Economic development and inflation: a theoretical and empirical analysis

André Roncaglia de Carvalho[1]
Rafael Ribeiro[2]
André M. Marques[3]

Resumo

O presente artigo analisa a relação entre inflação e desenvolvimento econômico. A literatura sobre o tema tem silenciado sobre a noção empírica de que países em desenvolvimento apresentam inflação média mais elevada do que economias desenvolvidas, ignorando portanto a existência de uma vasta gama de forças relacionadas ao desenvolvimento que afetam o nível da inflação. Apresenta-se um modelo teórico simples ligando a inflação a uma antiga tradição de economia do desenvolvimento, na linha de Kaldor e Kalecki, a qual orientou a seleção das variáveis sensíveis ao desenvolvimento. Evidência empírica é então levantada para testar a hipótese de que o desenvolvimento econômico implica um viés baixista às taxas de inflação, o que é feito utilizando um estimador do tipo feasible-GLS a uma amostra de 65 países com dados referentes ao período entre 2001 e 2011. O estudo encontrou uma correlação inversa entre os níveis de inflação e o conteúdo tecnológico das economias, medido pela participação de exportações de alta tecnologia, capital humano e desemprego cíclico, enquanto o grau de persistência inflacionaria, o crescimento dos termos de troca e o grau de abertura da economia afetaram positivamente a inflação. Nossos resultados também detectaram uma baixa e negativa correlação entre persistência inflacionária e desenvolvimento econômico, apontando para outras causas da inflação, a serem analisadas futuramente, tais como aspectos regionais, culturais e institucionais que geram maior memória inflacionaria no sistema.

Palavras-chave: desenvolvimento econômico; inflação; estimador FGLS.

Abstract

This paper studies the relation between inflation and economic development. The literature is still largely silent regarding the empirical notion that developing countries endure higher average inflation than developed economies, thus overlooking the existence of a vast array of development-related forces accounting for different inflationary behaviors. We set out a simple theoretical model linking the inflation phenomenon to a long-standing tradition of development economics, in the likes of Kaldor and Kalecki, which provided the development-sensitive variables. Empirical evidence is then garnered to test the hypothesis that economic development engenders a downward bias to inflation rates. Through the feasible-GLS estimator in a panel of 65 countries from 2001 to 2011 the study found an inverse correlation between inflation levels and the technological content of the economy measured by share of high-tech exports, human capital and cyclical unemployment, whilst directly related to the degree of inflation persistence and terms of trade growth. Our results also show an inverse and low correlation between inflation persistence and economic development, which points to other determinants of inflation persistence, to be dealt with in future research, such as regional, cultural and institutional aspects that instill greater inflationary memory into the system.

Keywords: Economic Development; Inflation; FGLS estimator.

JEL: N16, O54.

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[1] Department of Economics at Federal University of São Paulo (UNIFESP). Contact: andre.roncaglia.carvalho@usp.br
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[2] Department of Land Economy, University of Cambridge, UK. Contact: rsmribeiro@gmail.com
[3] Department of Economics at Federal University of Paraiba. Contact: 00094751@ufrgs.br

1 Introduction

After long-lasting theoretical debates between the early 1970s and late 1990s, the academic literature on inflation has reached a fair range of consensus. Despite some dissent regarding the specific causes and channels through which inflation is worked out into the system, it is generally accepted that inflation is caused by three primal causes. First, excess aggregate demand over supply is a typical feature of overheated economies enjoying full-employment of productive resources. Second, the cost-push component results from one-time or systematic shortages of productive resources - due to droughts, wars, etc. - or from market power enjoyed by monopolies and oligopolies, labor unions and carry-trade speculators, thereby swelling costs that are transmitted to prices of consumption goods. Finally, the inertial inflation component reflexively fuels inflation by way of an autoregressive mechanism imbued in distributional conflicts among social groups; persisting conflict is likely to crystalize in economic institutions practices such as indexation and other systematic revisions of prices, wages and rents that incorporate occasional shocks to inflation trends. Therefore understanding, predicting and taming inflation usually involve a weighted combination of these three central forces. Conventional policies are biased toward a demand-based diagnostics of rising prices whilst heterodox policy-prescriptions are mostly grounded on cost-related and institutional forces due to the recognition that firms in modern economies operate with excess capacity.

Notwithstanding this established wisdom, one might wonder about the extent to which these forces explain inflation in different economies. Are local features fully captured by the magnitude of parameters mediating between these inflationary forces and the response by price indexes? Or does historical and institutional variety imply qualitative differences among countries as to the behavior of inflation? As illustration of this point, one could recall that cost structures vary widely across the development spectrum due to specific and complex inter-related elasticities of supply, labor market regulations, State intervention in economically strategic markets (such as infrastructure), exchange-rate volatility and so forth. These are questions not easily addressed in simple and reductionist frameworks. However daunting may be such a challenge, their implications are clear and should provide enough motivation for any effort in this direction, namely: policy could be improved by taking heed of disregarded nuances and mechanisms, should other forces prove significant in accounting for inflation. Simply stated: inflation control is likely to require more than vigilant and rigorous monetary policy. By potentially overlooking the existence of a broader array of development-related forces accounting for different inflationary behaviors, current academic knowledge is likely to poorly inform both the public and policymakers who hold a stake in this matter.[4]

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[4] One topic only superficially touched upon in this paper refers to persistence of inflation. Often associated with lack of government willingness to cut demand in poorly managed undeveloped economies, this phenomenon is no stranger to developed economies, having been fairly well documented in time series data for OECD countries in the post-War era (see Fuhrer 2009). In fact, the European Central Bank has set up its own institutional branch to oversee the phenomenon: the *Eurosystem Inflation Persistence Network* (see Marques 2004 and O'Reilly & Whelan 2004). Persistence itself is quite encompassing and leaves few economies unaffected. It is thus a matter of degree on which we ponder: is there any relationship between the level of economic development and the observed level of inflation across countries? In addition to the monetarist narrative of a helicopter dropping money on the population, persistent inflation requires some level of price, wage, structural and institutional rigidity. A downwardly rigid behavior of prices may be related to a variety of causes, amongst which we could cite: informational asymmetries and other market imperfections, as well as a permanently expansionary fiscal, credit and monetary policies due to inadequate policy regimes (e.g. fixed exchange rates or inefficient taxation schemes). On the institutional realm, we can cite the widespread formal and informal indexation of contracts and prices, Government control over specific prices, such as the minimum wage and certain public utilities services, and, finally, the action of labor unions to tie wage revisions to the pace of lagged inflation. These rigidities are likely to amplify the impacts of random shocks, both internal and external, which may render some key macroeconomic prices more volatile - such as the exchange rate or the interest rate -, thereby allowing transient impacts to be absorbed by inflation trends. Extensions of the presente effort will lead to more thorough investigations of the relation between persistence and development, a connection that is conditionned upon the existence of correlation between development and level of inflation.

