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Changes in Inflation Predictability in Major Latin American Countries*

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Abstract: Forecasts of inflation in the United States since the mid eighties have had smaller errors than in the past, but those conditional on commonly used variables cannot consistently beat the ones from univariate models. This paper shows through simple modifications to the classical monetary model that something similar occurred in those major Latin American economies that achieved their own "Great Moderation." For those countries that did not attain macroeconomic stability, inflation forecasting conditional on some variables has not changed. Allowing the parameters that determine Granger causality to change when the monetary regime does, makes possible the estimation of parsimonious inflation models for all available data (eight decades for one country and five for the others). The models so obtained ouperform others in pseudo out-of-sample forecasts for most of the period under study, except in the cases when an inflation targeting policy was successfully implemented.
Keywords: Money, exchange rate, cointegration, inflation forecasting.
JEL Classification: C32, E41, E42, E52

Resumen: Los pronósticos de inflación en Estados Unidos desde mediados de los ochentas han tenido errores más pequeños que en el pasado, pero aquellos condicionales en variables usadas comúnmente no pueden superar consistentemente a los de modelos univariados. Este artículo muestra a través de sencillas modificaciones al modelo monetario clásico que algo similar ocurrió en aquellas de las principales economías latinoamericanas que alcanzaron su propia "Gran Moderación". Para aquellos países que no lograron estabilidad macroeconómica, los pronósticos de inflación condicionales en algunas variables no han cambiado. El permitir que los parámetros que determinan la causalidad Granger cambien cuando el régimen monetario lo haga hace posible la estimación de modelos de inflación parsimoniosos para todos los datos disponibles (ocho décadas para un país y cinco para los otros). Los modelos así obtenidos superan a otros en pseudo pronósticos fuera de muestra para la mayor parte del período de estudio, excepto en los casos donde una política de objetivos de inflación fue implementada exitosamente.
Palabras Clave: Dinero, tipo de cambio, cointegración, pronósticos de inflación.

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1 Introduction

Forecasting inflation is a more challenging task than textbook models based on monetary factors or slack measures suggest. For example, in the aftermath of the financial crisis of 2008 that caused a severe economic contraction in the United States and forced the Federal Reserve to apply an unprecedented monetary stimulus, both types of models failed to provide good inflation forecasts. On the one hand, predictions of surging inflation due to the huge expansion of the monetary base have not materialized so far. On the other hand, large negative output gaps and a high unemployment rate should have caused deflation if common Phillips curves were predicting well. This was the "missing deflation" episode that led Hall (2011) to propose that inflation should be regarded as a "near-exogenous" variable instead of the consequence of unused productive capacity. It was not always like this. There was a time when inflation was more easily referred to identifiable causes (see, for example, Stock and Watson, 2007).

Although it has been known for some time that predictability is a property that can change, the issue has not been explored fully.[1] This article makes a contribution on this topic by showing how and why the conditional predictability of inflation has evolved in six major Latin American economies (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela). These economies experienced different monetary regimes that in turn determined the behavior of inflation. Differently from most other papers on inflation models, the study covers many decades, eight for Mexico and five or six for the rest. Despite of this, the models here obtained are surprisingly parsimonious and derived from the same theoretical framework. This contributes to fill a notorious void of out-of-sample forecasting evaluation of inflation models in Latin America and provides some insights of more general use on why inflation dynamics changes.

The models discussed below consider the possibility that the central bank determines either the price level or the inflation rate and that the institution can achieve its objectives through either a monetary aggregate, the exchange rate or a pre-announced inflation target. These types of monetary regimes are the only ones seen in the countries here examined although others are certainly conceivable.

A very useful analytical simplification of this paper is that within each monetary regime, only the variables chosen by the central bank Granger cause inflation. Many factors (for example, tax increases

[1] Rossi and Sekhposyan (2010) find that the relative forecasting performance of models of U.S. GDP growth and inflation have varied over time. No examples on this issue were found for Latin American countries.

or climatic factors) can affect the inflation rate at some point, but most of the time their impacts are hard to identify under specific monetary policy and their effect on inflation appears only in the short run. These considerations imply changes in the Granger-casuality relations among monetary variables when the economy passes from one monetary regime to another. The resulting models are parsimonious and leave almost no room for other explanatory variables and, more to the point, produce good pseudo-out-of-sample forecasts.[2]

The models for Brazil and Mexico share some similarities, even though their inflationary and institutional experiences have been very different in several aspects. These two countries began with a regime with where the price level was determined by the money supply within the quantitative equation of money (QEM). At the beginning of the eighties, they switched to a regime where the price level was tied to the exchange rate through the purchasing power parity condition (PPP). Finally, around 2000, they adopted a preannounced inflation target policy. Chile had a regime with a price level target tied to the exchange rate until 1990 before adopting a preannounced inflation targeting framework. Argentina has had a price level target tied to money for the whole sample.

Neither Colombia nor Venezuela appear to have ever determined the price level, so for those countries the pass-through of money or the exchange rate has never been complete, as in the other countries under study. Venezuela had first a regime where the rate of inflation was determined through the money supply before moving, in 1977, into an regime where the inflation rate depended on the exchange rate movements. It has remained in that regime since then. Colombia was the only country where no clear-cut dates for regimes were found so both money growth and the exchange rate depreciation enter into the corresponding inflation model.

The results are useful for several purposes. For example, they provide a clear estimate for the pass-through to inflation from money, the exchange rate or from any other variable at each point of time. Another is that by splitting the sample into different regimes at given dates one can get better estimates. Thus if one believes that during the inflation targeting regime a Keynesian model can work, then one should constraint the analysis only to this subsample because in previous regimes nominal monetary factors were dominant.

The rest of the document is organized as follows. In section 2, there is a brief literature review.

[2] The adjective “pseudo” means that the “out-of-sample” period is part of the original data to obtain the model to be tested as a forecasting tool. These exercises consist in estimating the model only for part of the original sample and producing dynamic forecasts for the rest of it without reestimation.

Section 3 presents the data for the empirical analysis. Section 4 describes the theoretical framework and describes how it is used in a test of regime change. Section 5 shows the procedure to identify the dates of regime change, presents the results for the tests and the final models for each country. The evaluation of the out-of-sample forecasts of such models is in section 6. Section 7 offers the conclusions.

2 Literature Review

There is an abundant literature on inflation models for individual Latin American countries, but not so many articles that include a group of them, even less that study long samples and even fewer, if any, that apply out-of-sample forecasting comparisons. Some of the most important works on analysis of several Latin American countries are Marcet and Nicolini (2003, 2005) and Sargent, Williams and Zha (2009). Those articles mainly study high inflation periods and tie them to money growth for public deficit financing. They do not present any out-of-sample forecasting exercises.

Mexico is included only in the sample of Marcet and Nicolini (2005) although it never faced hyperinflation.[3]. This country is interesting because, as those authors show in their Figure 1.d, the relationship between money growth and inflation becomes less clear since the beginning of the 80s and breaks down completely from 1987 to 1995, precisely when inflation reached its highest levels.

Actually, the relationship between money growth and inflation has become weak in most economies during the last few decades. Teles and Uhlig (2013) uncovered, in a multi-country study, that since 1990 “With low variability of inflation it is not easy to find a one-to-one relationship between inflation and money growth.” According to Lucas and Nicolini (2013), in the United States “Long standing empirical relations connecting monetary aggregates like M1, M2 and the monetary base to movements in prices and interest rates began to fall apart in the 1980s and have not been restored since.”

The breakdown of the historical relationship between money and inflation has not been completely incorporated into regular discussions among economists. This could be seen in the disagreement among leading economists on the likely effect on US inflation of the Federal Reserve’s unprecedented monetary expansion . The predictions on this potential effect included positions that considered that: a) it would be inflationary; b) it would do nothing to inflation; c) it would be deflationary and; d) it could

[3]With annual data, its highest rate of inflation was 99 percent in 1987 although the twelve-months inflation reached its peak at around 150 percent at the beginning of 1988

do anything (indeterminacy). This debate took place mostly in blogs although there were some academic papers about it (for example, Williamson 2013, Schmitt-Grohé and Uribe, 2013, and Cochrane, 2014).

More generally, statistically solid relations between inflation and any other variables, not only money, have become hard to find. For Latin American countries, Schmidt-Hebbel and Werner (2002), among many others, found that the exchange rate pass-through, traditionally very important in explaining inflation in these economies, had become weak since the adoption of inflation targeting. Thus, models of inflation based on either money or the exchange rate have become rare. This makes important to ask how good other models are to forecast inflation. A possible answer could be obtained by looking at their performance in advanced economies, where they have been in use for a long time.

In developed economies, there has been ample evidence that other types of inflation models are not so great in forecasting inflation either. Stock and Watson (2007) point out that since the beginning of the Great Moderation, the predictable component of inflation has diminished. This finding was confirmed and extended to other developed economies by Faust and Wright (2013). Edge and Guykarnak (2011) show that although the claim that the Smetz and Wouters (2007) model produces forecasts as good as those of a Bayesian VAR remains true, in absolute terms the forecasts from both techniques are poor.[4] The bad forecasting performance of Phillips curve models became clearer during the financial crisis. Indeed, in both the United States and the euro zone, inflation did not seem to react to measures of idle capacity as existent models had suggested. This was known as the "missing deflation puzzle," that led Hall (2011) to propose that inflation could be regarded as a "near-exogenous" variable in macroeconomic models. Baretto et al. (2013) even propose a vertical Phillips curve, where inflation changes are unrelated to economic activity.

As a response to that, Del Negro et al. (2014) showed that the Smetz-Wouters model augmented with financial frictions was able to replicate the behavior of inflation and GDP during the recent crisis if the Phillips curve is very flat. Christiano et al. (2014) obtained a similar result by introducing into a New Keynesian model the fall of multifactor productivity and the rise of working capital costs seen during the Great Recession. Despite their great promise, these results do not necessarily imply that the Phillips curve will provide accurate predictions in the future nor that they have solved the problems

[4]The Smetz and Wouters (2007) model has become the standard for New Keynesian DSGE models and it has the nice features that it is estimated instead of calibrated and it is closer to be competitive in forecasting than any other model of its kind.

that model had in the past.

As a matter of fact, the problem of accurately predicting inflation might not have a simple solution. For example, Goodfriend and King (2009) showed within a stylized model that inflation becomes hard to predict based on the output gap if the central bank has credibility as an inflation fighter. A similar result seems to be applicable to the Latin American countries that credibly adopted inflation targeting. In several of those economies, inflation inertia has been reduced and, sometimes, inflation even behaves like noise around a constant.[5]

For emerging countries, the comparison in terms of pseudo out-of-sample forecasting performance of different inflation models is even scarcer than in the case of developed economies. One work that makes such comparisons for Mexico is Baillieu et al. (2003) who found that for the period 1983-2000 models based on the exchange rate easily beat other types of models.

Many studies of inflation implicitly or explicitly assume regime changes. The most common way to incorporate such assumption is the selection of a sample period with arbitrary start and end points. The typical justification is, if there is one, the existence of some supposedly important change in economic conditions. Although often very informative, those studies rarely prove the relevance of such regime changes and they are frequently silent on what happens out of those time boundaries.

The regime shifts here considered are based in changes in the parameters that determine Granger causality, which in the context of cointegrated systems are expressed as modifications of the weak exogeneity properties. In particular, a new regime is identified if the properties of Granger causality among variables in the system is modified. This is an unusual exercise but it is very useful in order to understand the changes in the dynamics of inflation. One of the very few papers that deal with changes in the causality structure within a cointegrated VAR is Barassi et al. (2007), who also expressed their surprise for the lack of tests for such changes, that they consider more likely than those in the cointegration coefficients. They propose some tests to detect a change in the adjustment coefficients in simple bivariate systems. Although they mention some possible situations where those changes could happen, they do not provide an explicit empirical example and base their study on simulated data.

One reason for the lack of analysis of changes of regimes defined by Granger causality might be that such mutations in the dynamics are hard to detect and regular methods to study cointegrated systems typically do not work with them. For example, likelihood ratio tests, as those in the Johansen

[5] That is with annual data. With quarterly or monthly data there might be seasonal factors and some autoregressive terms which are statistically significant.

method, run into trouble. Kurita and Nielsen (2009) show that when changes occur in the adjustment parameters, the Johansen's method is not applicable because "[those changes] are reflected in the impact parameter of the common stochastic trends, thereby affecting the asymptotic distributions of cointegration rank tests." Because of this, the approach here is to use unbalanced regressions and error-correction mechanisms to test for regime changes and cointegration.

3 Data and Unit Root Tests

Most of the data for this paper, with some exceptions, are taken from the IMF's International Finance Statistics (IFS). The frequency in all cases is annual. The series for Mexico were obtained from national sources (Inegi and Banco de Mexico). For this reason, the sample for Mexico starts in 1932 while for the others it begins in either 1950 or 1960. In all cases the sample ends in 2013. The price level for Brazil was obtained from the site Ipeadata. For Chile, the IFS series of currency starts in 1986 so money is mostly excluded from the corresponding analysis. However, the model with the exchange rate for that country works quite well so the missing data might not be so important after all. The US CPI series was obtained from the Bureau of Labor Statistics.

There are problems with the data of Argentina and Venezuela that are commented later as they affect the evaluation of the forecasting models. In the first country, the series for the official consumer price index was under scrutiny by the International Monetary Fund at the end of the sample. For Venezuela, for several years at the end of the sample, the exchange rate series in the IFS was probably not the reference that price setters were using given its wide disparity with the exchange rate in the parallel market.

The variables are in logs and represented by small case letters. As the data of different countries is never mixed, one letter represents the same variable for all countries. The local price level (p) is the corresponding CPI while the foreign price level (p^{us}) is the US CPI. The nominal exchange rate (e) is in local currency per dollar. The monetary aggregate (m) is currency. The measure of economic activity (y) is GDP.

Table 1 contains the Augmented Dickey-Fuller (ADF) unit root tests. The series for Argentina, Brazil, Chile and Mexico uniformly show that the variables in levels contain a unit root while in first differences they do not. However, the rejection of the unit root hypothesis is borderline in some cases, as it happens with inflation in Argentina and Brazil, where the unit root hypothesis is rejected only at the 10 percent level of significance. In the case of Chile the level of confidence is 5 percent while for Mexico is 1 percent. It is assumed that these and other differences are the result of the way central banks have conducted their monetary policy and they will be reflected in the form of the inflation models. Both the unit root properties and the form of the inflation models seem to be related to different targets set by the respective central banks.

