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REVIEW ARTICLE

Economic development and inflation: a theoretical and empirical analysis

André Roncaglia de Carvalho[a], Rafael S. M. Ribeiro[b] and André M. Marques[c]

[a]Department of Economics, Federal University of São Paulo, Osasco, Brazil; [b]Institute of Economics Research, School of Economics, Business and Accounting, University of São Paulo (IPE-USP), São Paulo, Brazil; [c]Department of Economics, Federal University of Paraiba, João Pessoa, Brazil

ABSTRACT

This paper studies the relation between inflation and economic development. The literature is largely silent regarding both the theoretical and empirical perspectives that undeveloped countries endure higher average inflation than developed economies. We present a simple theoretical model linking the inflation phenomenon to the tradition of development economics. Empirical evidence is 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, we aim at listing a number of variables most commonly used to explain differences in the stage of economic development across countries and identifying the most statistically relevant ones to account for differences in inflationary patterns. While our results show that inflation is inversely correlated with the level of the technological content of the economy (measured by share of high-tech exports), human capital and cyclical unemployment, it is directly related to the degree of inflation persistence and terms of trade growth. However, our findings still present an inverse and low correlation between inflation persistence and economic development, implying that development-sensitive variables allowed into the model can only partially account for the differences in inflation at different levels of economic development.

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1. Introduction

After long-lasting theoretical debates between the 1970s and late 1990s, the academic literature on inflation has reached a fair range of consensus (see Goodfriend and King 1997). 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: (i) excess aggregate demand over supply is a typical feature of overheated economies at full-employment of productive resources; (ii) the cost-push effect that could result from upward changes in the market power enjoyed by oligopolistic domestic companies, rising unit labor cost, increased prices of imported intermediate inputs, and one-time or

CONTACT André Roncaglia de Carvalho andre.carvalho@unifesp.br

systematic shortages of productive resources in general – due to droughts, wars, etc. – thereby swelling costs that feed through into prices of consumption goods; (iii) finally, a self-feeding component 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 while heterodox policy-prescriptions are mostly grounded on cost-related and institutional forces due to the recognition that firms in modern economies tend to 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 particularly relevant to account for differences in the magnitude of parameters mediating between these inflationary forces and the response by price indexes? 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 labor market regulations, 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 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 policy-makers who hold a stake in this matter.

This paper tackles these questions 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 undeveloped 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

The recent empirical literature on development economics has consistently overlooked the connection between economic development and inflation. 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.[1] 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 2003). The theoretical problem of inflation has thus become indelibly detached from development concerns.

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 Central Banking and technical aspects of inflation indices (see IMF (International Monetary Fund) 2016; chapter 3; Rogoff 2003; Romer and Romer 1997). Notwithstanding the truth they convey, these elements overlook shared economic and structural features related to each country's stage of development. Underlying institutional aspects of economies that explain various development trajectories are likely to play a significant role in macroeconomic performance and volatility (Acemoglu, Johnson, and Robinson 2001; Acemoglu et al. 2003; Acemoglu and Robinson 2012, chapter 11–12). 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.[2] 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.

At variance with the conventional literature, we point out that inflation is not strictly a matter of sound monetary policy and a rigorous control of government finances. Our work contributes to the literature by claiming that inflation might be also correlated with the stage of development of a given country. Were it not the case, undeveloped countries focusing its policies on price stability would receive pressure by Bretton Woods institutions to rapidly seek 1–2% inflation rates. This does not seem to be the case, for it is only suggested as an 'eventual' goal to be achieved. Besides, targets should be determined, it is advised, according to local economic reality (Fischer 1997, 16).[3]

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.

In what follows, a uniform theoretical approach explores the link between inflation and structural changes, spelling out the channels through which the development process affects the economy's price-output dynamics and, therefore, a country's inflation patterns. Next section provides a basic theoretical framework that will guide us through the cross-country empirical evidence.

