2017 and January 2020. The analysis is based on the approach of Cagan (1956) in the sense that it uses the criteria defined by Cagan to identify hyperinflationary episodes, and places special emphasis on the behavior of monetary factors (the supply of and demand for money) as the main direct determinants of hyperinflationary dynamics. Evidence is presented that the change in monetary dynamics through a jump in the rate of growth of the monetary base was a fundamental factor in the process of acceleration of the price level. The study also confirms that Cagan's condition of stability of the money demand was met during the hyperinflationary episode, and that the essential impulse of the hyperinflationary process was generated via expansion of the money supply and not an unstable behavior of the demand for money.

JEL N° E41, E51, E63.

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1. Introduction

Hyperinflation is a rare phenomenon, and the event that began in Venezuela towards the end of 2017 is quite particular for several reasons. Venezuela is an oil country, which even in situations of low oil prices and limited access to external financing, had been able to generate income that allowed the State to operate without resorting to a massive expansion of money. Except for the events that occurred during 2002 and early 2003, which involved a strike in the oil industry, episodes of social unrest since that date have never had a broad and lasting effect on economic activity and the State's revenue collection capacity. The Venezuelan hyperinflationary process is arguably the most severe that has been recorded in Latin America with interannual inflation rates of up to six digits according to the official measurement of the Central Bank of Venezuela and the National Institute of Statistics (BCV-INE), and a duration of slightly more than two years[1]. The impact of this hyperinflationary event on the population's standard of living at almost all levels has been devastating, generating an unprecedented emigration in the Latin American region.

The purpose of this work is to provide a detailed descriptive analysis of the hyperinflationary process and its immediate causes. The analysis is based on the approach of Cagan (1956) in the sense that it uses the criteria defined by Cagan to identify hyperinflationary episodes, and places special emphasis on the behavior of monetary factors (the supply of and demand for money) as the main direct determinants of hyperinflationary dynamics. Following Cagan (1956) framework, the study focuses on the period between December 2017 – January 2020 when the first monthly inflation above 50 percent was observed, and monthly inflation rates were frequently larger than this threshold level. The hyperinflationary event ended in January 2020 when the last monthly inflation above 50 percent was observed, and 12 continuous months of inflation rates below 50 percent were registered.

The document is divided into 9 sections including this introduction. Section 2 presents a brief historical review of the inflationary experience in Venezuela from 1951 to 2014. Section 3

[1]As reported by Sachs and Larrain (1993), the hyperinflation process in Nicaragua lasted longer (48 months), but its average monthly inflation rate (46.45%) is well below the 67.4% observed in the case of Venezuela for the period December 2017-January 2020.

describes the process of rapid acceleration of inflation that becomes evident from 2015 to the end of 2017, and that precedes the hyperinflationary event. Section 4 presents a descriptive analysis of the hyperinflationary process using monthly data from December 2017 to January 2020. This analysis focuses on the behavior of a small number of variables that tend to be closely linked during hyperinflationary processes. First, these variables are examined individually, and then their interaction is studied during the hyperinflationary episode. Sections 5 and 6 present econometric evidence of the relationship between the growth rate of the monetary base and the inflation rate, and the growth rate of the monetary base and the rate of change of the nominal exchange rate, respectively. In section 7, the behavior of the demand for money is examined, and the analysis of its stability is reproduced in the style of Cagan but in discrete time, following the presentation of this topic by McCallum (1989). Section 8 briefly discusses the process of informal dollarization that started to spread rapidly with the fall in the demand for money. Section 9 presents the conclusions of the study.

2.-A brief historical review

Table 1 presents the evolution of the growth rate of M1 (VM1), the inflation rate[2] (VIPC), and the growth rate of non-oil GDP (VPIBRNP) between 1951 and 2014. These 64 years are divided into six periods that are distinguished by relevant political and/or economic changes.

Table 1. Money growth, inflation, and non-oil real GDP growth (%)

	VM1	VIPC	VPIBRNP
1951-1960	9.00	1.88	8.22
1961-1973	9.35	1.64	7.01
1974-1982	19.35	11.18	4.39
1983-1988	21.71	16.41	2.62
1989-2002	39.29	44.17	0.42
2003-2014	56.93	29.35	5.07

Between 1950 and 1973 Venezuela was one of the most stable economies in Latin America and probably in the world. In the period 1951-1960, the average inflation rate was 1.88 percent,

[2]For this historical review, the inflation rate is measured based on the Consumer Price Index of the Caracas Metropolitan Area calculated by the Central Bank of Venezuela (BCV).

and the average growth rate of non-oil GDP was 8.22 percent. For the period 1961-1973, the average inflation rate was 1.64 percent, and the growth rate of non-oil output was 7.01 percent.

With the first oil boom (1973-1974) a substantial change became noticeable in the performance of the Venezuelan economy, which manifested in an upward trend in the inflation rate and a downward trend in the growth rate of non-oil GDP until the year 2002. In the period 1974-1982, the average inflation rate rose to 11.18 percent and non-oil GDP registered an average growth of 4.39 percent. Between 1983 and 1988 the average inflation rate was 16.41 percent (amid a broad price control scheme between 1986-1988) and the non-oil GDP growth rate was 2.62 percent. During the period 1989-2002, the average inflation rate accelerated to 44.17 percent and non-oil output growth decreased to 0.42 percent. During this phase (1974-2002), a close link is observed between the expansion of the money supply (measured through M1 or the monetary base) and the inflation rate.

Starting in 2003-2004, the Venezuelan economy enters another stage, in which a new oil boom allowed the government to combine a strongly expansive fiscal-monetary policy, a fixed overvalued exchange rate for the bolivar, and an extensive administrative control of prices. With this mix, average inflation dropped to 29.35 percent in the period 2003-2014 compared to the previous period (1989-2002), and non-oil GDP expanded at an average rate of 5.07 percent. In this period that ends around 2014, the acceleration of the M1 growth rate (56.93 percent) with respect to previous periods marks a weakening of the previously noted relationship between money growth and inflation.

3.-The path to hyperinflation[3]

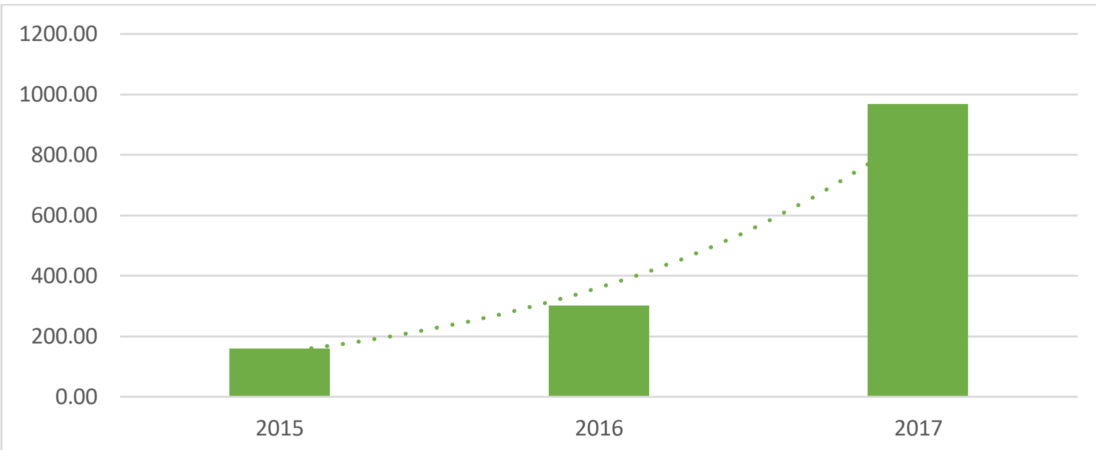
Although the period between 1973 and 2014 presented a growing monetary expansion, the Venezuelan economy was able to maintain inflation rates in the double-digit range.

