INFLATION DYNAMICS IN THE ABC (ARGENTINA, BRAZIL AND CHILE) COUNTRIES

Zarzosa Valdivia, Fernando
Universidad Nacional de Córdoba
Zarzosa.fernando@gmail.com

Farías, Juan Martín
Universidad Nacional de Córdoba
fariasmartin24@gmail.com

Buelens, Christian

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Abstract

This research estimates the dynamics of the headline or specific-component inflation and its persistence in Argentina, Brazil and Chile by autoregressive moving average models. Headline and specific-component inflation exhibit different behaviour within a country as well as between countries. In the case of Argentina, three samples were considered (1995-2006, 2007 – 2016 and 1995-2016) and our results show that the inertial inflation in Argentina increased after 2006.

Our results show that: a) the headline inflation response to an exogenous shock disappears after 40, 63 and 23 months in Argentina (full sample case), Brazil and Chile, b) the adjustment process after an exogenous shock hits an economy ranges between i) 4 and 70 months in Chile, ii) 10 and 80 months in Brazil; and iii), for Argentina, between 2 and 68 months for the sample 1995 and 2006 and 6 to 2400 months for the period 2007 -2016.

JEL Codes: E31, E37, C5
Keywords: Inflation, Persistence, Forecasting

I. Introduction

Inflation (the sustained increase of the price level of goods and services in an economy), appropriately measured, is a key variable for the evaluation of past economic performance as well as for the formulation of economic policymaking (System of National Accounts, (2009)). It is so particularly in emerging countries with experiences of chronic inflation, periods in which the inertial inflation is at its highest.

There are different theories about inflation; theories that differ in their assumptions, methodologies, diagnosis or prescriptions; see Heymann (1986) and Totonchi (2011) for a survey on inflation theories. Despite the underlying inflation theory, a precise understanding of inflation dynamics is imperative for any policymaker. The study of price dynamics is an empirical issue. The choice of either estimating an aggregate directly or its components (and then summing the component forecasts) depends on their relative performance. While the dynamics of direct inflation contain headline inflation as their dependent variable, the dynamics of indirect inflation are obtained by aggregating component-specific inflation rates, weighted by their share in the Consumer Price Index (CPI).[1,2]

In line with Buelens (2012), this research aims to assess the dynamics of direct and indirect inflation in Argentina, Brazil and Chile, the so-called ABC countries. There is no recent literature regarding the dynamics of the direct/indirect inflation in the ABC countries. Inflation dynamics are estimated by the best autoregressive moving average (ARMA) models selected by the Akaike information criterion. Our goal is also to measure the persistence of inflation by estimating the months in which inflation disappears (totally or the 50% of it) after a shock has hit the economy (long-run).

The remainder of the paper is organized as follows: Section 2 presents a literature review. Section 3 defines the relevant inflation measures, provides the data sources and analyses the evolution of inflation after 2003. Section 4 introduces the applied methodology. The evaluation of inflation persistence is presented in section 5. Section 6 concludes.

II. Literature review

The pattern of inflation is often at the heart of economic policy decision-making since it influences firms' price-setting behaviour or workers' wage-demands through its effect on the real interest rate and on inflation risk premia. Furthermore, the expected inflation rate impacts on savings and investment decisions. “Decision-makers hence need to have a view on the likely future path of inflation when taking measures that are necessary to reach their objective. Yet, while being indispensable to many decision-making agents, forming inflation expectations is generally both complex and costly: indeed, inflation forecasting requires an understanding of economic relationships, econometric modelling tools, access to data and other information” (Buelens, 2012, p. 4).

The amount of effort assigned to understand inflation dynamics has been directly related to its severity through history. For example, the *Great Inflation* period (1965 – 1982), a period in which inflation rose above normal levels throughout developed countries,

[1] Available data on the components of headline inflation are food and beverages, clothing, housing, household equipment, health, transport and communication, recreation, education and miscellaneous goods and services. Buelens (2012) disaggregates headline inflation in five main components, while some authors (e.g. Bermingham and D’Agostino (2011)) also study lower levels of disaggregation.

