

# Understanding the Evolving Inflation Process and its interaction with Monetary Policy: an application for Colombia and a group of Latin-American economies

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## Abstract

In this paper we analyze the inflation process for a group of Latin-American countries since 1960. Of this group, the Colombian case is an interesting one due to the fact that of all of Latin American countries, Colombia didn't suffered from hyperinflation and kept its inflation level around 20 percent for almost two decades. In order to study the interaction between monetary policy and this behavior, the methodology proposed follows the one described in Cecchetti et al (2007) in which each LAT-7 country's inflation path is decomposed into a time-varying trend plus a transitory component, each with time-varying volatility. This process is analogous to an IMA(1,1) with time varying coefficients. Despite the hyperinflations, we claim that the level and volatility of trend inflation display coincident hump-shape patterns which allow us to describe periods of high inflation and of Inflation Stabilization. We find that a change in the monetary regime is highly correlated with both of these periods and the, in general, low levels of inflation we see in Latin-American countries nowadays.

**KeyWords:** Inflation dynamics, Output Volatility, LAC-7, MCMC, Unobserved components stochastic volatility.

**JEL codes:** E31, E32, E52, C11, C13

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# 1 Introduction

During the 20th century Latin-American countries had a long tradition suffering the consequences from high inflation. Following a practice of financing either government or private spending by printing money, the central banks of the time were used as institutions whose main task was to facilitate the political programs that were implemented by leftist and rightist governments throughout the region.

The consequence of this behavior: high inflation, was a notorious result that made most of the Latin-American countries in this study appear, each one at its own time, in the unwanted list of the country with the highest inflation in the world. From the group of countries studied<sup>1</sup>, Colombia is an exception due to the fact that Colombian inflation was never above 32% in annual terms. Several papers have dealt with the behavior during hyperinflations, this paper instead studies the consequences in the dynamics of the inflation process that arise using an interesting characterization of the inflation process. The main goal of the paper consists in linking the behavior of current inflation with the monetary policy stance adopted by most of the analyzed Latin-American countries.

For Central Banks around the world the maintenance of a monetary anchor has proven fruitful in terms of good macroeconomic outcomes. Of the possible monetary anchors that central banks have at hand, inflation is one of the most popular. The management of a monetary policy instrument in order to achieve medium and long term levels of inflation has received the name of inflation targeting. Latin America has not been the exception and to this end we need to add the history of high inflation that many of the Latin American countries suffered during the 20th century. The hyperinflations that the most important Latin American economies suffered made of this countries the perfect candidates for inflation targeting.

Inflation targeting is one possibility but clearly is not the only one. The evaluation of the inflation targeting regime is not the purpose of this paper, since we have countries like Argentina for example, that used a currency board in order to control its inflation. Instead we evaluate the results in terms of inflation by using a monetary policy stance that has a monetary policy anchor, no matter what that anchor is. The point here is that the adoption of inflation targeting it is not necessary in order to see the good results in terms of inflation and output volatility, as long as a monetary anchor is chosen, lower levels of inflation will follow. A different story can arise if we think about the volatility of the

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<sup>1</sup>Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela.

Table 1: Data description for the countries under study

COUNTRY	INFLATION	GDP	BEGINNING OF INFLATION TARGETING
<b>Argentina</b>	1944M01 - 2008M01	1993Q01 - 2006Q4	
<b>Brazil</b>	1980M12 - 2007M12	1991Q02 - 2006Q4	1999M06
<b>Chile</b>	1958M01 - 2008M02	1996Q01 - 2006Q4	1991M01
<b>Colombia</b>	1955M01 - 2008M01	1977Q01 - 2007Q4	1999M09
<b>Mexico</b>	1970M01 - 2008M01	1981Q01 - 2006Q4	1999M01
<b>Peru</b>	1996M12 - 2008M02	1979Q01 - 2006Q4	1994M01
<b>Venezuela</b>	1951M01 - 2008M02	1996Q01 - 2006Q4	

inflation process. Depending on what the monetary anchor is, it is possible to have lower inflation and lower volatility at the same time.