3. The structure of the model

3.1. The price index

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

$$P_t = P_{Tt} + P_{St} + P_{At} \tag{1}$$

where P_{Tt}, P_{St}, and P_{At} are tradables, services, and administered prices, respectively.

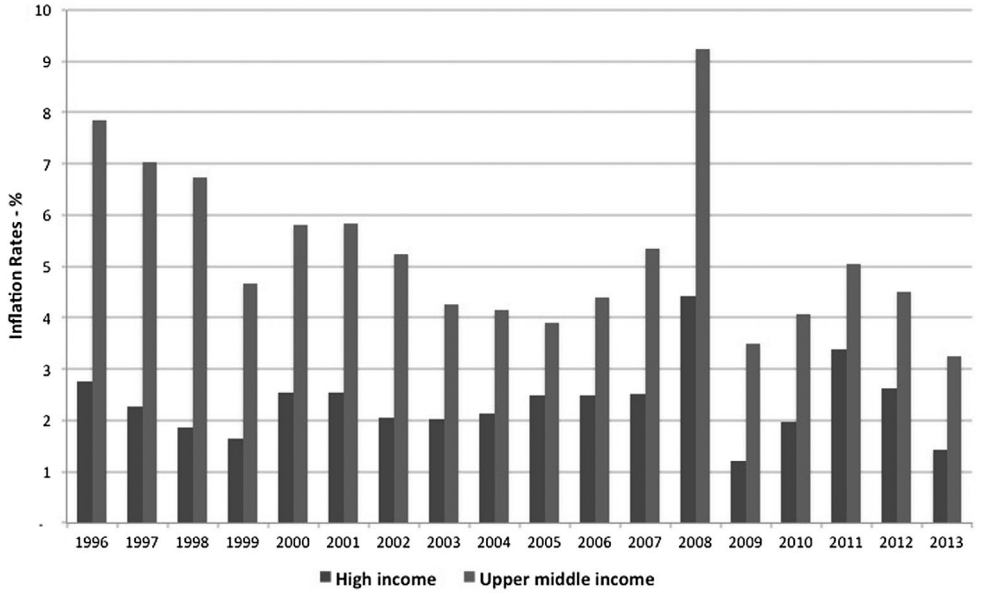

Figure 1. Inflation Rates for Country Groups classified according to income levels – 1996–2013.
Note: Data Source: World Bank. Authors' own elaboration.

In rates of change we obtain:

$$\pi_t = \alpha_T \pi_{Tt} + \alpha_S \pi_{St} + \alpha_A \pi_{At} \tag{2}$$

where $\pi_t = dP_t/P_t$ denotes domestic inflation, $\pi_{Tt} = dP_{Tt}/P_{Tt}$ is the tradables inflation, $\pi_{St} = dP_{St}/P_{St}$ stands for the services inflation, $\pi_{At} = dP_{At}/P_{At}$ is the inflation of administered goods and services, and $\alpha_T = P_{Tt}/P_t$, $\alpha_S = P_{St}/P_t$ and $\alpha_A = P_{At}/P_t$ are the share of each component in the overall price index. Next, we define each component of the inflation rate separately.

3.2. Tradables inflation

First, we describe the tradables inflation. Industrialized goods are commercialized in foreign markets. Hence, in the absence of transaction costs, the elimination of all arbitrage ensures that the price of domestically produced tradable goods equals the price of foreign goods when exchange rates are considered. More formally, it means that, as a linear approximation, the domestic tradables inflation is equal to the foreign tradables inflation plus the growth of nominal exchange rate, as follows:

$$\pi_{Tt} = e_t + \pi_{Tf} \tag{3}$$

where e_t is the growth of the nominal exchange rate measured as foreign prices in terms of domestic currency; π_{Tf} is the foreign tradables inflation rate. Henceforth, we assume $\pi_{Tf} = 0$ 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 both the foreign interest rate i_f and the country risk premium σ. The behavioral specification of e_t is given by:

$$e_t = \psi\left(i_f + \sigma - i_t\right) \tag{4}$$

where $\psi > 0$ is a parameter that measures the speed of adjustment of the nominal exchange rate growth e_t to changes in the gap between domestic interest rate and the foreign interest rate plus the risk premium $\left(i_f + \sigma - i_t\right)$ Equation (4) states that when domestic interest rates exceed foreign interest rates plus risk premium, capital inflow increases, thus appreciating the nominal exchange rate. Also, by definition, we have:

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

where r_t is the real interest rate.