[2] Direct estimations provide straightforward conclusions, but indirect estimation might be more consistent since it is highly related to the evolution of the component-specific prices; although not all estimated component-specific series are a-priori expected to vary in similar fashion. Policy recommendations regarding inflation require the assessment of the component-specific inflation. For instance, Hammond (2012, p. 19), for an inflation targeting setting, suggests that “there have been calls for the targets to explicitly include asset prices and particularly house prices. Others have argued in favour of targeting *domestically generated inflation*, in order to abstract from the headwinds and tailwinds of imported inflation”.

encouraged many attempts to deepen the understanding of inflation. Cogley and Sargent (2001) apply VAR models to study the dynamic of inflation and unemployment in USA after WW II. They observe a direct and close relationship between inflation mean, volatility and persistence: inflation persistence increase and become variable during 1970´s, when inflation rose, while it decreased in the 80s and 90s when inflation faced anti-inflationary measures. While measuring inflation persistence in the Eurozone during 1970-2000, Batini (2006)find that inertial inflation did not change significantly in the sample period even though there are different country-specific inflation patterns. They also find that European countries face high inflation persistence. Following Kouretas and Wohar (2012) and Levin and Piger (2004), much of the empirical findings assessing high inflation persistence in developed countries are sensible to changes in econometric techniques. Nonetheless, they conclude that inflation persistence has been decreasing during the decades after the Great Inflation.

The *Great Recession* might change the inflation dynamics. Dany and Holtemöller (2017) find changes in inflation level, volatility and persistence in the European Monetary Union after 2009. Moreover, Berganza et al. (2016) suggest that some structural inflation patterns might have been changing since the outbreak of the crisis, although there is no conclusive evidence yet. Buelens (2012) highlights that inflation forecasting has become more difficult after the financial crisis.

For the ten largest Latin American countries, Capistrán and Ramos-Francia (2006) measure inertial inflation by the sum of the autoregressive coefficient of an AR (p) model. They found, in all countries, a high degree of persistence; Chile exhibit the lowest inflation persistence while Argentina and Brazil the largest. They suggest the inertial inflation decreased only in few countries, such as Argentina and Brazil; they conclude that persistence does not seem to have changed in Chile. Noriega and Ramos-Francia (2009) find evidence of changes in the inflation persistence in Argentina and Brazil, but not in Chile. Applying AR (1) models for the period 2000-2013, Roache (2014) suggests that the inflation persistence is larger in Chile than in Brazil.

Based also on AR (p) models, D´Amato and Garegnani (2013) and D´Amato et al (2007) analyze the Argentinean inflation dynamics between 1961 and 2006. In line with Cogley and Sargent (2001), they found a direct relationship between inflation and its persistence, with huge increases in persistence during high inflation periods. It is surprising, however, the lack of up-to-date measures of inflation persistence in Argentina in the last decade.

III. Concepts, data sources and stylized facts

III.1 Inflation Concepts and Measurement

It has long been recognized that high inflation distorts the signaling property of relative prices. Measures of inflation vary depending on basket of goods and services considered. When the basket of goods and services is related to consumers, inflation is usually measured by the percentage change of a consumer price index (CPI). Also, the consumer based inflation is a weighted average of a set of component-specific price indices (based on sub-baskets of goods and services) and weights given by the share of each type of good in the total expenditure. Table 1 provides the list of the different types of goods included in the Consumer price indexes of the ABC countries.

Table 1: Component-specific price indexes types in the ABC countries

Reference	Argentina (9 levels)	Brazil (9 levels)	Chile (12 levels)
CPI-1	Food and beverages	Food and beverages	Food and non-alcoholic beverages
CPI-2			Alcoholic beverages and tobacco
CPI-3	Clothing	Clothing	Clothing
CPI-4	Health	Health	Health
CPI-5	Education	Education	Education
CPI-6	Transport and communication	Transport	Transport
CPI-7		Communication	communication
CPI-8	Housing	Housing	Housing
CPI-9	Household equipment	Household equipment	Household equipment
CPI-10	Miscellaneous goods and services	Miscellaneous goods and services	Miscellaneous goods and services
CPI-11	Recreation		Recreation and culture
CPI-12			Restaurant and hotels
Hereafter CPI-i, i=1-12 would refer to the respective component-specific price index			

III.2 Data sources

Monthly consumer price indexes from Argentina, Brazil and Chile were collected from 1995 to 2016; a period with moderate inflation and far from the hyperinflation crises experienced by Argentina and Brazil in the early 90s.

