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Inflationary memory as restrictive factor of the impact of the public expense in the economic growth: Lessons from high inflation Latin American countries using an innovative inflationary memory indicator

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# **Institute for Advanced Development Studies**



## **Development Research Working Paper Series**

**No. 13/2010**

### **Inflationary memory as restrictive factor of the impact of the public expense in the economic growth: lessons from high inflation Latin American countries using an innovative inflationary memory indicator**

by:

Ernesto Sheriff

November 2010

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**Inflationary memory as restrictive factor of the impact of the public expense in the economic growth: lessons from high inflation Latin American countries using an innovative inflationary memory indicator.**

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**ABSTRACT**

A new inflationary memory indicator was developed and applied here. A panel was built with the selected countries considering the economic growth as dependent variable in function of the convergence hypothesis, the inflation rate, the public expense and, the recursive variance of the inflation (VARINF) as inflationary memory indicator. The expected results of the panel were that the inflation and their variability affect the growth negatively neutralizing the possible effects that it could have the public expense on the same one. Five Latin American countries with experiences of high inflation were included (Argentina, Brazil, Bolivia, Peru and Nicaragua).

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## 1. INTRODUCTION

The inflation has been considered by the literature (Barro, 1997) as a factor that impacts negatively in the growth. However, one has argued frequently that not only the inflation rate but its uncertainty also causes a negative effect in the growth (Sachs, 1986). The central argument is that the uncertainty of the rate of inflation reflects uncertainty in the relative prices that it is in fact the variable on which the economic agents make their long term forecasts (investment for example). A bigger uncertainty of relative prices leads bigger rates of risk to the projects and therefore they affect the investment rate negatively causing a deceleration of the economic growth. The ways of quantifying the uncertainty of the inflation rate were referred to proxys of increment in the inflation rate and variance of the inflation rate. In the case of the inflation variance approach, indicators that show along the time the variation in the uncertainty of the inflation rate don't exist. Although in the case of "cross countries" the variance of the inflation was used along the available data for each country, in the case of time series measures for the variance are not observed for every year or temporary interval.

The inflationary memory, present in the long and short term decisions of the individuals, it affects in a negative way the economic growth, neutralizing the positive effects that under certain circumstances could have the public expense. In that sense, the long term determinants of the economic growth are linked to factors of economic type and, to psychological nature factors where the risk and the memory prevail. Usually the economic determinants are symmetrical. In this work the main hypothesis is that symmetry is not given in the facts because of psychological factors that have to do with the memory of the economic agents. More specific, the economic memory of inflation rate is represented here by the recursive volatility of the inflation rate, which can increase for violent increases in the inflation rate itself but also for abrupt decreases in the same one. It helps to explain why in periods of high inflation the economic growth fell until showing negative rates and, much more important still, it helps to explain why after a sustained decrease of the inflation rate; the economic growth didn't recover from a symmetrical way to this decrease.

Memory plays a central role when valuing risks. The starting period from which the risk is valued determines different dynamics to the evolution of the valuation of macroeconomic risk. In this work we stay as hypothesis that the memory of macroeconomic risk, represented as inflationary memory, is bound to macroeconomic shocks of a very remote past that goes back to the first big inflationary accelerations, for example the period 1952 - 1956 in the Bolivian case. (See Sheriff and Chacón, 2007).

In order to verify the previously described hypotheses, the investigation has two objectives: The present study looks for to apply a new indicator based in the time series indicator of economic memory, called recursive variance of the inflation rate (VARINF). VARINF reflects the state of the inflationary memory in every period of time. This indicator was applied to a group of countries to quantify the influence on the economic growth from this variable in a simultaneous way to the intervention of the State through the public expense. In order with our goals we estimate an econometric model that incorporates the inflation, the inflationary memory and the public expense as determinants of economic growth, using a panel of Latin American countries with experience of high inflation. The macroeconomic approach underlines the importance of the psychological variables in the economic decisions of the economic agents.

## 2. INFLATIONARY MEMORY AND PUBLIC POLICIES OF STABILIZATION AND GROWTH

There is huge empiric evidence about the negative effect that has the inflation on the economic growth (Barro, 1997). It is usual to expect that countries with high inflation tend to grow less than countries with low inflation. In turn, the observation of economies with high inflation experiences show that recovery of the growth has been slower once concluded the period of high inflation, in spite of the fact that the determinants that unchained the crisis were eliminated or controlled<sup>2</sup>. The hypothesis behind this hysteresis phenomenon has linked with the inflationary memory that is to say that the economic agents continue behaving as if they were in high inflation regime in spite of the fact that the inflationary crisis has already finished. The orthodox standard models (Barro, 1997) and

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<sup>2</sup> See Frenkel (1988) and Morales (1988).

heterodox (Frenkel, 1987) they have simply formalized the effect of the memory introducing lags of the inflation rate in models of time series linking inflationary inertia with inflationary memory which is clearly incomplete.

Starting from the inflationary accelerations of the decade of 50's and 60's, the inflationary memory has emerged as discussion element in the design of political macroeconomic, not only anti inflationary but also in the design of policies of employment and revenues. The central argument was that the inflationary memory was taking a count in economic decisions affecting in a negative way the effectiveness to the economic policies. Since these years it has been usual recommend to break the inflationary memory as an element that assures the effectiveness of the economic policies. It was central in the design of heterodox policies of stabilization (Pegurier and Salgado, 2002) but there is no evidence about and empirical approach for inflationary memory.

In the same way, the inflationary memory affects, according to the literature, the economic agents' different decisions, highlighting in first instance, the determination of periods of reference of the contracts, reducing them of annual terms until monthly and even weekly terms depending on the virulence of the inflation (Abreu, 2004). However, this aspect - the cutting in the periods of reference in the contracts - it is not a formalized variable neither associated explicitly to the inflationary memory.

Morales (1988) analyzes the Bolivian case and he indicates that the problems associated to the indexation of contracts (linked in turn to the heterodox treatment of the inflationary memory) they were less important in Bolivia in the design of short term of their program of stabilization of 1985. However, Chávez (1991) indicated that for that year, the stability still lack to be consolidated and it was probably a factor that was retarding the recovery of the main real variables (product, investment, consumption, employment). He mentioned the public's expectations as a central element in the economic programs' effectiveness adopted in 1985 and that up to 1991 it had not still been able to assure a path of growth.

In both cases, one has arguments that are not translated in a mathematical model neither their conclusions are subjected to empiric evidence. However, in both works the importance of the inflationary memory is shown in the stabilization design and in the later periods when the recovery of the real variables is looked for.

The Argentinean case has been source of a series of theoretical works and applications to its hyperinflationary process, well-known as heterodox macroeconomics. Frenkel (1988) argues that the inflationary memory shortens the period of the contracts and of its periods of revision, particularly in the labor market printing to the inflation a inertia that was tried to suppress with the Austral plan rehearsed by the government of Alfonsín in the middle of the 80's. Although Frenkel formalizes the inflationary dynamics and the economic activity in a combined way obtaining dynamic systems that illustrate the presence and the importance of the inertial inflation, he did not show in explicit way in his development, the inflationary memory to which gives a central role in this dynamics.

The Brazilian case has also been discussion object in a highly formalized environment. On one hand, the heterodox rehearsal of stabilization applied in the decade of the 80, well-known as Cruzado Plan, it printed an investigating dynamics in fields of the inertial inflation, the persistence of the inflation and the post inflationary rigidities, where in each one of these fields it frequently made an appointment the inflationary memory. In Shapiro and Filho (1987), they mention that bigger inflations to 100% during the validity of a labor contract spread to perpetuate the inflation. In turn, these authors point out that once the inflationary memory disappears, economic policies' conventional tools newly begin to be more effective. Finally they point out that the memory inflationary helps to explain why the recessive policies of the International Monetary Fund were less effective to reduce the inflation. The orthodox economic policies' inefficacy neither is formalized explicitly starting from the inflationary memory. Even after the application of the Real Plan, the literature continued mentioning the inflationary memory as important element in the economic dynamics of that country, such it is the case of the devaluation of the real one in 1997. The compared revision of Macedo and Nayyar (1994) of the programs of Brazil and India, they coincide in pointing out the effect of the inflationary memory in the stabilization dynamics and growth. The contribution of their work resides in extend the concept from an exclusive way to regional level (the inflationary memory) to an economy that also faced the same phenomenon. However, the absence of a formalization of the concept makes that the considerations are made in the mark of facts only stylized.

Bueno et al (2004) based on the Brazilian case also point out that starting from the elimination of the inflationary memory it would be possible to assure that the economic



agents begin to use with more intensity the national currency. This phenomenon is central for future specifications of the demand of money, where it was observed that the public spreads to prefer currencies foreign even many years after having been dominated the inflation.

Finally, also taking the Brazilian experience, Lemos (2004) argues that the long inflationary memory spreads to perpetuate the inflationary inertia from indexing formulas especially starting from the continuous revisions of the minimum wages. However, the intent is limited to establish dummy variables (logit) in order to explain the revisions of the minimum wages and where finally the aspect is not formalized referred to the inflationary memory.

Based on a theoretical model, Benassy-Queré, Agnes and Conré, Beoit (2003) point out in their intent of demonstrating why intermediate flotation regimes in the exchange rate subsist between fixed and flexible. In their words, a government will prefer a flexible exchange regime if the external shocks are big, if the inflationary memory is low, and if the pass-through is weak. This work incorporates the memory like part of the formation of inflationary expectations and an adaptative component of long memory would be exogenous to the model.

### 3. PSYCHOLOGICAL ANALYSIS OF THE INFLATIONARY MEMORY

In spite of the abundant material that exists on the topic, the concept of inflationary memory it has been linked to several meanings of the same one, it has had a non explicit formalization in the economic modeling. On one hand the inflationary memory is linked with the persistence of the inflation. In other words, when the economic foundations no longer supported big inflation rates, the inflation rate continued being high. That phenomenon was known as inertial inflation and it was linked to the memory of the economic agents that they continued incorporating in their contracts, indexing formulas (indexation) similar to those used in inflationary periods. Although this phenomenon (the inertial inflation and their persistence) has been research object, its link with the inflationary memory in time series has been weakly formalized incorporating dynamic outlines mainly in the inflation equations. This dynamic structure generally incorporated

finite and decreasing lags of the inflation rate determining a very short memory that must drain, in the worst of the cases, some months after of the stabilization program in absence of new shocks.