While there were signs of acceleration in the inflation rate since mid-2013, it is in 2015 when a first worrying jump in the growth rates of the monetary base, M1, and the inflation rate is

[3]Starting in this section the inflation rate is measured using the National Consumer Price Index calculated by the Central Bank of Venezuela (BCV) and the National Institute of Statistics (INE).

noted that marks an obvious break with the dynamics of previous years. In July 2015, the year-to-year inflation rate irreversibly enters the 3-digit range, and at the end of that year it stood at 180.9 percent. In 2016, the inflation rate reached 274.4 percent and in 2017 it rose to 862.6 percent (Graph 1).

Graph 1-Annual Inflation Rate 2015-2017 (%)



In a context of continuous acceleration, a new break in the dynamics of inflation can be observed in the last quarter of 2017, when the monthly inflation rate in October reached 31.92 percent and continued to accelerate until reaching 55.8 percent in December, thus exceeding the 50 percent monthly threshold suggested by Phillip Cagan (1956) to mark the beginning of a hyperinflationary process.

4.-The hyperinflationary process December 2017-January 2020. Descriptive analysis

This section describes the behavior of the main variables that interact during a hyperinflation process: prices, monetary aggregates, and the nominal exchange rate.

Based on Cagan's (1956) criteria to define a hyperinflation episode, December 2017, with a monthly inflation rate of 55.8 percent, is taken as the month of the beginning of the hyperinflationary process. Starting in December 2017, the monthly inflation rate repeatedly exceeded 50 percent[4]. The analysis closes in January 2020 when the monthly inflation rate was 62.23 percent. Thus, the Venezuelan hyperinflation episode lasted 26 months, and is the

[4]Cagan's definition of hyperinflation requires that the inflation rate exceed 50% monthly for at least a few months.

second longest hyperinflation event after the one in Nicaragua, of fifteen reported by Sachs and Larrain (1993).

The criteria used by Cagan (1956) to define a hyperinflationary process has been criticized by many economists for its ad hoc nature. However, to study the phenomenon accurately, it is essential to define certain specific limits. In the case of Venezuela, I will try to show that the jump towards a trajectory of monthly inflation rates frequently above 50 percent starting in December 2017 marked a substantial difference with respect to the inflationary experience with increasing monthly inflation rates, but under 50 percent of the period 2015.01 – 2017. 11. Thus, although Cagan's framework should not be taken as set in stone, it alerts us about the perils of rushing to classify any process of high inflation as hyperinflation.

4.1.-Behavior of the inflation rate

During 2018, the monthly inflation rate (vipc) was above 50 percent in all months, except February and March (Graph 2). The highest inflation rate of 2018 was recorded in September (127.74 percent).

In January 2019, the highest monthly inflation rate since December 2017 (196.63 percent) was recorded, and in February it remained above 100 percent (114.36 percent). However, from then on, the inflation rate began to decline markedly to values below 50 percent monthly between March and August, with a rebound to 52.24 percent in September (Chart 2). During the last quarter of 2019, the inflation rate remained below 50 percent. In January 2020, the monthly inflation rate accelerated to 62.23 percent, but again returned to rates below 50 percent in the following 12 months until January 2021.

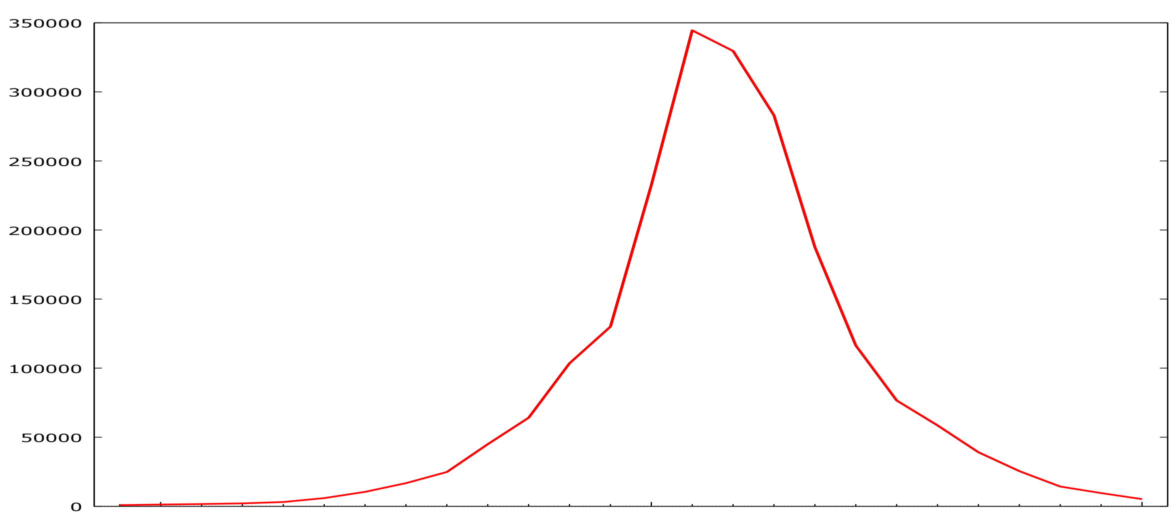
The average monthly inflation rate for the period December 2017 to January 2020 was 67.36 percent. In the Latin America region, only the Brazilian high inflation episode exhibited a slightly higher average monthly inflation rate (68.6 percent), but it lasted only four months between December 1989 and March 1990 (Sachs and Larrain, 1993).

Graph 2-Monthly Inflation Rate (%)

Table A1 (Appendix A) shows the frequency distribution of the monthly inflation rate observed between December 2017 and January 2020. Of the twenty-six monthly observations, fifteen exceeded 50 percent and five were above 100 percent.

On a year-on-year basis, the inflation rate (vipcyoy) increased rapidly to reach 130,060.2 percent in December 2018 (Graph 3). The year-on-year inflation rate continued to increase to a maximum of 344,509.5 percent in February 2019, and from there it began to decline. The interannual inflation rate reported by the BCV in December 2019 reached 9,585.5 percent. For January 2020, the recorded interannual inflation decreased to 5,197 percent.

Graph 3-Year-to-Year Inflation Rate (%)



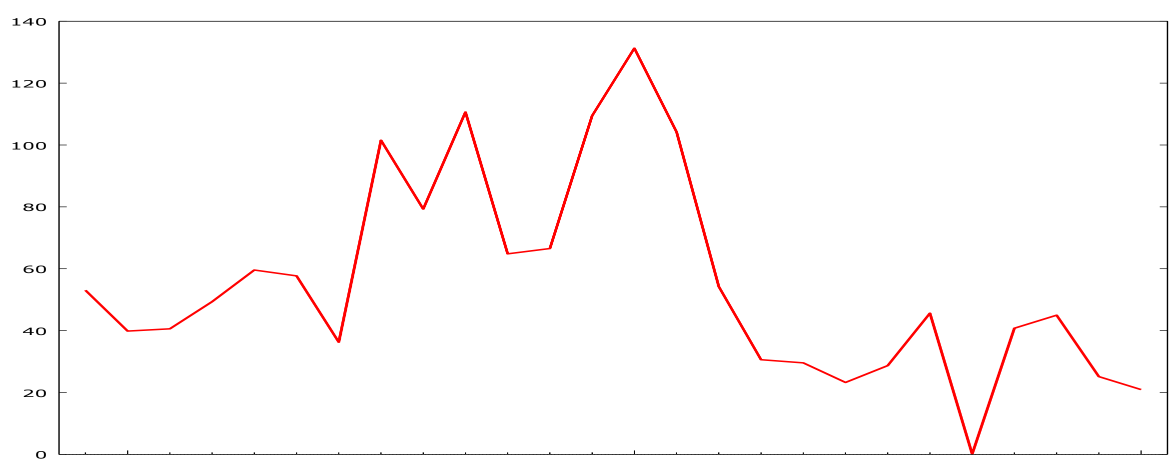
4.2.-Behavior of the monetary base and M1

As in all cases of hyperinflation that have been examined throughout history, the financing of the fiscal deficit through the expansion of the amount of base money issued by the central bank was the immediate cause of the hyperinflation (Bernholz, 2016) [5]. Thus, to understand the dynamics of a hyperinflationary process it is vital to examine the behavior of the monetary base in nominal terms.