Since there are different inflation regimes in the sample of countries at hand (countries with hyperinflation vs. countries that didn't suffered from such a problem) with different monetary policy stances, a question about the link between inflation levels and output volatility can be addressed as well. In particular, the literature has talked about the so called *great moderation*. The latter relates to the fact that developed economies have decreased the level of inflation at the same time that output volatility has decreased. With this in mind an analysis of the volatility of output is performed and the results are reported.

Table (1) shows the dates when inflation targeting was adopted for the set of Latin-American countries known as LAC-7<sup>2</sup>. As can be seen most of them have adopted inflation targeting.

## 2 The IMA(1,1) specification of inflation and extensions

A now *traditional* representation of the inflation process at a monthly frequency as shown by Stock and Watson (2006) is as follows

$$(1 - B)\pi_t = (1 - \theta B)\varepsilon_t. \quad (1)$$

$$\theta > 0$$

$$\varepsilon_t \text{ serially uncorrelated } [E(\varepsilon_t) = 0, E(\varepsilon_t^2) = \sigma_\varepsilon^2].$$

<sup>2</sup>Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela.

Table 2:  
**Autocorrelations of the First Difference of Inflation in the Lat7**

	<i>Sample without inflation targeting</i>				<i>Sample with inflation targeting</i>			
	Lag							
	1	2	3	4	1	2	3	4
Argentina	0.508	0.049	-0.284	-0.387				
Brazil	0.677	0.316	0.121	0.034	0.703	0.415	0.250	0.173
Chile	0.042	0.120	0.060	0.269	0.150	0.054	0.004	-0.206
Colombia	0.483	0.278	0.092	0.064	0.280	-0.073	-0.041	-0.047
Mexico	0.773	0.608	0.499	0.411	0.520	0.203	0.177	0.233
Peru					0.336	0.149	-0.001	0.081
Venezuela	0.530	0.321	0.176	0.169				

This representation is known as an IMA(1, 1) process. This process has proven useful due to the likely unit root in  $\pi_t$  and the positive first order autocorrelations, and generally small higher order autocorrelations, of  $(1 - B)\pi_t$ . Table (2) shows the autocorrelations for the set of countries under study. As can be seen, in the case of the inflation process for the LAC-7 economies, inflation is well represented by an IMA(1, 1) process.

Table (3) shows the estimated coefficients for this IMA(1, 1) model for the entire sample available for each country and for two subsamples, the period before inflation targeting and the period after inflation targeting was adopted. Of this set of countries, Chile and Colombia present the greatest changes in the coefficients<sup>3</sup>, although Brazil and Mexico coefficients statistically different as well.

This IMA(1, 1) model has an unobserved components (UC) representation of the form

$$\pi_t = \tau_t + \eta_t, \quad \eta_t \text{ serially uncorrelated } (0, \sigma_\eta^2) \quad (2)$$

$$\tau_t = \tau_{t-1} + \varepsilon_t, \quad \varepsilon_t \text{ serially uncorrelated } (0, \sigma_\varepsilon^2) \quad (3)$$

where  $cov(\eta_t, \varepsilon_s) = 0$ . for all  $t$  and  $s$ . Due to the different inflation regimes that Latin American economies have undergone, it is important to generalize the aforementioned model in order to take into account parameter instability and to study whether changes associated with the inflation process are due to continual parameter drift or discrete regime shifts. In particular, the literature has talked about the so called *great moderation*. The latter relates to the fact that developed economies have decreased the level of inflation at the

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<sup>3</sup>As checked by a Chow test.