Another linking of the inflationary memory has to do with the credibility. The design of many stabilization programs looked for to erase the inflationary memory of the public in such a way that is eliminated the previously mentioned inertia and the behavior "inflationary" still using indexation mechanisms when the same ones were no longer necessary. The central argument, appropriate with the previous one, it was that the most orthodox stabilization were more effective in presence of an inflationary memory erased by the own stabilization program.

#### A. NEUROECONOMICS OF INFLATIONARY MEMORY

Neuroeconomics is a new discipline that combines neuro sciences, psychology and economics, and studies how the human take economic choices (Glimcher, Camerer, Fehr, & Poldrack, 2009). Following to (Smith, 2009) there is three interdependent orders of mind/brain in the choice process. First, the order of the mind, where neuroscience surges with many advantages; second, the external order of economic trade and, third, the extended order of cooperation between market institutions and technology. The social brain looks have adaptative mechanisms for those actions that involves experience, memory, perception and personal knowledge<sup>3</sup>.

"The memory is the capacity that has an alive organism - or a society - of conserving a print of its experiences and of reacting in a situation in a such way that keeps relationship with that warehouse of experiences, that which puts in relation to the memory with the information and the knowledge" (Del Rey Morato, 2005, p. 239).

Memory has been considered synonym of knowledge or at least an indispensable condition for this. From the perspective of the Cognitive Psychology, it can be defined as a process that is part of the human system of prosecution of information whose function implies the registration, storage and recovery of data. (Ellis, 1986).

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<sup>3</sup> Op. Cit. Pág. 15.

It can be conceived as a constructive process in which the adaptative variation is the rule, this means that the information doesn't enter directly to the conscience, neither it reproduces literally, but rather it follows different phases in which are elaborated and they reconstruct integrative units, the information is contained in structures that act as reference marks that determine the organization lines, relationship and operation of the behavior. (Mahoney, 1983).

The cognitive structures that make possible the memory spread to introduce prejudices and distortions, since they are interconnected with judges, beliefs, emotions and interests of the fellows, it shows the quality multimodal of the human memory, so much in the registration moment or code of information like when upgrading the impressions. (Solís Macías, 2005).

These phenomena are supported by experimental studies in which it is explained that given a situation stimulus, outlines are activated that include in their contained information and other people's representations, denominated by some authors "intrusions" or "false alarms". Also the interference phenomena and inhibition have been commented. (Gutiérrez Calvo, 1998:81-109).

Recovery<sup>4</sup> or evocation, in general don't take place in a conscious way, this aspect has given place to distinguish among information "available" that cannot recover in direct form having still been coded and registered successfully and "accessible" the one that recovers voluntarily. The recovery will depend on several such aspects as: the type of task, the level of the individual's development, the prominence of outstanding indications (emotional or perceptual) the frequency in the repetition of the event and the way how these data are organized, that is to say the order in the registration phase will determine the easiness and recovery speed, as well as the possibility to carry out different manipulations and classifications. (Solís Macías, 2005; Robbie Case, 1984; Carretero, 2001)

A very important class of structures is those that represent the classification in the time. The adults spread to build the events of their experience in a mark of temporal

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<sup>4</sup> "The recovery of information of the memory is a sampling instance with substitution, in this sampling class the production of knowledge doesn't eliminate the information in the Long term Memory, the effect of this sampling leads to the production of a copy of the required information leaving intact the originally registered copy". (Solís Macías, 2005).

reference, in which the facts and life experiences of the past are linked and they anticipate the future events, this explains the importance of what is generally denominated "experience". The accumulated information is used to anticipate the events to come and to form expectations. (Carretero, 2001; De la Rey Morató, 2005)

Consequently, what we denominate inflationary memory refers to the prints of relative experiences to the economic phenomenon. Long periods of inflation or violent accelerations of the inflation constitute by the light of the previous paragraphs, stimuli that are stored in the memory of long term that they affect the behavior of people every time that "they extract" this information. In this way, the temporary outline in conjunction with the memory of long term would prevent to consider the effect of a violent inflationary acceleration and/or a long period with high inflation rates, as a phenomenon that has transitory effects in the behavior of the economic agents.

In inflationary contexts and post inflationary, the behavior of people can be drawn by the light of the temporary outline and the memory of long term: escape of the national money, indexation of contracts, speculation, high risk discount, etc. These structures will serve as reference marks that they will impact in the taking of decisions, expectations and future behaviors.

#### B. INFLATIONARY MEMORY AND EXPECTATIONS

An expectation is an informed prediction of future facts (Sheffrin, 1985). The variable expectations have been central in the theoretical developments of the last 50 years, beginning in the definitions and formalizations made in pioneer works of Allais (1958), Cagan(1956), Friedman(1956) and Muth (1961). From the psychological point of view, the expectation is one of the four variables inside Julian Rotter's motivational theory (Rotter, 1975), it allows to predict the behavior of a person in any given situation. In this theory, the expectation refers to the subjective anticipations of the individuals about the result of their behavior; the individual estimates the probability that a particular reinforcement happens if he/she behaves in certain way in a certain situation.

The expectations are based on the previous experience of an individual and they spread to reflect the form in that a person feels regarding a topic, not for force they are based on all

the pertinent objective data neither in the real estimate, based on true facts. (Rotter and Horschreich, 1975).

The formation of expectations is influenced by the perceptive selectivity. This process refers to the election of information that comes from the facts; the selectivity is guided in turn by those "personal constructions" or schematic patterns elaborated by the fellow. They serve as base to organize the preliminary design of an individual, guiding its strategies of facing a given situation. (Shulman, B. 1988).

Kazdin (2001) has pointed out how the expectations in the field of the clinical investigation influence in the behavior of the fellows, these effects were denominated "effects of non intentional expectations", to emphasize that the researcher cannot make nothing to influence in the answers of the fellows. The expectations can lead to modify the posture, the voice tone, the facial expressions, the form of giving the instructions, and to influence in the answers of the participants in an experiment. If we make an extrapolation to the economic behavior, it is justified the meaning of the economists in the sense that the expectations can still influence in the economic variables when their foundations have not suffered movement.

The effects of the expectations received considerable attention by the middle of the years sixty, in the context of the investigation in social psychology, they were carried out works in human and in primates identifying the characteristics of the fellows and how they behave, that is to say if they act in a professional, competent, and relaxed way, and they were related with the magnitude of the effects of the expectation. (Rosenthal, 1966, 1976 mentioned by Kazdin, 2001).

The theoretical work of the economists around the expectations, although it has been intense from the mentioned contributions, has concentrated their efforts in to construct models with expectations, that is to say, in adopting certain mathematical and statistical suppositions to introduce the expectations in the economic models. In that way, the economic hypotheses of expectations don't tell us how the agents form their expectations, they show us simply formulations that reflect a "as if they made it". "The fact that interests to the economic analysis is that the individuals act as if they were rational."

In that way the hypothesis of adaptative expectations, one of the oldest and more used, tells us that the economic agent will only correct her expectation if she makes a mistake and

in a proportion of this error (Cagan, 1956). The hypothesis of rational expectations tells us that the economic agent will build her expectation making use of all the available information and that her predictions, therefore, will differ only of the real values in random form (Muth, 1961).

Lucas's developments in 1976 and later tuned in a remarkable way the form of incorporating the expectations in the economic models. It responded to the epistemological tendencies of the time and it took into account many aspects referred to the imperfect, asymmetric and expensive information that was treated in previous papers (Sheriff and Chacon, 2007a and 2007b). Although these contributions are object of continuous revisions and amplifications, it is clear that there are many aspects that have not been still incorporate in a formal way, although intuitive. Such it is the case of the memory.

The emphasis in subjective states, in the mind of the fellows seen as economic agents, it has generated some explanations regarding the importance of the expectations in the function of demand of money. In general terms it is considered that the expectations are formed keeping in mind the data of the past, the available outstanding information in the moment that includes aspects like the structure of the economy, the government's actions and the strategies that this it will adopt in the future. Given these experiences that are reflected in the memory, the economic agents spread to not repeating their errors, to behave as if believes that the other ones would make it and, to form outlines of expectations for each economic structure. Is not reached to explain in Economy is how the fellows process the information that they prepare to elaborate their rational expectations and what role plays the memory in this process. The efforts in neuroeconomics are initially now but the memory is not mentioned in this way related to hysteresis and risk. See Glimcher et al (2009).

Almost all the works directed to the study of the dynamics of the inflation have tripped with the problem of expectations. In many of them it has been supposed that the expectations are rational and of perfect forecast. To assume that the expectations are formed rationally doesn't imply to discard an adaptative representation of the same ones. Shefrin (1985) mentions that under hyperinflation contexts a representation "rational" of the expectations it can be the adaptative. The shocks of credibility would only make

unnecessary the use of last information for the prediction of the inflation in presence of rational expectations.

In absence of shocks of credibility and supposing that the expectations are rational, the definition of the vector of information available  $I$  in the period  $\{t-1\}$  is large, since it includes quantitative information and qualitative information (context or states of the nature). So, different political contexts and different economic policies would lead to different inflation forecasts.

The consideration of the concept of inflationary memory prevents to make indiscriminate use of dummy variables to catch an isolated event of economic policies.

#### 4. INFLATIONARY MEMORY AND HYSTERESIS

The associations of certain type of economic decisions with the inflationary memory have a horizon of short and medium term, but the associations of certain hysteresis phenomena to the inflationary memory were less frequent. During the high inflation experience in Latin America many economic variables - particularly real variables as consumption, investment, exports, employment and money demand - showed negative rates of growth because the macroeconomic chaos where the inflation played an important role. Once reached the stabilization, the recovery of these variables was much slower than the reduction of the inflation rate. Even when all the foundations of such variables were already in the previous levels to the crisis, the same ones had not still recovered their initial levels. The inflationary memory has been behind these phenomena, in such a way that in horizons of medium long term, this variable continues affecting the economic agents' decisions. Another central aspect around the inflationary memory is that in spite of the multiple references around this variable and its importance in the design of economic policies, its formalization is not explicit. It has not been an economic series that reflects the state of the inflationary memory. Neither there is not an indicator that measures the effect of a erase of the memory. Neither one has an exact idea of how many periods is the average that an economic agent uses to determine her "memory" in inflationary terms. Even, it has not been, from the psychological point of view, to what type of memory refers the literature when speaks by inflationary memory.