In December 2017, a marked acceleration was observed in the monthly growth rate of the monetary base (vbm – Graph 4). This growth rate remained above 50 percent for eight months of 2018, and exceeded 100 percent during the months of July, September, and December. The highest value during 2018 was observed in September (110.7 percent). In January 2019, the highest monthly growth rate was recorded for the period under analysis (131.3 percent), and in February it reduced to 104.2 percent. From April 2019 to January 2020, the growth rate of the monetary base remained below 50 percent, but with growth rates greater than 40 percent in August, October, and November 2019.

The average monthly growth rate of the monetary base for the period analyzed was 55.69 percent.

Graph 4-Monthly Monetary Base Growth (%)

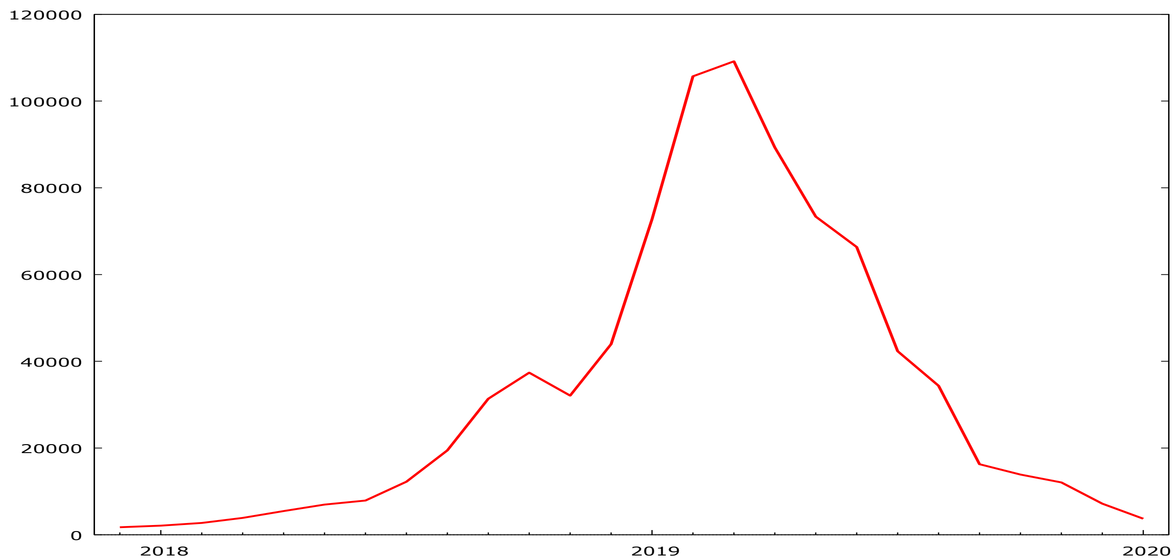


[5]At the end of 2009, a reform to the Law of the Central Bank of Venezuela was approved by the legislative branch under the control of the executive. This reform allowed the central bank to directly purchase securities issued by the state oil company (Petróleos de Venezuela -PDVSA). This is the essential mechanism that was used to finance the public sector and expand the monetary base.

Table A2 (Appendix A) shows that, of the twenty-six observations of the period under analysis, twelve were greater than 50 percent and five exceeded 100 percent.

Graph 5 indicates that, on a year-on-year basis, the growth rate of the monetary base (vbmyoy) persistently accelerated until October, and after an interruption of the upward rhythm in November, it reached 43,949.9 percent in December 2018. The maximum interannual growth was reached in March 2019 (109,161.9 percent). In April 2019, it began to decrease until reaching 7,172.4 percent in December 2019, and 3,702.4 percent in January 2020.

Graph 5- Year-to-Year Monetary Base Growth (%)

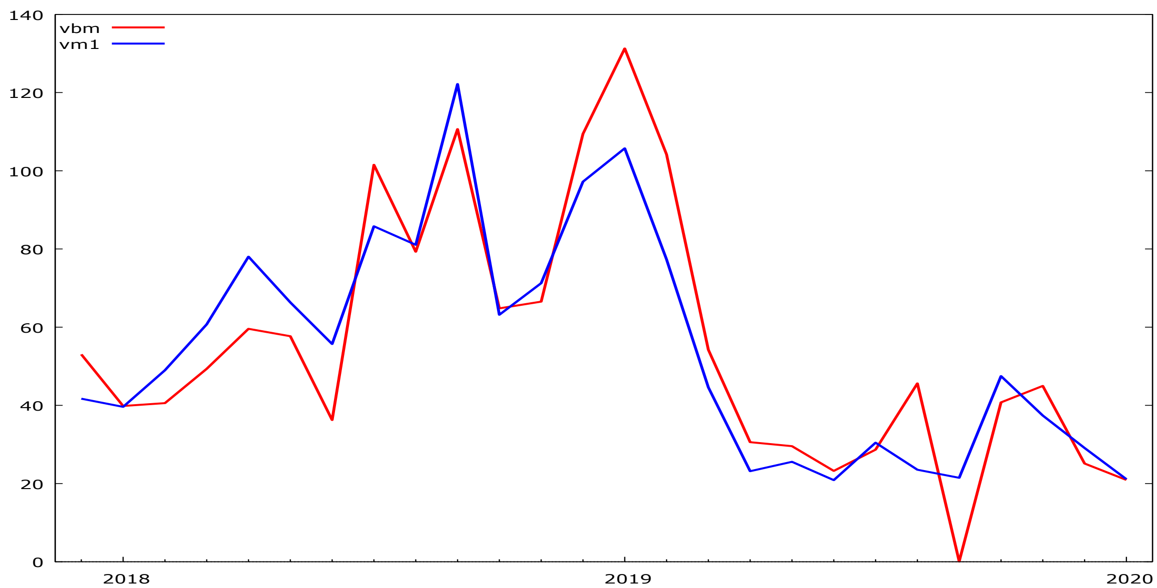


The hyperinflationary process accelerated and consolidated a phenomenon that had already been progressively occurring in previous years: the restricted monetary aggregate M1 (which in Venezuela includes cash held by the non-bank public, demand deposits, and savings deposits transferable through electronic means), became equivalent to the expanded money supply M2. As expected in a context of high inflation, it becomes impossible for economic agents to hold financial assets with nominal interest rates controlled at very low levels and restrictions on their mobilization.

Also, the close historical relationship observed in Venezuela between the monetary base and M1 strengthen during the hyperinflationary process. The contemporary correlation coefficient between these variables (vbm-vm1) is 0.92 during the period under analysis (Graph 6).

It is important to note that, amid pressures from the government, the BCV began to increase the legal reserve requirement on bank deposits, which started at 40 percent in December 2017, until taking it to 100 percent in February 2019. This measure, however, seems to have had a limited effect, and the decline in the M1 growth rate during 2019 appears to be mainly linked to the reduction in the expansion of the monetary base (Graph 6). Also, is important to observe that the destruction of the financial intermediation activity preceded the increases in legal reserve requirements and was due to the acceleration of inflation in combination with the control of nominal interest rates.