Table 3: IMA estimation for LAC 7 countries

ARGENTINA			
Sample	All sample 1948M01 - 2008M01	Without inflation targeting	With inflation targeting
$\hat{\theta}$	-0.51835		
$se(\hat{\theta})$	0.03192		
BRAZIL			
Sample	1980M12 - 2007M12	1980M12 - 1999M05	1999M06 - 2007M12
$\hat{\theta}$	-0.64821	-0.64821	-0.60468
$se(\hat{\theta})$	0.04247	0.05146	0.07999
CHILE			
Sample	1958M01 - 2008M02	1958M01 - 1990M12	1991M01 - 2008M02
$\hat{\theta}$	-0.03416	-0.03409	-0.15250
$se(\hat{\theta})$	0.04247	0.05035	0.06943
COLOMBIA			
Sample	1955M01 - 2008M01	1955M01 - 1999M08	1999M09 - 2008M01
$\hat{\theta}$	-0.37464	-0.37373	-0.51513
$se(\hat{\theta})$	0.03689	0.04017	0.09983
MEXICO			
Sample	1970M01 - 2008M01	1955M01 - 1998M12	1999M01 - 2008M01
$\hat{\theta}$	-0.62687	-0.62708	-0.56580
$se(\hat{\theta})$	0.03659	0.04196	0.08020
PERU			
Sample	1996M12 - 2008M02		
$\hat{\theta}$	-0.28341		
$se(\hat{\theta})$	0.08378		
VENEZUELA			
Sample	1951M01 - 2008M02		
$\hat{\theta}$	-0.41295		
$se(\hat{\theta})$	0.03485		

same time that output volatility has decreased. Since during the nineties inflation targeting, or some form of monetary anchor was adopted in most of the LAC-7 economies, it is interesting to study if a similar phenomenon occurred. Is it possible then, that the adoption of inflation targeting or a monetary anchor created a break in the inflation process? Is the IMA(1,1) specification an adequate approach when estimating the inflation process, or have the changes been more complex and progressive?

In this section the model proposed by Stock and Watson (2006) is considered. They take the unobserved component model in (2) and suggest a modification in which the variances of the permanent and transitory disturbances evolve randomly over time, that is, an unobserved components model with stochastic volatility (UC-SV). This model is expressed as

$$\pi_t = \tau_t + \eta_t, \text{ where } \eta_t = \sigma_{\eta,t} \zeta_{\eta,t} \quad (4)$$

$$\tau_t = \tau_{t-1} + \varepsilon_t, \text{ where } \varepsilon_t = \sigma_{\varepsilon,t} \zeta_{\varepsilon,t} \quad (5)$$

$$\ln \sigma_{\eta,t}^2 = \ln \sigma_{\eta,t-1}^2 + v_{\eta,t} \quad (6)$$

$$\ln \sigma_{\varepsilon,t}^2 = \ln \sigma_{\varepsilon,t-1}^2 + v_{\varepsilon,t} \quad (7)$$

where  $\zeta_t = (\zeta_{\eta,t}, \zeta_{\varepsilon,t})$  is *iid*,  $N(\mathbf{0}, \mathbf{I}_2)$ ,  $v_t = (v_{\eta,t}, v_{\varepsilon,t})$  is  $N(\mathbf{0}, \gamma \mathbf{I}_2)$ , and  $\zeta_t$  and  $v_t$  are independently distributed, and  $\gamma$  is a scalar parameter. In this model is the parameter  $\gamma$  the one that determines the smoothness of the stochastic volatility process. Also the shocks  $\eta_t$  and  $\varepsilon_t$  are considered as a transitory and permanent disturbances respectively.

Figure (1) plots the inflation series along with the smoothed estimates of the transitory shock ( $\sigma_{\eta,t}$ ) and the permanent shock ( $\sigma_{\varepsilon,t}$ ) standard deviations. This model was estimated using Markov Chain Monte Carlo (MCMC) with a  $\gamma = 0.05$  for most countries and  $\gamma = 0.03$  and  $0.1$  for the case of Brazil and Argentina respectively (for each country a total of 5000 iterations were performed).

From the figure it can be seen that there are substantial movements in the standard deviation of the permanent component, and this one has decreased since the nineties when data are available. At the same time, there is little change in the estimates of the variance of the transitory innovation.

In most cases, there is a broad coincidence of the rise of the inflation trend ( $\tau$ ) and the standard deviation of the trend ( $\sigma_\varepsilon$ ). The dating of this pattern is summarized in Table (4). Typically, if a country suffered from hyperinflations (as Argentina, Brazil, Chile,