In certain moment of the development of the art in this topic, it was associated this inflationary memory to the persistence of the inflation that in definitive is a topic separated from what implies the inflationary memory just as we are treating. The persistence of the inflation, that is to say, the presence of inflation rates above what the foundations would determine, is partly a consequence of the inflationary memory but it cannot be understood as the inflationary memory by itself.

Indeed, many economic real variables, as consumption, investment, exports, employment and holding of real balances, faced violent turndowns because the macroeconomic crisis where the inflation played a central role. After the successful stabilizations, the recovery of these variables was much slower than the reduction of the inflation rate. Even when all the foundations of such variables were already in the previous levels to the crisis, the same ones had not still recovered their initial levels. For it, we say that the inflationary memory has been behind these phenomena, in such a way that in horizons of medium long term, this variable continues affecting the economic agents' decisions.

## 5. A INNOVATIVE INDICATOR FOR INFLATIONARY MEMORY

We work with an indicator that measures the state of inflationary memory in each moment of the time, sensitive to the longitude of the memory, associated in turn to the credibility around the formation of a new data generating process for the inflation rate. We will call to this indicator VARINF (variance recursive of the inflation rate). The relevancy of VARINF will be illustrated to show how slow is the speed with which gets lost the memory of traumatic accelerations of the inflation rate, typical of periods of high inflation and hyperinflation. A measure of variance recursive is taken here but in a wider perspective, extending the concept of stochastic volatility proposed by Harvey and Shepard (1993).

VARINF is given as follow:

$$M_t^\pi = \frac{\sum_{t_o}^t (\pi_t - \bar{\pi}_t)^2}{t - t_o - 1}$$



We denote  $t_0$ , to the period of initialization of the agent's memory. A strong acceleration in the inflation rate drives to that the recursive mean of the inflation rate increases, causing in turn that the whole variance increases. However, when the inflation rate returns to its initial levels, even when the recursive mean also returns to its initial levels, the variance won't return to the same speed at these initial levels reproducing the phenomenon of asymmetry behind the periods of post stabilization. In order to the recursive variance begins a reversion toward the existent level before the acceleration of the inflation rate (for example a hyperinflation), the rate of inflation of every period should always be smaller than the existent recursive mean in the period of stabilization of the economy.

VARINF is useful to show how slow it is the speed with which gets lost the memory of traumatic accelerations of the inflation rate, typical of periods of high inflation and hyperinflation.

Taking into account the characteristics of the "inflationary memory" commented lines up and, the fact that the variability of an or more variable it is a factor that affects the risk, the measure of appropriate volatility it would be that that evaluates it in an accumulative way in the time and not in a moment of the same one. Following Harvey and Shepard (1993) the variances are also variable random and therefore, they also possess temporary properties.

On the other hand, when inflation rate diminishes (for example, when concluding a hyperinflation), the risk that the agents assign to the assets subject to the tax inflation doesn't diminish in the same proportion, reflecting a long memory as for variability of inflation. So that the recursive variance begins a reversion toward the existent level before the acceleration of the inflation rate (for example a hyperinflation), the rate of inflation of every period should always be smaller than the recursive mean in the period of stabilization of the economy.

Let see now the major properties of VARINF. To do this we propose a simple lineal relationship for a economic variable  $y$ :

$$y_t = X\beta + \phi\pi_t + \lambda M_t^\pi + u_t$$

Where  $y$  is a real variable object of study (growth, consumption, real balances, etc.);  $X$  is a vector wich includes the determinants of  $y$  settled by the economic theory. We called

$\pi$  to the variable that is associated to hysteresis phenomena;  $M$  is the economic memory.  $\Phi$ ,  $\beta$  and  $\lambda$  are parameters; finally  $u$  is a white noise and innovation residual. VARINF is the proxy indicator of  $M$  that reflects such inflationary memory, it implies that  $\lambda \neq 0$  and it does imply that it is a determinant of  $y$ . These characteristics are translated as follow:

$$M_t^\pi = \int_H^t f(\sigma_{\pi,t}^2, Z) dt$$

Where  $H$  is the most remote period since one has memory, it is associated to the credibility. The longitude of the memory goes from  $H$  to  $t$ .  $Z$  is a vector of exogenous variables to the inflation ( $\pi$ ) that affect the inflationary memory. Finally,  $\sigma_\pi^2$  is the variance of the inflation rate.  $H$  is the period of initialization of the agent's memory. If in the period  $t=1$  a credible change of policy takes place (for example the Bolivian stabilization in August of 1985), the representative agent will refer from now on her  $M$  perceptions.  $M$  will be calculated from the period  $t=1$  and will more representative of the given current risk for the new policy scene because the change was credible.

The characteristic of asymmetric between periods of high inflation and later periods of low inflation implies the following additional properties of  $M$ :  $\left| \frac{\partial M}{\partial \pi^+} \right| > \left| \frac{\partial M}{\partial \pi^-} \right|$ . The importance of the memory is central when valuing risks. The starting period from which the risk is valued determines different dynamics to the evolution of the valuation of macroeconomic risk. The memory of macroeconomic risk, represented as inflationary memory, is bound still, to macroeconomic shocks of a very remote past. The incorporation of agents memory in the valuation of the risk can make more relative the importance of another group of psychological determinants of the currency substitution (for example) which are the preferences, that is to say, to simply prefer the foreign currency for pleasure. VARINF has the properties listed and becomes an indicator that measures the state of the inflationary memory in each moment of the time, sensitive to the longitude of the memory, associated in turn to the credibility around the formation of a new process generator of data for the inflation rate.

In Anex 1 it is possible to see how VARINF is generated for many data generating processes. VARINF was simulated for unit root series, simple stationary series and long

memory stationary series. All the series were generated by Montecarlo simulations (2000 simulations were generated for each type of series).

VARINF shows a systematic behavior in all the simulations. When the time series are stationary with short memory VARINF shows the same pattern that we can expect for this type of series: almost constant. The most remarkable finding is the behavior in the presence of unit root and long memory stationary series. In both types of series VARINF shows hysteresis in all cases in which time series show increasing values for long time periods and a strong fall aftermath.

## 6. EMPIRICAL EVIDENCE

### A. HIGHLIGHTS OF SELECTED COUNTRIES AND DATA

A group of countries with complete series of rate of growth of the GDP per capita, public expense and inflation rate was taken. VARINF was calculated for each country that is in fact the indicator that will be presented in this work as contribution to the research applied in time series. Finally a panel was built with the selected countries considering the economic growth as dependent variable in function of the convergence hypothesis, the inflation rate, the public expense and, the recursive variance of the inflation. The expected results of the panel were that the inflation and their variability affect the growth negatively neutralizing the possible effects that it could have the public expense on the same one. The Latin American countries with experiences of high inflation included in the panel were Argentina, Brazil, Bolivia, Peru and Nicaragua. The main purpose of the econometric work was to isolate the inflation and its variability and not to estimate to all the determinant of the growth in the selected countries that they are varied Barro (1997).

The selected countries (Argentina, Bolivia, Brazil, Nicaragua and Peru) had hyperinflation experiences accompanied by abrupt fallen in the product and a slow recovery of the same one after their stabilizations. The selected countries (Argentina, Bolivia, Brazil, Nicaragua and Peru) had hyperinflation experiences accompanied by strong fallen in the product and a slow recovery of the same one after their stabilizations. In turn, all the hyperinflationary experiences occurred under a strong and active presence of the Public

Sector in the economy from a total intervention as Nicaragua, until a more heterodox intervention as Brazil and Argentina. In all the cases, it was observed the coexistence of high inflation rates and high public sector intervention. In these context a biggest public expense, even when it is not inflationary, it could activate inflationary expectations given the magnitude of the inflations supported by these countries.

Argentina (Anex 2.1.) supported two hyperinflations in 1989 in the last years of Raúl Alfonsín's government, after the failure of the Austral Plan rehearsed by the middle of the 80's. The GDP per capita fell in 8% and the recovery was quite quick in relation to other experiences that are analyzed in this work. Despite of it, for 1992, the GDP per capita had hardly reached at the effective levels in 1980. For this reason, this period was named the lost decade. The behavior of the inflationary variance shows that after the stabilization of 1991, the convergence at the previous levels is slow, even the inflationary acceleration of 2001 to 2005. The behavior of the public expense as percentage of the GDP (GARG) is pro cyclical, that is to say, it accompanies the cycle of the product, when in the 80's the product fell accompanied by high inflation, the public expense also made it.

Bolivia (see Anex 2.2.) had a longer hiperinflationary period among the years 1984 and 1985 with more than 15 months of continuous hyperinflation. Their GDP per capita did fall from 1981 up to 1986 and its recovery was the slowest among the selected countries. Once stabilized the economy in 1986 the variance of the inflation begins to converge far still in a slow way from the previous levels to 1982 in spite of the very low rates of registered inflation[on from 1995. In the period 1983-1987 the domestic saving and the economic growth were negative. In the fiscal side, the fiscal crisis begun in the period of democratic transition (1978-1982) it was increased by the crisis of foreign debt in 1982 and for the inflation from 1983 in a typical effect Tanzi - Olivera since the real collections fell as the inflation increased and one went more and more to the credit of the Central Bank to sustain the public finances. The severe fiscal adjustment of 1985 was not translated to a fiscal stabilization which was maintained with external help and internal financing. In real terms the negative figures were reverted almost by the middle of the 90's. Also, the main fiscal effort was focused in recovering the level of tax income, those which, after the tributary reform of 1987 grew quickly until placing a situation of primary surplus. All the goals of the different governments' policies that administered the economy between 1985 and 1995

didn't include increases in the real public expense, this fact gave stability to the sources of creation of public saving. The renegotiation of the foreign debt was another central element to be able to recover the sources of public saving. The public expense increased (as percentage of the GDP) in a quick way as the inflation diminished what implies that the inflationary memory could not be activated in presence of future accelerations of the public expense. In fact, in spite of the strong registered inflation, the relationship between inflationary memory and growth of the GDP per capita is practically does not exist (Illustration 4).