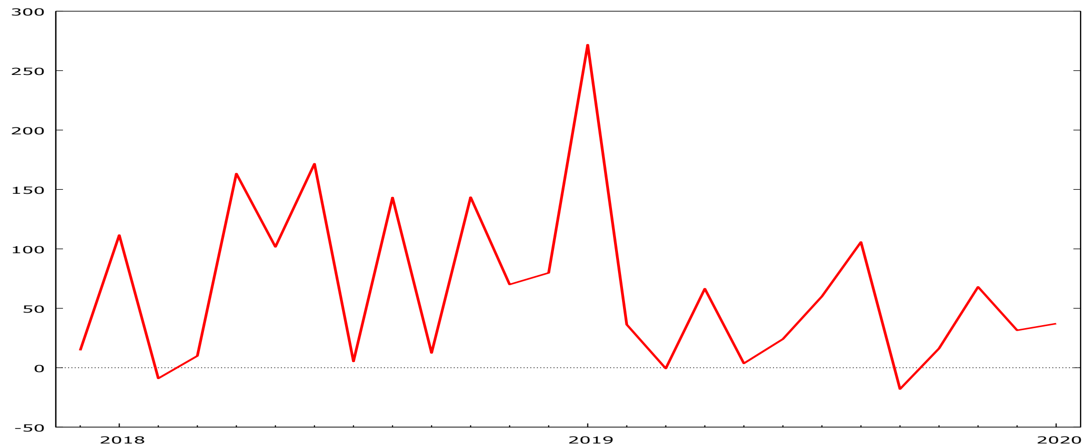
Graph 6-Monthly Variation Rate Monetary Base and M1 (%)



4.3.- Behavior of the nominal exchange rate

Graph 7 and Table 4 describe the evolution of the monthly variation rate of the nominal exchange rate (Bs./US dollar end of period - vs2). The highest monthly growth rate during 2018 was recorded in June (171.7 percent), however, one month with a negative variation rate was observed (February), and three months with variations below 10 percent. In 2019, the highest monthly variation was observed during the 26 months analyzed (271.8 percent in January), but from then on, a more moderate trend is noted in the monthly variation rates, with two negative observations (March and September), and three observations below 10 percent.

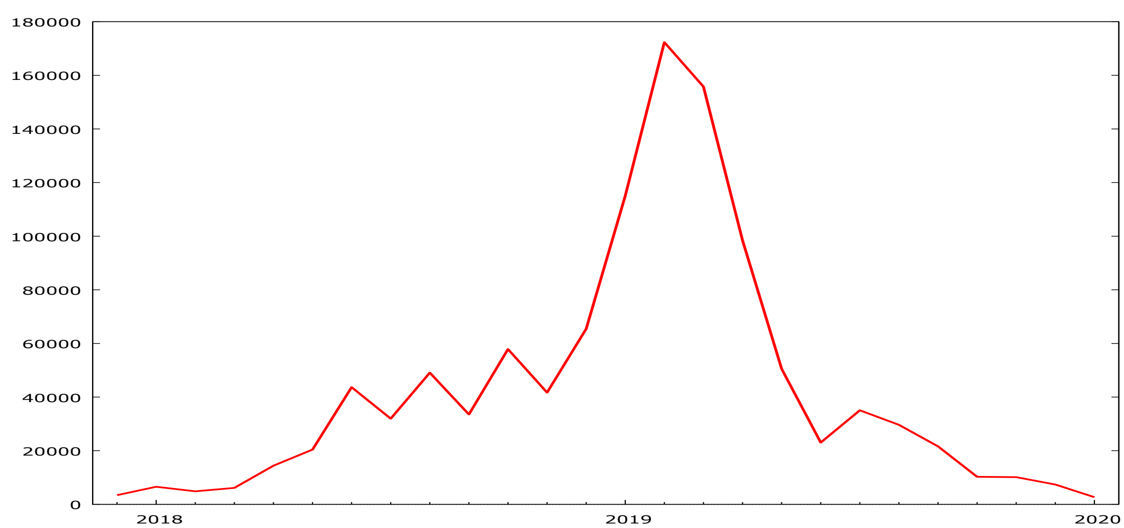
Graph 7-Monthly Variation Rate Nominal Exchange Rate (%)



As shown in table A3 (Appendix A), of the twenty-six monthly observations of the period under analysis, thirteen were above 50 percent and six observations were above 100 percent. The average monthly variation rate of the nominal exchange rate for the period examined was 66.19 percent.

On a year-to-year basis (Graph 8), the accumulated depreciation of the nominal exchange rate increased discontinuously until reaching 65,447.9 percent in December 2018, and a maximum of 172,321.4 percent in February 2019. From there it began to decrease (with a slight increase in July) until reaching 7,390 percent in December 2019, and 2,663 percent in January 2020.

Graph 8-Year-to-Year Variation Rate Nominal Exchange Rate (%)



4.4.-Inflation, monetary base growth, and exchange rate variations

In this section, I examine the joint behavior of the three variables that were studied separately in the previous sections.

Table 2 presents some descriptive statistics of the monthly growth rates of the three variables: CPI variation rate (vipc), monetary base variation rate (vbm), and nominal exchange rate variation rate (vs2).

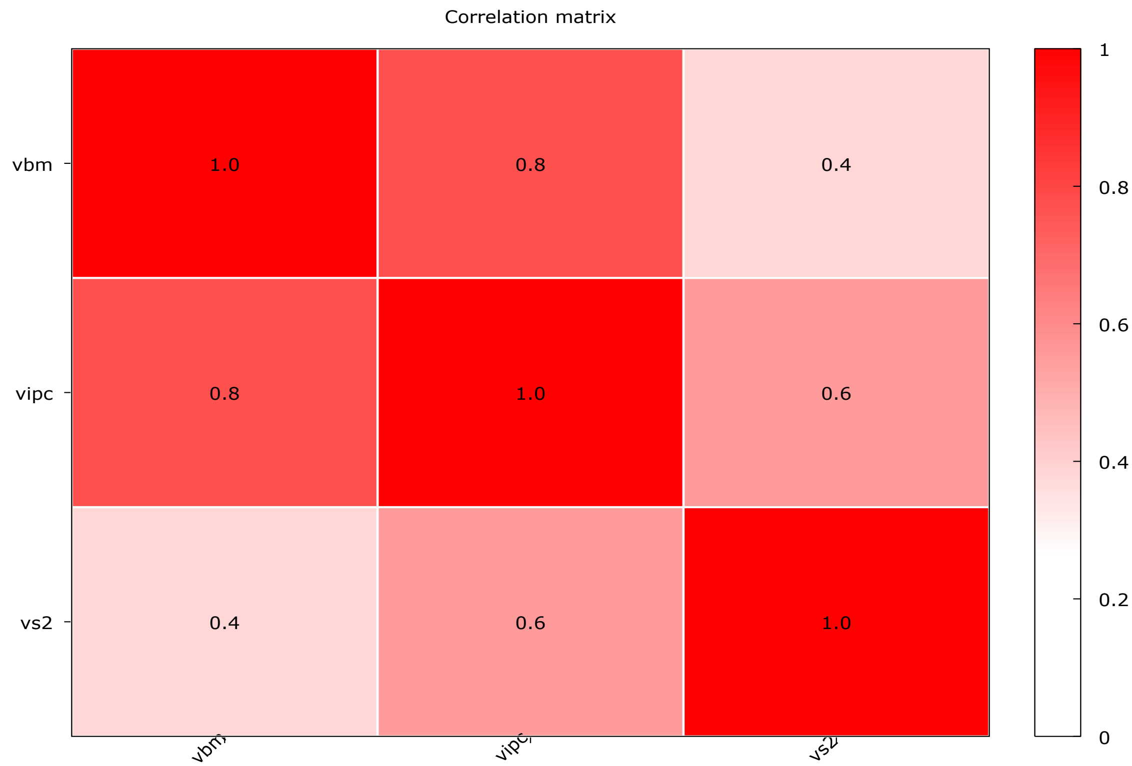
Table 2

Summary Statistics, using the observations 2017:12 - 2020:01					
Variable	Mean	Median	S.D.	Min	Max
vbm	55.7	47.5	32.6	0.0802	131.
vipc	67.4	55.7	42.4	19.4	197.
vs2	66.2	48.6	69.5	-17.9	272.

It can be seen that the average monthly growth rates exceeded 50 percent for all variables. The median of the monthly inflation rate was the only one that exceeded 50 percent, but the values of the median of the monetary base (47.5 percent) and the nominal exchange rate (48.6 percent) were remarkably close to this limit. An extremely high standard deviation was observed for all the variables, however, the one corresponding to the variations of the nominal exchange rate (69.5) is noticeable higher than that of inflation (42.4) and the variations of the monetary base (32.6).

