HIGH INFLATION, VOLATILITY AND TOTAL FACTOR PRODUCTIVITY

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ABSTRACT

This paper aims to evaluate empirically the relation between high inflation levels (definite by the inflation about more than two digits), inflation volatility (definite by the standard deviation of inflation) and the Total Factors Productivity (TFP) growth. Using the Generalized Method of Moments (GMM) estimation methodology, developed by Arellano and Bond (1991) and extended by Arellano and Bover (1995), in a dynamic panel data context, for 1960-2000 period and 18 Latin American countries. We find a negative relation between high inflation levels and TFP growth, and among inflation volatility and TFP growth; furthermore, we do not find a specific relation between low inflation levels and TFP growth.

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KEYWORDS: inflation; total factor productivity; dynamic panel data; Latin America.

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1. INTRODUCTION

In the last years, specially during the decade last, economic growth literature has given rise to a new analytical body, which exhibits three distinguishing characteristics (Sala-i-Martin, 2002): a greater bond between the theories and the methodology of data used to contrast them with the reality, endogenous technological progress and the approach of diverse branches of the economic discipline, taking place a luck of symbiosis.

These characteristics allow to take up in a systematic way the most outstanding characteristics of the economic growth, identified by Easterly and Levine (2002): on the one hand, the differences in growth rates between the countries are explained to total factor productivity (TFP) growth, and not by the accumulation of capital; on the other hand, a convergence in the per capita income between countries throughout years does not appear.

According to these circumstances, it is obvious to deduce that the identification of the determining growth factors is, largely, in the explanation of TFP, the literature stands out a series of factors, within which are the society institutions or societies under study and decisions adopted by the policymakers, who have the capacity to influence in the efficiency of an economy. Nevertheless, on the one hand, the promotion or introduction of good or bad institutions is not absolutely equal to which it corresponds to technology case, since it becomes more difficult development of new and better technologies in an economy that does not count on suitable institutions (Sala-i-Martin, 2002). On the other hand, a better understanding of national policies related to the long run growth may contribute to explain differences between countries with respect to per capita incomes and providing a sound base for recommendations to the policymakers, directed to enhance human well-being (Levine and Zervos, 1993).

Conceptually, the causality direction in the long term between inflation and growth are normally considered as directed from the distorted effects of a high inflation and variability resulting from relative prices to growth. A lower growth can occur via a reduction at, as well as through the depressive effect of uncertainty on investment, or through the adverse effects on credit allocation efficiency. These effects might dominate any cyclical relation in presence of high inflation levels during long periods. The distorted effects, nevertheless, do not appear so obvious at low inflation levels (Fisher, 1993).

In the short run, the reason by which the central banks must emphasize maintaining a low inflation comes, among other considerations, of the vision that inflation imposes costs that reduce people well-being. Since a monetary policy that reduces inflation apparently decelerates economic activity in the short run, it turns out useful to consider his benefits through a high output growth in the long run. In the short run, a greater real growth may be associated to a greater inflation. Frequently, this occurs because this sound growth is the result of an aggregated demand increase, which causes a pressure over prices. In order to reduce the inflation, the central bank must contain the aggregated demand, but this may temporarily reduce output and employment. Nevertheless all this vision is given in the short run, if inflation has an effect on output growth, is because it has an effect on the aggregated supply in the long run.

There is on literature, a broad range of forms by means of which inflation can affect the output growth: first, a higher inflation can make more difficult suitable families and firms decisions making when these receive market signals. When prices are increased in a permanent form, the agents find more difficult to distinguish relative prices changes of general level prices changes, which interferes with the efficient prices system operation, reducing therefore growth. Second, inflation imposes costs that would be nonexistent if prices were stable, like the well-known menu costs if prices and wages change frequently, the search costs on buyers and sellers when prices change, and the costs of maintaining monetary balances, which do not render interests, among others. Third, high inflation levels may affect the saving and investment decisions, reducing proportion of GDP destined to investment, causing thus that economy accumulates a less human or physical capital (Motley, 1994).

Until relatively few years ago, the standard tool of analysis has been made up regressions throughout a cross section of tens of countries. Nevertheless, this approach is not devoid of difficulties, since the regression analysis assumes that observations are taken from a different population, nevertheless worldwide we find so heterogeneous countries, which have insufficient characteristics like being considered and included in a same regression. Spite of the extension of a cross section countries study introduces a desirable variety of inflation experiences for the identification of the relation between inflation and output growth, the specification of a sufficiently accurate structural model for the aspects discussion refer to the direction of the causality, and at the same time that intermingle the individual characteristics of the countries, makes up a problem. As results of researches made in this area leads to a simple research of the reduced form relationship between inflation and output growth (Judson and Ophanides, 1996).