3.3. Services inflation

Second, we examine the services inflation. Services consist of all types of non-tradable goods such as electricity, water supply, real estate, construction, and local transportation. For methodological purposes, we do not include public services in the services inflation, as they respond to a different dynamics of price formation. Here, we consider that the services sector forms prices based on the standard mark-up pricing equation, which consists of a mark-up rate set over prime costs. For simplicity, we consider that the labor cost is the only component of the variable cost of domestic firms. This implies that the utilization of imported intermediate goods or any type of inputs in general, in the production process is negligible. In rates of change, the services inflation is equal to the growth of the mark-up factor plus the growth of nominal wages minus the growth of labor productivity in the sector, as follows:

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

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 for convenience that nominal wages grow at the same rate in all sectors of the economy.

We assume that the mark-up factor is positively related to time variations in the nominal 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. Then, we have:

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

where $\eta > 0$ is a parameter that measures the speed of adjustment of the mark-up with respect to interest rates variation over time.

Herein, we also assume that the growth of nominal wages is indexed to the expected inflation rate (π_{t+1}) and also depend on the unemployment rate (u_t), as follows:

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

where ρ is a constant that measures the sensitivity of the growth of nominal wages to expected inflation, ω denotes responsiveness of the rate of change of money wages to the rate of unemployment. Equation (8) shows that the growth of nominal wages depends directly on the expected inflation rate. Further, as regards wage-setting behavior, the rate of change of nominal wages also relates positively to workers' bargaining power, which 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 take heed of

the institutional framework of the economy that intermediates the conflicting claims over income between workers and capitalists in the wage decision-making process.

Lastly, we define the growth rate of labor productivity. Even though the level of the labor productivity may vary across different sectors, in equilibrium, the growth rate of labor productivity must be equal in all sectors of the economy. We may say that $q_t = q_{Tt} = q_{St} = q_{At}$, where q_t, q_{Tt}, q_{St}, and q_{At} 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 analyze the determinants of the growth of labor productivity of the economy, as follows

$$q_t = q\left(HC,\ K,\ growth,\ Tech\right) \tag{9}$$

where *HC* denotes the level of human capital, *K* is the stock of capital, *growth* accounts for the output growth rate, and *Tech* is the level of technological content of the economy. 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 by workers. 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 labor 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 Thirwall 1994). Lastly, another major determinant of the growth of labor productivity is the level of innovative activity. Innovation leads to a higher degree of product differentiation and quality and hence increases productivity (León-Ledesma 2002).

3.4. Administered prices

Administered prices are the prices of goods and services provided by governmental agencies and are not determined through regular forces of supply and demand. For simplicity, it is assumed herein that these prices are set by contracts heavily influenced by the expected inflation rate. Thus, in formal terms, we have:

$$\pi_{At} = \gamma \pi_{t+1} \tag{10}$$

where γ is the degree of indexation of the contracts regulating the supply of public goods and services.

3.5. The general model

Substituting Equations (3)–(10) into (2), and assuming in the long-run the real interest rate remains unchanged, $r_t = r_{t-1}$, after a great deal of manipulation we obtain the general equation that describes the domestic inflation:

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

where $\beta = -\left(1 + \alpha_S \eta\right) / \left[\alpha_T \psi - \alpha_S(\eta + \rho) - \alpha_A \gamma\right] \gtrless 0$ and, as a consequence, $\lambda = \left[\alpha_T \psi \left(i_f + \sigma - r_t\right) - \alpha_S \left(q_t + \omega u_t\right)\right] / \left[\alpha_T \psi - \alpha_S(\eta + \rho) - \alpha_A \gamma\right] \gtrless 0$.