— Table 1 here —

4 The Theoretical Framework and a Test of Regime Change

This section contains two closely related parts. The first one describes the conceptual model on which the analysis is based. In particular, it describes the long-run relations that are the base of the models for the periods when there was an easily identifiable (Granger) cause of inflation. The second part describes the role of the long-run equilibrium conditions in a test for regime change.

As in any other similar definition, a regime change here consists of a change of parameters. The main difference here is that the changes happen to be those that determine the directions of Granger causality. When the relations are among nonstationary variables, the parameters involved are those of speed of adjustment (also known as feedback parameters). This is crucial because, it imposes unusual restrictions on the formulation of the statistical models and the estimation methods that can be used. For example, Johansen's reduced-rank method cannot be used, as it will be discussed with some detail later on.

4.1 The Theoretical Framework

The monetary model for Latin American economies was used successfully by Marcet and Nicolini (2003, 2005) and by Sargent et al. (2009). The first authors constrained their study to periods with very high inflation but that of Sargent et al. (2009) goes to 2005, including years of moderate inflation. These authors include the public deficit as a key variable in their models and consider money to be the only direct driver of inflation. In contrast, the analysis presented here differs because in that it considers that money is just one instrument of several that can be used or not by the central bank, even when inflation is high. One example of when this could be happening is when a central bank targets a competitive exchange rate.

Despite the empirical success of the models in those papers, the monetary approach has been mostly abandoned. The reasons for this are two. First, it is commonly believed that the monetary model works only during periods of high inflation or the very long run (Romer, 2011). Second, the monetary model is regarded essentially as a relationship between money growth and the inflation rate where the former causes the latter. Given the ample evidence that shows that such causality and even the simple contemporary correlation between these two variables have weakened, it would seem that a monetary model has no place in modern times.

However, when it comes to forecasting there is not an obvious superiority of other approaches in a low inflation environment. As mentioned in the literature review, they did not produce good forecasts during the crisis and before. Thus, if there is not really a clear gain in forecasting power by switching models, one might as well stick with the monetary approach with some slight modifications that improve its fit to the data and the pseudo out-of-sample forecasting exercises.

In this paper, the central bank's reasons to pursue certain path for the price level or the inflation rate are not studied. Instead, the paper concentrates on the direct relationship of inflation with the central bank choices of targets and instruments. This allows to improve the goodness of fit to the data and to produce good pseudo out-of-sample forecasts within each regime. This is done through the identification of changes in the Granger causality properties.

The central bank can target either the price level or the inflation rate. For either objective, it can choose as its instrument a monetary aggregate, the exchange rate, an interest rate or a combination of them although, in most of the cases here examined, typically it will use just one instrument.

Such choices determine the dynamics of inflation only for the period when they are applied. This is what allows the use of the same theoretical framework to study each case for all available data of these Latin American countries. The identification of targets and instruments is purely empirical, dictated by the model's best fit for the data although in some cases key historical events signal when the changes of instrument or target ocurred.

Thus, the simplest version of the classical monetary model for a small open economy is based on an exogenous process for GDP, the QEM, the PPP condition and a rule that relates the objectives of the central bank with the price level or the rate of inflation. This rule can either be of the type used by Sargent et al. (2009), if the central bank is using money as its instrument, or another where the exchange rate is the instrument. The central bank can also set its policy with a rule that relates its inflation target with its policy interest rate (i.e., Taylor's rule).

In the Cagan (1956) money demand equation, which Marcet and Nicolini (2005) and Sargent et al. (2009) adopt, the scale variable (for example GDP) is completely excluded because with very high inflation its variations matter little. As there are significant periods when inflation was moderate or low, the approach here is to use the QEM in its traditional form. This is a long-run relationship where the price level is determined when the central bank uses money as its instrument.

The empirical analysis also gives a central role to PPP as a long-run equilibrium condition where the price level can be determined if the central bank opts for using the nominal exchange rate as its instrument. When the central bank adopts an inflation targeting approach, the price level is not longer determined within the QEM or the PPP equations. Instead, the price level fluctuates around a trend related to the inflation target.

$$m_t - y_t - p_t = -v_t \sim I(0) \quad (1)$$

$$e_t + p_t^{us} - p_t = rer_t \sim I(0) \quad (2)$$

Relation (1) is the QEM. Here, the price level, p_t, currency, m_t, and output y_t, are the determinants of money velocity v_t. Money is currency and so it can be considered as a real policy instrument, as opposed to broader aggregates. Equation (2) is the PPP condition, where to be a valid long-run equilibrium condition the real exchange rate rer_t has to be stationary.

These relationships are the starting point for the inflation models for Argentina, Brazil, Mexico and Chile because those countries had at some point a de facto price-level targeting regime tied to either money or the exchange rate. However, those relationships do not hold for either Colombia nor Venezuela despite the fact that money or the exchange rate have had a significant impact on inflation at some point. For these countries, the model of price level targeting cannot be applied.

It might be useful to state that QEM, or a more general money demand for two countries, along with the PPP condition and an uncovered interest rate parity are the ingredients for the monetary model of exchange rate determination. Despite the similarities, this investigation is not trying to study the exchange rate but the rate of inflation. In principle, it is possible to study both for the same ticket but that would stray the paper from its objective.

Nonetheless, before going into the empirical analysis, it is important to notice that equations (1) and (2) imply equation (3), often seen in studies of the classical monetary model for the exchange rate (Here, it will be used differently):

$$e_t + p_t^{us} = m_t - y_t + z_t^{e1} \quad (3)$$

where the residual $z_t^{e1} = rer_t - v_t$ is stationary. This equation can be used to study any of the variables in it but here this relationship will be useful to carry out some tests for Argentina, Brazil and Mexico. Thus, it will be helpful to keep in mind the relations among equations (1) to (3). They will be used below in some simple algebraic substitutions in the context of a test for a regime change.

4.2 A Test of Regime Change

This section offers an explanation for the test of regime changes for nonstationary variables and the role of equations (1) to (3) in it. The regimes here are defined by their Granger causality properties. Thus, there is a regime change when the Granger causality properties of the system change. A simple example is that if inflation was being driven by money in a regime but at some point such causality disappears, then there is a regime change.

This section describes a regime change test that applies when an economy starts from a monetary regime with price level target driven by a given instrument (money or the exchange rate). The test was used to detect the following cases: a) The economy remains in one regime for the whole sample (Argentina and Chile); b) the system retains the price level target but the instrument changes, for example money for the exchange rate, (Mexico and Brazil); c) the economy abandons price level targeting and moves into an inflation targeting regime (Brazil, Chile and Mexico).

To see why this test works, one has to consider the following. A price level target is at work when a percentage increase in the amount of money or the exchange rate, but not necessarily both, will be reflected as a similar increase in the price level in a long enough period. If money is the driving variable in a price determination regime, inflation would have as a chief explanatory variable the lagged velocity of money v_{t-1} in an error correction mechanism. On the other hand, if the exchange rate is the causing variable, then the lagged real exchange rate rer_{t-1} enters as an explanatory variable for inflation in an error correction mechanism.

However, there is further insight in considering an equivalent alternative yet unusual model for inflation if equations (1) to (3) hold during the periods when there was price level determination. This alternative model will be the base of the test for a regime change when there is a situation of this sort.[6] The alternative model uses the lagged values of the variables in equation (3) ($(e+p^{us})_{t-1}$ and $(m-y)_{t-1}$) instead of both v^{t-1} and rer^{t-1}. This alternative model should work if relations (1) to (3) hold. Later on, the alternative model will be used for an "unbalanced regression," which exact meaning will be discussed below.

First, it is important to realize that the coefficients of ($(e+p^{us})_{t-1}$ and $(m-y)_{t-1}$) must be of similar absolute value but opposite sign, as equation (3) implies. Second, in a regime when money is the driving variable, the variable $(e+p^{us})_{t-1}$ should have a negative sign. This is because equation (2) shows that such variable can be replaced by the lagged price level (plus a stationary error term that should not affect the estimated coefficient) and the coefficient of this must be negative in a model for inflation. Third, for a similar reasoning, in a regime where the exchange rate is the driving variable, the sign of $(m-y)_{t-1}$ should be negative.

Now, the test consists in estimating the alternative model for different samples and looking at what happens to the signs of the estimated coefficients. When equations (1) to (3) hold, the absolute value of the coefficients for ($(e+p^{us})_{t-1}$ and $(m-y)_{t-1}$) should be similar but their signs should be opposite in each subsample, as discussed above. The following cases were observed (countries can be mentioned in different cases because they could have experienced more than one regime change):

If the coefficients become statistically insignificant from a subsample to the other, then the monetary regime is not longer based on price level targeting. This occurred when countries moved into an inflation targeting regime (Brazil, Chile and Mexico in the last subsample). If the coefficients of each variable remained statistically significant then the monetary regime was still based on a price level target and two cases arise.

If the coefficients of those variables remain significant from one subsample to the other and the signs remain unchanged, the system continues in a price level determination regime with the same driving variable for the whole price level determination sample (Argentina and Chile, respectively). However, if the coefficients remain significant from one subsample to the other but they switch their signs, then the system has moved from one monetary regime with price level determination into another with a different driving variable (Mexico and Brazil).

The test above are not applied neither to Colombia nor to Venezuela because those countries have not had a price level determination so the coefficients are both statistically zero. This is because, as

[6] It is important to stress that such relations do not need to hold for the whole sample, only for when there was price level determination.

will be seen later, even though money and/or the exchange rate could have had important effects on the rate of inflation, the pass-through of any of those variables on prices has never been complete in both economies. Thus, for those countries a simpler and more direct approach was followed. This consists in looking at the behavior of the residuals of an initial regression based on either money or the exchange rate and then using an alternative model when there is evidence of a bad goodness of fit of the initial model. With this method it was found that Venezuela did have a regime change in the seventies while for Colombia is unclear.

5 Empirical Results

Several Latin American countries faced periods of high inflation. Those episodes coincided with situations of high fiscal deficits. Argentina, Brazil and Chile had periods of hyperinflation and are included in the sample studied by Sargent et al. (2009). They have, in that order, the highest average and variability for the inflation rate from 1950 to 2013. Periods of hyperinflation usually lasted just a few months. Since the nineties, most Latin American countries began enjoying the fruits of their policy reforms. Their macroeconomic indicators became less volatile and they were able to cope better with external shocks. The commitment to control their public deficits and the concession of legal autonomy to their central banks was key to success in several of them. In a sense, many Latin American countries reached their "Great Moderation." However, there are exceptions. Argentina and Venezuela still have to reach an environment of price stability as they still lacked the necessary fiscal framework and an autonomous central bank during the period under analysis. This last characteristic was also absent in Brazil.

Given their different circumstances, there cannot be a general inflation model for all of these economies and all times. Instead, a particular model is obtained for each country within each regime. This serves the main purpose of improving the pseudo-out-of-sample forecasting performance along the whole available sample. As central banks might change their objectives and instruments, the best variables to explain and forecast inflation might change and they did in most cases.

For the case of Mexico, there were well-identified dates of historical events that caused a change in the behavior of inflation. For the rest of the economies, when no public policy statement was identified, the general strategy was to fit a parsimonious inflation model for as long as the residuals are more or less well behaved. If a strong change in the behavior of the residuals was detected, a further analysis is carried out to see if there was a regime change where another inflation model fits the data better. The models for Mexico, Brazil and Argentina are studied with a customized test for regime change described in section (4).

5.1 Mexico

For this country, there were two publicly known events that were clearly reflected in the behavior of inflation. From 1932 to 1981, the Mexican central bank conducted its monetary policy determining the money supply to keep a constant real exchange rate. However, as the fiscal deficit was sometimes financed with currency creation, there were bursts of inflation. They were always followed by a proportional devaluation to reestablish the PPP condition. This process entailed a de facto monetary regime with a price level target achieved through the use of currency as the instrument.

In 1982, Mexico modified its macroeconomic policy framework. Two of the changes were crucial. One of them was the restriction to finance the public deficit with central bank credit. The other was a tendency to pursue a real exchange rate strategy to face current account problems.

From 1983 to 2000 the central bank determined the path of the price level but this time through exchange rate management. Although, from 1995 onwards, the country adopted a floating exchange rate regime, the relationship between the exchange rate movements and the rate of inflation continued as before. Thus, even with the floating exchange rate, the years 1995 to 2000 are placed in the regime when the exchange rate determined the price level.

However, when the central bank finally adopted an inflation targeting regime in 2001, the pass-through of exchange rate movements on the rate of inflation was considerably diminished, except for a brief episode around the financial crisis, as happened in other Latin American countries. The impact of these events are studied first through unbalanced regressions and then with parsimonious inflation models.

5.1.1 Unbalanced Regressions

There are no general tests to prove a regime change in the long-run causality properties of a cointegrated system. Nonetheless, the special characteristics of the inflation process in Mexico allow the application of the procedure described in the previous section. These special characteristics are that both the QEM and PPP seem to hold during the price level targeting period and that the dates of policy change are known. As discussed above, one can use equation (3) to see if there was a regime change. The idea is that if such relationship holds then the signs of the parameters are of similar absolute value and change if they are used in a model for inflation. In particular, one can estimate the following inflation model:

$$\Delta p_t = \beta_m (m - y)_t + \beta_e (e + p^{us})_t + \phi_m \Delta m_{t-1} + \phi_e \Delta (e + p^{us})_{t-1} \quad (4)$$

The left-hand side is a stationary variable. Those variables inside the parentheses are related to the price level through the QEM and PPP, respectively. However, they have stochastic trends and thus they lead to an *unbalanced regression*. As this is an important concept to be used here, it is useful to say some words about it.

An unbalanced regression is called so because the dependent variable has a different order of integration than some or all of the regressors. In general, for this kind of regressions neither regular statistics nor cointegration methods can be used to make inference. It is often thought, incorrectly, that all unbalanced regressions are spurious. A common counterexample to that assumption is the regression used in the ADF test, where under the null hypothesis the right-hand side variable is an I(1) variable and the left-hand variable is I(0). Another example is the unrestricted conditional error correction model. Thus, according to Banerjee et al. (1993), an unbalanced regression should not be a matter of concern "as long as the correct critical values are used." This is crucial for the test.