Additionally, it becomes conceptually difficult to interpret the regressions coefficients that include data throughout, we say, 100 countries averaged out 30 years, ones during business cycles, policy regime changes and disturbances that, at the same time, influence economic activity (Levine and Zervos, 1993). As way of partial solution to the series of problems described above, Fisher (1993) claims that panel data regressions maintain the time series variation for individual countries and may be more informative than cross section results.

Another problem that usually appears at this field research is in estimation outcomes are not robust under changes in the explanatory variables set, include in the regressions in order to control alternative effects from another series of conditions, which also affect the objective variable of study. In the context of cross section models, Levine and Zervos (1993) make a series of robustness exercises for the case of relation between inflation and economic growth, finding that this negative relation is statistically weak; contradicting therefore the unified vision that claims high inflation countries must reach low inflation levels to foster economic prosperity.

In this context, this paper aims to evaluate empirically the relation between inflation and TFP growth for 18 Latin America countries, during 1961-2000 period. For it, we make a dynamic panel data analysis. This paper is made up of three parts, the first part is a brief introduction: the second part is made up of five sections, in the first appears the procedure carried out in order to obtain an approach to TFP; the second section contemplates a brief description of variables used for countries of the region in dynamic panel data analysis; according to this, the third section displays a series of stylized facts respect to deceleration output growth episodes for countries of the region, which have encouraged the present study; fourth section describes the methodology developed by Arellano and Bond (1991) and extended by Arellano and Bover (1995) for dynamic panel data estimation, being used in order to improve some difficulties show in the cross section analysis of a great number of countries, said above; on the other hand, fifth section shows made estimation results. Finally, the third part concludes with a series of commentaries and recommendations.

2. METHODOLOGY

2.1. ESTIMATION OF TOTAL FACTOR PRODUCTIVITY (TFP)

We considered a Cobb-Douglas production function that depends on physical capital *K*, labor *L*, and *TFP* level *A* as equation (1), where we assumed constant returns on scale and perfect competition in the factors market.

(1) $$Y = A(K)^{\alpha}(L)^{1-\alpha}$$

Following Loayza et al. (2002), we introduce the labor quality associated with increases on educational attainment. Then, we considered the following variation of the production function with human capital:

(2) $$Y = A(K)^{\alpha}(HL)^{1-\alpha}$$

Where *H* is a labor force quality index base on educational attainment obtained of Barro and Lee (2000). Following Bernanke et al. (2001) and Loayza et al. (2002), to each country "*i*" we build H_i as a weighed average of population shares E_{ij} with educational level "*j*",

(3) $$H_i = \sum_j W_j E_{ij}$$

Where the weights W_j are based on social return to schooling for each educational level. We use W_j estimations based on Psacharopoulos (1994) for primary, secondary and superior education levels. Categories and their respective returns are: Non Education (benchmark) = 1, Incomplete Primary Education = 1.68, Complete Primary Education = 2.69, Incomplete Secondary Education = 3.91, Complete Secondary Education = 5.53, Incomplete Superior Education = 5.87, Complete Superior Education = 8.80.

Taking logarithms to the expression (2) and making some transformations, *TFP* can be obtained from the following equation (4):

(4) $$TFP = Y - S_K K - (1 - S_K) * (L + H)$$

Where:

TFP	: It is total factor productivity.
Y	: It is output in logarithms.
K	: It is physical capital stock in logarithms.
L	: It is labor force in logarithms.
H	: It is human capital index in logarithms.
S_K	: It is the share of physical capital in output.

And in growth terms the equation (4) can be expressed as following:

(4a) $tfp = y - S_K k - (1 - S_K) * (l + h)$

Where, the variables in minuscule are in difference logarithmic.

Labor's share it is calculated by Bernanke et al. (2001), labor force and the GDP belong World Development Indicators (2003), capital stock was constructed from Nehru and Dareshwar (1993)[1]. That way, by remainder we obtain total factor productivity (*TFP*).

2.2. DATA

As it was mentioned above, the study period concern the four last past decades (1961-2000), throughout five years periods (in order to avoid capturing relations of cyclical type between the involved variables); so that and since the used data correspond, to a great extent, the 2003 version of Worldwide Development Indicators series from the World Bank (World Development Indicators, WDI), which are in annual frequency; we make necessary transformations in order to adapt data to the study methodology.