The Brazilian case (Anex 2.3.) shows a quick reduction of the inflationary variance after the application of the Cruzado Plan, however, the crisis of the Cruzado Plan II and of the Real one in 1995 make that this variable increases beginning a slow convergence at the previous levels to its inflationary accelerations again. Newly in 1996, the GDP per capita returns at the levels of 1980 showing the severity once again with which the inflation affected to the growth. The public expense increased together with the inflation, where it is possible to infer that the inflationary memory could associate future accelerations before current increases of the public expense. The clearly inverse relationship between the inflationary memory and the growth implies that the efforts to make grow this economy constantly trip with the problem of the inflationary memory, so mentioned in the literature around this country.

The Nicaraguan case has a different dynamics since its inflationary acceleration is associated to deep changes in its economic structure and emergent politics of the Sandinist revolution in 1979. The collapse of the government regime at the end of the 80's, came accompanied by a hyperinflation (see Anex 2.4.). The strong nominal disorder that brings the inflation and the dominant political context in the period of high inflation they determine that the Nicaraguan case shows one of the most virulent hyperinflations in the world history. It is clear, therefore, the inverse relationship among the volatility of the inflation that reflects the inflationary memory and, the economic growth.

Finally, the Peruvian case shows a hyperinflation under Alan García's government at the end of the 80's being a long period comparable to Bolivia one. The successful stabilization however, not even in 2005 it allowed reaching the income levels of 1980 (Anex 2.5.). The public expense behaves in independent way of the cycle, fact that

facilitates a more active policy in periods of low inflation. In the same way that the Bolivian case, the inverse relationship between the memory of inflation and the rate of growth of the GDP per capita is hardly visible.

#### B. A FIRST GROWTH MODEL WITHOUT PUBLIC EXPENSE

We will show a model of growth here for the period 1980 - 2005. The data could be available from 1960 but problems with the measure of inflation of Brazil for the period previous to 1980 and of Nicaragua previous to 1970 determines a shorter sample. It was used the saving like percentage of the GDP like more approximate indicator to the pattern of Solow - Swan (Barro, 1997) and it incorporated the rate of discrete inflation (INFH) and the recursive variance of the inflation (VARINF) as proxy of inflationary memory. The convergence has been incorporate by means of the logarithm of the GDP per capita lag one period to reproduce the initial conditions of the convergence. The model was estimated by fixed-effects method, the most appropriate for this type of samples (See Model 1 in Table 1).

All the variables have the expected signs. In one hand the coefficient of the convergence rate is -0.29 showing that on the whole these economies have a moderate convergence. Additionally, this variable is significant to 1%. The variable SAV has positive sign but it is not significant. Fact that shows the scarce relevancy of the traditional models to explain the growth in these selected economies. The variable INFH shows negative sign and it is significant to 1%. It shows that if the inflation rate increases, it diminishes the economic growth according the previous literature (Barro, 1997). The variance of the inflation (VARINF), besides not being colinear with INFH, it is significant to 5% and its sign is negative. That is to say, when the variability of the inflation increases, the information of the relative prices is distorted and it discourages investment decisions and saving, consequently the rate of economic growth falls.

### C. ESTIMATIONS INCLUDING PUBLIC EXPENSE

A second standard model of growth was estimated here for the period 1980 – 2005 including the public expense of the selected countries. The model was estimated with fixed effects the most appropriate for this type of samples since  $T > N$  (Hsiao, 2000).

The early models didn't include in first instance the variables related to the inflation, showing the gross effect of the public expense. Later these variables were added to evaluate the role of the public expense in presence of inflation and its memory. The model had the following form:

$$\log\left(\frac{y_{it}}{y_{i,t-1}}\right) = \beta_0 + \beta_1 \log(y_{i,t-1}) + \beta_2 \left(\frac{I_{it}}{N_{it} y_{it}}\right) + \beta_3 \left(\frac{G_{it}}{N_{it} y_{it}}\right)$$

Where,  $y$  is the GDP per capita,  $I$  the gross formation of fixed capital,  $N$  the population and  $G$  the total public expense. The dependent variable is the rate of growth of the GDP per capita. The reached results were registered in Model 2 in Table 1.

As it is observed in the Model 2 of Table 1, the convergence coefficient is significant, negative and smaller than one in absolute value. Also, the coefficient corresponding to the gross formation of fixed capital is significant and positive. Both coefficients are appropriate with the economic theory (Lucas, 1997). In spite of such desirable characteristics, the coefficient corresponding to the public expense has a negative sign that implies an effect contrary to what the active policy of the public expense presuppose. The model was estimated with balanced sample that in spite of causing a strong loss of observations its asymptotic results are more reliable than in the case of having estimated the model with not paired sample. A third model was estimated using saving as percentage of the GDP instead of the gross formation of capital. In both cases, the econometric results show a smaller quality that the regression presented in the model 2.

#### D. ESTIMATIONS INCLUDING PUBLIC EXPENSE AND INFLATION RELATED VARIABLES

By the light of the previous result, we incorporated the variables related to the inflation, that is to say, inflation rate and inflationary memory in this form:

$$\log\left(\frac{y_{it}}{y_{i,t-1}}\right) = \beta_0 + \beta_1 \log(y_{i,t-1}) + \beta_2 \left(\frac{I_{it}}{N_{it} y_{it}}\right) + \beta_3 \left(\frac{G_{it}}{N_{it} y_{it}}\right) + \beta_4 \left(\frac{\pi_{it}}{1 + \pi_{it}}\right) + \beta_5 \frac{\sum_{i=t_0}^t (\pi_{it} - \bar{\pi}_t)^2}{t - t_0 - 1}$$

Where,  $\pi$  is the inflation rate. Notice that colineality doesn't exist among the inflation rate measured here and the recursive variance of the inflation. The results are in Table 1 model number 4.

The fourth model constitutes a better approach to the data generating process reflected in the evolution toward under of the information criteria indicators. In spite of the global improvement of the model, the behavior of the public expense changes substantial way, since of being significant in the first regression finishes being not significant in this new one. It implies it that we don't reject the hypothesis that their coefficient is zero that means that the public expense would not have effect of long term on the rate of growth of the GDP per capita. In turn, the inflation rate, measure as percentage loss of the purchasing power of a monetary unit (INFH), neither it is significant, although their sign is negative just as the theory suggests. On the other hand, the coefficient corresponding to the recursive variance of the inflation (VARINF) it is significant to 1%. The economic implication confirms the hypotheses of the work and they constitute the main contribution of the work.

First, the public expense would not have effect on the growth in presence of the inflation, mainly in presence of a significant inflationary memory. Second, it is not the inflation itself that affects the growth negatively, is its memory, in other words, the inflationary memory, the one that affects the growth, fact that the theory suggested but it didn't formalize until today.



**TABLE 1: Econometric estimations for selected countries**

Dependent variable		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
		CREC	CREC	CREC	CREC	CREC	CREC
Constant	Coefficient		0.43418	0.77874	3.28468	3.74290	2.82903
	Std. Error		0.17324	0.19395	0.80228	0.77183	0.72847
INFH	Coefficient	(0.00091)			(0.00035)		
	Std. Error	0.00012			0.00027		
VARINF	Coefficient	(0.00002)			(0.00017)	(0.00040)	(0.00155)
	Std. Error	0.00001			0.00006	0.00011	0.00006
LPIB(-1)	Coefficient	(0.29792)	(0.05357)	(0.09940)	(0.40165)	(0.42713)	(0.34488)
	Std. Error	0.04818	0.02185	0.02684	0.09903	0.08886	0.08972
SAV	Coefficient	0.00112		0.00131		0.00292	
	Std. Error	0.00098		0.00095		0.00156	
FBKF	Coefficient		0.00309		0.00485	0.00443	0.00466
	Std. Error		0.00110		0.00136	0.00171	0.00136
G	Coefficient		(0.00574)	(0.00269)	(0.00388)	(0.00388)	(0.00390)
	Std. Error		0.00159	0.00097	0.00350	0.00374	0.00353
INVEXT	Coefficient					(0.00438)	
	Std. Error					0.00190	
CTACTE	Coefficient					(0.00630)	
	Std. Error					0.00156	
Fixed effects	ARG	2.65523	0.05611	0.10773	0.37439	0.23293	0.31647
	BOL	2.08197	(0.02700)	(0.06469)	(0.20045)	(0.07573)	(0.16512)
	BRA	2.44504	0.04941	0.05060	0.12467	0.00491	0.10115
	NIC	2.04987	(0.07398)	0.07972	(0.25394)	(0.08532)	(0.21286)
	PER	2.28648	(0.00454)	0.01391	(0.04468)	(0.07680)	(0.03965)
	Obs	115	115	140	65	60	65
	R squared	0.43178	0.35719	0.22843	0.44375	0.56779	0.42623
	S.E. of regres.	0.03889	0.04159	0.04881	0.02786	0.02539	0.02804
	Schwarz crit.	(3.18886)	(3.26416)	(2.97833)	(3.84813)	(3.91360)	(3.88134)

#### E. A PARSIMONIOUS FINAL MODEL OF PUBLIC EXPENSE AND GROWTH IN PRESENCE OF INFLATION RELATED VARIABLES

In the search of a parsimonious model based on the result found in the previous section, it incorporated such variables as the foreign private investment (INVEXT) and the external balance in current account (CTACTE), finding results of smaller quality mainly in that referred to coherence with the economic theory (see Model 5 in Table 1). This way, it is presented the final model where G is only included with the only purpose of showing that it is not significant, denoting that its impact on the growth of long term is zero (Model 6). The model is more solid than the previous models, showing independent and spherical residuals.

### 7. CONCLUSIONS

The inflationary memory affects decisions of short and long run of the economic agents who consider in their decisions the inflationary history and also its uncertainty. It has been insisted in the literature about the role of the inflationary memory in the slow recovery of economies after supporting a period of high inflation. However, the available indicators are not reflecting the state of this inflationary memory in a moment of the time. The presence of an indicator of the state of the inflationary memory could help to the confrontation of several hypotheses arisen along the last years in the sense that the inflationary memory would be behind the slow recovery of important real variables after having finished periods of high inflation, well-known phenomenon as hysteresis. VARINF developed here responds to these critics.