To interpret equation (4), suppose that money is the driving variable for inflation. In this case the sign of the estimated parameter for $(m - y)_{t-1}$, β_m, should be negative. Now as PPP holds, β_e should be positive for reasons explained in the previous section. Moreover, the absolute value of β_m and β_e should be similar. This is because PPP allows the substitution of $(e + p^{us})_{t-1}$ for p_{t-1} plus a stationary error term that has no effect in the long run relationship. This substitution transforms the unbalanced regression into a conditional unconstrained error correction model (4) for the QEM where it is possible to use a standarized test for cointegration based on the Ericsson and MacKinnon (EM, 2002) tables.

Now, if the driving variable for inflation is the exchange rate then one can proceed in a similar way. This time the sign of the estimated parameter for β_e in equation (4) should be negative and β_m positive. Again, the absolute value of both parameters must be similar. This allows now the substitution β_m for p_{t-1} plus a stationary error term that has no effect in the long run relationship. The model for inflation is then another error correction mechanism for the PPP condition. Those sign changes and similar absolute values for the coefficients of the variables with stochastic trends occur only if the economy has moved from a money-based regime for inflation into another based on the exchange rate.

These switches in the sign of the coefficients imply variations in the speed of adjustment parameters in the models for inflation that change from being strongly significant in one regime to being zero in another regime and vice versa. This entails particular aspects that are not present in other types of models of regime or parameter changes. Indeed, those changes in the adjustment parameters from significant to zero and from zero to significant have implications on which other variables can enter into the short term dynamics of inflation. For example, when the coefficient β_m is negative then the contemporary variation of the exchange rate cannot enter as an explanatory variable for inflation because that variable is weakly endogenous in that regime. If the economy moves into a regime dominated by the exchange rate (i.e., when coefficient β_m is negative) then the contemporary variation of money cannot enter as an explanatory variable because it is a weakly endogenous variable. Finally, when neither money nor the exchange rate are determinants of the price level both β_m and β_e should be zero because even if $(m-y)_{t-1}$ and $(e+p^{us})_{t-1}$ cointegrate, they have no impact on inflation.

Because of the above, only the model for the whole sample includes the contemporary changes of both variables although, under the particular type of regime change just described, this should be incorrect. Also, as explained before, for the first regime, only currency growth is included. For the second regime only the change of the exchange rate is included. For the third regime neither variation is included but this makes no difference as they tend to be no significant anyway (except for one exception discussed later).

The results, obtained with the procedure general-to-specific inside the regime and the required constraints on the regressors, are in Table 2. In all models, the lagged levels of currency and foreign prices were included, but the presence of the contemporary changes of these variables depends on the assumed monetary regimes to avoid endogeneity problems. Thus, the model for the whole sample includes the contemporary changes of both variables. For the first regime, only currency growth is included. For the second regime, only the change of foreign prices are included. For the third regime, neither variation is included but in any case they are no significant. All estimated coefficients and tests statistics are in Table 2.

— Table 2 here —

It should be said here that in the tables for regressions the abbreviations “n.s.” (not significant) and “n.i.” are frequently used. The first abbreviation serves to indicate that initially one variable was included but it was deleted as part of the general-to-specific simplification process. The second abbreviation means that the variable cannot be included because it is endogenous inside the particular regime where the estimation was applied.

In all the equations, as expected, the estimated coefficients for lagged inflationary money $(myb - y)_{t-1}$ and foreign prices $(e + p^{us})_{t-1}$ are nearly identical in absolute value but with opposite signs. Thus, by considering that the absolute values are the same, one can factorize them and obtain equation (3), which is therefore confirmed as a valid long-run equilibrium relationship.

For the whole sample, those lagged variables have small coefficients (0.07 and -0.07) and small t values. It is important to remember that the distribution of these t statistics is not normal because the variables are nonstationary. As the asymptotic distribution for these statistics depends on the variables involved (Pagan and Wickens, 1989), there are no standardized tables to evaluate their significance. Fortunately, there is a useful detour.

From the definition of real exchange rate one can substitute $(e + p^{us})_{t-1}$ for $p_{t-1} + rer_{t-1}$ in the regression of the first column of Table 2:[7]

$$\begin{aligned} \Delta p_t &= 1.25 + 0.07(m-y)_{t-1} - 0.07(e + p^{us})_{t-1} + 0.51\Delta m_t + 0.34\Delta e_t \qquad (5) \\ &\quad +0.19\Delta e_{t-1} + \hat{u}_t \\ &= 1.25 + 0.07(m-y)_{t-1} - 0.07p_{t-1} + 0.51\Delta m_t + 0.34\Delta e_t \qquad (6) \\ &\quad +0.19\Delta e_{t-1} + (\hat{u}_t + 0.07rer_{t-1}) \end{aligned}$$

In the second line, $(e + p^{us})_{t-1}$ is substituted by p_{t-1} and $0.07rer_{t-1}$ is added to the original estimated error term to obtain a new error term $(\hat{u}_t + 0.07rer_{t-1})$. This becomes an unconstrained error correction model where inference is easier. The coefficient for the lagged price level inherits the t-value of -2.45. According to Table 3 in Ericsson and MacKinnon (2001) for a constant term and five regressors, the critical value of 10 percent of significance is -3.66. This confirms that the lagged nonstationary variables are not significant in this equation.

This happens because the sample includes three different regimes that generate a cointegrated vector autoregression (CVAR) with a different matrix of adjustment parameters for each regime. However, the changes of money and foreign prices are highly significant so money and the exchange rate give the

[7] It would be incorrect to substitute $(m - y)_{t-1}$ for p_{t-1} because the coefficient for the lagged price level must negative in order to have a valid error correction model.

illusion of being causes of inflation during the whole sample despite their well-known lack of predictive power since 2001. This is the result of not considering endogeneity problems caused by changes in the causality properties. In fact such problems can be seen directly in that the new error term, that includes the lagged real exchange rate, is correlated with the contemporary variation of the nominal exchange rate. This model fits the data within sample well but it performs porrly in out-of-sample forecasting, as will be seen in the next section.

Another aspect to note is that for regimes 1 and 2, the signs for the variables with a stochastic trend switch: In regime 1, the coefficient for $(m - y)_{t-1}$ is positive and that for $(e + p^{us})_{t-1}$ is negative. For regime 2 the opposite happens. This is the result of a regime change. To see this, one can make substitutions of variables. For the first regime, the PPP condition allows the substitution of the lagged foreign price level $(e + p^{us})_{t-1}$ for its long-run equivalent, the lagged price level p_{t-1}. With this, the unbalanced regression for the first regime becomes equivalent to an unrestricted error correction model.

Notice that the error term of the transformed regression now would contain an added term proportional to the lagged real exchange rate, as in equation (7). However, the new error term is still orthogonal to the regressors because during the first regime the lags of the real exchange rate do not impact contemporary values of money velocity. The t-statistic of -6.11 is far more negative than the critical value of 1 percent of significance of Table 3 for for three regressors (-4.09) of Ericsson and MacKinnon (2002), confirming the cointegration property for this relationship.

For the second regime, the QEM allows the substitution of lagged inflationary money $(myb-y)_{t-1}$ for the lagged price level p_{t-1}. From this, another conditional error correction model for inflation results but this time for regime 2 . Because in regime 2, the contemporary and lagged values of money velocity are uncorrelated with the real exchange rate, the new error term is still orthogonal to the regressors. The second lag of the inflation rate had to be added in order to eliminate autocorrelation in the regression errors. With this, the t-statistic coefficient for $(myb - y)_{t-1}$ can be used to assess the validity of the regression. Its value is -5.66, which easily exceeds the critical value for the 1 percent significance level in the Ericsson-MacKinnon Table 3 with a constant term and four regressors, -4.36.

For the third regime neither money nor the exchange rate are systematic causes of inflation so they disappear from the model except for the contemporary exchange rate depreciation, which has a small coefficient. This is barely significant and comes from the impact of the 2008 crisis, as in other Latin American countries.

The modified unbalanced regressions allow to conclude that: 1) in the first regime the adjustment coefficient for money velocity is significant and the one for the real exchange rate is zero; 2) for the second regime, the adjustment coefficient for money velocity is zero and the one for the real exchange rate becomes significant; 3) For the third regime, the adjustment coefficients for money velocity and the exchange rate are zero. Now a model for inflation for each subsample can be estimated.

5.1.2 Inflation Models

The inflation models for each regime are improved versions of the ones in Table 2 and have much better statistical properties. There is an error correction mechanism with different explanatory variables for the first two regimes. As the third one has no systematic causes for inflation other than the inflation target itself, it has the simple structure of a constant for each period. None of the equations contains any lagged values of the inflation rate, meaning that inertial inflation had no role after considering the effect of the excess of money over the amount needed for transactions $(m-y)$, which for short is called “inflation money.” In regime 1, currency was the monetary policy variable so the inflation process is represented as an error correction model within the QEM system (equation (7)). The results are in the first numerical column of Table 3.

— Table 3 here —

$$\Delta p_t = c_m + \alpha_{pm}\ p_{t-1} + \alpha_m\ (m-y)_{t-1} + \phi_m\ \Delta m_t + u_t^{pm} \tag{7}$$

The t statistic for the lagged price level coefficient α_{pm} is negative and highly significant, according to the Ericsson-MacKinnon (2002) tables, indicating that the QEM equation is a cointegration relationship. The contemporary impact of money growth ϕ_m is strong. With a value of about 0.5, it shows that half the long-run impact of money on prices occurs in the first year. All statistical tests except the N-step projection are satisfactory.

In the second regime, the exchange rate is the only systematic cause of inflation. Thus, the model comes from the PPP condition with the price level as the error-correcting variable and both the exchange rate and the foreign price level as weakly exogenous variables:

$$\Delta p_t = c_e + \alpha_{pe}\ p_{t-1} + \alpha_e\ (e + p^{us})_{t-1} + \phi_e\ \Delta(e + p^{us})_t + u_t^{pe} \tag{8}$$

The coefficient for the lagged price level α_{pm} is highly significant, showing the PPP condition is a cointegration relationship with the price level as the adjusting variable. The size of that coefficient

(-0.7) plus the contemporary effect of a depreciation on inflation ϕ_e is very high, implying a quick convergence. The high adjusted R^2 implies that there is almost no room for other explanatory variables. All the statistical tests are satisfactory. In this period, the parameters of the model do not show any signs of instability.

For the third regime, the central bank abandoned a price level target and adopted instead a modern preannounced inflation targeting framework. In such regime, neither money nor the exchange rate are systematic causes of inflation. This role is played by the inflation expectation itself. If the central bank's target enjoys credibility, this substitutes the other two drivers of inflation. Because of this, the forecast of inflation based on other variables becomes difficult and the inflation target itself becomes a key reference to forecast annual inflation. Maybe some variables can help at higher frequency but one should not expect a big improvement.

Since 2001, inflation has not followed the exchange rate movements as in the past. The sharp depreciation of the Mexican peso during the financial crisis of 2008 was not followed by a similar increment in prices (although there was a small and transitory co-movement). Instead, the mean reversion property of the real exchange rate was reflected in a revaluation of the nominal exchange rate nearly enough to erase the effects of the crisis.

The estimate for the autoregressive term is negative but nonsignificant. The only significant parameter turns out to be the constant, which is the average percent change of the price level during the inflation target regime. In the last couple of years such constant has decreased. The situation is similar to that of several other economies that have adopted an implicit or explicit inflation target, where the inflation process becomes close to noise around a constant. Actually, the weakening of the relationship between the inflation and the depreciations rates has been widely documented for Mexico thorough different statistical procedures.[8]

To end this section, it is useful to show graphically what happens to the behavior of residuals when a model changes regime. This simple procedure will be the basis for the identification of regime changes in the cases where no publicly known date of policy change is known. The good statistical properties of the regression for regime 1 in Table 3 are only maintained within the given sample (1932-1981). If

[8]See, for example, Capistrán et al. (2011) and Cortés (2013). The numerical differences between their results for the passthrough coefficient and that of this paper can be traced to the fact they use a VAR with many variables while this paper uses single equations. Those papers coincide in that the passthrough coefficient fell strongly since the adoption of inflation targeting in 2001.

one or two years are added to that subsample, the model begins to break down. This can be seen in Figure 1, that shows the actual and fitted value for inflation along with the residuals for a regression of inflation with the same explanatory variables but a sample augmented with two more years (1982-83). The residuals show that the regression fails completely in capturing the behavior of inflation in 1982 and 1983, producing two large outliers. This is important because this is one of the things that should happen if there is a regime change and the dependent variable is moving a lot. Of course, a Chow test (not reported) for the years 82-83 easily rejects a constant regime. This procedure to detect a monetary regime changes is applied to the cases of other countries where there are no public events or references that indicate them.

5.2 Brazil

The analysis for Brazil is similar to that of Mexico in that the South American country passes for the same regimes and even its corresponding dates of regime change are close to those of the other country. Because availability in the IFS database, the sample for this country is much shorter than that for Mexico as the real GDP series starts in 1963. The time span for the estimation goes from 1964 to 2013.

As in the case of Mexico, there are three regimes. In the first, from 1964 to 1979, the central bank had a price level target and money was the driving nominal variable. In the second, from 1982 to 1998, there was also a price level target but the exchange rate was the leading variable. In the third regime, from 1999 to 2013, there is an inflation target that was not tied to neither money nor to the exchange rate.

First, one has to explain how the dates of regime change were identified and afterwards a proof that these regime changes did occur with a procedure based on unbalanced regressions similar to that applied to Mexico. Following the example at the end of the section for Mexico, the dates of regime change were identified as follows. A regression based on money was obtained recursively from 1964 to 1972 and forward. To reduce the number of tables, the same regressions that end up as the final models are used here to show how the change points were identified. The first column Table 5 contains the estimates for this model from 1964 to 1979 and it works fairly well, as discussed below. However, extending the estimation sample forward the residuals become much more volatile suggesting that the model breaks down during the added years.

Figure 2 shows the residuals of the same model from 1964 to 1982. This behavior was interpreted as evidence of a monetary regime change. The end of the first regime was chosen at 1979. The next two years were transition years and it was difficult to find a place for them in any regime.