From previous section, the most outstanding variable for the present analysis comes given by TFP growth rate, it obtained as remainder. The variables set used in the estimation is shown following: the accumulated TFP growth rate for every five-year period; the accumulated inflation rate which has been rescaled, high inflation is defined by inflation levels about more that two digits; and low inflation on the contrary. On the other case a measurement of inflation variability comes from its standard deviation for every five-year period, expressed in logarithms; controlling by cyclical factors we have included the output gap at the beginning for every period; in order to capture transitional nature movements of the variables, an initial per capita GDP level each five-period is considered; On the other hand, in order to control originating effects other characteristics on the macroeconomic environment and economic policy management, we have included the private credit to GDP expressed in logarithms; the government consumption to GDP expressed in logarithms, and a commercial opening indicator represented by the volume average of exports and imports to GDP, also expressed in logarithms; additionally, controlling the stabilization policy effects we have included the output gap standard deviation.

[1] See appendix 1, where we show the methodology of computing capital stock

TABLE 1.- SOURCES OF VARIABLES USED

Capital Stock	Nehru & Dareshwar (1993), and authors' calculations
Educational attainment	Barro & Lee (2000)
Social return on education	Psacharopoulos (1994)
Labor's share	Bernanke & Gurkaynak (2001)
Labor force	World Development Indicators (2003)
Gross Dosmestic Product	World Development Indicators (2003)
Inflation	World Development Indicators (2003)
Goberment consumption (% GDP)	World Development Indicators (2003)
Private domestic credit (% GDP)	World Development Indicators (2003)
Trade (% GDP)	World Development Indicators (2003)
Output gap (Band-Pass Filter[2])	Authors' calculations

2.3. STYLIZED FACTS

An outstanding characteristic on the TFP growth evolution was a fall in the Eighties in most Latin America countries, which reflects the causes of the lost decade. Additionally, we observed high inflations in most countries of the region.

Next, it shows the accumulated contribution to growth and inflation of some Latin America countries that was included in the estimation. It is shown that the 80's lost decade had in most countries, a negative TFP growth rate that was combined to high inflations in this decade, which induces to think that there was a negative relation between TFP growth and the high inflation rates. These high inflation levels were associated with a high inflation volatility for the region.

[2] See appendix 2.