The stability condition of the inflationary process specified by equation (11) is $|\beta| < 1$. In other words, if $|\beta| < 1$, then short-run prices fluctuations will mitigate over time, as inflation has a tendency to converge toward its stationary level in the long-run. The equilibrium inflation rate is given by:

$$\bar{\pi} = \frac{\lambda}{1 - \beta} \tag{12}$$

Figure 2 below shows how current inflation rate converges toward the equilibrium inflation rate $\bar{\pi}$. The figure on the left shows the case in which inflation increases monotonically toward its equilibrium level. In terms of the formal model, this is the case when the parameter β is strictly positive, that is, $0 < \beta < 1$. The figure on the right side, however, depicts the case in which inflation fluctuates toward its stationary level in the long-run. More formally, this scenario happens when $-1 < \beta < 0$. Note that the larger the degree of indexation of wages ρ vis-à-vis the responsiveness of the mark-up growth to interest rates variation η, the more likely it is that β will be positively signed. Therefore, the parameter β embodies conflicting claims on income between workers and capitalists, as a sufficiently low degree of indexation of wages ρ yields a negatively signed β and hence generates greater volatility in the process of price convergence. Given a sufficiently low value of ρ, if inflation soars in time t, money wages will be poorly adjusted, thus causing inflation to drop sharply in time $t + 1$ through the cost channel. The inverse dynamics applies in the subsequent period and this process continues with diminishing intensity over time as prices converge toward the stationary state.

On the other hand, if $|\beta| > 1$, then the inflation rate is unstable. In Figure 3, we illustrate the scenario in which the actual inflation rate veers off from the equilibrium inflation rate $\bar{\pi}$. Given that $\beta = -\left(1 + \alpha_S \eta\right) / \left[\alpha_T \psi - \alpha_S(\eta + \rho) - \alpha_A \gamma\right]$ we see that a sufficiently high value of ρ yields a value of β higher than unity. It means that the inflation rate is more likely to grow exponentially when the capacity of workers to incorporate expected inflation into the growth of nominal wages ρ is sufficiently high relative to the sensitivity of the mark-up growth to interest rates variation η. The inflation dynamics also explodes in an oscillating

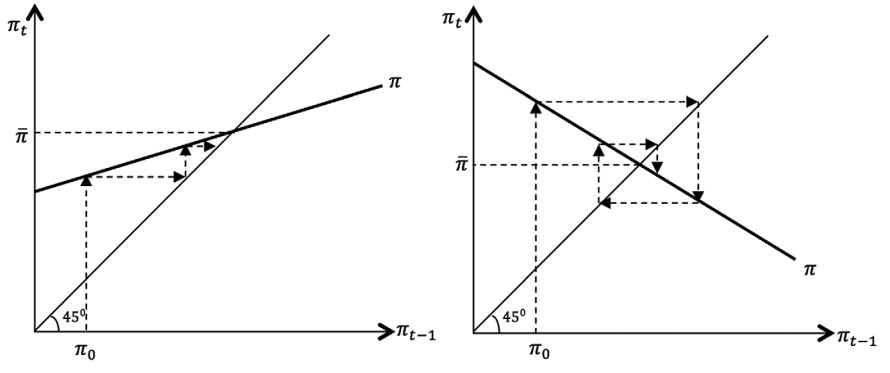

Figure 2. Stable inflation rate.