The inflationary memory helps to explain in a significant way hysteresis phenomena that were present after successful macroeconomic stabilizations. The state of the inflationary memory, as long as determinant variable in the taking of decisions, is quantifiable in an indirect way in models of time series (VARINF). Models of time series that incorporate the inflation and their variability encompass models that take only into account the inflation, for that the indicator of inflationary memory (VARINF) necessarily incorporates the volatility from the rate of inflation in an independent way to the expected value of the same one.

We introduce the inflationary memory as determinant of hysteresis phenomena in economies in periods post inflationary, particularly in Latin America. We were able to obtain an indicator that measures the state of the inflationary memory in each moment of the time, sensitive to the longitude of the memory, associated in turn to the credibility around the formation of a new data generating process for the inflation rate. VARINF has the congruent characteristics with the stylized facts present in the literature which are: accumulative effect across the time, asymmetric between periods of high inflation and later periods of low inflation and independent of the observed value of the inflation in a moment of the time.

The first model provides strong evidence in favor of the inclusion of the inflationary variance in the models of growth. The model 1 shows that the inflation and its memory, they are definitively significant and, they affect the economic growth negatively. It is strongly advisable to incorporate in more advanced models of growth this aspect since it helps to explain why the economies tend to grow slowly after having finished their experiences of high inflation.

The inflationary memory, according to the evidence here proportionate, it affects the economic growth negatively. The lessons that are extracted embrace a wide range of applications.

First, it is provided in this work an indicator concrete intertemporal, non collinear with the inflation, of the inflationary memory. It was calculated as the recursive variance of the inflation.

Second, this variable measured by this way allows justifying that before the inflation rate itself, its variability (memory) is the one that has bigger negative effects on the growth.

Third, while the sign and significance of VARINF (our inflationary memory indicator) stays unalterable when they are added different determinants in the classic equations of growth estimated in this work, the sign and significance of the expense public is no coherent with the basic hypotheses of the interventionists recommendations. The public expense, in economies with record of high inflation, seemingly would not have effects of long term on the economic growth. The evidence coming from the Latin American economies is solid in this aspect.

Fourth, is provided for the first time in the literature a multidisciplinary focus when studying the inflationary memory from the economic point of view and from the psychological point of view, being obtained in both analyses, consistent predictions in the sense that the inflationary memory conditions the behavior of the economic agents in a wide spectrum, since the inflationary shocks is introduced in the memory of long term.

The use of VARINF is recommended in those cases that an outstanding inflationary record is observed. In economies with low inflation, the variance among periods is homoscedastic and therefore, collinear with the constant of the regression model.

On the other hand, in economies with record of high inflation, the VARINF appears as a determinant of almost all the real variables of the economy, for example, private consumption, demand of money, investment and, like in this case, economic growth. It allows to evaluate hysteresis phenomena without having to go to statistical manipulations neither to create series of artificial data that reproduce the asymmetry. Therefore, the vein of recommended future investigation is around these points.

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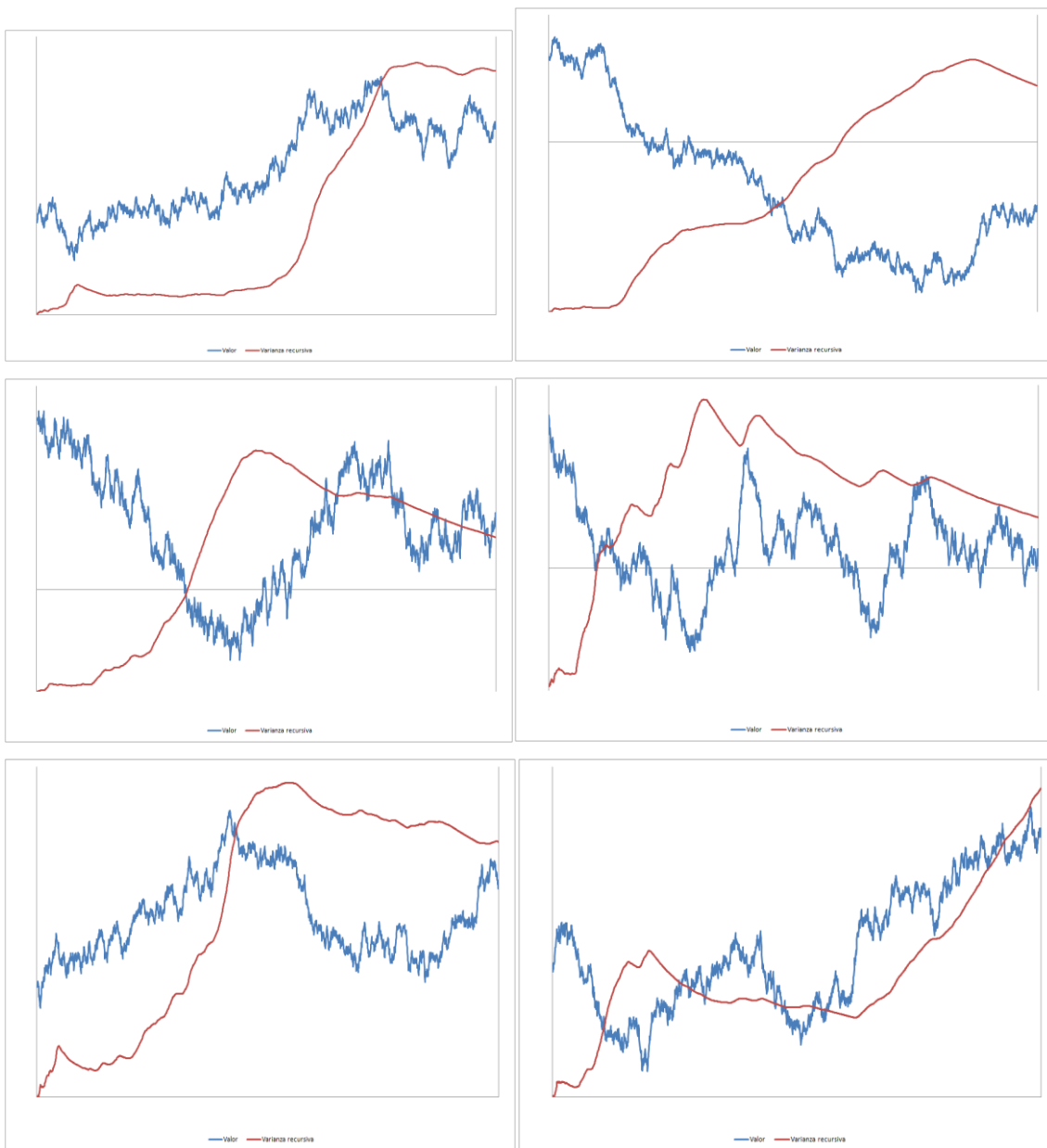
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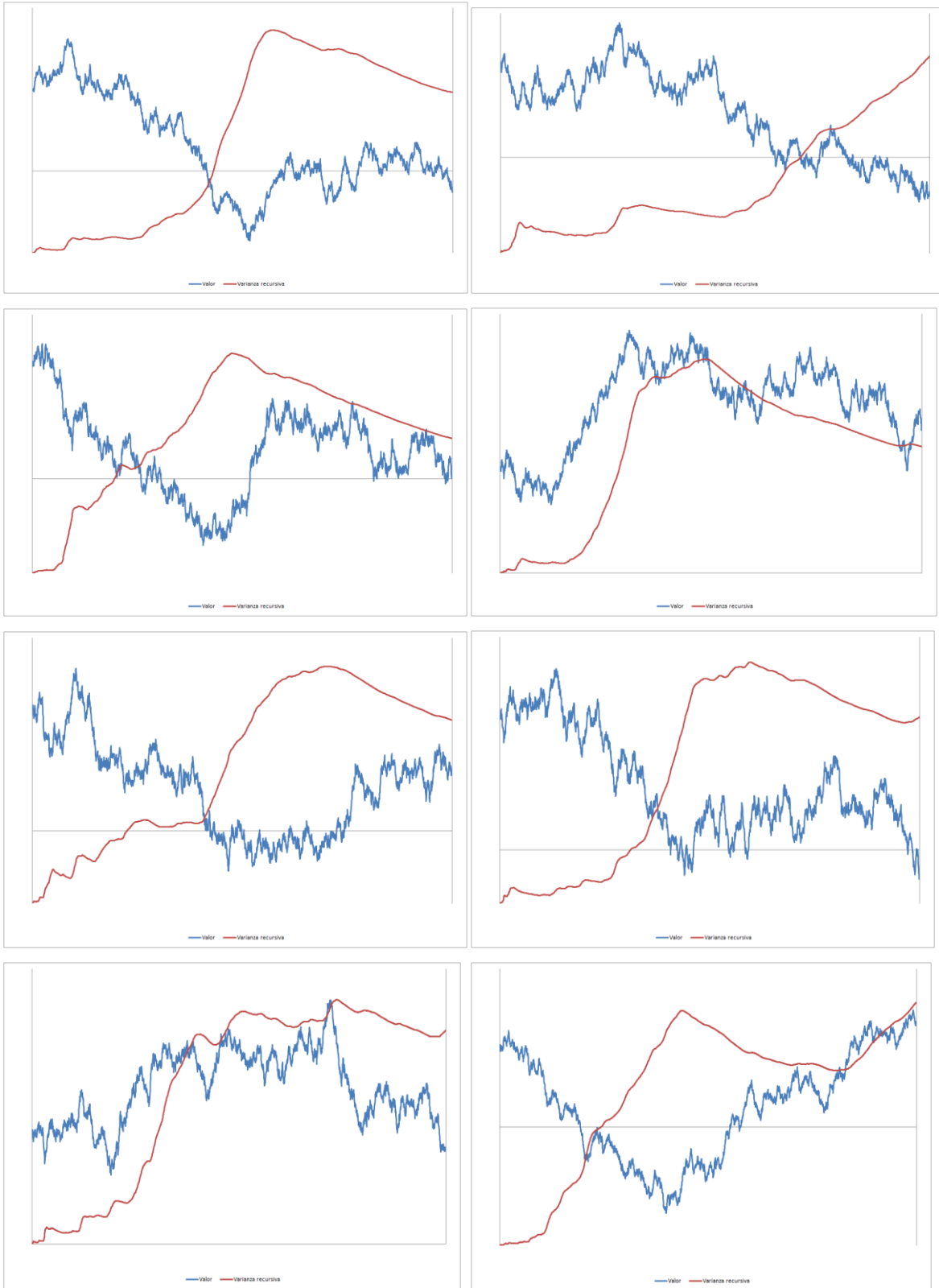
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## ANEX 1: MONTE CARLO SIMULATIONS WITH ECONOMIC MEMORY INDICATOR