— Figure 2 —

In 1999, the Brazilian central bank had to give up its predetermined exchange rate system and adopted a flexible one. Along with several measures of fiscal restraint, the country adopted an inflation targeting framework, which has been in place ever since. Thus, the second regime begins in the early eighties and ends in 1998. The third regime, with inflation targeting, goes from 1999 to the end of the sample.

5.2.1 Unbalanced Regressions

As in the Mexican case, it is possible to show that the regime changes in the Granger causality structure happened at the given dates with the use of unbalanced regressions. The results are shown in Table 4. As in the case of Mexico, for the whole sample (first numerical column), the two trending variables are nonsignificant while the ones for the contemporary changes of money and the exchange rate are highly significant and they add close to one. Furthermore, all tests displayed are passed easily. Thus, at first sight it looks as if money and the exchange rate have always been simultaneously important to determine the inflation rate in Brazil. However, this is wrong because that regression does not take into consideration that these explanatory variables switch the property of weak exogeneity.

— Table 4 —

To account for this aspect, a model for each regime must be estimated. The estimation for the first regime (1964-1979) does not include a constant. Instead, it includes an impulse dummy variable for the year 1968 for an outlier that causes the regression to break down. The estimated coefficients for the two trending variables, $(m-y)_{t-1}$ and $(e+p^{us})_{t-1}$, are very similar but with an opposite sign (0.23 and -0.27, respectively). As explained above, this implies that the quantitative equation of money was the rule to determine the price level in that period.

These unbalanced regressions must be turned into unrestricted conditional error correction models for which tabulated critical values exist (Ericson and MacKinnon, 2002). For this, the trending variable with the negative coefficient, $(e+p^{us})_{t-1}$, must be substituted by the lagged price level plus the lagged real exchange rate. This allows to compare the t value of the coefficient,-4.61, with the critical values from Table 3 of EM. This value easily exceeds that for four variables at the 1 per cent of significance (-4.36).

The estimates for the second regime (1982-1998) are in the third numerical column. Notice that 1980 and 1981 are left out because they are transition years that do not seem to fit well in either the first or the second regimes. This is equivalent to arbitrarily include them in either regression along with an impulse dummy variable for each year. Something similar happens with Mexico, where the transition year 1982 does not fit in any regime. This is a problem with other countries as well and it has been found in other studies on these countries. The causes are not clear but they suggest factors such as destabilizing expectations or a dollarization process (see Sargent et al. 2009).

The coefficients for the trending variables, $(m-y)_{t-1}$ and $(e+p^{us})_{t-1}$, are again similar in absolute value with opposite signs but these have switched. This is precisely the evidence of a regime change through the weak exogeneity property: one of the variables ceased to be error correcting and, as there must be at least one with this property, the other one becomes error-correcting.

To convert this unbalanced regression into a conditional error correction model, the variable with the negative sign, $(m-y)_{t-1}$ is substituted by the price level minus money velocity. This makes possible to compare the value of the t statistic -3.77 with the corresponding critical values of Table 3 in EM (for the 5 percent level is -3.5).

The estimated coefficients for the variables with stochastic trend in the third regime (1999-2013) are very small and far from being significant. This indicates a new regime change, where neither money nor the exchange rate determine the price level. Thus, there are two regime changes for the inflation process similar to those in Mexico.

5.2.2 Inflation Models

Now it is possible to obtain an inflation model for each regime. Table 5 contains the estimates. In regime 1 (1964-1978) the price level was determined within the QEM system. The first numerical column shows that the coefficients for the lagged price level and inflationary money have the right signs and similar absolute values (-0.61 and 0.66, respectively). The t value for the first of these variables is -5.92, which exceeds by far the critical value for the 1 percent level of significance from Table 3 of Eriscsson and MacKinnon (2002). The contemporary change of money has a coefficient of 0.31. The goodness of fit is very good although the regression fails two recursive tests.

— Table 5 here —

For regime 2, the price level was determined within the PPP condition. This is validated by the signs and similar absolute values of the coefficients for the lagged price level and foreign prices in local currency (-0.94 and 0.99, respectively). The t value for the first variable is also very high, proving that PPP is a long-run equilibrium relationship for Brazil. The contemporary rate of change of the exchange rate has a coefficient of 0.60. This coefficient and the high value of the speed of adjustment imply that the impact of a devaluation on prices occurred much faster than in the case of Mexico. The only problem detected in the table is the failure to pass the N-step projection test.

For regime 3, neither money nor the exchange rate enter as determinants of the price level and they are not significant if they get included. However, the rate of depreciation retains a tiny impact on inflation with a coefficient of 0.04. This effect seems to come mostly from the years around the 2008 crisis, when the Latin American currencies were subject to strong devaluations that had a positive albeit tiny impact on inflation.

5.3 Chile

For Chile, the IFS series for the monetary aggregate start in 1985, so it is not possible to analyze the role of money for many decades back nor to test a change of regime as in the case of Mexico. Because of these missing data, for this country, no unbalanced regressions are estimated and only monetary regimes 2 (exchange rate based price level target) and 3 (modern inflation targeting) are considered. The date to divide both regimes is 1991, when the Chilean central bank adopted the inflation targeting framework.

5.3.1 Inflation Models

Table 6 contains the estimated models for Chile during regimes 2 and 3. There is something peculiar about the relationship between the Chilean price level and the nominal exchange rate. In the cases of Brazil and Mexico this relationship was set through the PPP condition but in the Chilean case the foreign price level is absent. It is necessary to leave out such variable because, otherwise there would not be a long-run relationship. Aside from this, the behavior of the model is very good. The signs of the coefficients of the trending variables are of the opposite sign, negative for the price level and similar in absolute value.

— Table 6 here —

The t value for the price level is -5.18, which is more than enough for a 1 percent level of significance, according to the Ericsson-Mackinnon (2002) table 3. The contemporary rate of depreciation is also significant with a coefficient of 0.28. Differently from the cases of Brazil and Mexico, there is strong inertia shown in the significance of lags 1 and 2 of inflation. This might be because of a persistent practice of nominal indexation in the Chilean economy from the 60s to the beginning of inflation targeting in 1990.[9] The model only fails the Cusum test. Figure 3 shows no particular problems with residuals.

— Figure 3 here —

The model for regime 3, that of inflation targeting, does not contain a long-run relationship, but it still has strong signs of inertia (a high autorregressive term) if one estimates the model from the declared starting date of inflation targeting (1990). This could be because indexation practices survived for a long time, even during inflation targeting (a shorter sample starting in 2001 contains a significative autoregressive term). The nominal rate of depreciation still has some explanatory power that disappears if impulse dummy variables for 2008 and 2009 are included. The model passes all the statistical tests shown.

5.4 Argentina

The most relevant aspect in the case of Argentinean inflation is that during the whole sample of data available (1950-2013), there has been only one regime for price level determination and inflation dynamics. This corresponds to the one where the central bank sets the path of the price level through currency with some effect of lagged depreciations. The inflation model is obtained from the QEM equation. In this regime, money is the best predictor of inflation and this remains true in the 2008-2013 period when there was a controversy surrounding the dependability of official inflation figures.

5.4.1 Unbalanced Regressions

The examination of the residuals from this model does not reveal any particular change in inflation behavior at any point of the sample (Figure 4). However, one can ask why a regime is based on money and not on the exchange rate as the driving variable of inflation. To decide the issue, one can apply the

[9] See Lefort and Schmidt-Hebbel (2001).

unbalanced regression (4), as in the cases for Mexico and Brazil. The results are in Table 7.

—Figure 4 here—

As in the cases of Mexico and Brazil, the coefficients of the trending variables, β_m and β_e, have similar absolute value with opposite signs. The one with the positive sign is β_m so money is the weakly exogenous variable. This is because, to validly introduce the lagged price level into this equation, its coefficient, or speed of adjustment, must have negative sign. The same happened in the cases of Mexico and Brazil, discussed above.

— Table 7 here —

The main problem for the inflation model is the big jump in money velocity from 1988 to 1992, which has been studied by many authors. For example, Kamin and Ericsson (2003) have to use a ratchet variable[10] to obtain an error correction mechanism for M3. They considered this effect the result of the accelerated currency substitution process (dollarization) in Argentina at that time. Such ratchet effect would not work beyond their sample (1975-1992) because dollarization eventually was reversed and money velocity has been falling since 1993 although it is still well below the levels it had before 1989.

5.4.2 Inflation Model

As the QEM relationship seems to hold before and after the 1988-1992 period, albeit at different levels of average money velocity. The solution proposed here is far from perfect but the resulting model is reasonable. The model, is similar to the ones for Brazil and Mexico for regime 1, where the central bank determines the price level through money. This is a conditional error correction mechanism based on the QEM equation where the error-correcting variable is inflation. As there is only one long-run relationship driving the inflation process, the depreciation rate enters only in lags, even though the inclusion of its contemporary value does not change the results much.

Table 8 contains the inflation model estimates for Argentina. The coefficients for the lagged price level p_{t-1} and inflationary money $(m-y)_{t-1}$ are each of the right sign and similar in absolute value (-0.21 and 0.23, respectively), which implies that the QEM has been holding during the whole sample and that the price level is the error-correcting variable. Lagged inflation Δp_{t-1} has a coefficient of 0.34 showing little inertia. The contemporary and lagged values of money growth Δm_t are significant

[10]This is a variable defined as "the maximum inflation rate to date" (Kamin and Ericsson 2003)that works as a step dummy variable that helps to produce a cointegration relationship.

as it is the lagged value of the depreciation rate Δe_{t-1}. Two dummy variables were needed to obtain normality in the residuals. The first is for 1986 and the second for 1989, when the big jump in money velocity discussed before began.

— Table 8 here —

The estimation of the model until 2013 causes some problems because the model projects higher levels of inflation (typically above 20 percent) than the ones in the IFS series (10 percent or less) but this is not a problem of the model. As a matter of fact, the official inflation figures were questioned since at least 2008. The IMF sent a formal request to Argentinian authorities to apply "remedial measures to address the quality of the official data reported to the Fund for the Consumer Price Index for Greater Buenos Aires (CPI-GBA) and Gross Domestic Product (GDP)."[11] Since 2008 PriceStats produced a consumer price index that implied rates of inflation above twenty percent as the model of Table does 8.

5.5 Venezuela

In Venezuela neither the QEM nor PPP hold exactly so the inflation models are not based in cointegration relationships. This precludes that the Venezuelan central bank had had a price level target. This country has had two regimes for inflation, one (regime 1) dominated by money, from 1961 to 1976, and another (regime 2) dominated by the exchange rate, from 1977 to 2013. This country has not entered yet into a modern low-inflation, floating exchange rate target regime so there is no regime 3.

The identification of the dates of regime change was based on the examination of the residuals of a regression of inflation against money growth (contemporary and lagged one period). The model behaves well until 1976 but it breaks down afterwards, as can be seen in Figure 5. From 1977 onwards the model does not fit the data at all. Therefore, a model based on the exchange rate was tried.

— Figure 5 here—

5.5.1 Inflation Models

Table 9 shows the estimated models for each regime. No obvious public event was found to be a good explanation for the change in dynamics so the identification date relied on the properties of the residuals. As happened in the cases of Brazil, Chile and Mexico, in each regime only one variable has a systematic effect on inflation.

[11] http://www.imf.org/external/np/sec/pr/2013/pr1333.htm

— Table 9 —

The first thing to notice is that none of the models has lagged levels of prices, inflationary money or the exchange rate. This comes from the fact that neither QEM nor PPP hold exactly. Instead, for regime 1 the contemporary and the lagged rate of change of the monetary aggregate. The summation of these coefficients is barely 0.27 and, because there is no autoregressive term, this is also the long-run effect of money on the price level. Thus, the QEM is not nearly met for Venezuela so the relationship between prices and money can be hard to see. The contemporary depreciation of the exchange rate was included in some models but it was not significant.

For regime 2, money ceases to be a systematic factor and the nominal exchange rate takes its place. For this regime, only the contemporary exchange rate depreciation was significant with a coefficient of 0.26. However, as there is an autoregressive term equal to 0.55, the long-run impact of a depreciation is equal to 0.58. The model, despite its simplicity, seems very stable, with most statistical terms easily passed. The moderate R^2 of 0.68 shows that the explanatory power of the exchange rate is not overwhelming, leaving a lot to be explained. However, money is not a variable that helps to explain inflation in this regime.

5.6 Colombia

Colombia consistently had two-digit inflation rates from the sixties to the end of the nineties. The value of the currency was managed through different predetermined exchange rate systems. Although, the correlation between price inflation and the depreciation rate was strong, PPP does not hold for this country. This suggests that the central bank never targeted a price level through PPP, as other major Latin American countries in regime 2 did. Since 1999, the country has used a combination of flexible and managed exchange rate systems, at least during some years.[12] Since then, it has gradually converged to a full-fledged inflation-targeting strategy, which probably began to achieve since 2009.

For this country, no regime changes were found other than, possibly, that of 2009. Figure 6 shows that the residuals do not have a particular change of behavior along the sample Also, the model lacks variables in lagged levels, i.e., the model is not an error-correction mechanism. Although, neither QEM nor PPP are met in this country, both money growth and the exchange rate depreciation seem to have a role in the determination of the inflation process, being the only country among the ones here studied

[12] See Vargas (2005).

where this happens. This might occur because there could have been regime changes of short duration that are too difficult to identify.

— Figure 6 —

5.6.1 Inflation Models

Table 10 contains the estimated model for Colombia. Only the lagged values of money growth, exchange rate depreciation and inflation are significant. Thus, the long-run impact of money growth is equal to 0.64 while that of exchange depreciation is 0.36. Despite the simplicity of the model, this works well in out-of-sample forecasting.

— Table 10 here —

6 Out-of-sample Forecasting Performance Evaluation

Taking into consideration changes in Granger causality should be reflected in an improved forecasting performance. Good out-of-sample predictions are not necessarily implied by a satisfactory goodness of fit. The exercises in this section are, within the limits imposed by sample sizes, enough to discriminate among alternatives in most cases. The full sample is divided in as many regimes as suggested by the previous section. For each subsample, up to five models are estimated for one part of the data points (half of it, if there are enough observations). Next, for the rest of the subsample, inflation is dynamically forecast without reestimation.