Argentinean data from 1995 to 2006 and 2007 to 2016 were obtained from the National Institute of Statistics and Censuses (INDEC, Instituto Nacional de Estadísticas y Censos) and the Statistics Bureau of San Luis Province, respectively. San Luis inflation data were used after 2006 because the INDEC suffered a significant loss of credibility after that year.[3]Three cases have been considered for Argentina: The first starting in 1995 and ending in 2006, the second one starting in 2007 and ending in 2016 and a full sample period, starting in 1995 and ending in 2016.

The Brazilian Extended National Consumer Price Index (IPCA) was obtained from the Brazilian Institute of Geography and Statistics (IBGE, Instituto Brasileiro de Geografia e Estatística); Extended National Consumer Price Index-15 (IPCA-15) and Special Extended National Consumer Price Index (IPCA-E) Brazilian CPI´s reflect also consumption patterns, but the IPCA can be easily benchmarked to the Argentinean and Chilean CPI´s.

Chilean price indexes from 1999 up to 2016 were collected from the National Institute of Statistics (INE). Data on previous periods are splice data from other sources.

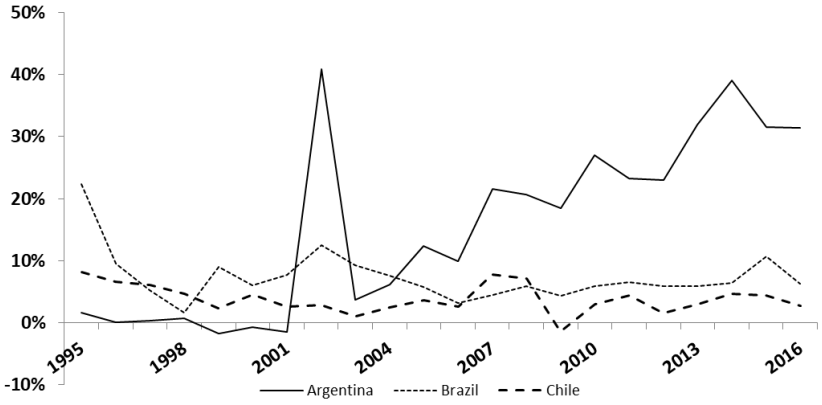
[3] Government intervention at INDEC and its consequences have been widely discussed. For instance, ATE-INDEC (2014) describes thoroughly the INDEC independence impairment; while Berumen and Veker (2011) analyze changes on the CPI´s methodologies and on the reliability of the data due to INDEC intervention.

III.3 Stylized Facts

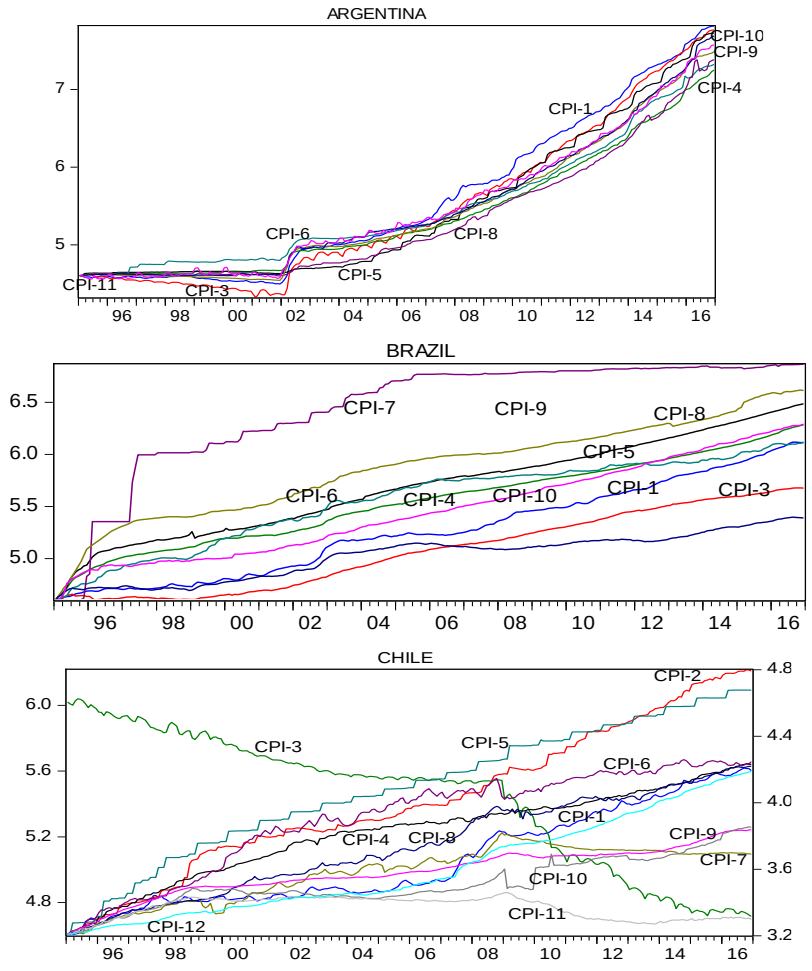
The first Latin-American countries that introduced inflation targeting were Brazil, Chile, and Colombia in 1999. They were followed by Mexico in 2001, Peru in 2002, Uruguay in 2007 and more recently, Argentina; see Cottani and Oliveros-Rosen (2016).