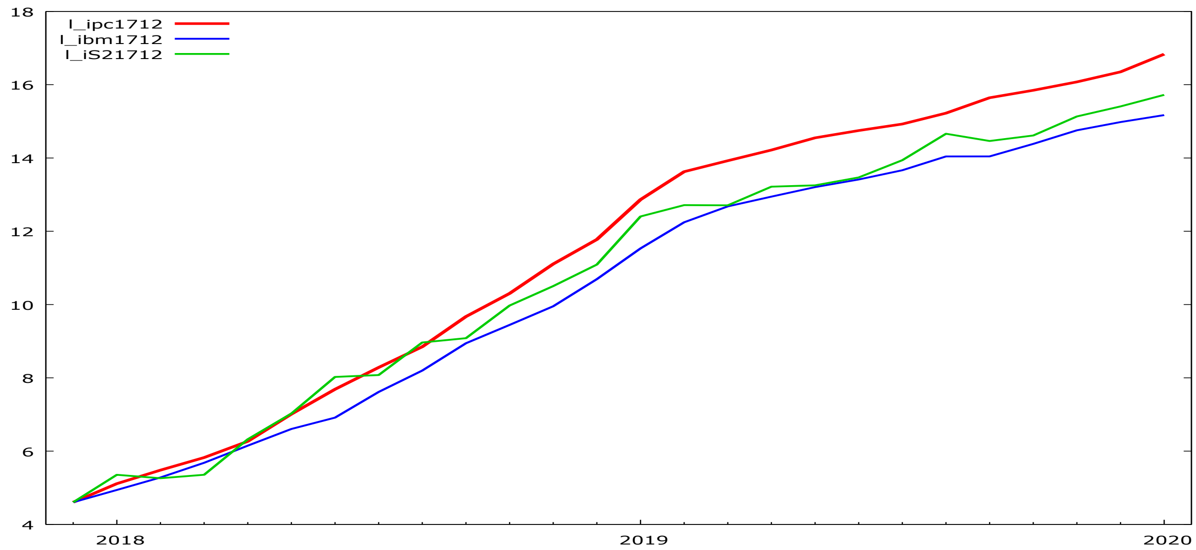
Table 3 shows the correlation matrix for the three variables under analysis. The highest correlation was obtained for the inflation rate (vipc) and the growth rate of the monetary base (vbm), which is 0.77. The correlation coefficient between variations in the nominal exchange rate (vs2) and the inflation rate (vipc) was 0.55. The lowest correlation coefficient was obtained between the variations of the nominal exchange rate (vs2) and the rate of variation of the monetary base (vbm), – 0.38.

Table 3



To evaluate the behavior of these variables in levels, graph 9 shows the logarithm of indices with base 2017.12=100 for the CPI, the monetary base, and the nominal exchange rate. This graph shows that the accumulated inflation rate was higher than the accumulated growth rate of the monetary base, an expected result due to the fall in the demand for money analyzed in section 7. However, the lag in the accumulated growth of the nominal exchange rate in relation to that of the CPI is a result that breaks with what has been observed in most recorded hyperinflationary events (Bernholz, 2016). Although the nominal exchange rate began to move in line with the price level until mid-2018, from that moment on it started to lag, giving rise to a relative overvaluation of the real exchange rate for the period under study, which contrasts with the tendency towards undervaluation that usually occurs during hyperinflationary events.

Graph 9 -CPI, Monetary Base, Nominal Exchange Rate. Indices 2017.12=100



5.- Inflation and monetary base growth. Econometric analysis

''Extreme increases in the price level cannot occur without commensurate increases in the money stock, which are usually less than proportional due to the reduction in demand for real monetary balances.''

(Cagan, 1989)

This section discusses econometric estimates that support Cagan's (1956, 1989) position that the evolution of the nominal quantity of money was the crucial variable in hyperinflationary dynamics in the case of Venezuela.[6]

An equation estimated by Ordinary Least Squares (Table B1-Appendix B) indicates that the monthly variation rate of the monetary base (vbm) has a statistically significant effect on the monthly inflation rate (vipc) with a coefficient close to one. A bootstrapping exercise with 9,999 replications indicates that, with 95 percent confidence, the coefficient that relates vbm to vipc is between 0.68 and 1.34.

[6]In the econometric estimates presented throughout the text, we follow McCallum 's (2012) argument that the problem of spurious regression between non-stationary (or strongly autoregressive) variables arises in those cases in which the estimated equation presents problems of autocorrelation of the residuals. Therefore, in the equations presented particular care is taken to obtain results free of the autocorrelation problem.

A similar regression including the inflation rate lagged by one period (Table B2-Appendix B) indicates that this variable has a relatively low coefficient of 0.15 and is in fact not statistically different from zero. Thus, during the hyperinflationary episode, the inflation rate does not exhibit persistence.

Table B3 (Appendix B) presents the results of estimating the regression of vipc against vbm for the period of most moderate inflation between 2015.01-2017.11. Note the marked difference in the effect of contemporaneous changes in the monetary base on inflation for the two periods. For the period before hyperinflation, the vbm coefficient is 0.074 versus almost one during hyperinflation.

Furthermore, the addition of the lagged inflation rate for this pre-hyperinflationary period generates a high (0.75) and statistically significant coefficient (Table B4-Appendix B).

An alternative specification for this period shown in table B5 (Appendix B), replaces the lagged value of vipc with lags one and two of the growth rate of the monetary base. In this specification, the coefficients of the contemporaneous and lagged values of the growth rate of the monetary base are positive and statistically different from zero. The sum of the coefficients is 0.36.

The above results reinforce the idea that the dynamics of inflation and its relationship with the monetary expansion were notably different during the hyperinflationary event compared to the preceding period of more moderate high inflation (2015.01-2017.11) and support the relevance of using the Cagan criterion as a tool to identify hyperinflationary events.

6.- Variations in the nominal exchange rate and monetary base growth. Econometric analysis

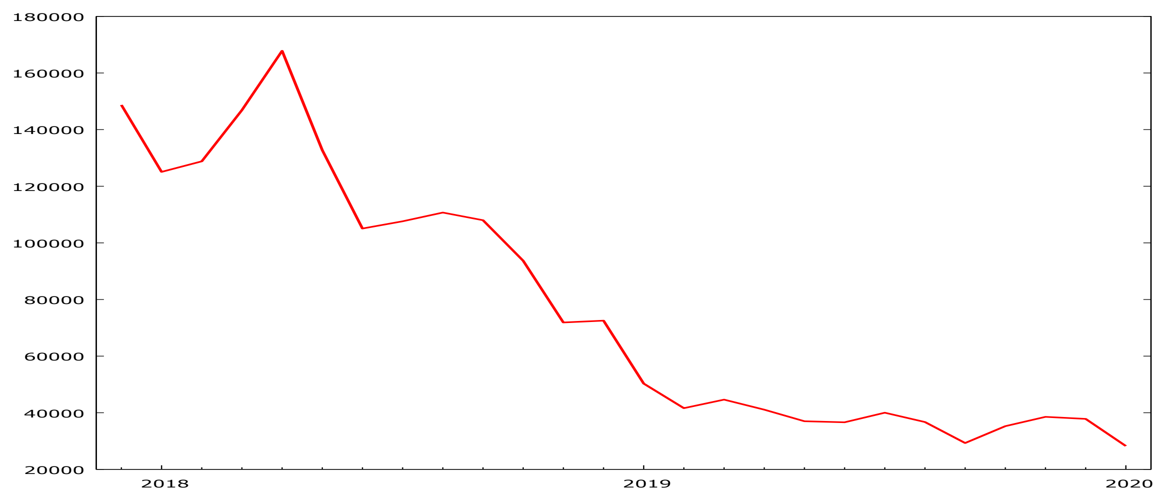
It was previously indicated that the contemporaneous correlation coefficient between the variations in the nominal exchange rate and the monetary base was relatively low (0.38) for the period under study. There is, however, evidence that the behavior of the monetary base was a central variable in the dynamics of the exchange rate, despite the high variability and somewhat atypical behavior that this variable exhibited during the hyperinflationary process.