The root mean squared error (RMSE) for each forecast is calculated. This often, but not always, identifies which model is relatively better within each regime. In most cases, the best models in terms of the RMSE are usually the ones pointed out by the previous section. However, the dominant model in a regimen is found through the Diebold-Mariano test (Diebold and Mariano, 1995), which will be referred as DM, with the small sample correction as suggested by Harvey et al. (1997). This correction consists in two modifications. The first consists in rescaling the Diebold-Mariano statistic by one factor depending on the number of forecasting data points and the number of steps ahead of the forecasts. The second is the use of the t-student distribution with degrees of freedom given by the number of forecast points instead of the standard normal distribution. The tables report the p-value of the adjusted Diebold-Mariano statistic (DMpv) next to the RMSE. The model that is used as the benchmark for the comparisons is identified by a p-value of 1. All the exercises here are based on one-step-ahead forecasts and the loss function used to obtain is the DM statistic is the absolute value of the forecast errors.

The exercises for the six countries are distributed in three tables. Mexico and Brazil are together, as they have similar regimes (two with implicit price-level target and one with inflation targeting). Argentina and Chile are in the next table because those countries had only one price-level targeting regime although Chile arrived at some point to an inflation targeting regime. The third table of this section contains Colombia and Venezuela, as they never had price level targeting.

6.1 Mexico and Brazil

The inflation models in competition for each country are those analyzed in the previous section plus two more. For regimes 1 and 2, the first model is labeled as “Combined,” and it includes money and the exchange rate (the first numerical columns in Tables 2 and 4). The second model is the “Pure Monetary” model (first numerical columns in Tables 3 and 5). The third one is the “Pure Exchange Rate” model (second numerical columns in Tables 3 and 5). The fourth model is a simple AR(1) model (no other lags are significant in each case). The last one is a “Naive” model, where the average of half the corresponding subsample is used to forecast the rest. It should be noticed that this model is the one that should fare at least as well as any other in a regime with a preannounced inflation targeting regime no tied to money nor the exchange rate.

For regime 3, the one with inflation targeting, the first three models cannot be estimated meaningfully due to the very small sample and, more importantly, that the significance of the variables on which each of them is based vanishes as the countries abandoned the price level target regimes, as discussed in the previous section. Those models were estimated anyway but they were also complemented by other three models, where the variables in levels were suppressed and only the rates of change were considered. Thus, for regime 3, the alternative “Combined” has as regressors the depreciation rate, lagged money growth and a constant. “Pure Monetary” has a constant and the lagged money growth rate. The results are displayed in Table 11. Estimation and forecasting periods are shown at the top of the respective column.

— Table 11 here —

The first thing to notice is that none of the models does well in all regimes, as should be expected for what was discussed before. The “Pure Monetary” model works well in both countries only in regime 1. However, for Mexico in that regime, it is outperformed in both the RMSE and the DM test by the "Combined" model. This happens because by being estimated from 1932 to 1956, the latter model contains information on money, including the lagged level and the contemporary rate of change, as the monetary one, and the insertion of the exchange rate lagged level helps in the forecasts. The reason is that the peak of the exchange rate depreciation in 1976 compensates an increase in the short-run impact of money growth that is not included in the monetary model for being estimated until 1956. The other models do less well in that regime as they are beaten in both the RMSE and the DM test by both models where money has the central role. In Brazil, the monetary model in regime 1 dominates in terms of the RMSE but there is no statistically meaningful superiority, according to the DM test as none of the p-values is less than 0.05. The reason for this might be the short available sample for forecasting (4 data points).

For regime 2, the reference model is "Pure Exchange Rate". In both countries, it dominates in terms of the RMSE but it only does it in Mexico in terms of the DM test. In this country, the combined model does well enough to be beaten only at the 10 percent level of significance. The reason for the resilience of the combined model in this regime is that it includes the lagged level of the exchange rate and contemporary exchange rate, the same as the "Pure Exchange Rate" model. In the case of Brazil, the lack of dominance of the "Pure Exchange Rate" model is likely due to the small sample to make the comparison (5 data points).

In regime 3, as a modern preannounced inflation target framework was adopted by the two countries, traditional monetary variables lost much or all of their usefulness to forecast inflation. As the error correction models used in the two previous regimes ceased to be useful, they should not beat a simple inflation forecast based on either an autoregressive process or a constant. As said before, two estimations were made. Only the ones for the simplified models are presented but the ones based on the original models yield similar RMSE and DM tests. This is not surprising because the monetary variables in inflation targeting regime are little or no significant in either of the regression models. The forecasts for the two countries in this regime are from 2008 to 2013, so they cover the period of the crisis and the recovery.

In Mexico, during regime 3, the "Naive" model based on the average of inflation from 2001 to 2007 has a RMSE similar (up to hundredths) to those of the other models but, interestingly enough, it handily beats them with the DM test. In the case of Brazil, the RMSE of all models are closer but the reference model becomes the one with the depreciation rate in it. It appears that in Brazil, the exchange rate passthrough did not disappeared as completely as in Mexico. This forecasting power from the exchange rate seems to come from the episode around the crisis when in Brazil there was some impact of the exchange rate depreciation on inflation. In 2014 and 2015, Brazil had an outburst of inflation well above the official band. This high inflation appears associated to the depreciation that the real had. It might be related to the fiscal problems the country faced in those years. On the contrary, similar depreciations in Mexico during the same years did not appear to have caused much impact on inflation as this reached its lowest levels since the CPI began to be published (1969).

6.2 Chile and Argentina

These two countries only experienced one regime with implicit price level targeting although in the case of Chile there was not data on money to analyze the role of this for the whole sample. Thus, for Chile there is a comparison only for regime 2, the one where the exchange rate is the forcing variable. The inflation process of this country carries much inertia so the autoregressive model used in the comparisons has two lags. When the country adopted inflation targeting, differently from what happened in Mexico and Brazil, the autoregressive component did not disappear so there is no naive model. Argentina never abandoned regime 1, the one driven by money. Table 12 contains the results for the two countries. The many n.a. in it indicate that those countries did not reach a given regime.

— Table 12 —

In Chile, the regime 2 model was estimated from 1954 to 1972 and forecasts were made from 1973 to 1990, before the country adopted inflation targeting. The pure exchange rate model easily beats the AR(2) model in both RMSE and the DM test. During regime 3, the roles are inverted and it is the autoregressive model the one that dominates in both counts.

In Argentina, money has always been the leading driver of inflation. The model based on money was estimated from 1951 to 1996, a long period that avoided the difficult years at the beginning of the 1990s when occurred the big jump in money velocity discussed above. As in the case of Chile, the autoregressive model had two significant lags. A model based on the exchange rate and a combined one were also estimated. As expected, the model based on money beats the other three models in a significant way. The model for Argentina has some difficulties to follow the path of inflation since 2008, but this is mostly due to the fact that official data was not tracking the path of inflation accurately (Cavallo, 2012) as was discussed before. Estimating the model until 2007 and forecasting the years

2008 to 2013, the path of inflation follows that of the data of PriceStats.com, a privately-produced price index.

6.3 Colombia and Venezuela

These countries never had price level targeting regime but in Table 13 their regimes are also labeled as those of the other countries. The models for the two countries are simple dynamic models and not error correction mechanisms. In the case of Colombia, there was only one regime, that is dominated by a combined model that contains simultaneously exchange rate depreciation and money growth. The superiority is not so strong with respect the model based on the depreciation rate (p-value of 0.07). The model was also estimated from 1965 to 2004 and inflation was forecast dynamically without re-estimating and conditioning on the values of money growth and the depreciation rate. The result was that the price level forecasted by the model was just 4 percent above the actual price level at the en of the sample. This suggests that the country had not achieved completely the characteristics of a full-fledged inflation target, as in Chile and Mexico, where neither money nor the exchange rate help to predict inflation. However, since 2009 Colombia has attained inflation rates within its policy range of 3 ± 1 percent which might the final transition to a period with all the expected characteristics of inflation targeting.

— Table 13 here —

In Venezuela there were two regimes. In the first one, estimated from 1961 to 1972, money was the driving variable and so the pure monetary model dominates with both the RMSE and the DM test during the forecasting period 1973-1976. For the second regime, where models were estimated from 1977 to 2007, the exchange rate model dominates although it has the highest RMSE. The model works fairly well until 2006, when the relationship between inflation and the exchange rate depreciation is altered. This could have been because from 2005 to 2009 the official exchange rate remained fixed but many price setters were not bound to accept it as a pricing reference. Actually, the eventual rise of the official nominal exchange rate in 2010 and 2011 followed sustained increases of inflation. In 2013, the official exchange rate grew faster than the price level but it was not enough to match the amount of accumulated inflation since 2005.

7 Conclusions

Conditional predictability of inflation has evolved in Latin American countries depending on the actions of the central banks. The study of such changes was carried out, whenever possible, with a test derived from the long-run relationships of the classical monetary model. Such relationships imply changes in the signs of the coefficients of the monetary variables in an inflation model if there was a regime change. These regime changes were identified by the properties of Granger causality among those variables. The test is based on unbalanced regressions that are transformed to conditional error-correction models for inflation. The test was used in the cases where there was a price level targeting regime. For the other cases, the regime change was identified by the analysis of the behavior of simple dynamic regressions.

All the six countries in the sample started with monetary regimes where either currency or the exchange rate were the driving force of inflation. Argentina, Brazil, Chile and Mexico had at some point an implicit price level target depending on either money (through the QEM) or the exchange rate (according to PPP). For those countries, the pass-through of money or prices to the price level has been either complete or zero. Neither Colombia nor Venezuela ever had complete pass-through of either money or the exchange rate, but the impact of those variables was still important. For five of the countries (except Colombia), during the periods when either money or the exchange rate (but not both) was the main tool of the central bank to determine inflation, nothing else seemed to affect inflation systematically. Only for Colombia both the depreciation rate and the rate of growth of money were simultaneously important to determine the inflation rate.

The robustness of the results was put to test with pseudo out-of-sample exercises for each monetary regime and country through both the root mean square error and the Diebold-Mariano test modified for small samples. In most cases, the models suggested by the theoretical framework dominate the rest. Indeed, at different points in the nineties, Brazil, Chile and Mexico, abandoned other regimes in favor of inflation targeting. This, together with prudent macroeconomic policies, caused that inflation began to behave as it does in the United States or other developed countries, where it is hard to forecast on the basis of a specific cause. In that regime, simple autoregressive or naive models become competitive. This tendency of inflation to become hard to predict with multivariate methods, that rarely beat univariate models, is common in stable economies that implicitly or explicitly have adopted a preannounced inflation target.

References

[1] Amisano, G. and Gabriel Fagan (2010), "Money Growth and Inflation: A Regime Switching Approach," European Central Bank, Working Paper Series No. 1207/June.

[2] Arbelaez, M.A., Ulpiano Ayala and James Poterba (2002) "Debt and Deficits: Colombia's Unsustainable Fiscal Mix," Informe Mision del Ingreso Publico, Informes de Investigacin, Fedesarrollo.

[3] Baillieu, J., Daniel Garcés, Mark Kruger and Miguel Messmacher (2003), "Explaining and Forecasting Inflation in Emerging Markets: The Case of Mexico," Working Papers 03-17, Bank of Canada.

[4] Banerjee, A., J.J. Dolado, J.W. Galbraith, and D.F. Hendry (1993), "Cointegration, Error Correction, and the Econometric Analysis of Nonstationary Data," Oxford University Press, Oxford.

[5] Barassi, M., Guglielmo Maria Caporale and Stephen Hall (2007), "A Comparison Between Tests for Changes in the Adjustments Coefficients in Cointegrated Systems," Fordham University, CRIF Seminar series 4-1-2007.

[6] Bassetto, M., Todd Messer, and Christine Ostrowski (2013), "Forecasting inflation and the Great Recession," *Economic Perspectives*, Federal Reserve Bank of Chicago, V. 37, Third Quarter.

[7] Cagan, P. (1956): The Monetary Dynamics of Hyperinflation, in *Studies in the Quantity Theory of Money*, ed. by M. Friedman. University of Chicago Press, Chicago, IL.

[8] Capistrán, C., Raúl Ibarra-Ramírez and Manuel Ramos Francia (2011), "Exchange Rate Pass-Through to Prices: Evidence from Mexico," Working Papers 2011-12, Banco de México.

[9] Cavallo,A. (2012), "Online and official price indexes: Measuring Argentinas inflation", *Journal of Monetary Economics*, http://dx.doi.org/10.1016/j.jmoneco.2012.10.002

[10] Christiano, L.J., Martin S. Eichenbaum and Mathias Trabandt (2014) "Understanding the Great Recession". NBER Working Paper No. 20040.

[11] Cochrane, J. H., (2014) "Monetary Policy with Interest on Reserves," Manuscript, University of Chicago Booth School of Business.

[12] Cortés, J., (2013), "Una Estimación del Traspaso de las Variaciones en el Tipo de Cambio a los Precios en México", Documentos de Investigación 2013-02, Banco de México.

[13] Del Negro, M., Marc P. Giannoni and Frank Schorfheide (2014) "Inflation in the Great Recession and New Keynesian Models," NBER Working Paper No. 20055 April.

[14] Diebold, F. X. and Roberto S. Mariano (1995), "Comparing Predictive Accuracy," *Journal of Business and Economic Statistics*, 13, 253-265.

[15] Edge, R. M. and Refet S. Gürkaynak (2011), "How Useful are Estimated DSGE Model Forecasts?", Finance and Economics Discussion Series 2011-11, Federal Reserve Board.

[16] Espinoza, R, Hyginus Leon and Ananthakrishnan Prasad (2012), "When Should We Worry about Inflation?," World Bank Econ Review, 26 (1).

[17] Ericsson, N. R. and James G. Mackinnon (2002), "Distributions of error correction tests for cointegration," *Econometrics Journal*, v.5, pp285-318.

[18] Friedman, M. (1987) "Quantity Theory of Money," *The New Palgrave: A Dictionary of Economics*, v. 4, pp. 3-20.

[19] Goodfriend, M. and Robert G. King (2009) "The Great Inflation Drift", NBER Working Paper No. 14862, April.

[20] Hall, R.E. (2011) "The Long Slump", *American Economic Review*, 101 (April 2011): 431469.