### ANEX 2.1. SIMULATIONS WITH UNIT ROOT SERIES

$Y_t = Y_{t-1} + u_t$  . Number of simulations:2000

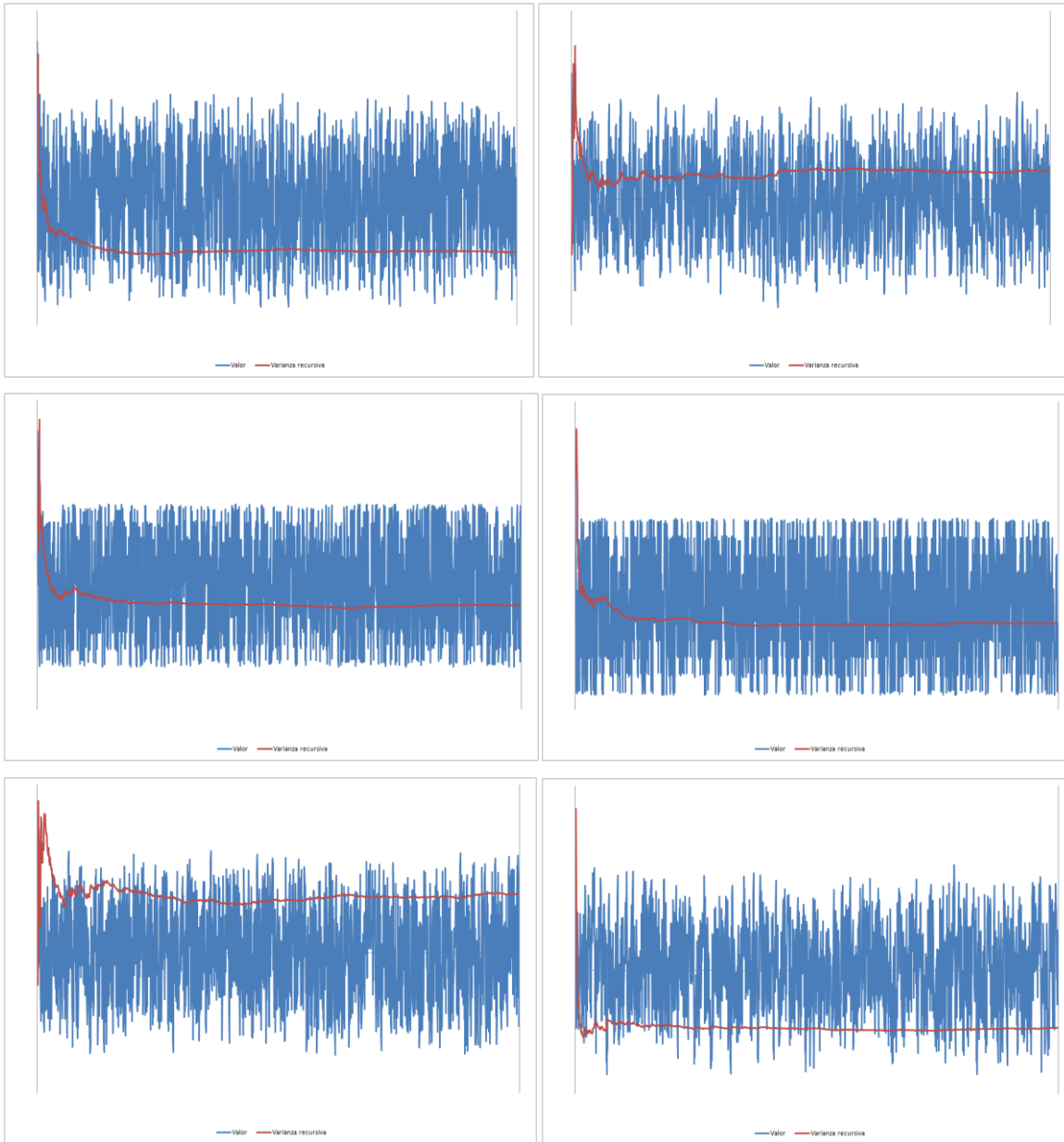






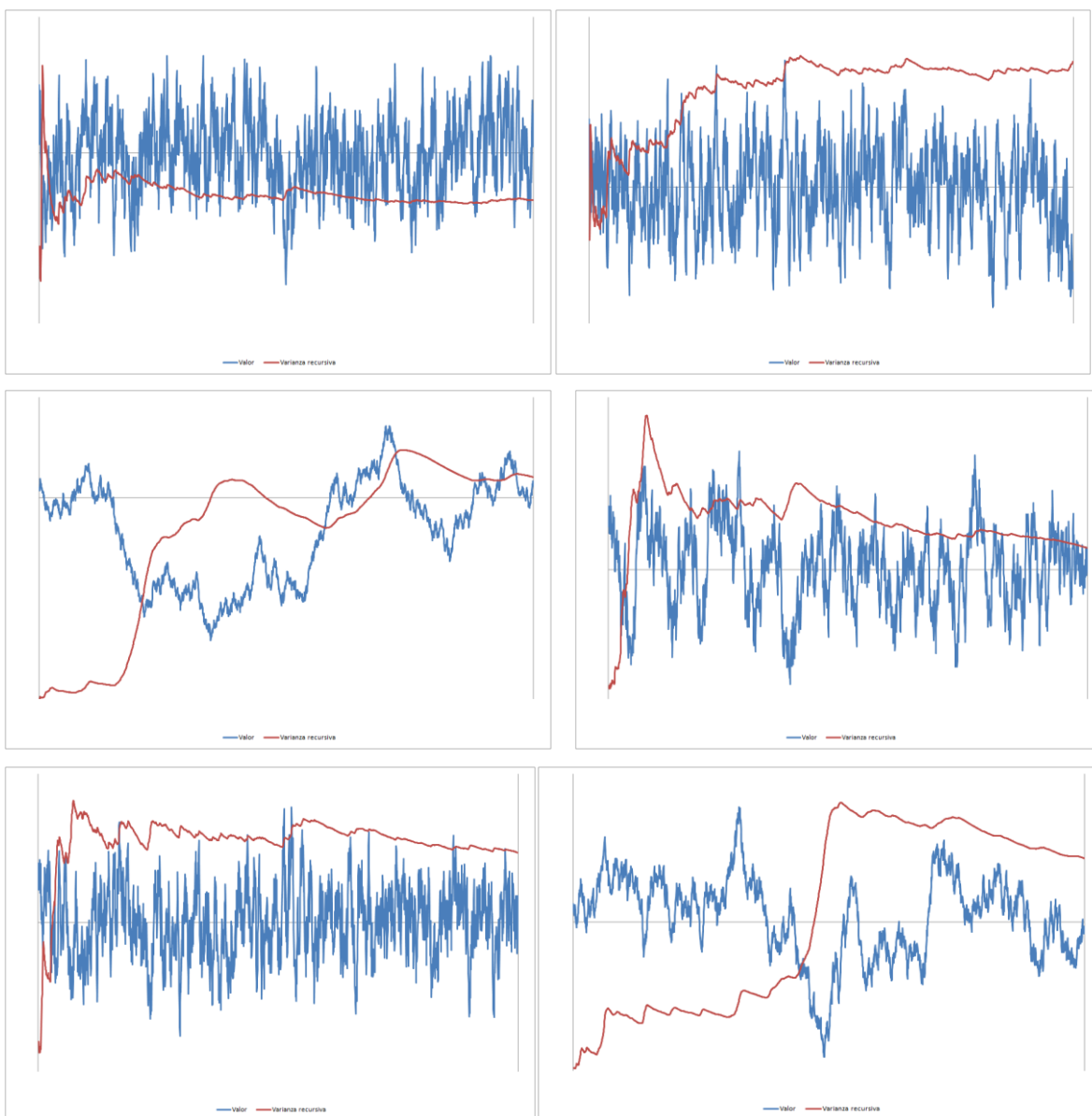
## ANEX 2.2. SIMULATIONS WITH STATIONARY SERIES

$Y_t = \delta Y_{t-1} + u_t, \delta < 0.5$ . Number of simulations: 2000



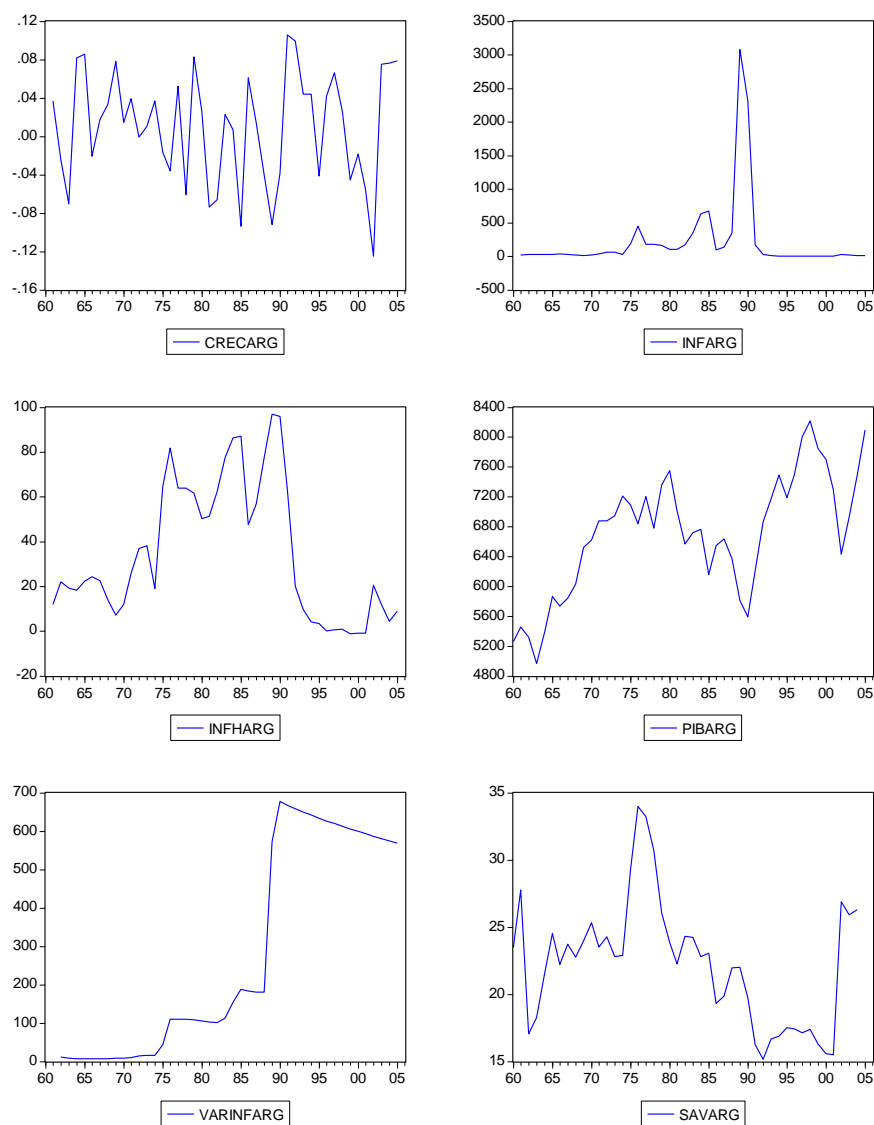
### ANEX 2.3: SIMULATIONS WITH LONG MEMORY STATIONARY SERIES