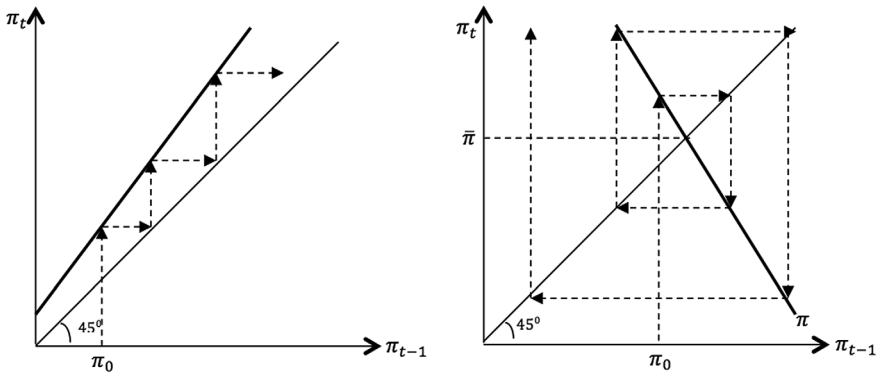

Figure 3. Unstable inflationary dynamics.

trajectory when ρ is sufficiently low relative to the magnitude of η. In short, other things held constant, the inflation rate only converges asymptotically toward its steady state when the value of the parameter ρ falls within a certain range of its domain. It means that the ability of workers to incorporate past inflation into nominal wages in the bargaining process should neither greatly exceed nor fall short of certain boundaries determined by the structure of the economy.

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 to changes in the nominal interest 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. We can also observe that a higher sensitivity of administered prices to expected inflation γ raises the absolute value of β; however, if γ is either sufficiently high or low it can also destabilize the inflationary dynamics.

3.6. Inflation in developed and undeveloped countries: a static comparative analysis

Now we discuss based in our theoretical model the reason why inflation tends to be systematically higher in undeveloped countries than in developed countries, that is $\bar{\pi}_{\text{Dev}} < \bar{\pi}_{\text{Und}}$. By equation (12) the equilibrium inflation rate is positively related to the degree of indexation β and the exogenous term λ.

Figure 4 shows how a higher value of λ shifts the inflation curve upward. Given that $\lambda = \left[\alpha_T\psi\left(i_f + \sigma - r_t\right) - \alpha_S\left(q_t + \omega u_t\right)\right] / \left[\alpha_T\psi - \alpha_S(\eta + \rho) - \alpha_A\gamma\right] \gtrless 0$, undeveloped countries tend to have higher inflation due to: (i) higher rates of currency devaluation, since, by Equation (4), we know that the rate of change of nominal exchange rate e_t is directly related to the country's risk premium σ and the foreign interest rate i_f, and inversely related to the real interest rate of the country; the rationale behind it states that a big currency devaluation immediately hits the domestic price index as tradables price soars; in more sophisticated formal framework, currency devaluation also affects prices through the channel cost, as it raises the price of imported intermediate inputs; (ii) lower labor productivity q_t, thus

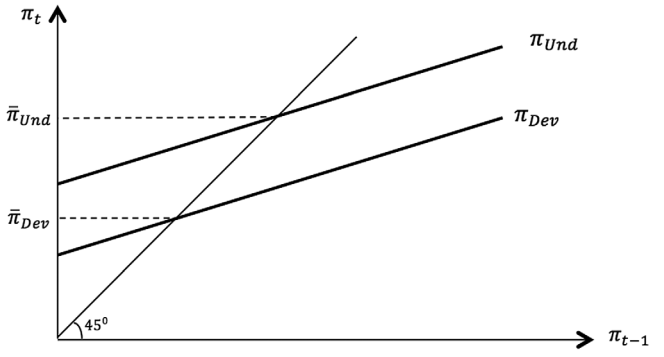

Figure 4. Static comparative analysis.

yielding higher unit labor costs; (iii) higher sensitivity of money wages to changes in the unemployment rate ω; and iv) poor capacity of central banks in these countries to steer nominal exchange rate and prices by manipulating interest rates; while a higher value of parameter $\alpha_T\psi$ increases the ability of the central bank to manage prices through corrective monetary policy measures (by reducing β in absolute value), it may also increase the equilibrium level of the inflation rate by increasing the responsiveness of domestic prices to changes in the nominal exchange rate (by raising λ). Lastly, we claim that differences in the degree of indexation β across countries can also account for different inflationary behaviors. For simplicity, in figure 4 we illustrate two countries featuring the same degree of indexation β. We decided to represent both countries with a β less than unity and positively signed, without loss of generality. Nevertheless, it is worth mentioning that a lower (higher) β yields more gradual (steeper) inflation curve, whereas a negatively signed β gives us a downward sloping inflation curve.