[21] Harvey, D., Stephen Leybourne, and Paul Newbold (1997), "Testing the equality of prediction mean squared errors." *International Journal of Forecasting*, 13(2), 281-291.

[22] Kamin, Steven B. and Neil R. Ericsson (2003) "Dollarization in post-hyperinflationary Argentina," *Journal of International Money and Finance*, 22, pp. 185211.

[23] Lefort, F. and Klaus Schmidt-Hebbel (2002), "Indexation, Inflation, and Monetary Policy", Edited by Fernando Lefort and Klaus Schmidt-Hebbel, Banco Central de Chile.

[24] London, Simon, "Lunch with the FT: Milton Friedman," Financial Times, June 7, 2003.

[25] Lucas, R.E. and Juan Pablo Nicolini (2013) "On the Stability of Money Demand", Meeting Papers 353, Society for Economic Dynamics.

[26] Marcet, A. and Juan Pablo Nicolini (2005) "Recurrent Hyperinflations and Learning," *The American Economic Review*, Vol. 93, No. 5, Dec., pp.1476-1498.

[27] Marcet, A. and Juan Pablo Nicolini (2005) "Money and prices in models of bounded rationality in high inflation economies," European Central Bank, Working paper Series, No. 469, April.

[28] Pagan, A. R. and M. R. Wickens (1989), "A survey of some recent econometric methods," *Economic Journal* 99, pp. 962-1025.

[29] Romer, D. (2011), "Advanced Macroeconomics", McGraw-Hill Series Economics.

[30] Rossi, B. and Tatevik Sekhposyan (2010) " Have Models' Forecasting Performance Changed over Time, and When? ", *International Journal of Forecasting*, 26 (4), 2010, 808-835.

[31] Sargent, Thomas; Williams, Noah; Zha, Tao (2009), "The Conquest of South American Inflation.", *Journal of Political Economy*, April 2009, v. 117, iss. 2, pp. 211-56.

[32] Schmidt-Hebbel, K. and Alejandro Werner (2002), "Inflation Targeting in Brazil, Chile, and Mexico: Performance, Credibility, and the Exchange Rate", Central Bank of Chile Working Papers No. 171, July 2002.

[33] Schmitt-Grohé, Stephanie, and Martín Uribe (2013), "The Making Of A Great Contraction With A Liquidity Trap and A Jobless Recovery," Manuscript, Columbia University.

[34] Smetz, F. and R. Wouters (2007) "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach", American Economic Review 97(3), 586-607.

[35] Stock, James W. and Mark W. Watson (2007), "Why Has Inflation Become Harder to Forecast?" *Journal of Money, Credit, and Banking*, Supplement to Vol. 29, No.1 (February): 3-33.

[36] Vargas, H. (2005), "Exchange rate policy and inflation targeting in Colombia", Inter-American Development Bank, W.P. 539.

[37] Williamson, S. (2013), "Scarce Collateral, the Term Premium, and Quantitative Easing", Federal Reserve Bank of Richmond and St. Louis.

Tables and Figures

Table 1: ADF Unit Roots Tests

Argentina Variables 1950-2013	Level	Difference
Price Level (p)	-0 .81	-1.8[c]
Exchange Rate (e)	-0 .41	-4.8[a]
Inflationary Money ($m - y$)	-1 .04	-2.7[a]
Money (m)	-0 .46	-3.9[a]
Foreign Prices ($e + p^{us}$)	-0 .41	-4.7[a]
Brazil Variables 1960-2013	**Level**	**Difference**
Price Level (p)	-0 .75	-1.8[c]
Exchange Rate (e)	-1 .57	-1.9[a]
Inflationary Money ($m - y$)	-0 .87	-2.9[b]
Money (m)	0 .83	-2.1[b]
Foreign Prices ($e + p^{us}$)	-0 .96	-1.9[c]
Chile Variables 1960-2013	**Level**	**Difference**
Price Level (p)	-1 .79	-2.0[b]
Exchange Rate (e)	-1 .97	-2.0[b]
Inflationary Money ($m - y$)	-3 .01	-1.7[c]
Money (m)	-3 .7	-1.4
Foreign Prices ($e + p^{us}$)	-1 .93	-1.8[c]
Colombia Variables 1950-2013	**Level**	**Difference**
Price Level (p)	-1 .79	-0.8
Exchange Rate (e)	-1 .34	-1.9[c]
Inflationary Money ($m - y$)	0 .12	-5.7[a]
Money (m)	-1 .61	-1.19
Foreign Prices ($e + p^{us}$)	-1 .46	-1.5
Mexico Variables 1950-2013	**Level**	**Difference**
Price Level (p)	-0 .25	-3.5[a]
Exchange Rate (e)	0 .96	-4.8[a]
Inflationary Money ($m - y$)	0 .67	-7.6[a]
Money (m)	0 .98	-7.6[a]
Foreign Prices ($e + p^{us}$)	0 .97	-5.2[a]
Venezuela Variables 1950-2013	**Level**	**Difference**
Price Level (p)	1 .07	-1.17
Exchange Rate (e)	1 .63	-1.57
Inflationary Money ($m - y$)	4 .41	-0.71
Money (m)	0 .98	-0.8
Foreign Prices ($e + p^{us}$)	1 .59	-1.41

[a], [b], [c] Unit Root Hypothesis Rejected at 1%, 5%, 10% significance level, respectively.

Table 2: Unbalanced Regressions For the Mexican Inflation Rate (Δp_t) in Each Regime

Regressors	Full Sample 1932-2013	Regime 1 1932-1981	Regime 2 1983-2000	Regime 3 2001-2013
constant	1.25 (2.39)	3.46 (6.65)	-7.46 (-5.27)	n.s. .
$(m-y)_{t-1}$	0.07 (2.43)	0.2 (6.81)	-0.46 (-5.66)	n.s. .
$(e+p^{us})_{t-1}$	-0.07 (-2.45)	-0.18 (-6.11)	0.40 (5.20)	n.s. .
Δm_t	0.51 (7.33)	0.5 (8.06)	n.i. .	n.s. .
Δe_t	0.34 (7.92)	n.i. .	0.53 (7.33)	0.08 (1.95)
Δp_{t-1}	n.s. .	n.s. .	n.s. .	n.s. .
Δp_{t-2}	n.s. .	n.s. .	-0.24 (-2.73)	n.s. .
Δm_{t-1}	0.12 (2.71)	n.s. .	n.s. .	n.s. .
Δe_{t-1}	0.19 (4.18)	n.s. .	n.s. .	n.s. .
T	81	49	18	13
ADF statistic	-8.30^a	-7.84^a	-5.36^a	-4.03^a
Adjusted R^2	0.87	0.77	0.94	0.42
SE	0.06	0.06	0.07	0.01
Jarque-B	0.42	0.59	0.76	0.63
LM(1) autocor	0.14	0.13	0.06	0.71

t statistics are between parentheses.

n.s. means excluded for being nonsignifcant and n.i. means it was not included.

A n.s. variable is included because it was in the original general model for the regime.

A n.i. variable is weakly endogenous within the regime.

^{a}, ^{b}, ^{c} represent 1%, 5%, 10% significance level, respectively.

ADF statistic to test the stationarity of the residuals of an unbalanced regression.

For Jarque-B and the LM(2) Autocor statistics the p values are provided.

Table 3: Inflation (Δp_t) Model in Each Regime for Mexico

Regressors	Regime 1 1932-1981	Regime 2 1983-2000	Regime 3 2001-2013
constant	3.64 (5.77)	-1.73 (-5.41)	0.04 21.09
p_{t-1}	-0.21 (-5.31)	-0.76 (-7.72)	n.i. .
$(m-y)_{t-1}$	0.24 (5.84)	n.i. .	n.i. .
$(e+p^{us})_{t-1}$	n.i. .	0.73 (7.37)	n.s. .
Δm_t	0.45 (6.99)	n.i. .	n.s. .
Δe_t	n.i. .	0.54 (9.79)	0.08 (3.2)
Δm_{t-1}	n.s. .	n.s. .	n.s. .
Δe_{t-1}	n.s. .	n.s. .	n.s. .
T	49	18	13
Adjusted R^2	0.68	0.96	0.42
SE	0.05	0.05	0.01
Jarque-B	0.16	0.94	0.63
LM(2) autocor	0.63	0.36	0.71
LM(1) arch	0.91	0.75	0.93
$CUSUM$	pass	pass	pass
$CUSUM^2$	pass	pass	pass
N-step proj.	fail	pass	pass

t statistics are between parentheses.
n.s. means excluded for being nonsignificant.
n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
For Jarque-B, LM(2) autocor LM(2) arch the p values are provided.

Table 4: Unbalanced Regressions For the Brazilian Inflation Rate (Δp_t) in Each Regime

Regressors	Full Sample 1964-2013	Regime 1 1964-1979	Regime 2 1982-1998	Regime 3 1999-2013
constant	-0.10	n.i.	-2.94	-0.06
	(-0.38)	.	(-3.79)	-0.66
$(m-y)_{t-1}$	-0.02	0.23	-0.66	-0.01
	(-0.33)	(4.56)	(-3.77)	-1.11
$(e+p^{us})_{t-1}$	0.02	-0.27	0.67	0.02
	(0.34)	(-4.61)	(3.80)	1.4
Δm_t	0.69	0.70	n.i.	n.i.
	(10.00)	(6.36)	.	.
Δe_t	0.31	n.i.	n.i.	0.05
	(5.27)	.	(7.61)	(2.60)
$d1968$	n.i.	-0.17	n.i.	n.i.
	.	(-2.66)	.	.
Δm_{t-1}	n.s.	n.s.	n.s.	n.s.
	.	.	.	.
Δe_{t-1}	n.s.	n.s.	n.s.	n.s.
	.	.	.	.
T	50	16	17	15
ADF statistic	-6.45^a	-4.07^a	-4.00^a	-3.67^b
Adjusted R^2	0.98	0.84	0.96	0.80
SE	0.14	0.06	0.25	0.01
Jarque-B	0.31	0.59	0.80	0.11
LM(1) autocor	0.88	0.13	0.90	0.94

t statistics are between parentheses.

n.s. means excluded for being nonsignifcant and n.i. means it was not included.

A n.s. variable is included because it was in the original general model for the regime.

A n.i. variable is weakly endogenous within the regime.

^{a}, ^{b}, ^{c} represent 1%, 5%, 10% significance level, respectively.

ADF statistic to test the stationarity of the residuals of an unbalanced regression.

For Jarque-B and the LM(2) Autocor statistics the p values are provided.

Table 5: Inflation (Δp_t) Model in Each Regime For Brazil

Regressors	Regime 1 1964-1978	Regime 2 1982-1998	Regime 3 1999-2013
constant	1.86 (4.95)	8.44 (5.18)	0.05 (5.68)
p_{t-1}	-0.61 (-5.92)	-0.94 (-5.07)	n.i. .
$(m-y)_{t-1}$	0.66 (5.40)	n.i. .	n.i. .
$(e+p^{us})_{t-1}$	n.i. .	0.99 (5.16)	n.i. .
Δm_t	0.31 (2.6)	n.i. .	n.s. .
Δe_t	n.i. .	0.60 (6.08)	0.04 (3.36)
d_2003	n.i. .	n.i. .	0.09 (7.61)
T	16	18	15
Adjusted R^2	0.90	0.95	0.81
SE	0.04	0.25	0.01
Jarque-B	0.60	0.54	0.98
LM(2) autocor	0.38	0.49	0.57
LM(1) arch	0.41	0.79	0.22
$CUSUM$	pass	pass	fail
$CUSUM^2$	fail	pass	fail
N-step proj.	fail	fail	pass

t statistics are between parentheses.
n.s. means excluded for being nonsignificant.
n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
The Ericsson-MacKinnon critical values of 1% significance for the first two regressions is -4.09.
For Jarque-B, LM(2) autocor LM(2) ARCH the p values are provided.

Table 6: Inflation (Δp_t) Model in Each Regime For Chile

Regressors	Regime 2 1954-1990	Regime 3 1991-2013
constant	-0.58 (-4.60)	n.s. .
p_{t-1}	-0.31 (-5.18)	n.i. .
e_{t-1}	0.31 (5.18)	n.i. .
Δm_t	n.i. .	n.s. .
Δe_t	0.28 (6.60)	n.s. .
Δp_{t-1}	0.70 (6.11)	0.73 (16.59)
Δp_{t-2}	-0.31 (-3.48)	n.i. .
d_{2008}	n.i. .	0.04 (3.62)
d_{2009}	n.i. .	-0.05 (-4.50)
T	37	23
Adjusted R^2	0.93	0.96
SE	0.11	0.00
Jarque-B	0.46	0.72
LM(2) autocor	0.41	0.06
LM(1) arch	0.67	0.45
$CUSUM$	fail	pass
$CUSUM^2$	pass	pass
N-step proj.	pass	pass

t statistics are between parentheses.
n.s. means excluded for being nonsignificant.
n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
The Ericsson-MacKinnon critical values of 1% significance for the
first two regressions is -4.09.
For Jarque-B, LM(2) autocor LM(2) ARCH the p values are provided.

Table 7: An Unbalanced Regression For the Argentinean Inflation Rate (Δp_t)

Regressors	Full Sample 1964-2013
constant	0.83 (5.73)
$(m-y)_{t-1}$	0.29 (5.90)
$(e+p^{us})_{t-1}$	-0.26 (-5.99)
Δp_{t-1}	0.35 (10.00)
Δm_t	0.25 (4.33)
Δe_t	0.48 (8.79)
$d1968$	n.i. .
Δm_{t-1}	-0.30 (-3.81)
Δe_{t-1}	n.s. .
d_{1986}	-0.30 (-3.81)
d_{1989}	-0.75 (-4.16)
T	54
ADF statistic	-5.65^a
Adjusted R^2	0.96
SE	0.16
Jarque-B	0.22
LM(1) autocor	0.23

t statistics are between parentheses.
n.s. means excluded for being nonsignifcant and n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
^{a}, ^{b}, ^{c} represent 1%, 5%, 10% significance level, respectively.
ADF statistic to test the stationarity of the residuals of an unbalanced regression.
For Jarque-B and the LM(2) Autocor statistics the p values are provided.