    This paper tackles these questions - albeit preliminarily - by formalizing and testing the existence of a relation between economic development and inflation. The literature has been largely silent on this issue, despite the fact that simple descriptive statistical analysis supports the empirical notion that developing countries endure higher average inflation than developed economies. The argument is organized in four sections beyond this introduction. The second discusses the relation between inflation and economic development. Section 3 presents the theoretical model undergirding the empirical analysis, which is the object of section 4. The last section concludes the paper pointing out limitations and a future research agenda on this topic.

2 Economic Development and Inflation: bad policies or hidden connections?

The recent empirical literature on development economics has been timid about the connection under scrutiny here. Most studies undertake the task of verifying correlations between inflation and growth. Even so, the only study on the matter seems to be Bruno and Easterly (1998), which have found no such correlations between growth rates and inflation in a sample of countries, although they were mostly focused on high inflation experiences.[5] The fact that the majority of countries managed to curb inflation in the 1990s - and to keep it under control ever since - paved the way to the notion that an era of "Great Moderation" had finally begun (Rogoff 2004). The problem of inflation became indelibly detached from development concerns.
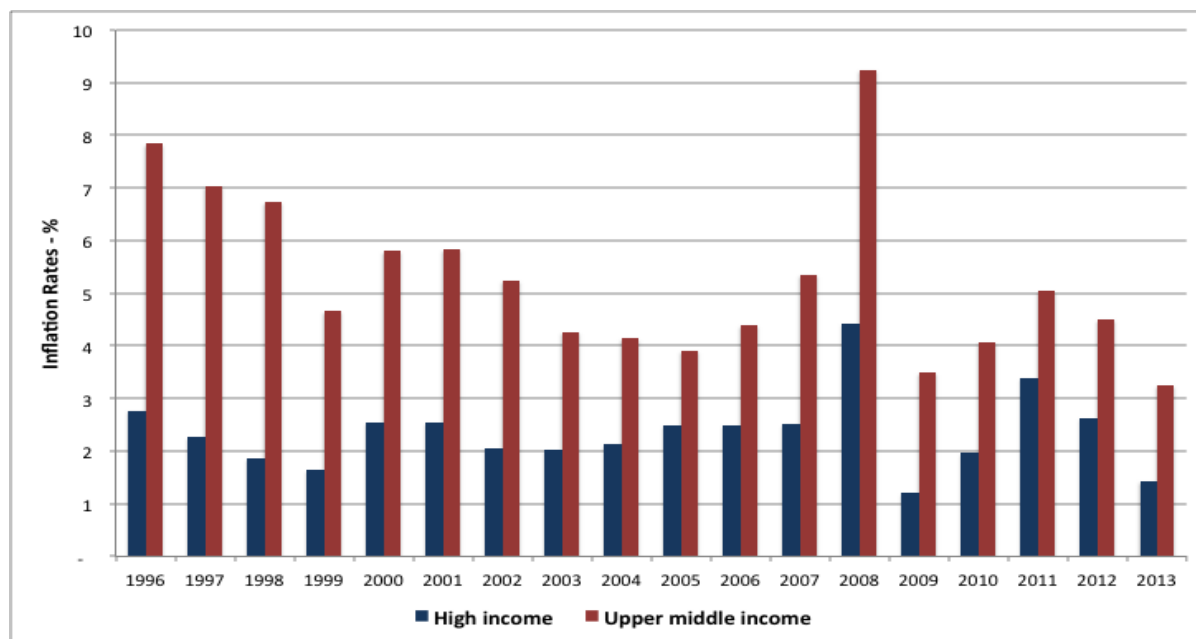

Figure 1 - Inflation Rates for Country Groups classified according to income levels – 1996-2013. Source: World Bank.

    As a result, no empirical study, to the best of our knowledge, has been able to account for what simple descriptive statistics reveal, namely, that low- and middle-income countries are prone to have higher inflation scores than high-income countries (see Figure 1). One possible explanation for such a gap in the literature may be the difficulty in deriving general statements from country-specific empirical data. This is hardly any surprise. There is a high variance of inflation scores within these low- and middle-income sub-samples, which clearly owes to their heterogeneous institutional and productive frameworks.

    Difference in inflation rates among countries is then frequently – and squarely - ascribed to credibility of governments, the quality of institutions of monetary policy, practical arrangements in

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[5] Two papers back in the late 1950s undertook this task. Wai (1959) and Bhátia (1960) also found no clear relationship between economic growth and inflation. Both were also constrained by the idea that development was a synonym with growth, a very common connotation at the time.

Central Banking and technical aspects of inflation indices. Notwithstanding the truth they convey, these elements overlook shared economic and structural features related to each country's stage of development. The empirical divide regarding the inflationary behavior between high income and upper middle-income countries observed in the data is a real phenomenon yet in search of a theory.[6] However, the difficulties in building one are quite daunting, for it must take heed of the productive structure, degree of openness, distributive profiles (policy-induced and otherwise), as well as several institutional and historical specificities. These aspects taken together may reveal deep-seated sources of downward inflexibility of prices, which add up to - and enhance - the more close-to-surface mechanisms affecting the level of inflation.

The determinants of price patterns are intricate and thus do not subject easily to empirical decomposition into separate and independent components. Supply and demand schedules undergo simultaneous determination, leading to the empirical problem of identifying an instrumental variable that can provide some information about the pricing process. Furthermore, during a process of development, the productive structure undergoes sharp changes in relative prices. The practical impossibility of enhancing productivity simultaneously in all sectors implies that some sectors present more elastic supply than others, which engenders a dual productive system (see Chenery 1975).

Economic development invites permanent changes in the composition of aggregate supply and in the relative prices of tradable and non-tradable goods; if sectional prices are downwardly inflexible, inflation must rise to restore consistency to the system. Under such a process, inflation may prove resistant to conventional demand-management policies. An inflation-free development process has two basic conditions: i) Favorable terms of foreign trade guarantee balanced external accounts, which precludes excessive currency devaluation and subsequent rising inflation due to the exchange-rate pass-through mechanism; ii) A technology-driven dynamic compatibility between the profiles of supply and demand to prevent sector-related price pressures from becoming widespread. The literature termed this process a "cost disease", following Baumol (2012), when related to developed economies´ trend of services-dominated productive structure. However, when a premature process of deindustrialization affects low-income countries, it is expected to diminish not only the flexibility of aggregate supply to changes in aggregate demand but also the share of high-tech goods and services in total exports value. Hence, self-sustaining cost-shift inflation can be explained on the basis of structural changes swaying the economy towards labor-intensive sectors. The latters' sluggish innovating thrust sets limits to increases in labor productivity, while labor market inter-sector dynamics and widespread indexation render prices inflexible downwards.