FIGURE 1.- TFP GROWTH AND INFLATION, 1961 – 2000

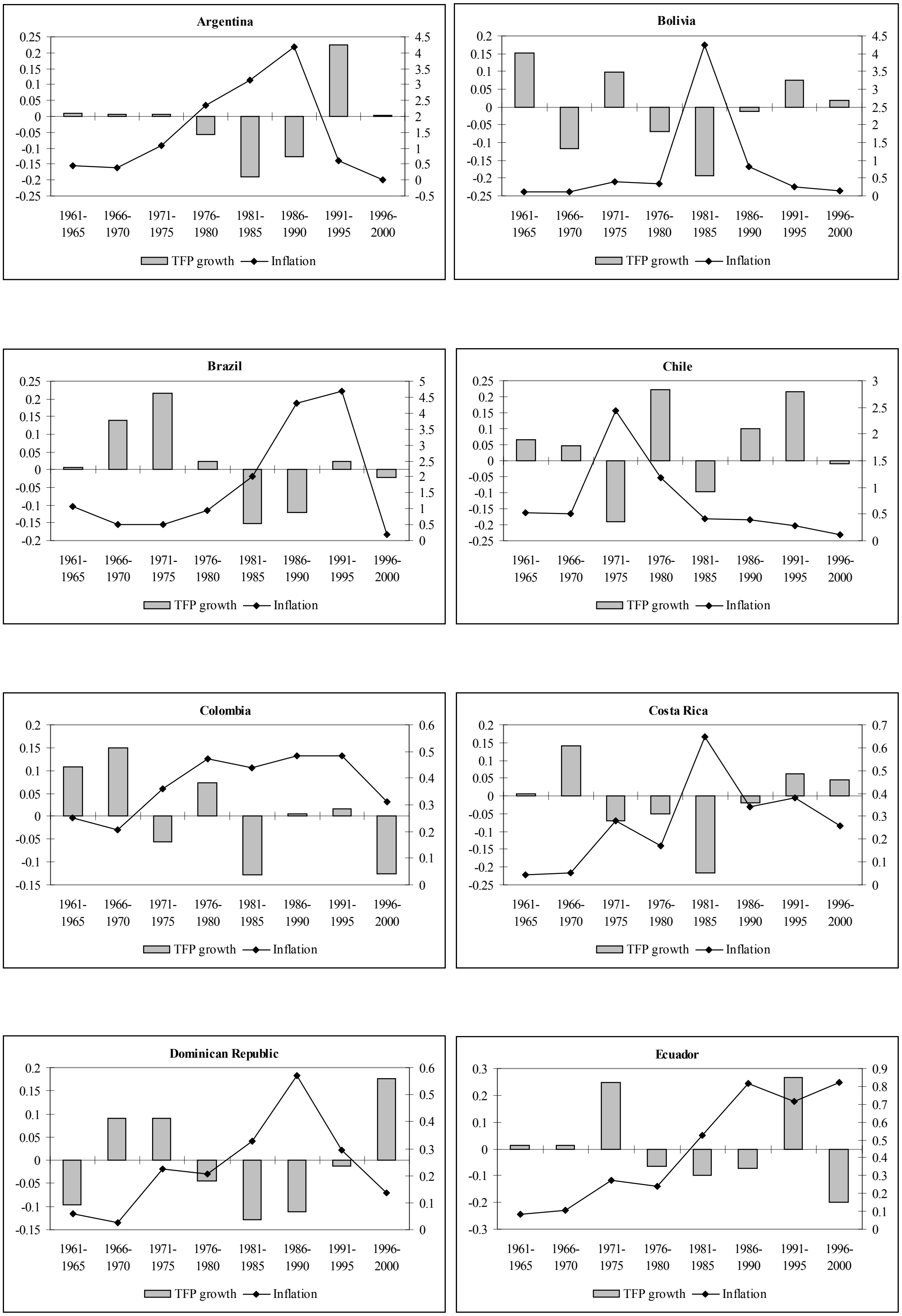


FIGURE 1.- TFP GROWTH AND INFLATION, 1961 – 2000 (CONT.)

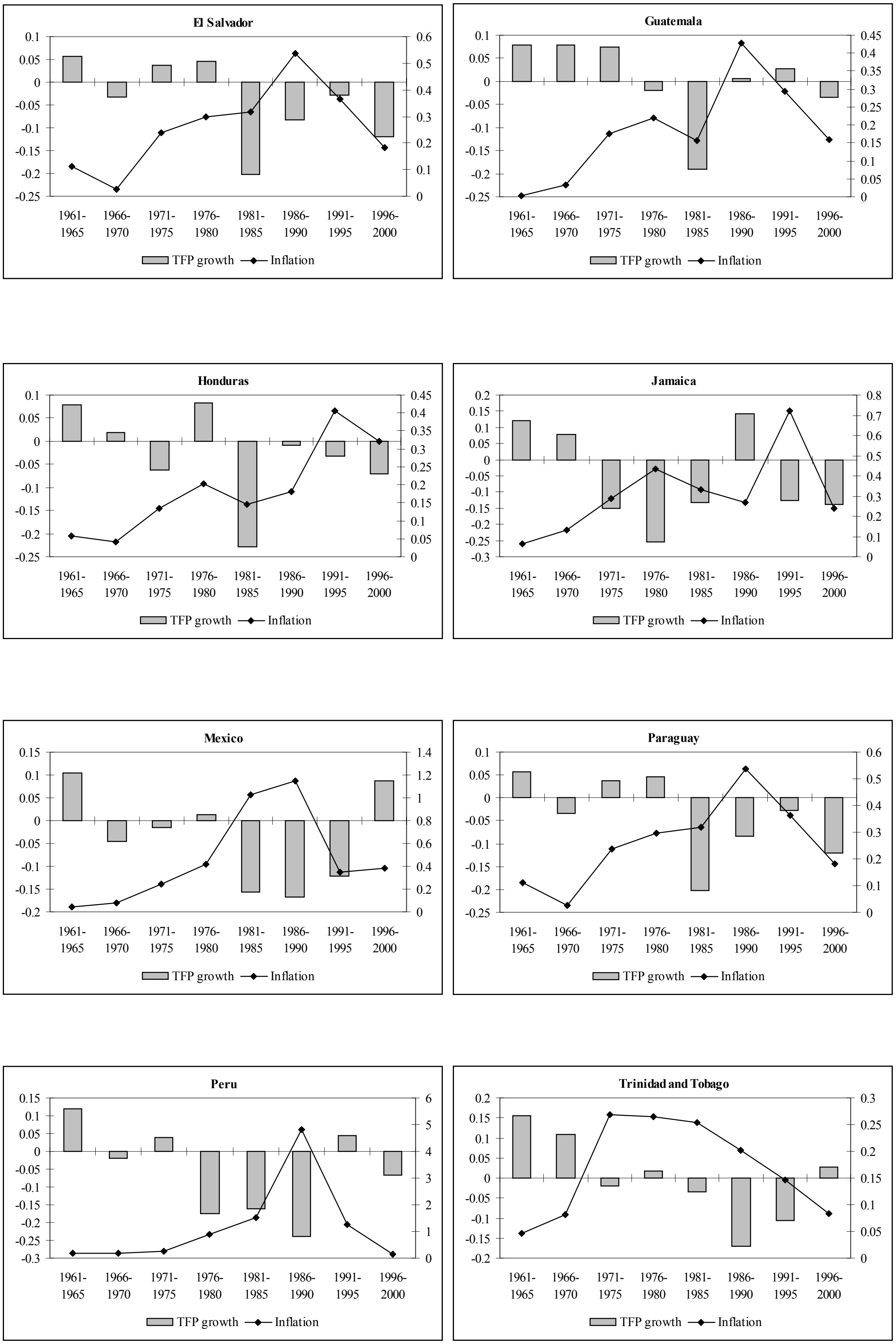
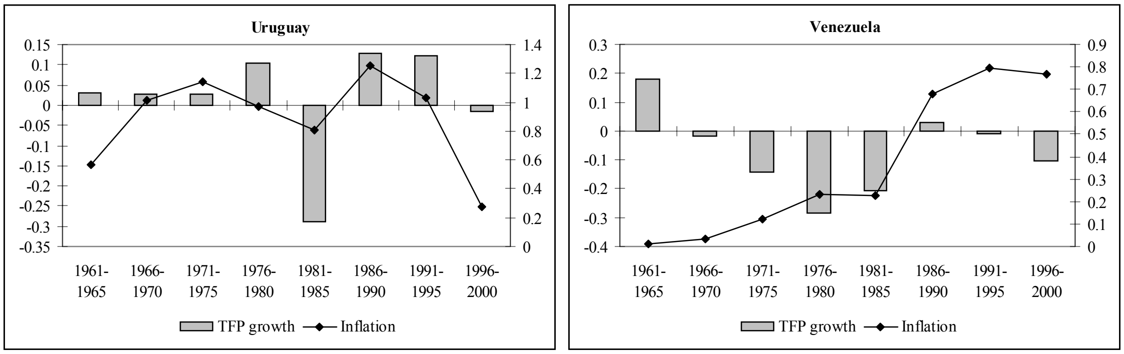