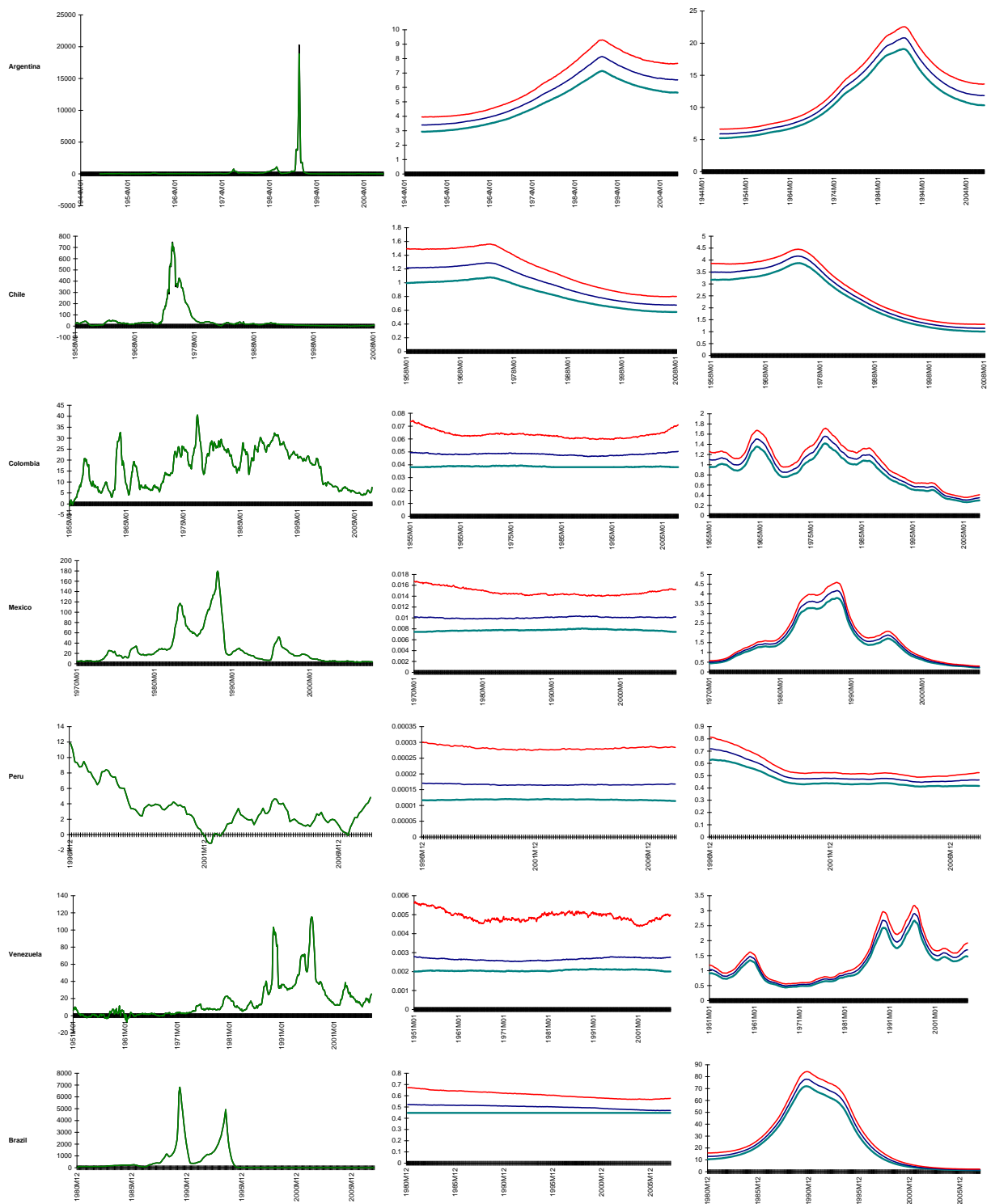


Figure 1: Inflation and Inflation volatility in the LAC-7.

Mexico and Venezuela from our sample) the magnitude of the standard errors move at a similar interval and the latest increases in inflation occurred during the nineties. From this set of countries it is interesting to show that Chile presents the lowest increase in the standard deviation of the permanent component ( $\sigma_\varepsilon$ ). Colombia started its process of lowering inflation in the nineties after reaching a level of inflation that, despite high (32% in January 1990) was not considered hyperinflation. It is interesting to point out as well that the countries that haven't adopted inflation targeting (Argentina and Venezuela) have lowered inflation as well but not as fast as the countries with inflation targeting. In the case of Argentina, the adoption of a currency board certainly helped.