In a seminal influential paper, Olivera (1964, p. 325) spelled out the consequences of a relative price variation upon the money price level. He further underlined that, in the presence of any degree of nominal price inflexibility, such changes in the general price level are not reversible. This means that, following a displacement of equilibrium relative prices, restoring the previous position will not wipe off the increase in the price level brought about by an alteration of that situation. In fact, a movement aiming to reset the previous configuration of relative prices would most likely cause an additional increase in money prices. Thus, if adjustments are carried out in oscillating patterns, the total increase in the latter is bound to be much greater, depending on the amplitude and frequency of the intervening fluctuations. Olivera divided the economy between the technologically backward agricultural sector and the industrializing sectors. As rising wages in the industrial sectors met a rigid food supply, relative prices could only be made consistent with the productivity differentials between these two sectors by way of higher inflation. Once industrialization was fairly advanced, technological spillover effects would increase the productivity of agriculture and these rigidities were likely to succumb (see also Greenwald & Stiglitz 2006). Influenced

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[6] Underlying our working hypothesis is the assumption that the relation between inflation and the level of development is a group phenomenon, where some common set of forces sustains inflation rates in developing countries above those endured by high-income countries. Countries classified within the same range of development may still display distinct inflation trends, while being bound by a shared structural "inflation floor".

by the challenges faced by developing economies in the 1960s and by the focus of catching-up policies, the Latin American structuralist school failed to anticipate the development problems faced by fully industrialized countries, namely: the process of deindustrialization.

In that regard, Colin Clark's (1957) and Fuchs's (1968) influential hypothesis stated that an industrialized economy progresses by shifting aggregate demand from manufacturing towards services sector. Rowthorn & Rasmawamy (1999, p. 19-20) have suggested that deindustrialization should not be readily construed as a symptom of a country's failure in nurturing a competitive manufacturing structure, but inkling of a country's economic maturity, usually linked to rising standards of living. This "natural" trend is caused, the authors argue, by North-south dynamics led to a displacement of manufacturing employment towards labor-abundant developing economies.[7]

One of the implications of this structural change is the shifting of resources from technologically progressive sectors (mostly manufacturing) to those typically more labor-intensive (services in general), which face downwardly rigid cost structures. Baumol (1967 and 2012) and Baumol, Blackman & Wolff (1985) indicated that wages in the service sectors tend to change according to productivity rates in the technologically progressive sectors, independently of the former's own productivity scores. Developed economies undergoing this process are thus more prone to suffer from a "cost disease", that is, a rising pressure on the general level of prices owing to an increasingly more costly provision of services, which can only be curbed by raising productivity - or diminishing costs - in non-manufacturing sectors.

Matters are much blurrier when it comes to developing economies, where the catching-up process led to the settlement of industry but not necessarily to the establishment of innovation-producing sectors. This shortcoming implies that deindustrialization is likely to come at the cost of having a more commodity-concentrated export profile and a hypertrophied services sector.[8] The economic structure becomes more rigid and more susceptible to external shocks, both underlying forces acting upon inflation; in short: random shocks are coupled with highly absorptive inflation trends.

The link between inflation and structural changes has not been, thus far, framed in a uniform theoretical approach. Our attempt here seeks to contribute to this latter endeavor by suggesting the channels through which the development process (see Rodrik 2015) affects the economy's price-output dynamics and, therefore, its inflation patterns. In what follows, we provide a basic theoretical framework that will guide us through the cross-country empirical evidence.

3 The model

The price index

We assume that the domestic price index (P_t) is given by

(1) $P_t = P_{Tt} + P_{St} + P_{SMt}$

where P_{Tt}, P_{St} and P_{SMt} are tradables, services and state-managed prices, respectively.

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[7] The authors found that deindustrialization in developed economies was caused primarily by "*interactions among shifts in the pattern of demand between manufactures and services, the faster growth in productivity of manufacturing as compared to services, and the associated fall in the relative price of manufactures*". The increase in the share of services in the composition of output has thus been understood as a "natural" outcome of a successful process of economic development (p. 14). The paper's focus is set on the Asian countries, particularly China, South Korea and India, sidestepping the heterogeneity among the countries composing the Global South.

[8] A spawning literature has dealt with the various dimensions of the problem. We refer the reader to Dasgupta & Singh (2006), Cimoli, Fleitas & Porcile (2013) and Canuto, Fleischhaker & Schellekens (2015). On a more positive approach towards services-related structural change, Nordås & Kim (2013) find that in low-income countries, that "*better services contribute to moving up the value chain in industries where a country already has technological capacity and comparative advantage, but better services alone may not stimulate product differentiation in sectors where a country is far from the competitive edge* – at least not in the short run".

In rates of change we obtain

(2) $\pi_t = \alpha_T \pi_{Tt} + \alpha_S \pi_{St} + \alpha_{SM} \pi_{SMt}$

where π_t denotes domestic inflation, π_{Tt} is the tradables inflation, π_{St} stands for the services inflation, π_{SMt} is the inflation of state-managed goods and services, $\alpha_T = P_{Tt}/P_t$, $\alpha_S = P_{St}/P_t$ and $\alpha_{SM} = P_{SMt}/P_t$. Next, we define each component of the inflation rate separately.

Tradables inflation

First, we describe the tradables inflation. Industrialized goods are commercialized in foreign markets. Hence, tradable goods have their prices determined in the foreign trade, as follows

(3) $\pi_{Tt} = e_t + \pi_f$

where e_t is the growth of the nominal exchange rate measured as foreign prices in terms of domestic currency; π_f is the foreign inflation rate. We assume $\pi_f = 0$ to save notation.

It is also assumed that the growth of the nominal exchange rate e_t is inversely related to the domestic nominal interest rate i_t and depends positively on the foreign interest rate i_f and the country risk premium σ. The behavioural specification of e_t is given by

(4) $e_t = \psi(i_f + \sigma - i_t)$

where $\psi > 0$ is a parameter that measures the speed of adjustment of the domestic interest rate to the foreign interest rate. Also, by definition, we have

(5) $i_t = r_t + \pi_{t+1}$

where r_t is the real interest rate.

Services inflation

Second, we examine the services inflation. This sector sets prices based on the standard mark-up pricing equation, as follows

(6) $\pi_{St} = \phi_t + w_t - q_{St}$

where ϕ_t is the growth rate of the mark-up factor, w_t is the growth rate of nominal wages and q_{St} is the growth rate of labor productivity in the service sector.

We assume that the mark-up factor is positively related to the real interest rate, as a raising interest also increases overhead costs of firms and hence forces firms to set higher margins over prime costs of production (Hein, 2008). Then, we have

(7) $\phi_t = \eta(i_t - i_{t-1})$

where $\eta > 0$ is a parameter that measures the speed of adjustment of interest rates over time. Herein we also assume that the nominal wages are indexed to the expected inflation rate (π_{t+1}) and also depend on the unemployment rate (u_t), as follows

(8) $w_t = \rho \pi_{t+1} - \omega u_t$

where ρ is a constant that measures the degree of indexation of wages, ω denotes a constant. Equation (8) shows that the growth of nominal wages depends directly on the persistence of past inflation. The rate of change of nominal wages is also positively related to the bargaining power of workers in the process of wage settlements which, in turn, is assumed to depend negatively on the unemployment rate. That is, the lower the unemployment rate, the better the conditions for workers to bargain for higher wages. Hence, we draw upon the works of Marx and Kalecki and take into account the institutional framework of the

economy that intermediates the conflicting claims on income between workers and capitalists in the wage decision-making process.