Next, we run an empirical model in order to test the statistical significance of the exogenous variables and the degree of indexation presented in our theoretical framework for a sample of developed and undeveloped countries.

4. Methodology and empirical framework

4.1. Description of the data

In this study, we seek to empirically analyze the inverse relationship between the level of inflation and the degree of development for a sample of developed and undeveloped countries over the last years. The rationale behind the inverse relationship between inflation and the degree of development states that in a mature economy the degree of inflation persistence and the propagation of shocks are expected to be smaller. More specifically, in the present work we try to identify, within a set of variables most commonly used to explain the stage of economic development of a country, which ones are the most statistically relevant to explain also the inflation differentials between developed and underdeveloped countries.

Following the theoretical model outlined in the previous section, Table 1 below presents the explanatory variables used in our empirical model, as well as the expected sign of the correlation between each explanatory variable and the dependent variable, namely the

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 data set and Barro/Lee Homepage for HC.

inflation rate. First in the list is the degree of development, measured by the level of per capita Gross National Income (GNI – constant 2011, in US$).

The variable TRADE accounts for the impact of variations in the degree of openness to foreign trade of an economy on domestic prices. Its expected sign is ambiguous. On the one hand, a higher degree of trade openness may induce a fall in prices. As domestic firms compete in foreign markets, they might be forced to reduce the mark-up factor set on prime costs in order to gain market share, thus causing a decrease in the level of domestic prices. On the other hand, the degree of trade openness can also be positively related to the price level. When the supply of domestically produced goods is sufficiently inelastic, a higher degree of openness followed by an increased foreign demand for the country's exports may lead to soaring prices. For example, in the short- to medium-run, the supply of commodities in undeveloped countries may be inelastic. In these countries, a higher degree of openness caused by rising exports of commodities may lead to a shortage of food and raw materials internally, thereby fomenting an inflationary process. In short, the sign of the partial effect of changes in the degree of openness on inflation ultimately depends on which effect prevails. In cross-country studies, a negative relation emerges between inflation and trade openness. Romer (1993) presents evidence of negative and significant correlation using data for a cross-section of countries. However, as pointed out by Wynne and Kersting (2007, 9) '[w]ith more countries participating in the global economy, there will be increased demand for scarce raw materials, which presumably will be reflected in their price, offsetting the price-level effects of cheaper imports'. In other words, an increased degree of openness might yield unwanted effects in terms of price control.

The high technology exports (XTEC) accounts for the influence of the level of technological content of a country on the inflation rate. An inverse relationship between XTEC and inflation is expected as technological progress and its spillover effects upon other sectors (diffusion) are directly related to the growth of labor productivity, thus reducing unit labor costs and allowing firms to set lower prices.[4]

Growth of Terms of Trade (GTT) represents the price effect of a change in export prices relative to import prices on domestic inflation. Terms of trade are used as a proxy for the real exchange rate since both are strongly correlated. Furthermore, we use the relative prices of exports and imports since it is these relative prices to which exporters and importers respond, thus providing the 'microfoundations' on which the model is based. We claim that firms' export and import decisions are more likely grounded on relative prices of exports

and imports. A positive GTT fuels inflation as it raises the price of tradables. Currency devaluation makes both the exports and imports of the home country become more expensive in terms of domestic currency (see Gruen and Dwyer 1995). The rationale behind the positive correlation between terms of trade and the price level is that rising prices of tradables following devaluation is passed through into the overall price index. Since the dependent variable is inflation, the growth – instead of levels – of terms of trade performs better as explanatory variable.