A regression estimated with the Cochrane- Orcutt method to correct for autocorrelation (Table B6-Appendix B), indicates that the coefficient that links the monthly growth rate of the monetary base (vbm) with the rate of variation of the nominal exchange rate (vs2) is statistically significant and close to one.

7.- The demand for money

Until now, I have presented evidence indicating that the hyperinflationary event in Venezuela maintained most of the fundamental characteristics that have been recorded for other hyperinflationary experiences throughout history (Bernholz, 2016). Apart from the close relationship observed between the growth rate of the monetary base and the inflation rate, the sharp fall that the demand for money (real M1) exhibited implies that the price level was increasing more rapidly than the money supply (Graph 10).

Graph 10 - M1 in Real Terms



However, it is interesting to note that the decline in money demand did not begin immediately. It is in April 2018 that a pronounced decrease in real balances was observed which, with some brief interruptions, lasted until September 2019. Starting in the last quarter of 2019, a slight stabilization of real balances is observed.

McCallum (1989) reports Cagan's (1956) estimates of the average monthly inflation rate and the minimum to initial ratio of real money balances for the seven hyperinflationary episodes covered by his study. The minimum to initial real monetary balance ratio for the case of Venezuela is 0.19 with an average inflation rate of 67.4 percent. This result suggests a relatively pronounced drop in the demand for money with respect to the results reported by Cagan for events with average monthly inflation rates closer to those of the Venezuelan episode: Austria (0.35 – 47.1 percent); Hungary WWI (0.39 – 46.0 percent); Poland (0.34 – 81.1 percent); Russia (0.27 – 57.0 percent). However, for episodes with average monthly inflation rates of three digits or more, the minimum to initial ratio of real monetary balances is much lower than that of Venezuela: Germany (0.03 – 322 percent); Greece (0.007 – 365 percent); Hungary WWII (0.003 – 19,800 percent).

It is also interesting to comment that, although the marked reduction in the demand for money is mainly associated with the opportunity cost generated by high inflation, it is important to keep in mind that the immense contraction that the Venezuelan economy registered in the period 2015-2019[7] also contributed to the sharp decline in the demand for monetary balances.

A central theme in Cagan's (1956) analysis of hyperinflation, and one that many economists today misinterpret, is that the demand for money tends to fall with the acceleration of the inflation rate that originates from the expansion of the supply of money, but the demand for money still exhibits a stable behavior. One of the main objectives of Cagan's study was to present evidence that supported the proposition that the behavior of the demand for money is, even during hyperinflationary process, well behaved rather than erratic or irrational (McCallum, 1989; Olivo 1996). This last contention is crucial, since it follows that the hyperinflationary process cannot be self-generated or the product of self-fulfilling prophecies, but rather the impulse of the expansion of the money supply documented in section 5 is decisive in sustaining the hyperinflationary dynamics.

In this section, I follow McCallum (1989) who reproduces Cagan's (1956) analysis in discrete time to analyze the issue of the stability of the demand for money during the hyperinflationary episode in Venezuela (2017.12 - 2020.01).

[7] During the period 2015-2018 for which official figures are available, GDP contracted 47.29%.

The following simplified version of the demand for money is a central ingredient in Cagan's (1956) model:

$m_t - p_t = \gamma + \alpha\pi_t^e + u_t$ (1)

m_t =logarithm of the nominal stock of money

p_t =logarithm of the price level

π_t^e =expected inflation rate ($p_{t+1} - p_t$)

u_t =stochastic error term

Cagan uses the adaptive expectations hypothesis to model the expected inflation rate:

$\pi_t^e - \pi_{t-1}^e = \lambda(\pi_t - \pi_{t-1}^e)$,$0 \leq \lambda \leq 1$ (2)

Solving for the expected inflation rate at *t* in the previous expression, and substituting it into the money demand equation, we obtain the expression:

$m_t - p_t = \gamma + \alpha[\lambda\pi_t + (1-\lambda)\pi_{t-1}^e] + u_t$ (3)

Now we lag the money demand equation one period and solve it for $\pi_{t-1}^e = (m_{t-1} - p_{t-1} - \gamma - u_{t-1})/\alpha$. Substituting this expression into equation (3), we obtain:

$m_t - p_t = \gamma\lambda + \alpha\lambda\pi_t + (1-\lambda)(m_{t-1} - p_{t-1}) + v_t$ (4)

$$v_t = u_t - (1-\lambda)u_{t-1}$$

The stability condition for this equation, or what Cagan called the reaction rate (ε) is:

$$\left|\frac{\alpha\lambda + 1 - \lambda}{1 + \alpha\lambda}\right|$$

The estimation of equation (4) with correction for autocorrelation and monthly data for the period under study is shown in table B7 (Appendix B). The results reported in table B7 imply that the stability condition or reaction index yields a value of ε=1.0488 >1, inconsistent with Cagan's approach that the demand for money presents a stable behavior during the hyperinflationary episode. To verify the previous result, a new estimation using an ARMA model plus the lagged value of the inflation rate is presented in table B8 (Appendix B). This regression generates a result that in principle supports Cagan's hypothesis regarding the stability of money demand, with a reaction index of 0.9495<1. However, this reaction index is very close to one and the 95 percent confidence interval is (0.89 - 1.04).

Although these results based on the estimation of the demand for money do not favor Cagan's criterion, it is widely known that his econometric analysis contains flaws that cannot be ignored. Mainly, under the hypothesis that the money supply is exogenous, p_t is the main endogenous variable of the model. Therefore, π_t is not an exogenous or predetermined variable.

To address this problem, we directly estimate the equation for the logarithm of the price level p_t derived from the money demand function:

$$p_t = \frac{-\gamma\lambda}{1+\alpha\lambda} + \frac{1}{1+\alpha\lambda}\Delta m_t + \frac{\alpha\lambda + 1 - \lambda}{1+\alpha\lambda} p_{t-1} + \frac{\lambda}{1+\alpha\lambda} m_{t-1} - \frac{1}{1+\alpha\lambda}\nu_t$$

$$\Delta m_t = m_t - m_{t-1}$$

Note that in the equation of p_t, the coefficient of p_{t-1} is the reaction index or the condition for the dynamic stability of the price level that must be less than 1 in absolute value.

Let us estimate first p_t maintaining the assumption that the money supply is exogenous. The results obtained by applying the Cochrane- Orcutt method to correct autocorrelation are shown in Table B9 (Appendix B). All estimated coefficients present the expected signs and are statistically significant at the commonly used significance levels. In this case the coefficient of the lagged price level (l_ipc_1) is 0.52, which implies that the dynamic stability condition is met. The 95 percent confidence interval for this coefficient is (0.15 - 0.88).

Table B10 (Appendix B) presents the result of estimating the equation for p_t assuming that the money supply is endogenous, using Two-Stage Least Squares (2LS). In the estimation of the first stage, the growth rate of m1 (ld_m1), the inflation rate lagged one period (ld_ipc_1) and the predetermined variables (l_m1_1, l_ipc_1) are used as instruments. All estimated coefficients have the expected signs and are statistically significant at the commonly used significance levels.

In this case, the Cagan reaction index $\varepsilon = 0.58 < 1$ is not quite different from that obtained previously and is clearly compatible with the dynamic stability of the price level. The 95 percent confidence interval for this coefficient is (0.31 - 0.84).

The results of the estimation of equations for the price level give us more robust empirical evidence that Cagan's condition of stability of the money demand was met during the hyperinflationary episode in Venezuela, and that the essential impulse of the hyperinflationary process was generated via expansion of the money supply and not an unstable behavior of the demand for money.