Lastly, we define the growth rate of labor productivity. In equilibrium, the growth rate of labor productivity must be equal in all sectors of the economy, we can say that $q_t = q_{Tt} = q_{St} = q_{SMt}$, where q_t, q_{Tt}, q_{St} and q_{SMt} are the growth of total labor productivity and the growth of labor productivity in the tradables, services and state-managed sectors, respectively (see appendix 1). Hence, we can replace q_{St} by q_t in equation (6) and analyse the determinants of the growth of labor productivity of the economy, as follows

(9) $q_t = q(HC, K, growth, Tech)$

Proponents of the endogenous growth theory argue that increasing human capital (HC), which can be proxied by years of schooling of the labor force, for example, also raises productivity (Lucas, 1988); in other words, the higher the share of population with a college degree or above, the higher the level of collective skills and the creation of value per worker. Endogenous growth theory also states that the process of capital deepening creates positive externalities through *learning-by-doing,* which affects positively the growth of productivity (Romer, 1986), whereas from a Kaldorian perspective, output growth is one of the main determinants of labor productivity. Kaldor (1966) highlights the concept of endogenous technological progress driven by demand (this is the widely known Verdoorn's Law).

This law states the statistical relationship between the growth of labour productivity and manufacturing output; empirical evidence for the same relationship between these two variables seems to be very weak for the other sectors of the economy (McCombie and Thirlwall, 1994). Lastly, another major determinant of the growth of labor productivity is the level of innovative activity ($Tech$). Innovation leads to a higher degree of product differentiation and quality and hence increases productivity (León-Ledesma, 2002).

State-managed prices

Third, the State-managed prices are set by contracts heavily influenced by the expected inflation rate. Thus, in formal terms, we have

(10) $\pi_{SMt} = \gamma \pi_{t+1}$

where γ is the degree of indexation of the contracts from the public utilities services.

The general model

Substituting equations (3)-(10) into (2), and assuming for convenience that $r_t - r_{t-1}$, after a great deal of manipulation we obtain the general equation that describes the domestic inflation

(11) $\pi_t = \beta \pi_{t-1} + \lambda$

where $\beta = -(1 + \alpha_S \eta)/[\alpha_T \psi - \alpha_S(\eta + \rho) - \alpha_{SM}\gamma] \gtrless 0$

$\lambda = \alpha_T \psi(i_f + \sigma - r_t) - \alpha_S(q_t - \omega u_t) \gtrless 0$

The stability condition of the inflationary process specified by equation (11) is $|\beta| < 1$. The equilibrium inflation rate is given by

(12) $\bar{\pi} = \dfrac{\lambda}{1 - \beta}$

Assuming that in equilibrium the inflation rate must be strictly positive we have that $\beta < 1$. Note that by equation (11) the inflationary dynamics can still be unstable if $\beta < -1$. Figure 2 below shows how current inflation rate converges towards the equilibrium inflation rate $\bar{\pi}$. In terms of the formal model we have $0 < |\beta| < 1$.
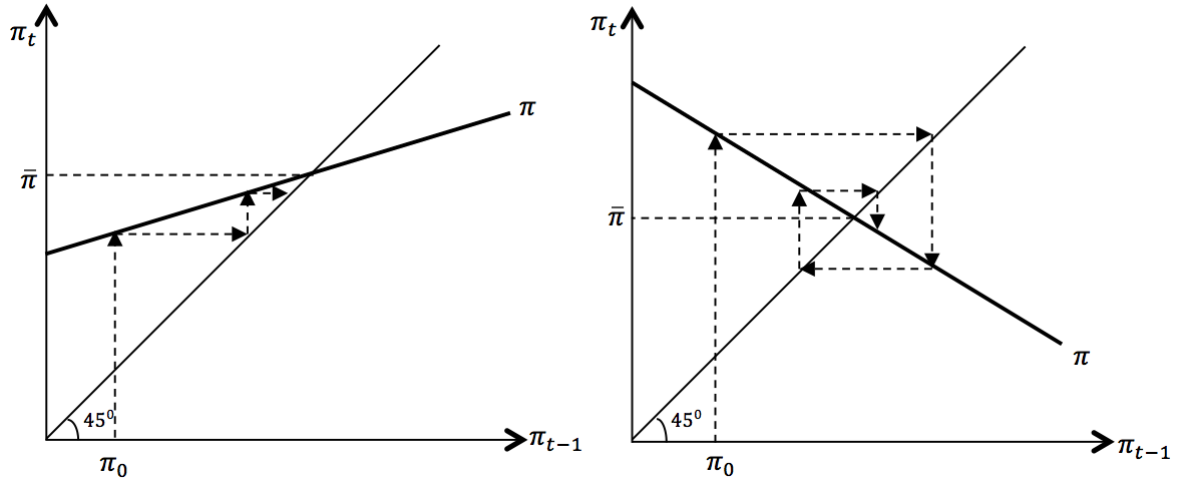
Figure 2 - Stable inflation rate

On the other hand, if $|\beta| > 1$, then the inflation rate is unstable. In Figure 3 we illustrate the scenario in which $|\beta| > 1$. In this case, the actual inflation rate veers off from the equilibrium inflation rate $\bar{\pi}$. Given that $\beta = -(1 + \alpha_S\eta)/[\alpha_T\psi - \alpha_S(\eta + \rho) - \alpha_{SM}\gamma]$, the inflationary dynamics is more likely to become unstable when the mark-up sensitivity to nominal interest rate variation, η, is sufficiently high. A higher capacity of workers to incorporate expected inflation into the growth of nominal wages, ρ, also increases the likelihood of price instability. We can also observe that a higher sensitivity of State-managed prices to expected inflation raises the absolute value of β.

Additionally, a higher share of the tradable goods sector α_T (which can be seen as a proxy for the degree of openness of an economy to foreign trade) associated with a more significant responsiveness of the growth of nominal exchange rate ψ increases price stability; a higher $\alpha_T\psi$ enhances the capacity of central banks to control inflation through an inflation targeting regime, for instance.
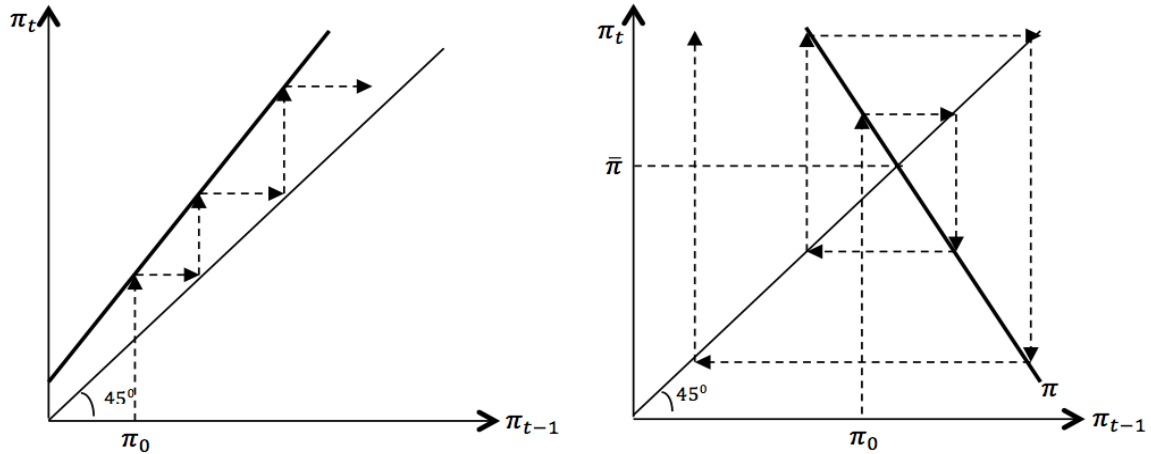