$Y_t = \delta Y_{t-1} + u_t, 0.5 < \delta < 0.99$ . Number of simulations:2000



## ANEX 2: DATA FIGURES

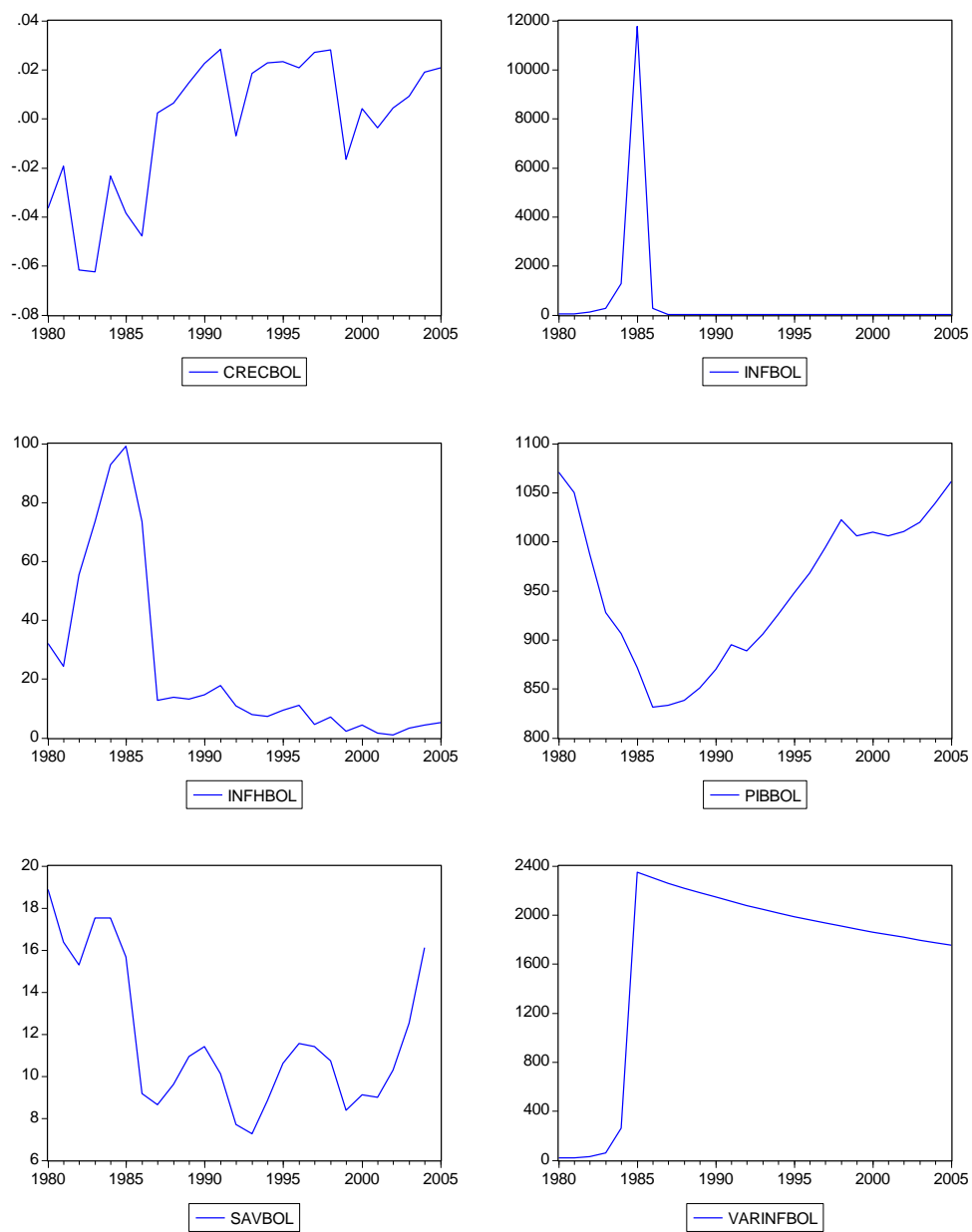
Figure 1: Argentina<sup>5</sup>



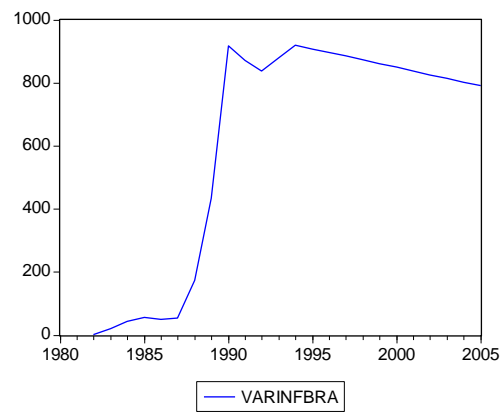
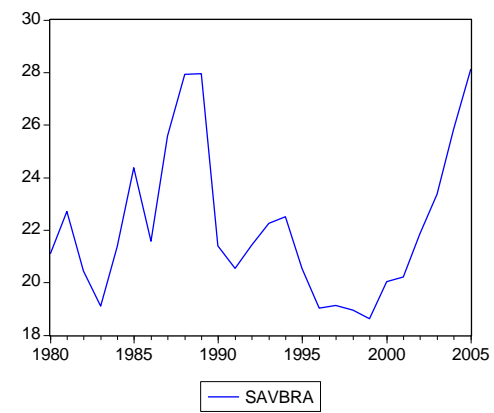
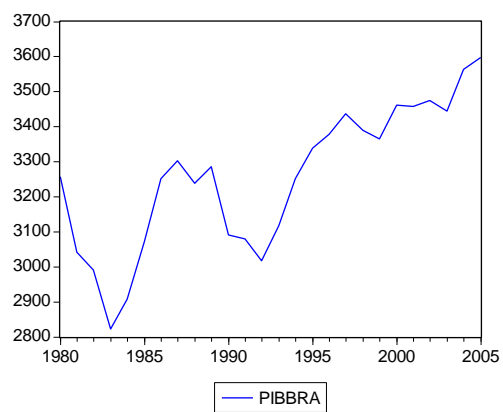
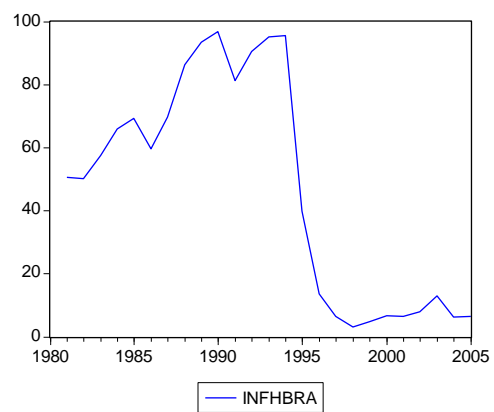
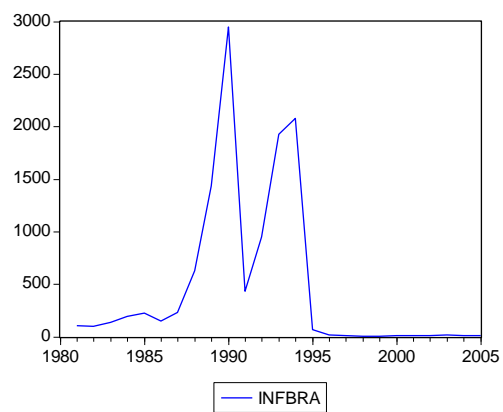
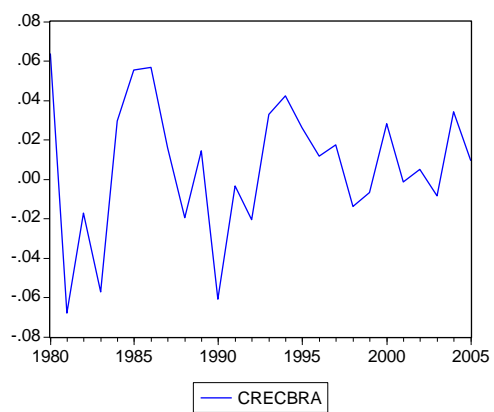

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<sup>5</sup> CREC denotes growth of the GDP per capita, GDP denotes GDP per capita in constant dollars of the year 2000, INF denotes inflation rate, INFH it denotes inflation rate like percentage of income (value maximum 100% in hyperinflation). VARINF denotes variance recursive of the inflation and SAV it denotes gross saving as percentage of the GDP. Source: World Development Bank (WDI database).