8.- The demand for money and the advance of dollarization

The counterpart to the marked process of contraction of the demand for money (increase in the velocity of circulation) that was described in the preceding section, and that has been observed in other hyperinflationary events, was an informal dollarization (without formal agreements with the US government and the US Federal Reserve). Bernholz (2016) identifies this phenomenon as Thiers' Law, which is the opposite of Gresham's Law: good money displaces bad money. To the extent that hyperinflation destroys the basic functions of the local currency as a medium of exchange, unit of account, and store of value, foreign currency is the only viable option for economic agents.

Although no formal statistical information is available, there is abundant anecdotal evidence about the rapid increase in transactions of goods and services that were quoted and carried out directly with US dollars throughout the territory of Venezuela, and particularly in the border areas.

This dollarization process was further reinforced by the presence of a series of factors that in one way or another were also linked to the hyperinflationary phenomenon, and whose relative importance is difficult to weigh: a) the general collapse of the Venezuelan economy gave rise to a massive emigration of Venezuelans who, through remittances, help their relatives who remain in the country; b) the monetary authorities were unable to maintain an adequate stock of coins and banknotes to satisfy the population's cash needs in bolivars; c) the nominal limits established for electronic transactions were generally inadequate in the context of hyperinflation; d) the proliferation of a large number of informal activities, many of them illegal in nature.

The dollarization process of the Venezuelan economy shows, however, an element that breaks with a characteristic common to most of the historical hyperinflationary experiences studied (Bernholz, 2016): the real exchange rate tended to appreciate and not to depreciate as it is seen in graph 9. Although towards the beginning of the hyperinflationary process the nominal exchange rate in the parallel market (Bs./US$) moved closely with the price level, starting in mid-2018 it began to lag. Certain particular characteristics of the informal dollarization that occurred in Venezuela can explain this phenomenon. On the one hand, the large Venezuelan diaspora that sent remittances to the country increased the supply of dollars when they sent them in cash or through some channel that incorporated them into the formal Venezuelan payment system. However, since a significant number of Venezuelans (individuals and firms) maintained accounts in the United States financial system, a seemingly non-trivial number of remittances were channeled through transfers between accounts within this country. In this case, remittances reduced the pressure on the demand for foreign currency instead of expanding supply. This also allowed Venezuelans to carry out transactions of goods and services within the country directly using instruments of the US payment system such as Zelle electronics transfers. The other element that may have contributed to significantly reducing the pressure on the parallel exchange rate was the expansion of informal/illegal activities that generated foreign currency.

9.-Conclusions

This work follows the approach of Cagan (1956) and focuses on evaluating the role of monetary factors (supply of and demand for money) in the development of the hyperinflationary process that affected Venezuela between the December 2017 and January 2020. Evidence is presented that the change in monetary dynamics through a jump in the rate of growth of the monetary base was a fundamental factor in the process of acceleration of the price level. The econometric evidence suggests that the coefficient that links the growth rate of the monetary base and the inflation rate increased in the hyperinflationary period with respect to the preceding period of more moderate inflation. During the hyperinflationary episode, this coefficient was close to one, and inflationary inertia did not emerge as a relevant factor.

As in other hyperinflationary episodes observed in the past, the rapid decline in money demand (increased velocity of circulation) exacerbated the rate of price acceleration above the monetary expansion. However, the econometric estimation of the price equation that is derived from the demand for money specified by Cagan (1956), indicates a stable behavior of the price level (even when the money supply is considered as an endogenous variable). This allows us to reject the hypothesis that some analysts have put forward, that the hyperinflation episode in Venezuela was a self-generated phenomenon due to the disorderly fall in the demand for money in which changes in the supply of money had negligible impact.

Econometric evidence is also presented that the behavior of the monetary base was a central variable in the behavior of the nominal exchange rate, despite its very high variability, and the tendency to appreciate that this variable exhibited during the hyperinflationary process.

Finally, it is important to comment briefly how the hyperinflationary episode in Venezuela ended. From its peak of 130,060 percent in 2018, inflation fell rapidly to 9,586 percent in 2019, and in 2021 the inflation rate (686.4 percent) was already below the value of 2017. This steep reduction in inflation occurred in the context of a very opaque fiscal adjustment forced by the rapid decline of seigniorage revenues, without any major institutional reform, no international financial support, and the continuing default on the US$ 160 billion of public sector foreign debt (more than 300 percent of the country estimated GDP in US dollars). Thus, a substantial reduction in money growth attained a strong decline in inflation without structural modifications in the fiscal and monetary institutions of the country. Of course, a sustainable reduction of inflation toward levels consistent with price stability is not possible without a strong macroeconomic program that includes reforms that promote fiscal and monetary discipline in the present and the future (Olivo, 2023).

Appendix A. Frequency distributions

Table A1

Frequency distribution for vipc, obs 85-110

number of bins = 11, mean = 67.3603, sd = 42.4411

interval	midpt	frequency	rel.	cum.	
< 28.244	19.382	4	15.38%	15.38%	*****
28.244 - 45.969	37.107	7	26.92%	42.31%	*********
45.969 - 63.694	54.832	4	15.38%	57.69%	*****
63.694 - 81.419	72.557	3	11.54%	69.23%	****
81.419 - 99.144	90.282	3	11.54%	80.77%	****
99.144 - 116.87	108.01	2	7.69%	88.46%	**
116.87 - 134.59	125.73	2	7.69%	96.15%	**
134.59 - 152.32	143.46	0	0.00%	96.15%	
152.32 - 170.04	161.18	0	0.00%	96.15%	
170.04 - 187.77	178.91	0	0.00%	96.15%	
>= 187.77	196.63	1	3.85%	100.00%	*

Table A2

Frequency distribution for vbm, obs 85-110

number of bins = 11, mean = 55.6876, sd = 32.5754

interval	midpt	frequency	rel.	cum.	
< 13.120	6.5599	1	3.85%	3.85%	*
13.120 - 26.240	19.680	3	11.54%	15.38%	****
26.240 - 39.360	32.800	4	15.38%	30.77%	*****
39.360 - 52.479	45.919	6	23.08%	53.85%	********
52.479 - 65.599	59.039	5	19.23%	73.08%	******
65.599 - 78.719	72.159	1	3.85%	76.92%	*
78.719 - 91.839	85.279	1	3.85%	80.77%	*
91.839 - 104.96	98.399	2	7.69%	88.46%	**
104.96 - 118.08	111.52	2	7.69%	96.15%	**
118.08 - 131.20	124.64	0	0.00%	96.15%	
>= 131.20	137.76	1	3.85%	100.00%	*

Table A3

Frequency distribution for vs2, obs 85-110					
number of bins = 11, mean = 66.1896, sd = 69.4636					
interval	midpt	frequency	rel.	cum.	
< -3.4360	-17.923	2	7.69%	7.69%	**
-3.4360 - 25.539	11.052	8	30.77%	38.46%	***********
25.539 - 54.514	40.026	3	11.54%	50.00%	****
54.514 - 83.489	69.001	5	19.23%	69.23%	******
83.489 - 112.46	97.976	3	11.54%	80.77%	****
112.46 - 141.44	126.95	0	0.00%	80.77%	
141.44 - 170.41	155.93	3	11.54%	92.31%	****
170.41 - 199.39	184.90	1	3.85%	96.15%	*
199.39 - 228.36	213.88	0	0.00%	96.15%	
228.36 - 257.34	242.85	0	0.00%	96.15%	
>= 257.34	271.83	1	3.85%	100.00%	*

Appendix B. Econometric results

Table B1: OLS, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: vipc					
HAC standard errors, bandwidth 2 (Bartlett kernel)					
	Coefficient	*Std. Error*	*z*	*p-value*	
const	11.7415	10.4508	1,124	0.2612	
vbm	0.998764	0.173747	5,748	<0.0001	***

Mean dependent var	67.36027	SD dependent var	42.44106
Sum squared resid	18567.78	SE of regression	27.81470
R-squared	0.587667	Adjusted R-squared	0.570487
F(1, 24)	33.04406	P-value(F)	6.35e-06
Log-likelihood	−122.3165	Akaike criterion	248.6331
Schwarz criterion	251.1492	Hannan-Quinn	249.3576
rho	−0.095535	Durbin-Watson	2.130419