FIGURE 1.- TFP GROWTH AND INFLATION, 1961 – 2000 (CONT.)



2.4. DYNAMIC PANEL DATA MODELS

The estimation methodology of Generalized Method of Moments (GMM) developed mainly by Arellano and Bond (1991), and Arellano and Bover (1995) for dynamic panel data models. The technical discussion of this chapter is based on Loayza et al. (2002).

The regression equation can be expressed at the following form:

(5) $$y_{i,t} = \alpha X_{i.t-1} + \beta Z_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

Where y represents the dependent variable, X represents a set of lagged explanatory variables, and Z represents a set of contemporary explanatory variables. μ is the unobserved country specific effect, λ is the time specific effect, ε is the time varying error term, i and t represent the country and time period respectively.

The dynamic panel data estimators use internal instruments, defined as instruments based on previous realization or sample path of the explanatory variables, considering better, thus, the potential joint endogeneity of the regressors.

Nevertheless, this method does not control the complete endogeneity, but for a weak type of this it does. To be practitioners, we assumed that the explanatory variables are only weakly exogenous, that mean they may be affected by contemporary and past realization of growth rate, but not being correlated with future realization of the error term. Then, the weak exogeneity assumption implies that future growth rate innovations do not affect the contemporary inflation.

First, weak exogeneity does not mean economic agents do not take count future growth expectation in their inflation decision. This assumption means in the future, non-anticipated growth shocks do not influence on the contemporary inflation level, that is, innovations on growth should not affect the contemporary inflation level.