Table 8: Inflation (Δp_t) Model for Argentina

Regressors	Regime 1 1950-2013
constant	0.45 (4.72)
p_{t-1}	-0.21 (-5.26)
$(m-y)_{t-1}$	0.23 (5.16)
Δp_{t-1}	0.34 (5.02
Δm_t	0.31 (5.37)
Δm_{t-1}	-0.21 (-2.81)
Δe_{t-1}	0.31 (6.01)
d_{1986}	-0.69 (-3.72)
d_{1989}	1.89 (10.36)
T	55
Adjusted R^2	0.95
SE	0.16
Jarque-B	0.71
LM(2) autocor	0.28
LM(1) arch	0.32
$CUSUM$	fail
$CUSUM^2$	pass
N-step proj.	pass

t statistics are between parentheses.
n.s. means excluded for being nonsignificant.
n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
For Jarque-B, LM(2) autocor LM(2) ARCH the p values are provided.

Table 9: Inflation (Δp_t) Model in Each Regime for Venezuela

Regressors	Regime 1 1961-1976	Regime 2 1977-2013
constant	-0.01 (-1.09)	n.s. .
Δm_t	0.12 4.18	n.s. .
Δe_t	n.s. .	0.26 (4.83)
Δm_{t-1}	0.15 (5.67)	n.s. .
Δp_{t-1}	n.s. .	0.55 (5.38)
T	16	37
Adjusted R^2	0.90	0.68
SE	0.01	0.08
Jarque-B	0.57	0.67
LM(2) autocor	0.24	0.74
LM(1) arch	0.59	0.77
$CUSUM$	pass	pass
$CUSUM^2$	pass	pass
N-step proj.	pass	pass

t statistics are between parentheses.
n.s. means excluded for being nonsignificant.
n.i. means it was not included.
A n.s. variable is included because it was in the original general model for the regime.
A n.i. variable is weakly endogenous within the regime.
For Jarque-B, LM(2) autocor LM(2) ARCH the p values are provided.

Table 10: Inflation (Δp_t) Model for Colombia

Regressors	Regime mixed 1965-2013
constant	-0.01 (-0.58)
Δm_{t-1}	0.27 (2.58)
Δe_{t-1}	0.15 (2.86)
Δp_{t-1}	0.58 (5.86)
T	49
Adjusted R^2	0.74
SE	0.04
Jarque-B	0.74
LM(2) autocor	0.20
LM(1) arch	0.00
$CUSUM$	pass
$CUSUM^2$	fail
N-step proj.	fail

t statistics are between parentheses.
For Jarque-B, LM(2) autocor LM(2) ARCH the p values are provided.

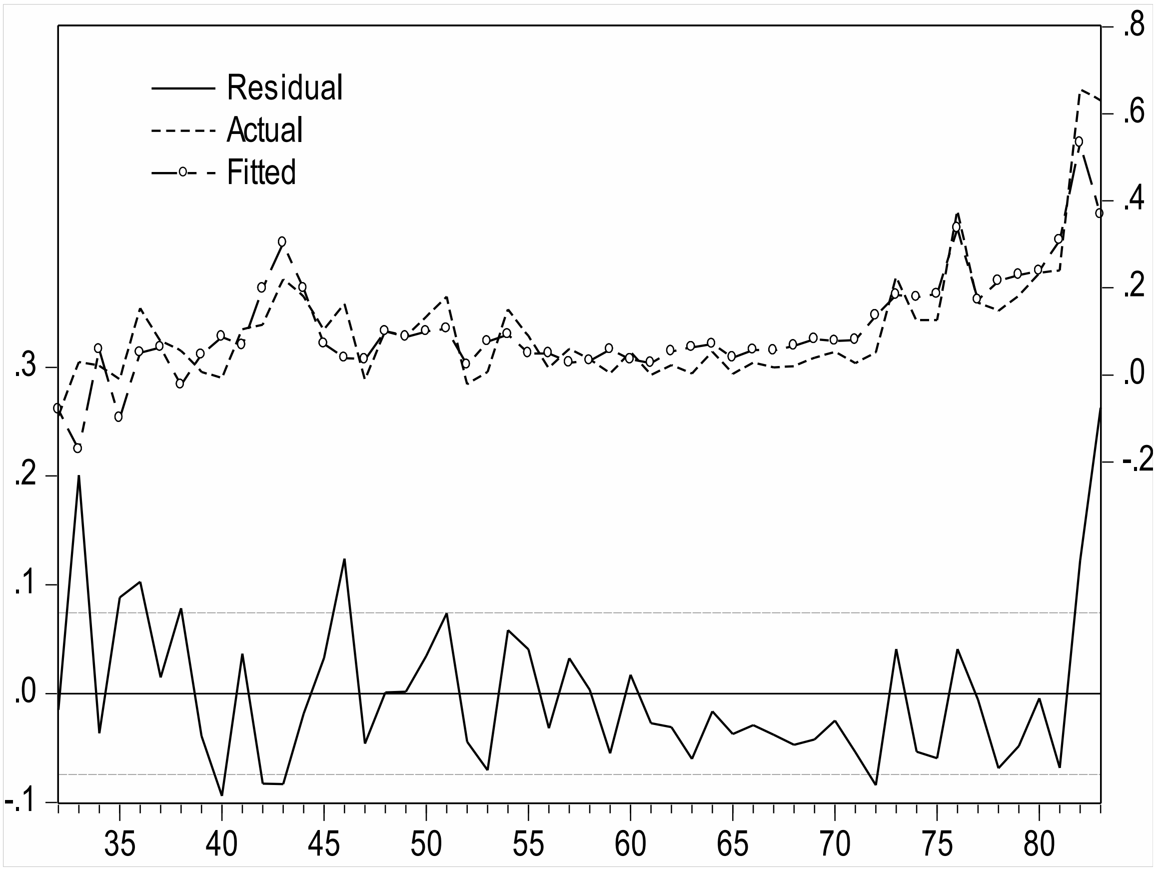

Figure 1: Residuals of Observed and Fitted Values for Inflation at the End of Mexico's Regime 1

Table 11: Forecasting Comparisons in Mexico and Brazil

Models for Mexico	Regime 1 E. 1932-56 F. 1957-81		Regime 2 E. 1983-92 F. 1993-2000		Regime 3 E. 1983-2000 F. 2001-2013	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
“Combined”	0.04	1.00	0.12	0.08	0.01	0.00
“Pure Monetary”	0.05	0.00	0.13	0.00	0.01	0.00
“Pure Exchange Rate”	0.08	0.00	0.06	1.00	0.01	0.00
“AR(1)”	0.10	0.00	0.17	0.00	0.01	0.00
“Naive”	0.10	0.00	0.29	0.02	0.01	1.00

Models for Brazil	Regime 1 E. 1964-74 F. 1975-78		Regime 2 E. 1982-93 F. 1994-1998		Regime 3 E. 1982-1998 F. 1999-2013	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
“Combined”	0.12	0.08	0.51	0.25	0.01	0.00
“Pure Monetary”	0.07	1	5.40	0.16	0.02	0.00
“Pure Exchange Rate”	0.10	0.44	0.03	1.00	0.02	1.00
“AR(p)”	0.15	0.13	2.37	0.22	0.01	0.00
“Naive”	0.08	0.18	1.55	0.19	0.01	0.00

RMSE is root mean square error and DMpv is the p-value (t-student distribution) for the Diebold-Mariano test with small sample correction (Harvey et al., 1997).

E. and F. mean the estimation and forecasting period, respectively.

“Combined” is $\Delta p_t = \beta_m (m-y)_{t-1} + \beta_e (e + p^{us})_{t-1} + \phi_m \Delta m_t + \phi_e \Delta e_{t-1}$

“Pure Monetary” is $\Delta p_t = \beta_m (m-y)_{t-1} + \beta_p p_{t-1} + \phi_m \Delta m_t$

“Pure Exchange Rate” is $\Delta p_t = \beta_e (e + p^{us})_{t-1} + \beta_p p_{t-1} + \phi_e \Delta e_t$

“AR(p)” is $\Delta p_t = \sum_i^p \beta_i \Delta p_{t-i}$ with p=1 for both countries.

“Naive” is the average of inflation of half the sample except for Regime 3 that goes from the beginning of regime 3 to 2007.

Table 12: Forecasting Comparisons in Chile and Argentina

Models for Chile	Regime 1 E. n.a. F. n.a.		Regime 2 E. 1954-72 F. 1973-90		Regime 3 E. 1991-2007 F. 2008-2013	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
"Pure Exchange Rate"	n.a.	n.a.	0.35	1.00	0.04	0.00
"AR(2)"	n.a.	n.a.	0.58	0.00	0.02	1.00

Models for Argentina	Regime 1 E. 1951-1996 F. 1997-2013		Regime 2 E. n.a. F. n.a.		Regime 3 E. n.a. F. n.a.	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
"Combined"	0.15	0.02	n.a.	n.a.	n.a.	n.a.
"Pure Monetary"	0.13	1.00	n.a.	n.a.	n.a.	n.a.
"Pure Exchange Rate"	0.23	0.00	n.a.	n.a.	n.a.	n.a.
"AR(2)"	0.59	0.05	n.a.	n.a.	n.a.	n.a.

RMSE is root mean square error and DMpv is the p-value (t-student distribution) for the Diebold-Mariano test with small sample correction (Harvey et al., 1997).

E. and F. mean the estimation and forecasting period, respectively.

"Combined" is $\Delta p_t = \beta_m (m-y)_{t-1} + \beta_e (e + p^{us})_{t-1} + \phi_m \Delta m_t + \phi_e \Delta e_{t-1}$

"Pure Monetary" is $\Delta p_t = \beta_m (m-y)_{t-1} + \beta_p p_{t-1} + \phi_m \Delta m_t$

"Pure Exchange Rate" for Chile is $\Delta p_t = \beta_e e_{t-1} + \beta_p p_{t-1} + \phi_e \Delta e_t$

"Pure Exchange Rate" for Argentina is $\Delta p_t = \beta_e (e + p^{us})_{t-1} + \beta_p p_{t-1} + \phi_e \Delta e_t$

"AR(p)" is $\Delta p_t = \sum_i^p \beta_i \Delta p_{t-i}$ with p=1 for Argentina and p=2 for Chile.

Table 13: Forecasting Comparisons for Colombia y Venezuela

Models for Colombia	Regime 1 E. n.a. F. n.a.		Regime 2 E. n.a. F. n.a.		Regime Combined E. 1961-1990 F. 1991-2013	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
"Combined"	n.a.	n.a.	n.a.	n.a.	0.05	1
"Pure Monetary"	n.a.	n.a.	n.a.	n.a.	0.07	0.00
"Pure Exchange Rate"	n.a.	n.a.	n.a.	n.a.	0.06	0.07
"AR(1)"	n.a.	n.a.	n.a.	n.a.	0.08	0.05
Models for Venezuela	**Regime 1 E. 1961-1972 F. 1973-1976**		**Regime 2 E. 1977-2007 F. 2008-2013**		**Regime 3 E. n.a. F. n.a.**	
	RMSE	DMpv	RMSE	DMpv	RMSE	DMpv
"Combined"	0.02	0.02	0.07	0.54	n.a.	n.a.
"Pure Monetary"	0.01	1.00	0.05	0.00	n.a.	n.a.
"Pure Exchange Rate"	0.07	0.00	0.09	0.01	n.a.	n.a.
"AR(1)"	0.06	0.00	0.06	0.00	n.a.	n.a.

RMSE is root mean square error and DMpv is the p-value (t-student distribution) for the Diebold-Mariano test with small sample correction (Harvey et al., 1997).

E. and F. mean the estimation and forecasting period, respectively.

"Combined" is $\Delta p_t = \phi_m \Delta m_t + \phi_e \Delta e_{t-1}$

"Pure Monetary" is $\Delta p_t = \phi_m \Delta m_t$

"Pure Exchange Rate" is $\Delta p_t = \phi_e \Delta e_t$

"AR(p)" is $\Delta p_t = \sum_i^p \beta_i \Delta p_{t-i}$ with p=1 for both countries.

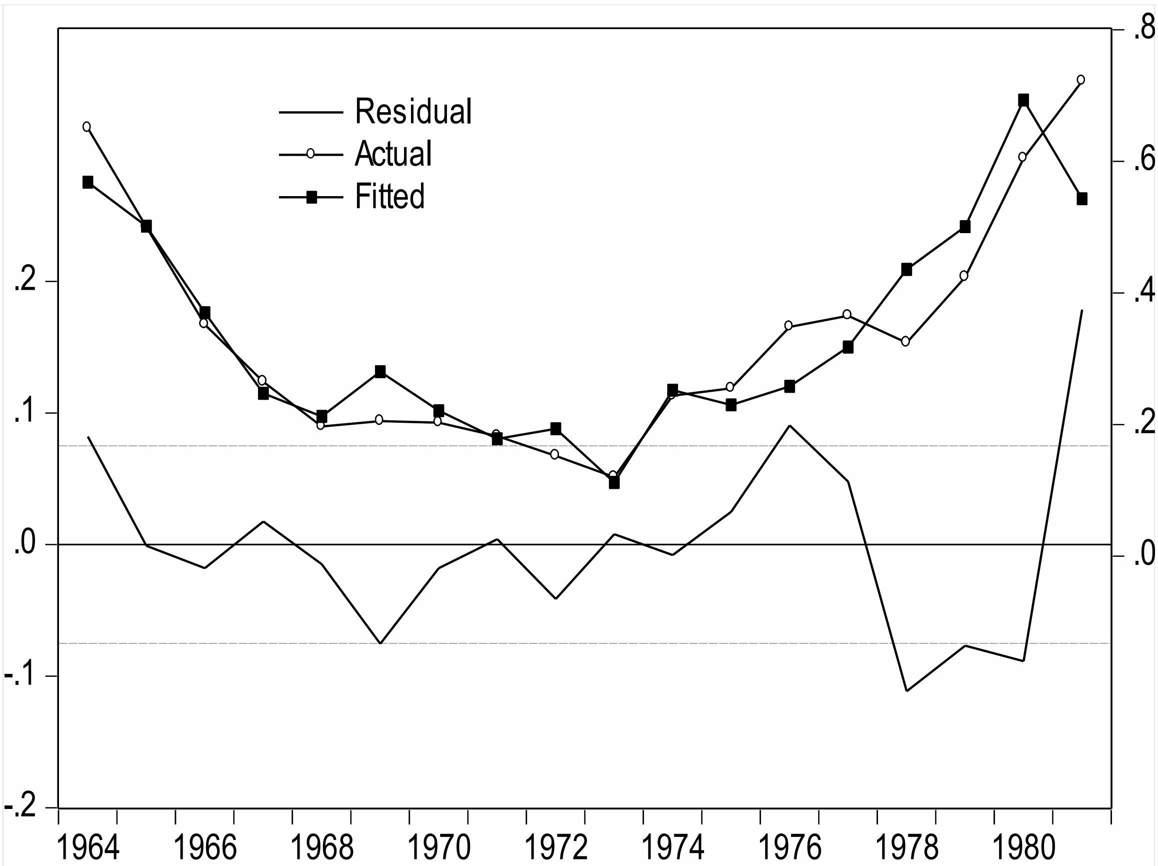

Figure 2: Residuals of Observed and Fitted Values for Inflation at the End of Brazil’s Regime 1