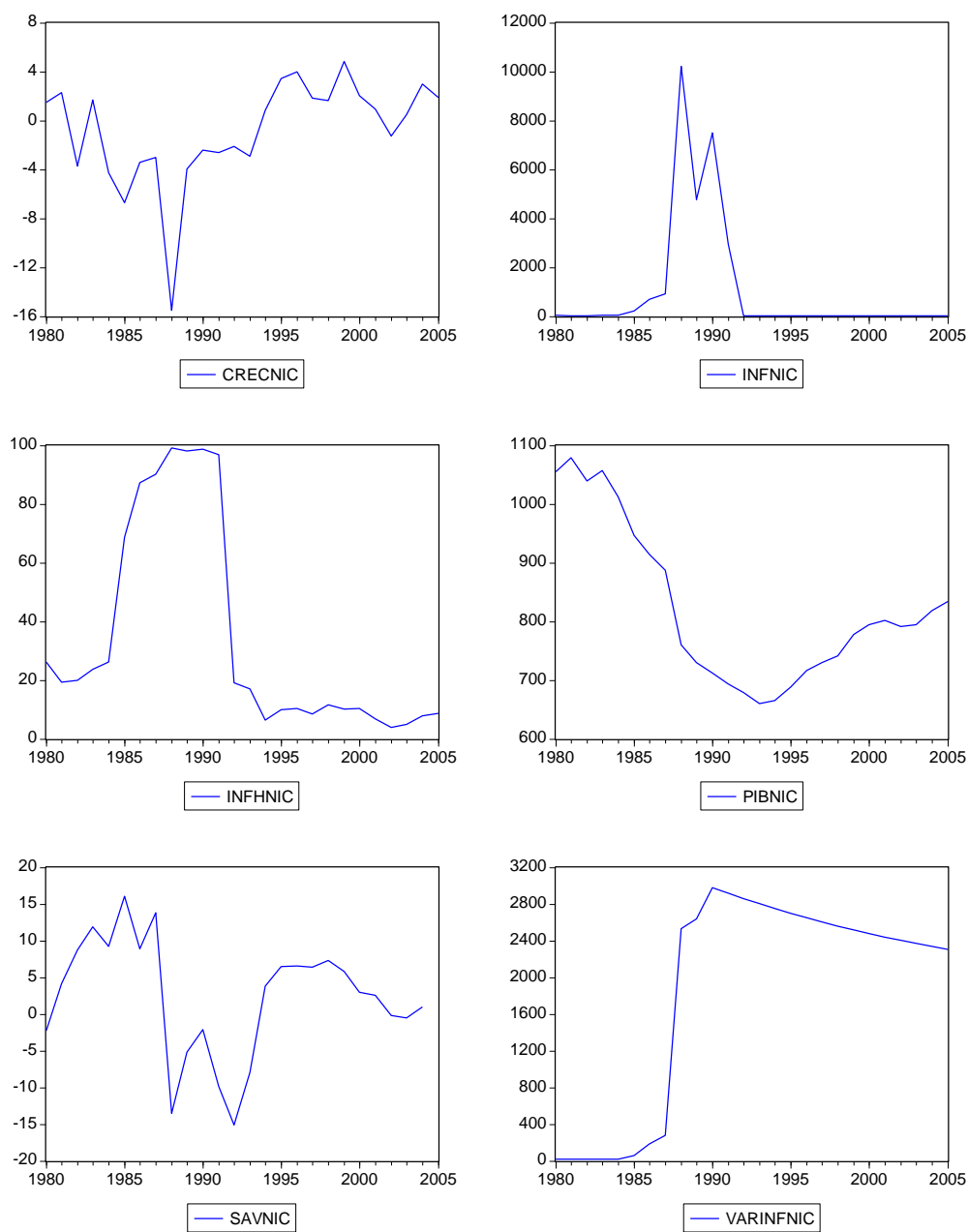
**FIGURE 2: BOLIVIA**



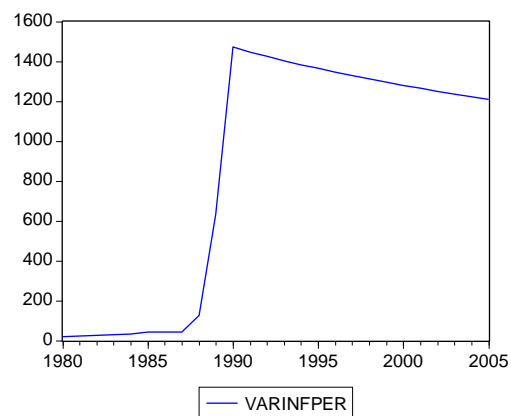
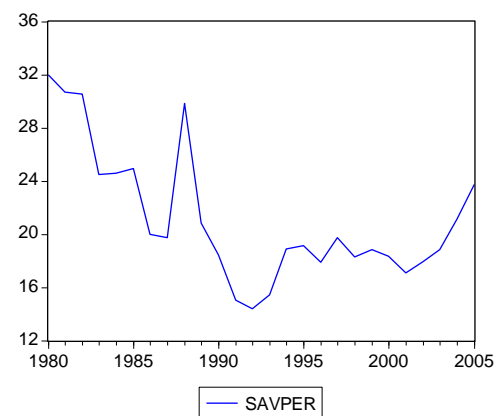
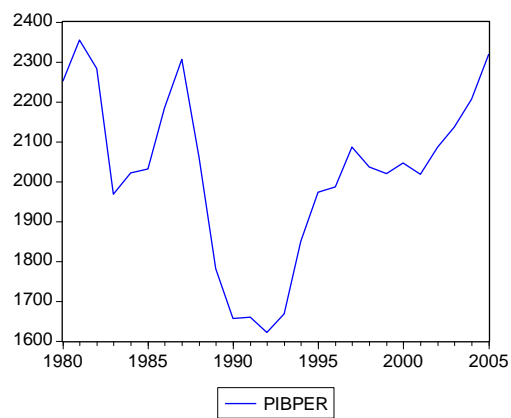
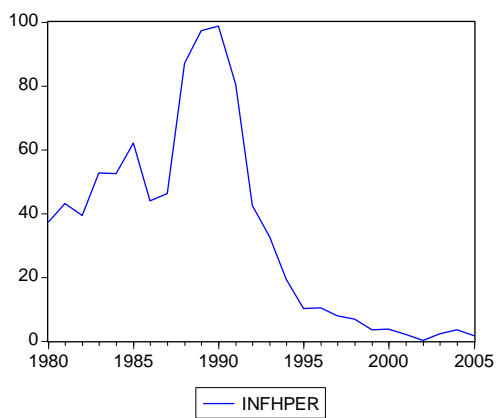
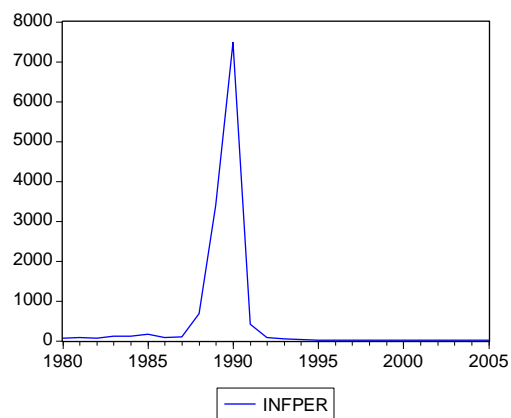
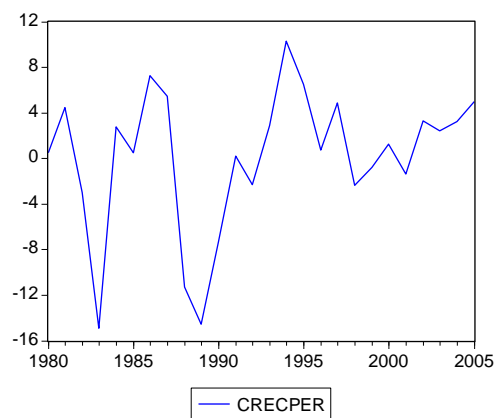
**FIGURE 2: BRASIL**



**FIGURE 3: NICARAGUA**



**FIGURE 4: PERÚ**



### ANEX 3: INFLATIONARY MEMORY VARIATION IN PRESENCE OF A DISCRETE CHANGE IN INFLATION RATE

Let  $\sigma_{t_0}^2 = \frac{\sum_0^{t_0} (\pi_i - \bar{\pi}_0)^2}{n}$  recursive variance of inflation in stabilization period  $t_0$ . Next period's variance is

given by  $\sigma_{t_0+1}^2 = \frac{\sum_0^{t_0} (\pi_i - \bar{\pi}^*)^2 + (\pi_{t_0+1} - \bar{\pi}^*)^2}{n+1}$ , where  $\bar{\pi}^* \cong \bar{\pi}_0 + \frac{\pi_{t_0+1} - \bar{\pi}_0}{n+1}$ . Assuming a long sample

$\frac{n}{n+1} \approx 1$ . The variance can be re written as follow  $\sigma_{t_0+1}^2 = \sigma_{t_0}^2 + (\pi_{t_0+1} - \bar{\pi}_0)^2$ . Conclusion: When inflation rate changes the change over the variance will be negative only if the new inflation rate is lower than recursive inflation rate at the moment of stabilization.  $\Delta\sigma_t^2 \approx 2(\pi_t - \bar{\pi}_0)\Delta\pi_t$ .



## Anex 4: Model G

Dependent Variable: CREC?  
Method: Pooled Least Squares  
Sample (adjusted): 1993 2005  
Included observations: 13 after adjustments  
Cross-sections included: 5  
Total pool (balanced) observations: 65

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.829033	0.728468	3.883538	0.0003
LPIB?(-1)	-0.344876	0.089722	-3.843816	0.0003
VARINF?	-0.000155	6.27E-05	-2.479999	0.0162
FBKF?	0.004660	0.001357	3.433552	0.0011
G?	-0.003896	0.003527	-1.104643	0.2740
Fixed Effects (Cross)				
ARG--C	0.316470			
BOL--C	-0.165117			
BRA--C	0.101151			
NIC--C	-0.212858			
PER--C	-0.039645			
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.426230	Mean dependent var		0.016659
Adjusted R-squared	0.344262	S.D. dependent var		0.034628
S.E. of regression	0.028041	Akaike info criterion		-4.182407
Sum squared resid	0.044033	Schwarz criterion		-3.881338
Log likelihood	144.9282	Hannan-Quinn criter.		-4.063616
F-statistic	5.200001	Durbin-Watson stat		1.479059
Prob(F-statistic)	0.000070			