Arellano and Bond (1991) suggest the first difference of regression equation to remove the country specific effect, as it follows:

(6) $$y_{i,t} - y_{i,t-1} = \alpha(X_{i.t-1} - X_{i.t-2}) + \beta(Z_{i,t} - Z_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1})$$

This procedure solves the econometric problem, namely the country specific effect, but it introduces a correlation between the new error term $\varepsilon_{i,t} - \varepsilon_{i,t-1}$, and lag of the dependent variable $y_{i,t-1} - y_{i,t-2}$, when this is included in $X_{i.t-1} - X_{i.t-2}$. In order to indicate this correlation and endogeneity problem, Arellano and Bond (1991) propose to use lags of the explanatory variables in levels like instruments. Under assumption there is no serial correlation in the error term ε, in addition to the explanatory variables W, where $W = [X, Z]$, are weakly exogenous, we can use the following moments conditions:

(7) $$E\left[W_{i,t-s}(\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0, \qquad \text{for } s \geq 2;\ t = 3,...,T.$$

Using these moments conditions Arellano and Bond (1991) propose a GMM estimator in two stages. In the first stage, the error terms are assumed to be independent and homoskedastic, between countries and on the time. In the second stage, the obtained first stage residual are used to construct a consistent estimation of variances and covariances matrix, so that independence and homoskedasticity assumptions are relax.

There are several problems with the estimator in difference. Alonso-Borrego and Arellano (1999) and Blundell and Bond (1998) show that if lag of the dependent variable and the explanatory variables are persistent on the time, lags of the levels of these variables are weak instruments for the regression in differences. Simulation studies show that the estimator in difference has a great bias in finite samples and a poor precision.

In order to indicate these problems, an alternative method that jointly estimates the regression in difference with the regression in levels, proposed by Arellano and Bover (1995). Using Monte Carlo experiments, Blundell and Bond (1998) show that the system estimation reduces the potential bias in finite samples and the associated asymptotic imprecision with the estimation in difference. The key reason for this improvement is the inclusion of the regression in levels that does not eliminate the transversal variation and intensifies the error measurement power. In addition, the variables in levels maintain a strong instruments correlation, that the variables in differences. However, use of the regression in levels comes with the cost of requiring an additional assumption. This requirement occurs because the regression in levels does not directly eliminate the country specific effect. Instead of it, the appropriate instruments must be used to control the country specific effect. The estimator uses lags of explanatory variables difference like instruments that are suitable ones under assumption that the correlation between μ and the explanatory variables levels are constant on the time, such that:

(8) $$E\left[W_{i,t+p} \cdot \mu_i\right] = E\left[W_{i,t+q} \cdot \mu_i\right], \qquad \text{for all } p \text{ and } q.$$

Under this assumption, there is no correlation between the differences of the explanatory variables and country specific effect, e.g., this assumption implies that inflation could be correlated with country specific effect, but this correlation does not change throughout time. Then, under this assumption lags of the variables in differences are suitable instruments for the regression in levels, and the moments conditions for the regression in levels are as it follows:

$$(9) \qquad E\left[(W_{i,t-s} - W_{i,t-s-1}) \cdot (\varepsilon_{i,t} + \mu_i)\right] = 0 \quad \text{for } s = 1;\ t = 3,...,T.$$

Then, system makes up of the joint regression in differences and levels, with the moments conditions of the equation (7) applied to the first part of system, the regression in differences, and moments conditions of the equation (9) applied for the second part, the regression in levels. Since lags of the variables in levels are used like instruments in the regression in differences, only the most recent differences are used like instruments in the regression in levels. As in the estimator in differences, the model is estimated in two stages having generated consistent and efficient coefficients.

However, in the two step estimates of the standard errors tend to be severely downward biased (Arellano and Bond 1991; Blundell and Bond 1998), a finite-sample correction to the two step covariance matrix derived by Windmeijer (2000), it corrects this problem.

The GMM estimator consistency depends on the assumptions validity that the error term ε, it does not exhibit serial correlation and the instruments validity. We used two types of tests propose by Arellano and Bond (1991) to prove these assumptions. First it is a Sargan test of restrictions over-identification, which tests the overall validity of the instruments by analyzing the sample analogous of the moment conditions used in the estimation procedure; this proves minimized value of the one step GMM criterion function, but the Sargan test is not robust to heteroskedasticity or autocorrelation. However, for two step estimation the Hansen *J* test is more appropriate, this proves minimized value of the two step GMM criterion function, and is robust. Under the null hypothesis of the validity of the instruments, these tests have a distribution χ^2 with (*J*-*K*) freedom degree, where *J* is the number of instruments and *K* number of regressors. The second test examines the no serial correlation assumption of the error terms. It tests if the differentiated error term is serial correlated of second order. By construction, the error term probably is correlated of first order. It is not possible to be used the error terms of the regression in levels, since they include the country specific effect. Under the null hypothesis of no second order serial correlation, this test has a standard normal distribution.