Figure 1 displays the evolution of Argentina, Brazil and Chile annual inflation as well as of the specific-components indexes. Before the 1990s, when inflation was an important problem throughout much of the world, inflation rates in the ABC countries were highly volatile. After anti-inflationary measures in the early 1990s, inflation decreased and remained low in the ABC countries. In Argentina, inflation exhibits an upward trend after the collapse of its exchange rate at the end of 2001.

Figure 1: Inflation in the ABC countries (1995-2016)



Source: Own elaboration based on INDEC, IBGE and INE.



The second, third and fourth charts of Figure 1 shows the evolution of the seasonally adjusted component-specific price indexes in the ABC countries (in logarithms); price indexes were adjusted by ARIMA XII seasonality adjustment method (a more detail analysis is provided Table 2 and by Census (2011)). As expected, different components exhibit different variations; their behaviour thus should be separately estimated.

Table 2: Seasonalities applied to the logarithm of the CPI indexes in ABC

Variables		CPI	CPI-1	CPI-2	CPI-3	CPI-4	CPI-5	CPI-6	CPI-7	CPI-8	CPI-9	CPI-10	CPI-11	CPI-12
	1st	N	N		N	N	N	N		N	N	N	Y	
A	**2nd**	Y	N		Y	N	Y	N		N	N	N	N	
	3rd	N	N		N	N	N	N		N	N	N	N	
B		Y	Y		Y	Y	y	N	N	N	N	N		
C		N	N	N	N	N	N	N	N	N	Y	N	N	N

Y and N indicate whether the series exhibit stochastic seasonality or not.
A, B and C refer to Argentina, Brazil and Chile, respectively.
1st, 2nd and 3rd refer to the Argentina 1995-2006, 2007-2007 and 1995-2016 samples, respectively.

IV. Methodology

In this section, the dynamics of head-inflation and specific-component inflation are evaluated based on Autoregressive Moving Average, *ARMA* selected by information criteria methods. The first differences (or inflation) of the logarithm of all price indexes are measured, and Dickey-Fuller and Phillips-Perron unit root tests are applied to the corresponding inflation series.[4]Tables 3 show shows that in all cases, inflation rates are stationary at the 1% significance level.

[4] Following Enders (2014), these unit root tests are applied under the null hypothesis that the corresponding series were generated by a unit-root (non-stationary) process. A data-generating process X is covariance stationary when: a) $E(X_t) = E(X_s)$; $\forall\, t, s$, b) $V(X_t) = V(X_s)$; $\forall\, t, s$; and c) $Cov(X_t, X_{t+h}) = Cov(X_t, X_{t+h+s}) isconstant\ \forall\, t, s, h$.

Table 3: Observed ADF and PP statistics (Ho: There is a unit root)

Country	Augmented Dickey-Fuller (ADF)			Phillips-Perron (PP)		
	Argentina	**Brazil**	**Chile**	**Argentina**	**Brazil**	**Chile**
CPI	-3,963 **	-5,366 ***	-5,410 ***	-45,355 ***	-58,564 ***	-153,377 ***
CPI-1	-4,048 ***	-5,593 ***	-4,667 ***	-54,605 ***	-83,559 ***	-154,354 ***
CPI-2			-5,094 ***			-285,226 ***
CPI-3	-3,640 *	-4,215 ***	-3,825 **	-66,938 ***	-74,838 ***	-303,120 ***
CPI-4	-3,535 *	-4,344 ***	-5,496 ***	-152,877 ***	-58,612 ***	-257,461 ***
CPI-5	-3,456 *	-3,412 *	-3,173 *	-40,685 ***	-175,578 ***	-98,168 ***
CPI-6	-4,586 ***	-6,940 ***	-4,330 ***	-94,821 ***	-162,341 ***	-329,701 ***
CPI-7		-7,260 ***	-6,973 ***		-25,522 **	-142,407 ***
CPI-8	-4,292 ***	-9,660 ***	-6,125 ***	-98,718 ***	-213,135 ***	-182,179 ***
CPI-9	-3,959 **	-6,140 ***	-3,559 **	-54,708 ***	-207,812 ***	-276,922 ***
CPI-10	-3,474 *	-6,842 ***	-3,860 **	-134,588 ***	-249,340 ***	-285,059 ***
CPI-11	-4,452 ***		-5,267 ***	-62,882 ***		-212,162 ***
CPI-12			-5,607 ***			-292,929 ***