Figure 3 - Unstable inflationary dynamics

Inflation in developed and undeveloped countries: a static comparative analysis

Now we discuss the reason why inflation tends to be higher in undeveloped countries than in developed countries, that is $\bar{\pi}_{Dev} < \bar{\pi}_{Und}$. By equation (12) the equilibrium inflation rate is positively related to the degree of indexation β and exogenous factors described by λ. Figure 4 below shows how a higher value of λ shifts the inflation curve upwards. Given $\lambda = \alpha_T\psi(i_f + \sigma - r_t) - \alpha_S(q_t - \omega u_t) \gtrless 0$, undeveloped countries tend to have higher inflation due to higher rates of currency devaluation, since, by (4), $e_t =$

$\psi(i_f + \sigma - i_t)$; country risk premium σ and the foreign interest rate i_f are positively related to e_t and, consequently, to $\bar{\pi}$, whereas a higher real interest rate r_t reduces λ and $\bar{\pi}$.

We can also deduce that increased labor productivity q_t reduces unit labor costs and hence controls inflation. Once again, the higher $\alpha_T \psi$, the higher the capacity of central banks to reduce inflation by raising interest rates. Lastly, buoyant demand conditions, which is inversely related to the unemployment rate u_t, also tends to raise inflation as excess capacity utilisation decreases.
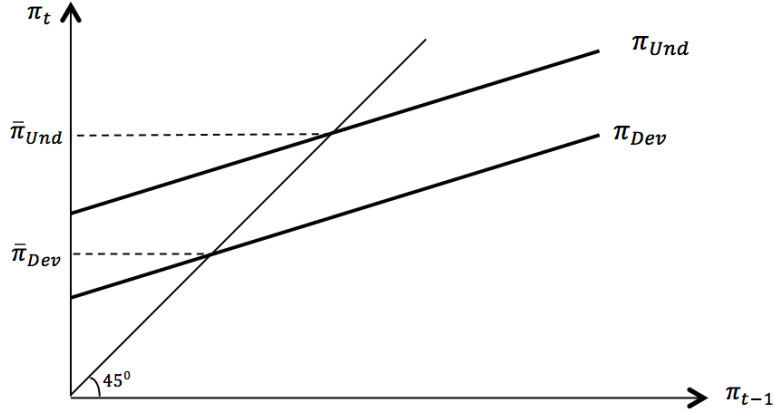

Figure 4 - Static comparative analysis

4 Methodology and empirical framework

4.1 Description of the data

In this study we are interested in analyzing the strength of the relation between the level of inflation and the degree of development, explaining in what conditions the level of inflation is dependent upon of the level of development in a heterogeneous sample which includes developed and less developed countries.

Holding other conditions constant, we expect an inverse correlation between the level of inflation and the degree of economic development. The question posed in these terms means that some factors that often affects per capita GNI, like human capital level, does not necessarily affects the inflation rate. We are assuming that is possible to isolate marginally some supply or cost conditions related with productivity and degree of technological development which affect inflation from demand conditions, like unemployment rate and overall level of economic activity. Both types of influence may be proxied by an adequate number of macro variables listed below.

The dependent variable of the study is the level inflation rate, measured as variation in the consumer price index (%) and the degree of development is measured by level of per capita Gross National Income (constant 2011, in US$). We adopt a set of additional variables which intend to represent a set of factors which may help to explain in what conditions the behavior of inflation in high and low income countries is affected by that postulated relation. From our previous theoretical discussion the main variables available on the World Bank database to be related in an econometric model are shown in the Table 1. Along with the variables, we set the theoretical expected sign of the correlation between inflation and that variable in the last column of the Table.

The relation between inflation (INFL) and the degree of development (GNI) have an expected negative sign. Other factors held constant, the higher level of development lower the level of inflation rates. This is so because in a mature economy the degree of inflation persistence and the propagation of shocks are expected to be low. The technological capability of a mature economy tends to be higher than a less developed country, which contributes to higher TFP growth and lower inflation making the supply smooth in relation to demand conditions.

Moreover, the cost conditions of undeveloped economy are somewhat different from a developed country, implying great differences in productivity. The issue of income distribution may play some

important factor as well, because the indexation of wage and inflation resulting in some rigidities to reduce and maintain inflation in lower levels in less developed economies. These features imply that for a set of lower income countries the persistence of inflation is expected to be higher and then the propagation of shocks are expected to be high. Accordingly, higher the level of economic development, lower the level of inflation persistence to be observed.

Table 1 - *Description of the variables used in the study*

Variable	Description	Expected sign
INFL	Variation in the consumer price index (%)	---------
GNI	Level of per capita GNI (purchasing power standard, constant 2011, US$)	-
TRADE	Sum of exports and imports of goods and services measured as a share of gross domestic product (%).	-/+
XTEC	High-technology exports (% of manufactured exports).	-
GTT	Growth of terms of trade (%). The net barter terms of trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year (2000 = 100).	+
HC	Index of human capital per person, based on years of schooling (Barro/Lee, 2012) and returns to education.	-
UR	Unemployment rate (%) to account business cycle intensity.	-

Source: Authors' elaboration from the World Bank dataset and Barro/Lee Homepage for HC.

TRADE was included to measure the degree of openness and its influence on domestic prices. Its expected sign is unclear, since this channel of influence may produce a lower inflation domestically when international competition prevails. This may occur in an environment of flexible markup and cost conditions, however, otherwise, it may result in a rise in inflation by when it reduce the supply of domestic commodities in relation to changes in demand.