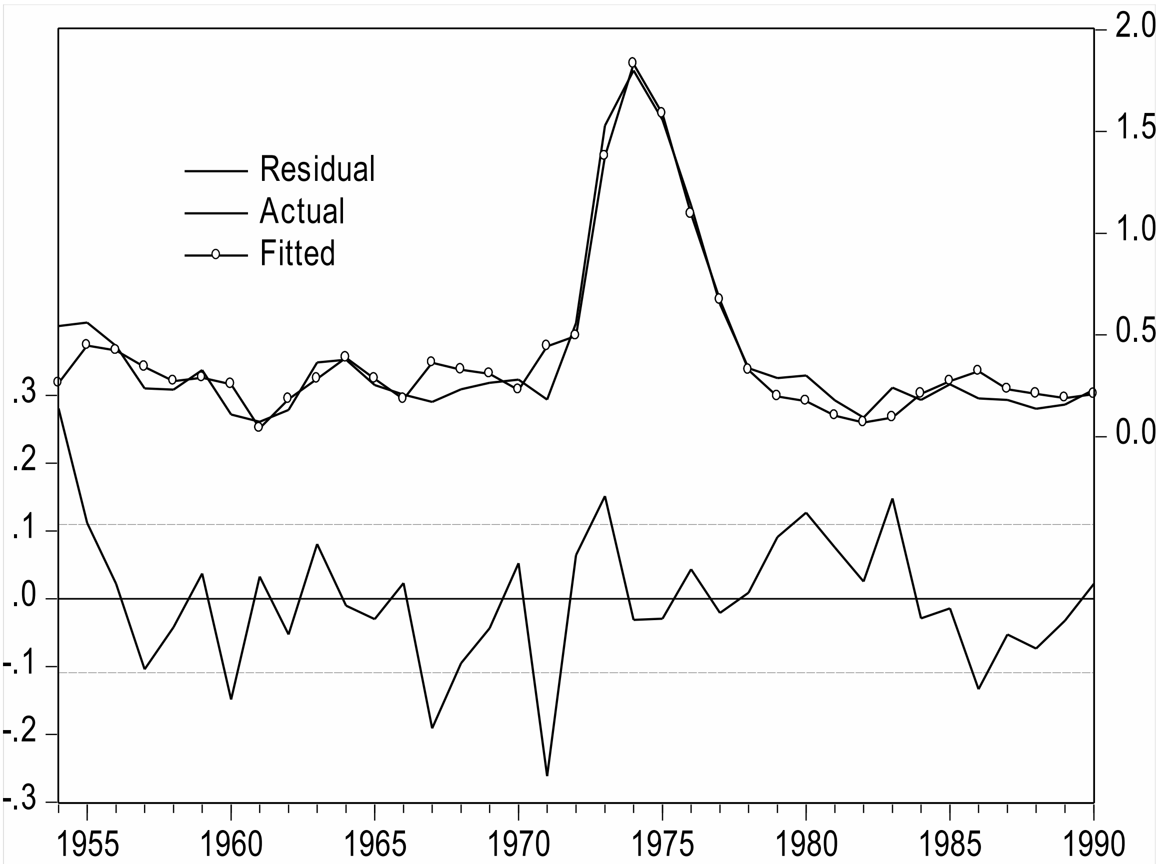

Figure 3: Residuals of Observed and Fitted Values for Inflation for Chile's Exchange Rate Regime

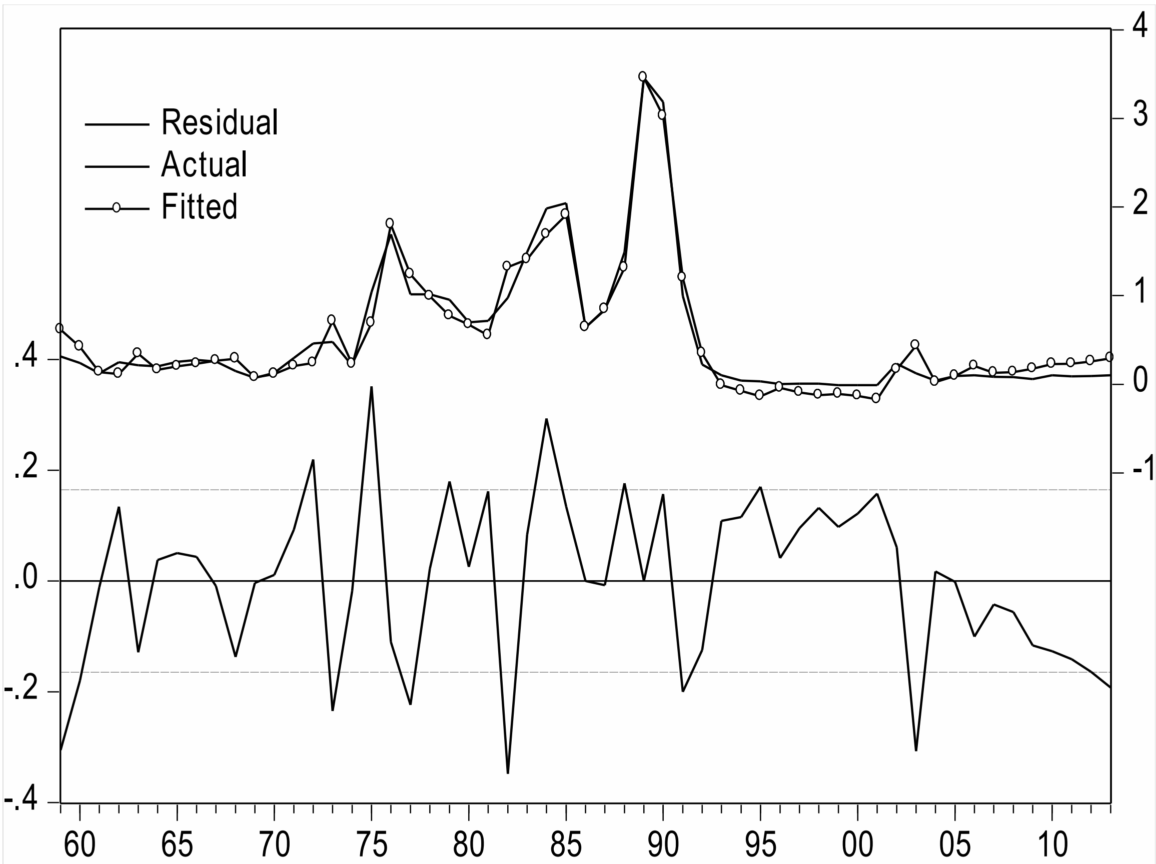

Figure 4: Residuals of Observed and Fitted Values for Inflation for Argentina's Whole Sample

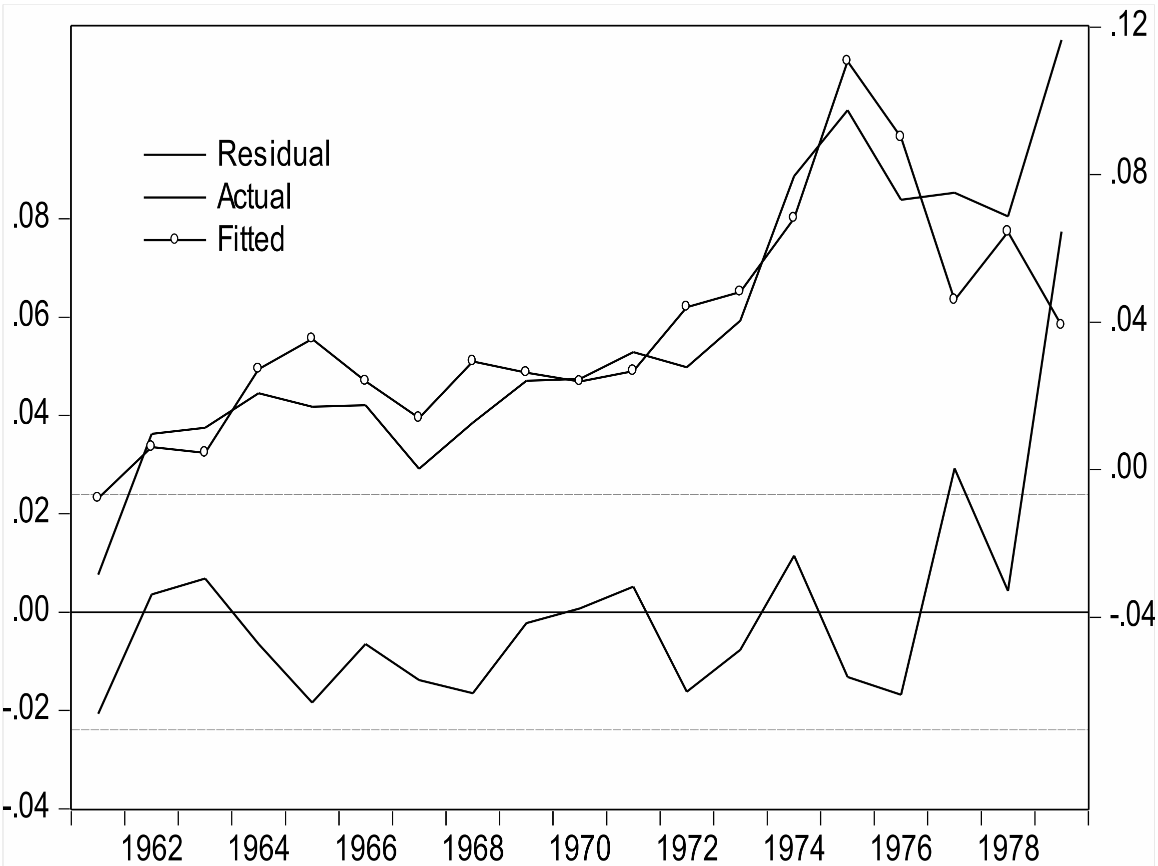

Figure 5: Residuals of Observed and Fitted Values for Inflation at the End of Venezuela's Regime 1

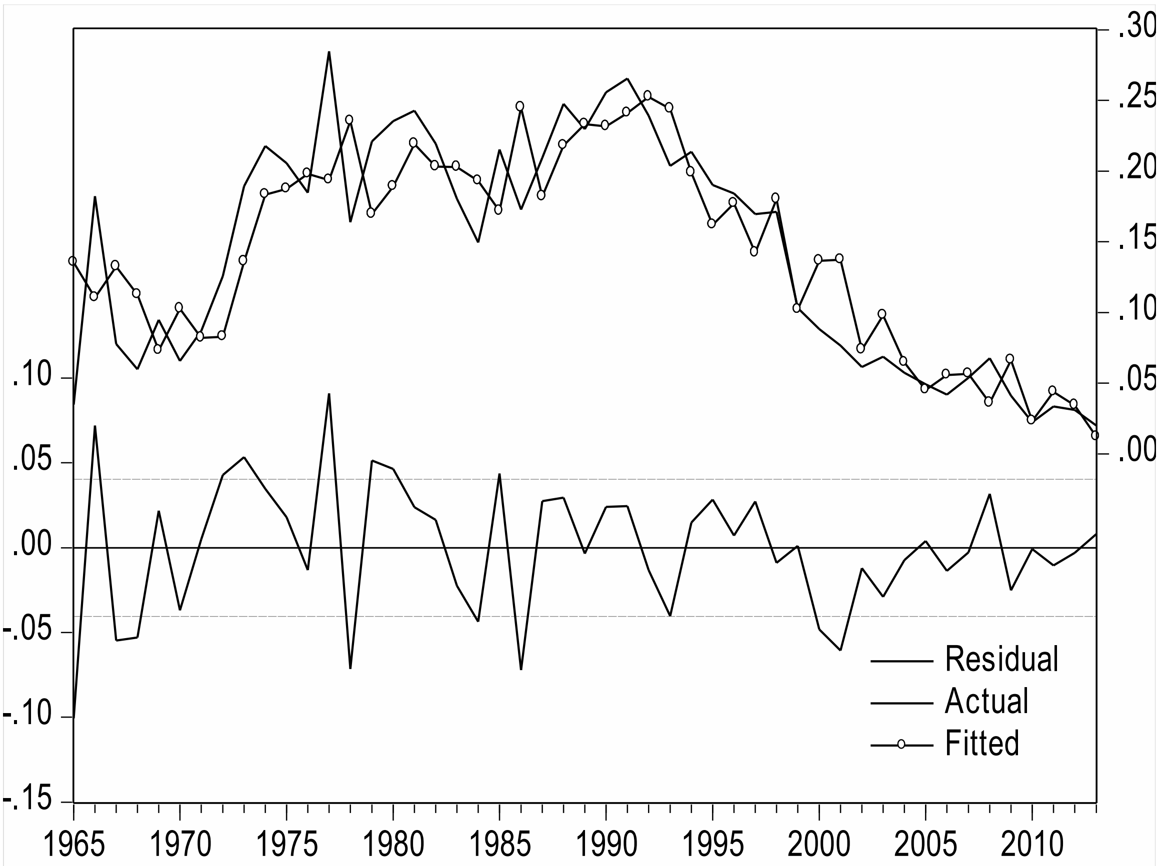

Figure 6: Residuals of Observed and Fitted Values for Inflation for Colombia’s Whole Sample