Table B2: OLS, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: vipc					
HAC standard errors, bandwidth 2 (Bartlett kernel)					
	Coefficient	*Std. Error*	*z*	*p-value*	
const	8.96040	7.65454	1,171	0.2418	
vbm	0.864609	0.324946	2,661	0.0078	***
vipc_1	0.154299	0.209740	0.7357	0.4619	

Mean dependent var	67.36027	SD dependent var	42.44106
Sum squared resid	17954.24	SE of regression	27.93956
R-squared	0.601292	Adjusted R-squared	0.566622
F(2, 23)	45.84916	P-value(F)	9.44e-09
Log-likelihood	−121.8797	Akaike criterion	249.7594
Schwarz criterion	253.5337	Hannan-Quinn	250.8463
rho	−0.156992	Durbin-Watson	2.245270

Table B3: AR, using observations 2015:01-2017:11 (T = 35)					
Dependent variable: vipc					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	13.9859	3.68495	3,795	0.0006	***
vbm	0.0735142	0.0347676	2,114	0.0421	**
u(-1)	1.30367	0.160473	8.1239	<0.0001	***
u(-2)	−0.447544	0.167426	-2.6731	0.0116	**

Statistics based on the rho-differenced data:			
Sum squared resid	301.4192	SE of regression	3.022237
R-squared	0.826135	Adjusted R-squared	0.820867
F(1, 33)	4.470878	P-value(F)	0.042117
rho	0.036467	Durbin-Watson	1.827571

Statistics based on the original data:			
Mean dependent var	12.87286	SD dependent var	7.131237

Table B4: Cochrane-Orcutt, using observations 2015:01-2017:11 (T = 35)					
Dependent variable: vipc					
rho = 0.398096					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2.41686	1.91459	1,262	0.2160	
vbm	0.106839	0.0434526	2,459	0.0195	**
vipc_1	0.751117	0.267776	2,805	0.0085	***

Statistics based on the rho-differenced data:			
Sum squared resid	272.5093	SE of regression	2.918204
R-squared	0.842422	Adjusted R-squared	0.832573
F(2, 32)	38.59667	P-value(F)	2.96e-09
rho	0.062488	Durbin-Watson	1.868538

Statistics based on the original data:			
Mean dependent var	12.87286	SD dependent var	7.131237

Table B5: AR, using observations 2015:03-2017:11 (T = 33)					
Dependent variable: vipc					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	8.34079	1.64267	5.078	<0.0001	***
vbm	0.124248	0.0354879	3.501	0.0014	***
vbm_1	0.148777	0.0494516	3.009	0.0052	***
vbm_2	0.0908125	0.0524727	1.731	0.0935	*
u(-1)	1.20101	0.147446	8.1454	<0.0001	***
u(-2)	−0.628871	0.164975	-3.8119	0.0006	***

Statistics based on the rho-differenced data:			
Sum squared resid	225.1332	S.E. of regression	2.786255
R-squared	0.862423	Adjusted R-squared	0.848191
F(3, 29)	7.967662	P-value(F)	0.000504
rho	−0.014837	Durbin-Watson	2.020388

Statistics based on the original data:			
Mean dependent var	13.26895	S.D. dependent var	7.146449

Table B6 : Cochrane-Orcutt, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: vs2					
rho = -0.450355					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	11.5863	17.3621	0.6673	0.5109	
vbm	0.986288	0.272855	3,615	0.0014	***

Statistics based on the rho-differenced data:			
Sum squared resid	83069.14	SE of regression	58.83208
R-squared	0.311575	Adjusted R-squared	0.282891
F(1, 24)	13.06605	P-value(F)	0.001386
rho	−0.034473	Durbin-Watson	2.054117

Statistics based on the original data:			
Mean dependent var	66.18965	SD dependent var	69.46360

Table B7: AR, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: l_m1r					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.0208357	0.510672	−0.04080	0.9678	
ld_ipc	−0.454572	0.0874307	−5,199	<0.0001	***
l_m1r_1	1.02657	0.0825600	12.43	<0.0001	***
u(-4)	0.476946	0.209094	2.2810	0.0321	**
u(-5)	0.513406	0.193309	2.6559	0.0141	**
u(-9)	−0.403794	0.221868	-1.8200	0.0818	*

Statistics based on the rho-differenced data:			
Sum squared resid	0.194208	SE of regression	0.091890
R-squared	0.978441	Adjusted R-squared	0.976566
F(2, 23)	77.69477	P-value(F)	5.88e-11
rho	0.075191	Durbin-Watson	1.337939

Statistics based on the original data:			
Mean dependent var	6.484987	SD dependent var	0.597631

$$l\_m1r = m_t - p_t$$

$$ld\_ipc = p_t - p_{t-1}$$

Table B8 AR:ARMAX , using observations 2017:12-2020:01 (T = 26)					
Dependent variable: l_m1r					
Standard errors based on Hessian					
	Coefficient	*Std. Error*	*z*	*p-value*	
const	6.62326	0.681039	9,725	<0.0001	***
phi_1	0.967698	0.0390897	24.76	<0.0001	***
theta_1	0.651515	0.247000	2,638	0.0083	***
ld_ipc	−0.359432	0.111238	−3,231	0.0012	***

Mean dependent var	6.484987	SD dependent var	0.597631
Mean of innovations	−0.035722	SD of innovations	0.123434
R-squared	0.959843	Adjusted R-squared	0.956352
Log-likelihood	15.35788	Akaike criterion	−20.71576
Schwarz criterion	−14.42528	Hannan-Quinn	−18.90433

	Real	*Imaginary*	*Modulus*	*Frequency*
A.R.				
Root 1	1.0334	0.0000	1.0334	0.0000
M.A.				
Root 1	-1.5349	0.0000	1.5349	0.5000

LM test for autocorrelation up to order 12 -
Null hypothesis: no autocorrelation
Statistical test: Chi- square(10) = 7.29289

Table B9: AR, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: l_ipc					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−4.87896	1.72334	−2,831	0.0097	***
ld_m1	0.864368	0.168923	5,117	<0.0001	***
l_m1_1	0.560035	0.200939	2,787	0.0107	**
l_ipc_1	0.515439	0.175443	2,938	0.0076	***
u(-2)	−0.354231	0.194067	-1.8253	0.0816	*

Statistics based on the rho-differenced data:			
Sum squared resid	0.312969	SE of regression	0.119272
R-squared	0.999246	Adjusted R-squared	0.999143
F(3, 22)	18150.42	P-value(F)	1.80e-37
rho	0.181334	Durbin-Watson	1.540143

Statistics based on the original data:			
Mean dependent var	18.16060	SD dependent var	4.074731

$$l\_ipc = p_t$$

$$ld\_m1 = m_t - m_{t-1}$$

Table B10: TSLS, using observations 2017:12-2020:01 (T = 26)					
Dependent variable: l_ipc					
Instrumented: ld_m1					
Instruments: const ld_ipc_1 l_m1_1 l_ipc_1					
HAC standard errors, bandwidth 2 (Bartlett kernel)					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−4.58681	1.34633	−3,407	0.0025	***
ld_m1	1.19793	0.231734	5,169	<0.0001	***
l_m1_1	0.497941	0.153122	3,252	0.0037	***
l_ipc_1	0.576095	0.133321	4,321	0.0003	***

Mean dependent var	18.16060	SD dependent var	4.074731
Sum squared resid	0.447715	SE of regression	0.142656
R-squared	0.998922	Adjusted R-squared	0.998775
F(3, 22)	7169.553	P-value(F)	4.90e-33
Log-likelihood	8.665301	Akaike criterion	−9.330603
Schwarz criterion	−4.298216	Hannan-Quinn	−7.881457
rho	0.142128	Durbin's h	0.988168

Hausman test -
Null hypothesis: OLS estimates are consistent
Asymptotic test statistic: Chi- square(1) = 6.50501
with p-value = 0.0107571
Weak instrument test -
First-stage F- statistic (1, 22) = 35.0317

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