*, ** and *** indicate that the null is rejected at 10%, 5% and 1% confidence levels, respectively.
Argentinean unit root test for the sub-samples 1995-2006 and 2007-2016 are available upon request.

Although inflation rates are stationary, they might be influenced by their past levels or by systematic errors incurred when estimating them. As a result, their dynamics are evaluated by using *ARMA (p,q)* models, where p is the number of lags of the corresponding inflation rate and q refers to the number of moving average (MA) terms; autoregressive integrated moving average models are not considered since inflation rates exhibit stationary behaviour. Extended *ARMA (p,q)* models are considered by adding crisis dummy variables (variables with one in the period in which the observed value exceeds certain threshold, but zero elsewhere),as well as economic policy dummy variables (variables with ones in certain periods, but zero elsewhere) that take into account the effects of certain economic policies.[5] These dummy variables aim to correct the impact that exogenous shocks or economic policies might have on the data generation process and, therefore, on the selection procedure of the corresponding information criteria. The following ARMA (p,q) models are selected:

$$\pi_t^j = \sum_{i=1}^{p^j} \alpha_{t-i}^j \pi_{t-i}^j + \sum_{i=1}^{q^j} \beta_{t-i}^j e_{t-i}^j + \sum_{i=1}^{k^j} \delta_i^j D_i^j + e_t^j \qquad (0.1)$$

[5] We identify periods in which observed values exceeds 2.5 times their standard deviations for Argentina (sub-sample, 1995-2006) and Brazil and Chile. In the case of the Argentinean (full sample and sub-sample 2007-2016) the threshold was considered by 3 times the corresponding standard deviations.

where $\pi_t{}^j$ refers to the corresponding *j*-inflation rate, *p* and *q* indicate the order of the autoregressive and moving average parts, respectively, both of which could reach values up to 12. D refers to the added dummy variables.

There are various methodologies to select the p and q values according to the Data Generating Process (DGP) of the analyzed series. For instance, according to the *Box-Jenkings* procedure, p and q values are selected on basis of the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). Sample variability of the correlation and partial autocorrelations may, however, lead to patterns that are not easily associated with a particular process order and, therefore, imply a significant degree of subjectivity when identifying q and p.

In this research the Akaike (AIC) information criteria is used to select, for each series, the best *ARMA (p,q)* model out 144 alternatives. These information criteria are defined as follows:

$$IC = -2*\mathrm{L} + \mathrm{k}*(\mathrm{p}+\mathrm{q}) \tag{0.2}$$

where L is the maximum value of the Log likelihood of the corresponding ARMA (p,q) model AND $k = 2$ for the AIC criterion.

This information criteria counter balance the goodness of fit of a model against the number of parameters it includes; there are other criteria, like the SIC criterion, which leads to more parsimonious models than the AIC criterion since the SIC criterion penalizes the inclusion of exogenous variables more than the AIC criterion.

Once the best models from equations (1.1) have been selected for each type of inflation series, the presence of autocorrelation and the normality of the residuals are evaluated by the Ljung-Box Q-statistic and the Shapiro-Wilks tests.[6]

Table 4 presents the p and q order of the selected models according to the AIC criterion, each model includes crisis and economic policy dummy variables.[7]

[6]The Ljung-Box Q-statistic rejects the null that any of a group of autocorrelations of a series (i. e. $r_k^2 = 0 \ \forall k = 1, 2, ..., J$) when its observed Q statistic exceed its critical value. Under the null of a normally distribution, the Shapiro-Wilks rejects the null hypothesis when its observed *W* statistic is larger than its critical value. The Q and W statistic are formally defined as follows:

$$Q = N\left(N+2\right)\sum_{j=1}^{J}\frac{r_j^2}{\left(N-j\right)} \quad \text{and} \quad W = \frac{\left(\sum_{i=1}^{n} a_i \mu_{(i)}\right)^2}{\sum_{i=1}^{n}\left(\mu_i - \bar{\mu}\right)^2}$$

where N is the number of observations, r_j^2 is the j-order residuals autocorrelation. $\mu_{(i)}$ refers to the ordered residuals and $\bar{\mu}$ to their mean, a_i are constants that depend on the mean, variance and covariance of the statistic of a sample of size n from a normal distribution.