For the purpose of international comparisons, it is interesting to look at high and low values for the time varying standard deviation in trend inflation,  $\sigma_\varepsilon$ . When  $\sigma_\varepsilon$  is high, it signals that trend inflation ( $\tau$ ) is unstable and is more likely to rise or fall. Similarly, a low value of  $\sigma_\varepsilon$  tells us that  $\tau$  is relatively stable, so it is more likely to stay where it is. Of this entire set of countries Colombia presents the lowest value of  $\sigma_\varepsilon$  for the current period (2000 – 2008), however, it is important to point out the remarkable behavior of countries like Brazil and specially Mexico, that having suffered from hyperinflations have lowered its levels of inflation and of the standard deviation at a rapid pace.

### 3 Real GDP in the LAC-7

Real GDP growth rates are well characterized by low order autoregressive (AR) models, this suggests a model of the form

$$y_t = \alpha_{0,t} + \sum_{j=1}^p \alpha_{jt} y_{t-j} + e_t, \quad \text{where } e_t = \sigma_{e,t} \zeta_{e,t} \quad (8)$$

$$\alpha_{jt} = \alpha_{jt-1} + b_t \quad (9)$$

$$\ln(\sigma_{e,t}^2) = \ln(\sigma_{e,t-1}^2) + v_{e,t} \quad (10)$$

where  $y_t$  denotes the growth rate of real GDP, the values of  $\alpha$  are four AR coefficients ( $p$  is set to 4), and  $e_t$  is the AR regression error term. The AR coefficients are allowed to drift through time as shown in equation (9), where  $b_t$  is an *iid* zero mean error term, and the regression error follows the same volatility process introduced in the previous section.

Using data on annual growth in real GDP the equations (8) – (10) are estimated and its main results are shown in Figure (2). Here we can see that Argentina, Brazil and



Table 4:  
**Changes in the Inflation Process Across the Decades**

	<b>Average of Inflation Trend (<math>\tau</math>)</b>							
	Full sample	1940-49	1950-59	1960-69	1970-79	1980-89	1990-99	2000-08
Argentina	237.56	21.90	30.45	23.27	137.90	495.23	728.83	9.04
Brazil	487.79					321.42	1023.28	7.30
Chile	49.64		32.36	25.19	181.51	21.49	11.78	3.17
Colombia	16.16		8.79	10.95	19.56	23.49	22.18	6.45
Mexico	28.70				14.70	69.88	20.52	5.21
Peru	3.41						6.59	2.21
Venezuela	16.78		1.72	1.22	6.61	22.94	47.96	19.19
Average	120.01	21.90	18.33	15.16	72.06	159.07	265.88	7.51
	<b>Median of standard deviation of Trend (<math>\sigma_\varepsilon</math>)</b>							
	Full sample	1940-49	1950-59	1960-69	1970-79	1980-89	1990-99	2000-08
Argentina	12.06	5.89	6.17	7.61	12.15	18.97	16.16	12.18
Brazil	16.72					21.34	49.30	2.40
Chile	2.67		3.49	3.58	3.94	2.40	1.46	1.17
Colombia	1.02		1.10	1.15	1.23	1.14	0.58	0.34
Mexico	12.39				1.12	3.57	1.60	0.37
Peru	0.48						0.64	0.47
Venezuela	1.08		0.98	0.62	0.65	1.22	2.26	1.53
Median	2.66	5.89	2.30	2.37	1.23	2.98	1.60	1.17

Chile present a recent increase in the volatility of GDP while Colombia, Mexico, Peru and Venezuela have decreased the volatility of output. The differences in GDP volatility among countries, shows that there is something else (probably international factors) that helps to increase or decrease (like the Venezuela case) the volatility of output.

## 4 Summary

This paper has presented estimates of trend inflation for the LAC-7 countries for the post was period when available, along with estimates of the volatility of trend inflation. The estimates suggest three broad conclusions

- The level and volatility of inflation typically rose during the seventies and most recently during the nineties when a series of international financial and currency crises hit Latin-America. Inflation fell in the nineties for most of the countries and we could say this is a synchronized pattern. Colombia and Venezuela appear to be significant outliers.
- The reduction in variability of real acitivity across the LAC-7 countries was far less synchronized with countries even increasing recently this variability.
- The stabilization of inflation in the LAC-7 countries means that the current estimate of the volatility of trend inflation is at the sample low in each country and still high compared to the G-7 economies for example.