The high-technology exports (XTEC) was included to account for the influence of more sophisticated exports, as a proxy for technological development of supply conditions of the countries and a negative influence on the level of inflation is expected because the technological upgrading are related to TFP growth and it produces spillover effects of technology upon other sectors (diffusion). This may reflect big changes toward a more sophisticated and technological advanced sectors of the economy allowing a high growth rate of demand and low unemployment be sustained in an environment of stable and low inflation, where the China is the best example (from a commodity export based to the largest exporter of high-technology products in the world, see Woo (2012) for a detailed study and Blanchard and Johnson (2013) for a description). Growth of terms of trade (GTT) represents the price effect of a change in export prices relative to import prices on domestic inflation: if a developing country experienced an upward trend in oil price or agricultural products which is its basic product for exports, we assume that this is associated with higher domestic relative prices because the direct and income effects of terms of trade may predominate over substitution effects in a float exchange rate regime. A rise in terms of trade is less inflationary when the exchange rate is floating than when the exchange rate is fixed. This is so because the existence of a flexible exchange rate reduces the direct effect on prices, the income and substitution effects leading to a less inflationary effect (Gruen and Dwyer, 1995).

The index of human capital per person is associated with the abilities to work and produce more efficiently. Since there is some sort of influence on skills of labor, we expect a negative effect of this measure of the ability of workers on the inflation rate because of the ability to learn and produce with higher productivity. As well known in the literature of FDI on output growth, the technological diffusion process requires a minimum threshold of labor force qualification to produce some positive effect on

productivity and real income of a country (Woo, 2012). The important mechanisms of technology diffusion lie in imports of capital and intermediate commodities that embodies technologies. However, the assimilation in domestic processes requires a minimum of ability of product and labour markets, beyond the government, trade and competition policies. Lastly, to account the intensity of the business cycle and demand conditions (recessions and expansions) and its effects on product and labour markets we used the annual variation in the unemployment rate, whose expected effect on inflation is negative.

All computations and plots were done in *R* (R Core Team 2015) and the database was organized for a sample of 65 countries ranging from 2001 to 2011 ($T = 11$ years) according to availability of information from World Bank dataset, in a context of swings in economic activity. The complete list of sample countries used in the study is put on the Appendix. At the end we have N = 65 * 11 = 715 complete data points.

4.2 Empirical Framework

In order to verify whether there is significant relation between the behaviors of inflation rates according to the degree of development, we specify the following basic model,

$$(13) \qquad y_{i,t} = \alpha_0 + \beta_0 GNI_{it} + \lambda_t + \varepsilon_{it} ; \quad i = 1, 2, ..., N; \ t = 1, 2, ..., T.$$

where $y_{i,t}$ is the annual inflation rate in the country i at time t, and λ_t is the time effect, included to account business cycle movements which simultaneously affects all countries. ε_{it} is the idiosyncratic error which we assume is well-behaved and independent of regressors. The model above can be extended to account the degree of persistence in inflation rates by adding an autoregressive component,

$$(14) \qquad y_{it} = \alpha_0 + \varphi y_{i,t-1} + \beta_0 GNI_{it} + \lambda_t + \varepsilon_{it} , \ |\varphi| < 1$$

The inclusion of lagged dependent variable beyond to account persistence of inflation also help to control for omitted variable bias. The use of time series, cross-section panel data allows employing both the cross-section and time series dimension leading to a large number of observations, increasing the degree of freedom and reducing the collinearity among explanatory variables. Beyond that, this methodology allows to control for country-specific, time-invariant 'fixed effects', beyond the inclusion of the dynamic lagged dependent variable. However, the estimation of individual 'fixed-effects' implies a large loss in degrees of freedom, since there are *n* additional parameters to be estimated. Thus, the assumption above is that the country-specific, time-invariant 'fixed effects' do not exist in these data. This means that our hypothesis is that the best model to describe these sample countries is a Pooled OLS. This assumption is tested and the results are presented below. As explained above, the model (14) above can be expanded by a number of additional factors which help to explain in what conditions there is an expected negative relation between the level of inflation and the level of development of countries, thus the complete model reads,

$$(15) \qquad y_{it} = \alpha_0 + \varphi y_{i,t-1} + \beta_0 GNI_{it} + \beta_1 TRADE_{it} + \beta_2 HC_{it} + \beta_3 XTEC_{it} + \beta_4 GTT + \beta_5 UR_{it} + \varepsilon_{it}$$

For reasons of efficiency, after testing for heteroskedasticity we adopt the general FGLS based on a two-step estimation process: first an OLS model is estimated, and then its residuals $\hat{\varepsilon}_{it}$ are used to estimate a more general error covariance matrix given by,

$$(16) \qquad \hat{V} = I_n \otimes \hat{\Omega}$$

In which,

$$(17) \qquad \hat{\Omega} = \sum_{i=1}^{n} \frac{\hat{\varepsilon}_{it} \hat{\varepsilon}_{it}^T}{n}$$

To obtain more efficient estimator given by,

(18) $$\hat{\beta} = \left(X^T \hat{V}^{-1} X\right)^{-1} \left(X^T \hat{V}^{-1} y\right)$$

where y is the dependent and X a matrix of independent variables. Lastly, we extend the model (15) beyond that independent variables to estimate an AR(1) coefficient for each individual country to measure the persistence of inflation in each particular country and to search an inverse correlation between initial per capita income and the degree of persistence of inflation.

4.3 Results and discussion

Before presenting the results for all specified models (13)-(15) we have performed the pre-tests for nonstationary panel data along with the semiparametric test for the null of absence of unobserved effects suggested by Wooldridge (2002, 10.4.4). In this case, the test is designed to verify whether there are no unobserved effects in the residuals. The statistic of the test is asymptotically distributed as a standard Normal regardless of the distribution of the errors and it also not rely on homoscedasticity. The no rejection of null favors pooled OLS model.

Table 2 - *Results for the null of absence of unobserved individual effects*

Model	z-statistic	p-value
Basic	2.6928***	0.0071
Extended with lagged inflation rate	0.3630	0.7166
Extended with lagged inflation rate and all variables	0.3277	0.7432

Source: Authors' elaboration.

Note: *** statistically significance at $P = 0.01$ level.

The results for the unit root tests in the heterogeneous panels are shown in the Table 8 in the Appendix. From those results we are able to reject the null of unit root in all cases. Important to notice, we apply the unit root test for heterogeneous panels introduced by Im et. al. (2003) because its main advantage is that it accommodates heterogeneity across groups such as individual specific effects and different patterns of residual serial correlations. This test produces a more reliable inference. As can be inferred from the results exposed in the Table 3, once we allow for a more general version of the basic relation between inflation and the degree of development, no evidence of individual effects in the residuals was found.

Table 3 - *Results for the basic model with lagged dependent variable*

Dependent variable: Inflation rate	Pooled OLS	Pooled OLS	Pooled FGLS
Constant	7.0114***	3.1393***	3.4582***
	(26.7980)	(11.2793)	(6.6758)
Lagged Inflation Rate	-----------	0.5585***	0.4893***
	-----------	(20.0630)	(6.6450)
Per capita GNI	-0.000113***	-0.000051***	-0.000055***
	(-11.502)	(-6.3675)	(-6.8482)
Observations	715	650	650
R^2	0.15651	0.4987	0.49335
F-statistic	132.302***	321.826***	----------

Source: Authors' elaboration.