[7]The list of dummy variables used is available upon request.

Table 4: Best Performance Models

ARMA (p,q) models					
Country	**Argentina**			**Brazil**	**Chile**
	Full Sample	**1995-2006**	**2007-2016**		
CPI	(1,0)	(7,1)	(1,0)	(5,2)	(6,2)
CPI-1	(2,10)	(0,7)	(12,0)	(8,0)	(1,0)
CPI-2					(3,0)
CPI-3	(4,5)	(12,1)	(2,2)	(2,1)	(0,12)
CPI-4	2,3	(1,0)	(7,2)	(7,11)	(1,1)
CPI-5	(7,11)	(2,2)	(1,1)	(1,12)	(12,2)
CPI-6	(2,8)	(3,2)	(3,2)	(2,7)	(0,11)
CPI-7				(12,1)	(1,0)
CPI-8	(5,2)	(3,1)	(1,0)	(2,11)	(1,0)
CPI-9	(1,1)	(1,1)	(1,1)	(1,1)	(3,3)
CPI-10	(1,2)	(2,5)	(3,1)	(7,2)	(1,1)
CPI-11	(1,1)	(2,0)	(1,2)		(12,0)
CPI-12					(1,1)

The first and second number of each cell refer to the p and q order of the best selected *ARMA (p,q)* model. Autocorrelation and normality tests on the residuals as well as selected models based on the SIC criterion are available upon request.

V. Inflation Dynamics: Impulse response functions

Figure 2 shows the impulse response functions corresponding to each ARMA model. The adjustment process of the different price indexes varies between countries as well as between the different component-specific price indexes. The impulse response functions show that the adjustment process after a shock has hit the economy is not instantaneous, but exhibits certain inertia in its adjustment. The characteristics of the adjustment process can be monotonous or cyclical; both of which could exhibit an overshooting behaviour or not; overshooting occurs when the adjustment process generates a pattern showing an up movement in the first periods of the shock and then a (monotonous or cyclical) down movement.

The impulse response functions associated to the estimated ARMA models also show different levels of persistence of inflation after an exogenous shock hits it. For instance, the headline inflation response to an exogenous disappears after 40, 63 and 23 months in Argentina (full sample case), Brazil and Chile, the first 50% of such adjustment occurs in no more than seven months. In Chile the adjustment process after an exogenous shock hits the economy ranges between 4 and 70 months, except in education and restaurant and hotels. In Brazil, prices adjust to an exogenous shock between 10 and 80 months. In Argentina, the persistence of inflation has increased after 2006; the range of the inflation response after an exogenous shock hits the economy lies between 2 and 68 months for the sample 1995 and 2006, but between 6 to 2400 months for the period 2007 -2016.

Table 5, which is based on the impulse response functions, compiles for each country and type of specific-component inflation their corresponding inflationary inertia. It also indicates the necessary periods in which the 50% of the adjustment takes after an exogenous shock has hit the economy.