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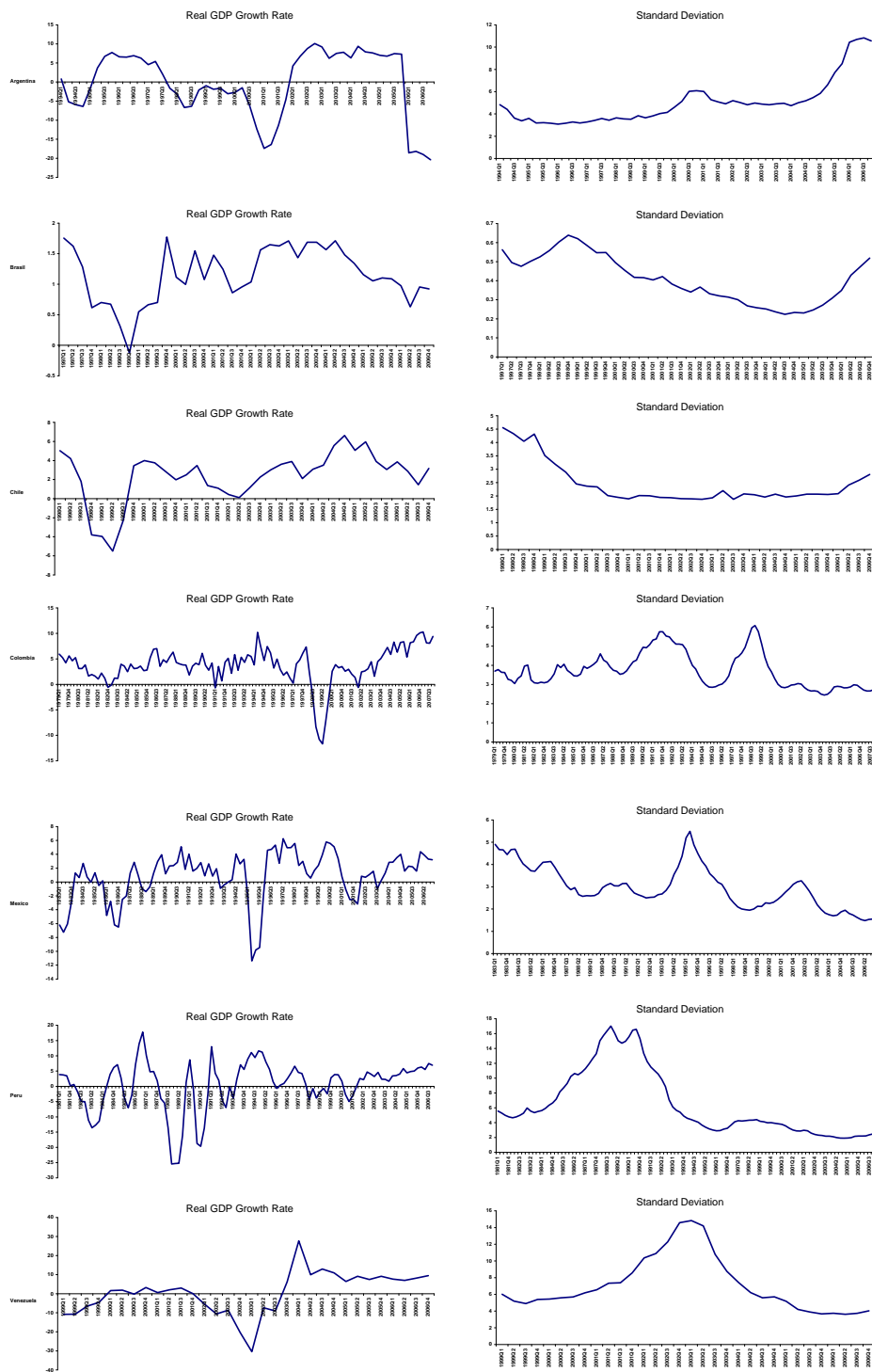


Figure 2: Annual Real GDP growth rates and volatility in the LAC-7

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