Notes: (*i*) *** statistically significance at $P = 0.01$ level. (*ii*) To obtain the results for last column we used the estimation in two steps by FGLS (Wooldridge, 2002, 10.4.3 and 10.5.5); (*iii*) the *t*-statistic between brackets in case of pooled regression and z-statistic in case of FGLS estimates. We included the time dummies in all regressions.

Since all variables may be considered stationary and there is no evidence of fixed-effects in these data, for the last two versions of the extended model (14)-(15) we adopt a Pooled OLS regression and later the

FGLS estimator to account for heteroskedasticity. To get a first approximation, we first estimate the more basic model without and with lagged dependent variable, to generate information without our selected controls.

From the results exposed in the Table 3, three main conclusions can be drawn. First, all coefficients have the expected signs and are statistically significant at conventional levels of probability. Second, there is a negative and significant relation between the degree of development and the inflation rate in the sample of countries. Third, when the lagged dependent variable is present the sign and the significance of the first relation remains, but the absolute magnitude of its coefficient is lower. Additionally, the goodness-of-fit of the model has increased by more than three times when that variable is included.

The results for the more complete version of the estimated model are shown in the Table 4 by using Pooled OLS and two steps FGLS estimators following the suggestion of Wooldridge (2002), since results for the former estimator indicate rejection of the null of absence of heteroskedasticity in the residuals. From Table 4, when we account for heteroskedasticity with more efficient estimator, we can also infer that lower dispersion for coefficients is found, but their magnitude and signs still remain unaffected, except for human capital, which no significant influence was found before.

The first conclusion to be drawn is that the magnitude and sign of per capita income and its influence on inflation rates are similar to the first result presented before. When we analyze the results from the more efficient estimator, we note that only human capital does not exert significant influence on the inflation rates. All estimated coefficients present the theoretically expected signs and are all significant at 0.01 level of probability. Additionally, we observe that there is a significant interaction between the level of persistence of inflation and degree of economic development.

Table 4 - *Results for extended model*

Dependent variable: Inflation rate	Pooled OLS	Pooled FGLS
Constant	3.3417***	2.4695***
	(4.2739)	(5.2459)
Lagged Inflation Rate	0.5255***	0.5018***
	(11.5436)	(43.6552)
Per capita GNI	-0.00005***	-0.00005***
	(-4.1847)	(-18.6286)
Terms of trade growth	0.0218	0.0207***
	(1.0756)	(40.7786)
Human capital	-0.1952	0.01940
	(-0.6322)	(0.1873)
Trade	0.0052**	0.0067***
	(2.4587)	(7.3667)
Technological exports	-0.0176*	-0.0145***
	(-1.7024)	(-11.0856)
Unemployment growth	-0.3143***	-0.3150***
	(-3.8051)	(-55.2897)
Lagged Inflation*GNI	0.000004	0.000004***
	(1.1984)	(32.7076)
Observations	650	650
B P test for heteroskedasticity	540.9916***	---------
R^2	0.5169	0.51161
F-statistic	85.7306	----------

Source: Authors' elaboration.

Notes: (*i*) *** statistically significance at *P* = 0.01 level. (*ii*) For the models (14) and (15) we used the estimation in two steps by FGLS (Wooldridge, 2002, 10.4.3 and 10.5.5); (*iii*) the *t*-statistic between brackets in case of pooled regression and z-statistic in case of FGLS estimates. We included the time dummies in all regressions.

To further explore this result, we estimated the model (15) with all variables applying the panel regression with AR(1) Prais-Winsten correction and panel weighted least squares in which each country has an estimates of the individual degree of persistence of inflation, measured by the individual autoregressive coefficient of lagged inflation rate. The results are plotted in the Figure 5 below where the initial income is related to the degree of persistence of inflation in each country. This last result is used at end by correlating the individual autoregressive coefficient with the initial degree of development. The correlation coefficient estimates are show in the table 5, in which a negative and low correlation was detected. Table 5 also presents the results of three main correlation coefficients to infer about the relation between the initial degree of development and the inflation persistence. The main conclusion is that, we find a low but negative association in all correlation sample statistics.

Table 5

Type of correlation coefficient	Initial income and AR(1) coefficient
Pearson	-0.0491
Spearman	-0.0723
Kendal	-0.0433

Source: Authors' elaboration.

The explanation for that lies in those circumstances by which this correlation was determined, mainly the degree of technological content of the economy, degree of openness and terms of trade, beyond the state of demand. In spite all these factors are been controlled for, from the Figure 1 below there seems to be a regional or institutional component that tied the degree of persistence of inflation with income in a group-level phenomenon. We speculate that the most probable reason for this low correlation may be the absence of proper controls, like the regional and institutional controls for a grouping effect in the sample countries.
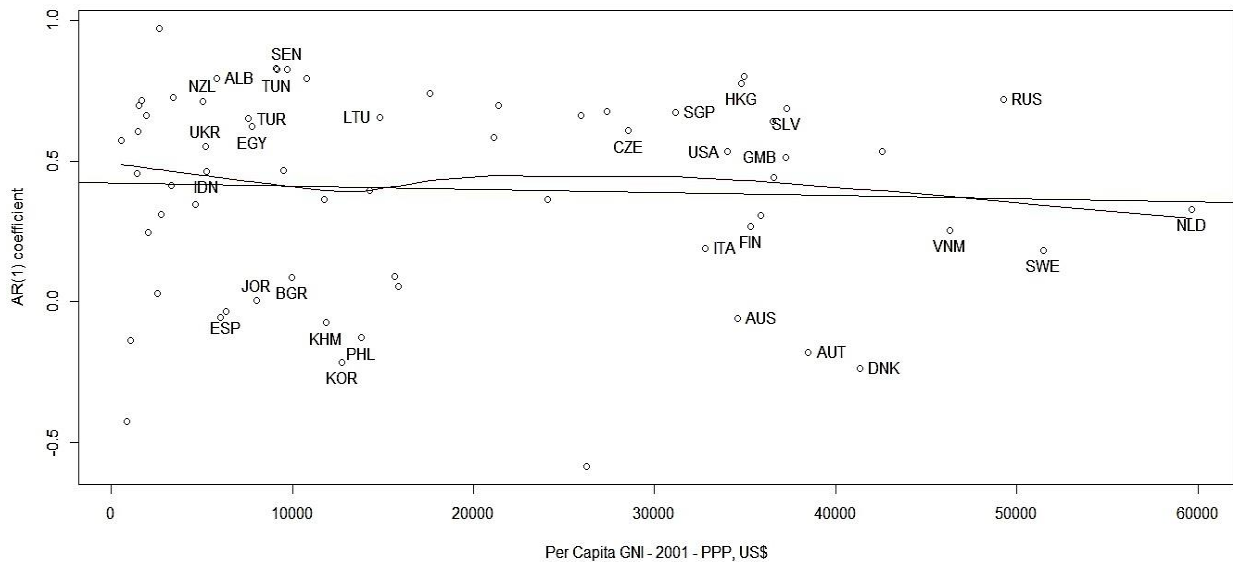

Figure 1 - Dispersion between the inflation persistence and the initial per capita income, US$.