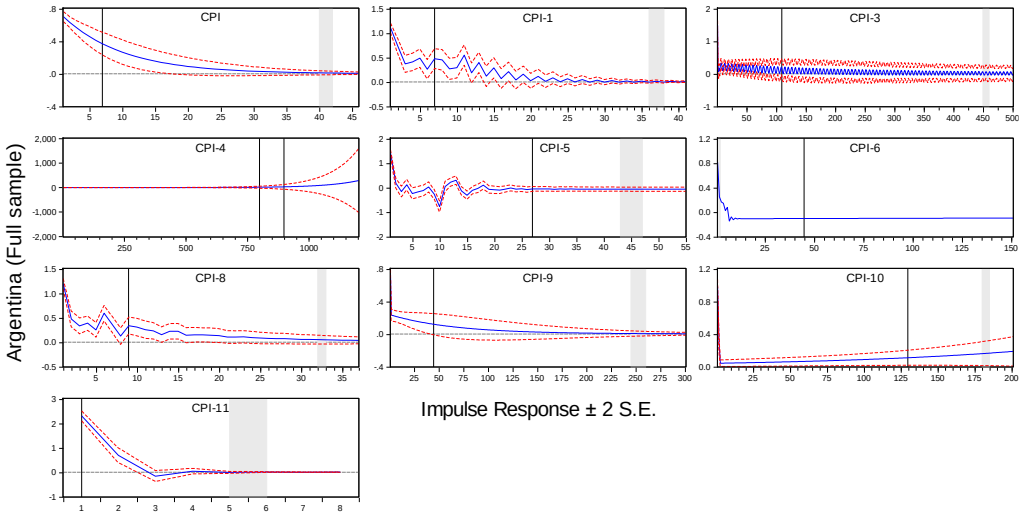
Table 5: Persistence behaviour:Inflation rates adjustment process

Price Indexes	Argentina									Brazil			Chile		
	Full Sample			1995-2006			2007-2016								
	Ov	t_{Lr}	50%t	Ov	t_{Lr}	50%t	Ov	t_{Lr}	50%t	Ov	t_{Lr}	50%t	Ov	t_{Lr}	50%t
CPI	N	40	7	N	63	17	N	63	5	N	63	14	N	23	7
CPI-1	N	38	7	N	8	3	N	77	44	N	60	18	N	10	2
CPI-2													N	10	2
CPI-3	N	450	11	N	72	37	N	2400	1370	N	72	37	N	14	7
CPI-4	N		900*	N	7	1	N	200	110	N	64	14	N	4	1
CPI-5	N	45	27	N	6	1	N	6	1	N	14	7	N	399	110
CPI-6	N	120	45	N	2	1	N	120	45	N	12	2	N	13	1
CPI-7										N	40	5	N	8	1
CPI-8	N	33	6	N	7	1	N	10	2	N	38	13	N	7	1
CPI-9	N	260	45	N	22	5	N	635	360	N	10	1	N	70	15
CPI-10	N	180	130	N	15	7	N	162	83	N	80	34	N	22	5
CPI-11	N	6	1	N	N	1	N	10	1				N	44	N
CPI-12													N	200	54

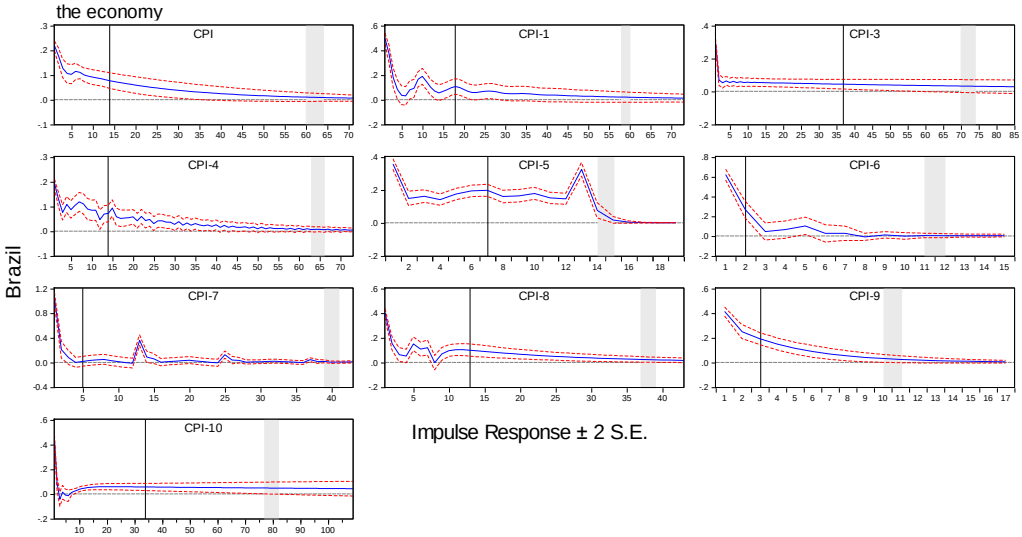
where Ov (overshooting) indicates that a shock generates a pattern showing an up and down movement, t_{Lr} refers to the months in which inflation disappears after a shock hit the economy(long-run), and 50%t shows the periods in which the 50% of the adjustment takes place after a shock hit the economy.