2.5. RESULTS

For the estimation, we have grouped the variables in every five-year periods, for the case of transitional convergence we take the logarithm of GDP per capita at the beginning of each period; in the case of the Cyclical Reversion, we have considered the output cycle at the beginning of every period (the used method was the Band-Pass Filter that is most standard on literature); in the case of inflation, it was accumulated every five years and High Inflation variable was considered if within every five years at least three years inflation was greater than two digits, the opposite we have considered for Low Inflation; for the case of the Inflation Volatility variable we considered the inflation standard deviation within every five-year period.

The estimation results of the tables 2 show there is a negative relation between High Inflation and TFP Growth, whereas is not any relation between the low inflation variable and TFP Growth, which supports the evidence of other studies that claimed the relation between inflation and output takes place at high inflation levels, and not having been found a relation at low ones (Fisher, 1993).

TABLE 2.- HIGH INFLATION AND TFP GROWTH

Dependent Variable: TFP growth		
Explanatory Variable:	System GMM One step	System GMM Two step
Transitional Convergence	-0.0178	0.0036
Log[initial per capita GDP]	(-1.36)	(0.07)
Cyclical Reversion	-2.0967	-2.0329
Initial output gap	(-6.66)*	(-5.87)*
High Inflation	-0.0332	-0.0292
Log[1+rate inflation about more than two digits]	(-2.80)*	(-1.94)***
Low Inflation	-0.0813	0.0361
Log[1+rate inflation about less than two digits]	(-0.68)	(0.27)
Financial intermediation	0.0800	0.0420
Log[private domestic credit/GDP]	(0.36)	(0.10)
Trade Openness	-0.3122	-0.2006
Log[Trade/GDP]	(-2.09)**	(-0.78)
Government Burden	-1.5192	-2.9298
Log[government consumption/GDP]	(-1.93)***	(-2.40)**
Cyclical Volatility	-1.2106	-0.8052
Standard deviation of output gap	(-2.27)**	(-0.91)
Constant	0.2110	0.1473
	(3.31)*	(0.75)
Sargan test of over-identification (*p–value*)	0.117	-
Hansen test of over-identification (*p–value*)	-	0.173
Serial-correlation test, first order (*p–value*)	0.002	0.017
Serial-correlation test, second order (*p–value*)	0.886	0.657
Number of countries	18	18
Number of observations	144	144

*, ** and *** significant at 1%, 5% and 10%, respectively. *T* statistics are in parentheses.
In two-step estimation are computed the Windmeijer finite-sample correction

Another literature branch identifies the inflation volatility effect as negative effects on growth, a high but predictable inflation could be preferred to a low but more volatile inflation (Judson et al., 1996). Tables 3 show the inflation volatility variable has a negative relation to TFP Growth.

Estimations[3] show as the high inflations as a greater inflation volatility has a negative effect on TFP growth, and therefore, on economic growth; whereas low inflations seem not having any effect.

TABLE 2.- INFLATION VOLATILITY AND TFP GROWTH

Dependent Variable: TFP growth		
Explanatory Variable:	System GMM One step	System GMM Two step
Transitional Convergence	-0.0176	-0.0021
Log[initial per capita GDP]	(-1.34)	(-0.04)
Cyclical Reversion	-2.1133	-2.1625
Initial output gap	(-6.72)*	(-8.48)***
Inflation Volatility	-0.0918	-0.0786
Log[1+standard deviation of inflation]	(-2.38)**	(-2.53)**
Financial intermediation	0.0218	-0.0046
Log[private domestic credit/GDP]	(0.10)	(-0.01)
Trade Openness	-0.2775	-0.2334
Log[Trade/GDP]	(-1.91)***	(-0.96)
Government burden	-1.4588	-2.7430
Log[government consumption/GDP]	(-1.88)***	(-2.23)**
Cyclical Volatility	-1.3237	-1.1760
Standard deviation of output gap	(-2.55)**	(-1.78)***
Constant	0.1972	0.1776
	(3.20)*	(0.94)
Sargan test of over-identification (*p–value*)	0.107	-
Hansen test of over-identification (*p–value*)	-	0.180
Serial-correlation test, first order (*p–value*)	0.002	0.012
Serial-correlation test, second order (*p–value*)	0.690	0.854
Number of countries	18	18
Number of observations	144	144

*, ** and *** significant at 1%, 5% and 10%, respectively. *T* statistics are in parentheses.
In two-step estimation are computed the Windmeijer finite-sample correction

[3] Estimations were made by Stata 8.