Finally, the Figure 1 above plots the correlation between the initial degree of development and the inflation persistence. The curve line is a smoothed nonlinear function adjusted to the data, and the right line is the trend line of the regression, in which persistence is explained by the initial level of income plus a constant. From the above results, we may conclude that there are sound reasons helping to explain why a number of countries may endure a higher level of inflation which is dependent upon its degree of development and their technical supply conditions, held constant demand aspects. These theoretical expected results were partially corroborated by a detailed empirical examination through a cross-section, panel data analysis.

5 Concluding Remarks

This paper studied the relation between economic development and level of inflation and found a statistically significant inverse correlation between them. Our panel comprised data for 65 countries between 2001 and 2011 and revealed that inflation levels are affected by development-related factors. Results indicate that our theoretical model adequately portrayed the problems at hand, whereby expected signs were all vindicated by empirical tests, namely: the persistence of inflation, growth of terms of trade, degree of openness to trade were positively related to inflation, whereas heightened levels of economic prosperity (*per capita* income), of the share of high-tech exports and of unemployment growth corresponded to lower inflation rates. The connection between human capital and inflation was not statistically significant, probably due to the former's long-term nature, falling short of revealing a more clear effect in time range defined by our data sample. Further improvements are required to empirically unearth the impacts of productivity on inflation rates in cross-country data samples.

Moreover, the fact that per capita income maintained some explanatory power over inflation rates suggests that our model did not exhaust the set of development-related forces affecting inflation. Although this is partly frustrating, it opens up possibilities for further investigations. For instance, there seems to be a regional or institutional component tying the degree of persistence of inflation with per capita income in a group-level phenomenon. We speculate that the most probable reason for this low correlation may be the absence of proper controls, like the regional and institutional controls for a grouping effect in the sample countries. We intend to delve into these matters in subsequent studies.

In spite of these shortcomings, the paper offers valuable insight regarding the complex nature of the drivers behind inflation in different countries. Its relevance is twofold. First, it addresses a deficiency in the academic literature on inflation, which has strikingly ignored the empirical fact that developing countries are subject to higher inflation levels on average than developed economies. This issue is seldom mentioned and, when it is, arguments are superficial and attribute these differentials to circumstantial aspects of monetary policy rigor and institutional detail, such as Central Bank independence or the adoption of some variant of the inflation-targeting regime. Under this hastened approach, inflation is stripped of its long-term forces, which are brought in whenever convenience dictates. This point leads to our second contribution, that is, its policy implications.

However preliminary, our conclusions question the widely held understanding that inflation control is but a matter of Central Bank's credibility and willful austerity in daily management of aggregate demand. Our narrative supports the long-standing structuralist views (both Latin American and Anglo-Saxon) that long-term development-related features act upon the level of inflation a country is likely to endure, no matter how determined and stern its central bankers prove to be. This is not to say that a vigilant monetary policy cannot be effective in curtailing inflation; it only means it is likely to leave the latter's original causes unaffected or, which is worse, reinforce them through adverse – because overlooked - channels. As a result, we claim inflation control should not be construed as the realm of sole monetary policy but a part of a broader development policy, whose primary objective is to enhance a country's capabilities of catching up with those already developed whilst disciplining the distribution of income and wealth accrued from the collective effort of production. Not taking heed of these forces is bound to render moot the most sincere determination by policymakers engaged in inflation control.

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Appendix 1

Total labor productivity is given by

$$Q = Q_{Tt} + Q_{St} + Q_{SMt}$$

where the upper-case letter Q denotes the level of labor productivity in all sectors. In rates of change we obtain

$$q = v_T q_{Tt} + v_S q_{St} + v_{SM} q_{SMt}$$

where $v_T = Q_{Tt}/Q$, $v_S = Q_{St}/Q$ and $v_{SM} = Q_{SMt}/Q$. In other words, the parameter v stands for the share of labor productivity of each sector in the total labor productivity. In equilibrium, the values of v_T, v_S and v_{SM} must be constant otherwise there is a growing sectoral imbalance in the economy. More formally, if the shares v are constant, then the labor productivity of all sectors are growing at the same rate as the total labor productivity of the economy, that is $q_t = q_{Tt} = q_{St} = q_{SMt}$.

Appendix 2

Table 6 below describes the sample countries used in the study. The table 7 we present the summary statistics of variables and the table 8 presents the results for unit root tests on variables.

Table 6 - *Sample of Countries*

1. Albania	14. Czech Republic	27. India	40. Mexico	53. South Africa
2. Armenia	15. Denmark	28. Indonesia	41. Moldova	54. Spain
3. Australia	16. Egypt, Arab Rep.	29. Ireland	42. Morocco	55. Sweden
4. Austria	17. El Salvador	30. Israel	43. Mozambique	56. Switzerland
5. Benin	18. Estonia	31. Italy	44. Netherlands	57. Tanzania
6. Botswana	19. Finland	32. Japan	45. New Zealand	58. Thailand
7. Bulgaria	20. France	33. Jordan	46. Norway	59. Tunisia
8. Cambodia	21. Gambia, The	34. Kazakhstan	47. Paquistan	60. Turkey
9. Canada	22. Germany	35. Korea, Rep.	48. Philippines	61. Uganda
10. Central African Republic	23. Greece	36. Kyrgyz Republic	49. Portugal	62. Ukraine
11. Costa Rica	24. Guatemala	37. Latvia	50.Russian Federation	63.United Kingdom
12. Croatia	25. Hong Kong SAR, China	38. Lithuania	51. Senegal	64. United States
13. Cyprus	26. Hungary	39. Malaysia	52. Singapore	65. Vietnam

Source: authors' elaboration.

Table 7 - *Summary statistics*

	Minimum	25% quantile	Median	75% quantile	Maximum
INFL	-4.480	1.980	3.370	6.251	54.400
TRADE	20.260	56.200	74.640	105.650	447.060
XTEC	0.0283	4.394	9.85339	19.444	74.178
UR	-12.000	-0.600	-0.100	0.400	17.000
GTT	-29.040	-2.304	-0.3450	2.0402	33.8462
GNI	571.800	6,322.400	16,111.300	35,660.300	73,239.400
HC	1.157	2.263	2.823	3.095	3.619

Source: Authors' elaboration from the World Bank and Barro/Lee homepage for HC.

Table 8 - *Results for the null of unit root test in all variables.*

Variable	Individual intercept	Individual intercept and trend
INFL	-16.3129***	-39.0166***
TRADE	-10.1962***	-32.0534***
XTEC	-11.1306***	-49.672***
UR	-22.6547***	-50.9553***
GTT	-24.3078***	-69.741***
GNI	-6.8648***	-140.6304***
HC	-50.1291***	-56.2144***

Source: authors' elaboration.

Notes: (*i*) *** statistically significance at $P = 0.01$ level; (*ii*) the best lag length was obtained by using the AIC criterion and fixing the *p* max = 3 following the suggestion of Im et. al. (2003, p. 71).