* indicates that even for the 25% of the adjustment may occur 800 months after the exogenous shock hit the economy.

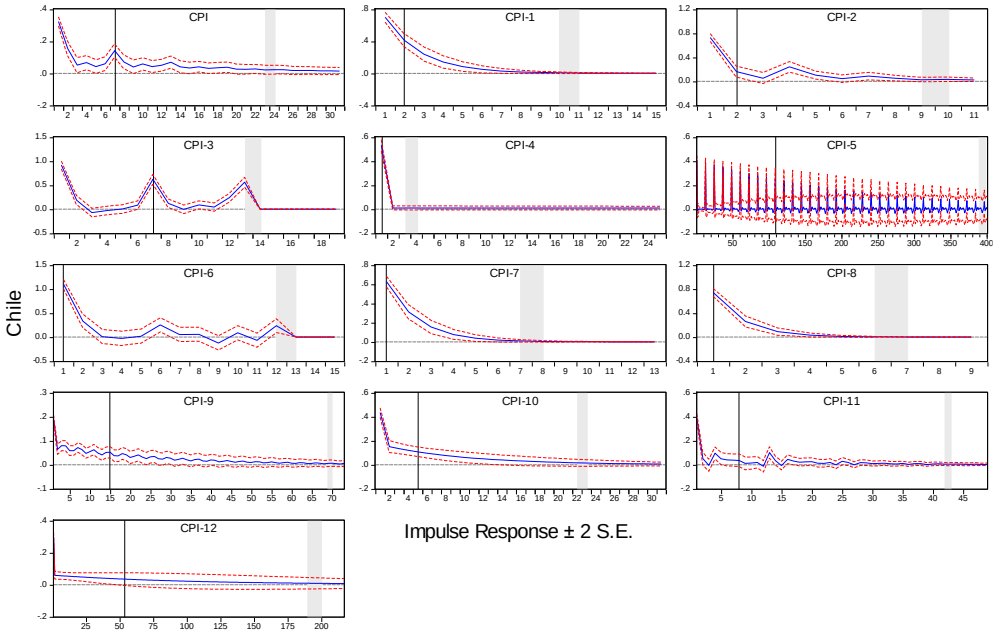
Figure 2: Impulse response functions in the ABC countries



The line and shadow area indicate the period at which the adjustment or 50% of it takes places after a shock hits the economy



The line and the shadow area indicate the period at which the adjustment or 50% of it takes places after a shock hits the economy



The line and the shadow area indicate the period at which the adjustment or 50% of it takes places after a shock hits the economy

VI. Conclusions and Future Extension

This research analyses the inflation dynamics and its persistence in Argentina, Brazil and Chile. The dynamics of inflation are estimated by autoregressive moving average models. Headline inflation as well as specific-component inflation exhibit different behaviour in a country as well as between countries. In the case of Argentina, three samples were considered (1995-2006, 2007 – 2016 and 1995-2016) and our results show that the dynamics of inflation in these three samples differs.

The impulse response functions associated to the estimated ARMA models show different levels of persistence of inflation after an exogenous shock hits it. For instance, the headline inflation response to an exogenous disappears after 40, 63 and 23 months in Argentina (full sample case), Brazil and Chile, the first 50% of such adjustment occurs in no more than seven months. In Chile the adjustment process after an exogenous shock hits the economy ranges between 4 and 70 months, except in education and restaurant and hotels. In Brazil, prices adjust to an exogenous shock between 10 and 80 months. In Argentina, the persistence of inflation has increased after 2006; the range of the inflation response after an exogenous shock hits the economy lies between 2 and 68 months for the sample 1995 and 2006, but between 6 to 2400 months for the period 2007 -2016.

Policy recommendations regarding inflation require a detail insight into the persistence or inertial inflation of headline or specific-component inflation.

This research can be extended by estimating ARDL (autoregressive distributed lag) models. Up to now, outliers have been considered exogenously determined, but they can also be considered stochastic in the sense that they change inflation not only in a certain period, but that they have time-effects depending on the data generation process of the corresponding variable. In line with the current literature, the number of specific-component inflation variables could be reduced to 5 or three aggregate components. Also seasonal movements can be introduced into the models instead of using seasonally adjusted time series. Finally, likely heteroskedasticity in inflation series may be included into the estimations using generalized autoregressive conditional heteroskedasticity models.

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