3. CONCLUDING REMARKS

The present study have attempted to analyze the inflation impact on total factor productivity (TFP), Using the Generalized Method of Moments (GMM) estimation methodology in a dynamic panel data context, for 1960-2000 period and 18 Latin American countries, the first result show high inflation (definite by the inflation about more than two digits) periods has had a negative impact on TFP growth, whereas low inflations (definite by the inflation about less than two digits) have not had a negative impact on it.

Equally, greater inflation volatility levels (definite by standard deviation of inflation) have a negative impact on TFP growth, and therefore, on the economic growth.

Then in the long run, there is evidence of a negative relation as between high inflation levels as inflation volatility on TFP growth; keeping as a lesson that a country must keep low and stable inflation levels; so that a sustainable economic growth be reached.

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APPENDIX 1.- CONSTRUCTION OF CAPITAL STOCK

The physical capital stock series of Nehru y Dareshwar (1993) cover 92 countries from 1950 to 1990. These series were calculated by the perpetual inventory method based on the following accumulation equation:

(1a) $$K_t = (1-d)^t K(0) + \sum_{i=0}^{t-i} I_{t-i}(1-d)^i$$

where K_t is the capital stock in t period (1987 constant prices), $K(0)$ is the initial capital stock (in period 0), I_{t-i} is gross fixed domestic investment in the *t-i* period, and *d* is the depreciation rate. Nehru y Dareshwar (1993) have estimated $K(0)$ by a modification of technique proposed by Harberger (1978).

The procurement based on assumption that at stationary stage output growth rate (*g*) is equal to capital stock growth. Rewritten the equation (1a) we get:

(2a) $$(K_t - K_{t-1}) / K_{t-1} = -d + I_t / K_{t-1}$$

Que implica:

(3a) $$K_{t-1} = I_t / (g + d)$$

Thus, in period *0*, the capital stock can be computed as:

$$K(0) = I_1 / (g + d)$$

Depreciation rate is assumed at 4% and output growth rate (g) is got from market- price real GDP, thus, the remainder series is computed from the equation (1a).

Since capital stock covers 1950-1990 period, we use gross fixed domestic investment from *World Development Indicators* (2003) to complete the capital stock series.

APPENDIX 2.- BAND-PASS FILTER

Baxter and King (1999) have designed moving average filter that allows to isolate certain frequencies (it is the number of times that a cycle repeats in a certain period) of series and obtaining the cyclical component. This filter, called also Band-Pass, uses as weights frequency functions that are desired to extract.

The ideal filter is an infinite order moving average that cannot be applied actually. That is why, it is necessary to limit the finite value average size (truncation lag *k*). This generates a filter approached *a(L)*.

(1b) $$a(L) = \sum_{h=-k}^{k} a_h L^h$$

Where L is the lag operator and a_h are sample weights of the filter that is obtained through the inverse transformation of Furier:

(2b) $$\alpha_k(w) = \sum_{h=-k}^{k} a_h e^{-iwh}$$

Where $\alpha_k(w)$ is ideal sample weight of the filter.

This filter takes advantage with respect to other cycle estimation methods which allows exactly extracting the frequency band that is considered as a business cycle. In addition, it has particularity to eliminate tended and irregular components getting as a result only the cycles. The main Baxter and King filter characteristic is to separate the cyclical component among p and q periods of length, by means of a weighed moving average of n periods, where:

(3b) $$(Y_t^{pot} - Y_t) = \sum_{i=1}^{n} a_i Y_{t-i} + a_0 Y_t + \sum_{i=1}^{n} a_i Y_{t+i}$$

The weights of moving average (a_j) are determined by the following rule:

(4b) $$a_j = (sen(jw_1) - sen(jw_2)) / j\pi \qquad j = 1,2,3,...,k$$

(5b) $$a_j = (w_1 - w_2) / \pi \qquad j = 0$$

Where $w_1 = 2\pi / p$ y $w_2 = 2\pi / q$

The lags amount include in the filter is important, because they define the accuracy of weights. There is no an ideal lags number, but as much lags are included in the moving average, better it will be the approach with the ideal filter, at the cost of a greater data loss over and under the value of interest, so that, the choice of k will depend on the data amount available and necessary of approximating the filter to the ideal one. In our case, given the annual data frequency, we used a value of $k = 3$, a period of length among $p = 2$ and $q = 8$, and an autoregressive parameter that is used to replace the values that are lost at the end of the series, by the application of a truncated moving average.