The index of human capital per person is associated with the workers' abilities to produce more efficiently. We expect a negative effect of this measure of the ability of workers upon the inflation rate, through the productivity channel. It is well known in the literature that the technological diffusion process requires a minimum amount of labor force qualification to produce some positive effects on productivity and real income of a country (Woo 2012).

Lastly, we account for the intensity of the business cycles (recessions and expansions) and its effects on domestic prices through changes in the dynamics of the labor market. Buoyant demand conditions tighten the labor market and encourage workers to bargain for higher wages, thereby putting an upward pressure on prices. Thus, the yearly change in the unemployment rate exerts a negative expected impact on inflation.

The database consists of a sample of 65 countries, ranging from 2001 to 2011 ($T = 11$ years) according to availability of information from World Bank data set, in a context of dwindling economic activity. The complete list of sample countries used in the study is put on the Appendix 2. At the end we have $N = 65 * 11 = 715$ complete data points.[5]

4.2. Empirical framework

Broadly speaking, the idea here is to test the empirical relationship between economic development and inflation. To begin with, we assess the partial effect of changes in the stage of economic development of a country, proxied by the level of per capita GNI, on inflation. For methodological purposes, first we regress the inflation rate only against the per capita GNI, and then we include in the baseline equation the inflation rate with a lag as an explanatory variable in order to account for the degree of persistence of inflation. Having done that, we move on to the next step of our empirical model. Since economic development is such a broad concept with multiple determinants, just pointing out that different stages of economic development may give rise to differences in the level of inflation across countries does not help much in terms of policy. This problem raises a couple of questions, such as: Do all the determinants of economic development also have an effect on inflation? If they do, then what are the determinants of economic development? If not all the determinants of economic development also impact on inflation, then what are the most relevant variables that could explain both economic development and inflation? Our theoretical model sheds some light on this issue by suggesting a number of variables that could explain economic development and ultimately inflation. The aim of our empirical work is to verify if the explanatory variables listed in the theoretical model are statistically relevant to explain inflation.

In order to investigate whether there is significant relation between the behaviors of inflation rates and the degree of development, first we specify the following basic model:

$$y_{i,t} = \alpha_0 + \beta_0 GNI_{it} + \lambda_t + \varepsilon_{it}\,; i = 1, 2, \ldots, N; t = 1, 2, \ldots, T. \tag{13}$$

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 for business cycle fluctuations simultaneously affecting all countries. ε_{it} is the idiosyncratic error, which is assumed to be well behaved and independent of regressors.

Second, we extend the model above by including the degree of persistence in inflation rates through the addition of an autoregressive component:

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

The inclusion of a lagged dependent variable to account for the degree of persistence of inflation also helps to control for omitted variable bias. The use of time series, cross-section panel data allows us to employ both the cross-section and time series dimension, thus resulting in a larger number of observations, increasing the degree of freedom and reducing the colinearity among explanatory variables. Further, this methodology enables us to control for country-specific, time-invariant unobserved effects, in addition to the lagged dependent variable. However, the estimation of individual unobserved 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 unobserved effects do not exist in these data. This means that our hypothesis is that the best model to describe this sample of countries is a Pooled OLS. This assumption is tested and the results are presented below. As aforementioned, 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 is given by:

$$y_{i,t} = \alpha_0 + \varphi y_{i,t-1} + \beta_0 \mathrm{GNI}_{it} + \beta_1 \mathrm{TRADE} + \beta_2 \mathrm{HC}_{it} + \beta_3 \mathrm{XTEC} + \beta_4 \mathrm{GTT} + \beta_5 \mathrm{UR}_{it} + \varepsilon_{it} \tag{15}$$

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 are used to estimate more general error covariance matrix given by:

$$\hat{V} = I_n \otimes \hat{\Omega} \tag{16}$$

in which,

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

to obtain more efficient estimator, as follows:

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

where y is the dependent and X a matrix of independent variables.

Lastly, we extend the model (15) by including an AR(1) coefficient for each individual country to measure the persistence of inflation in each particular country and to investigate the correlation, if there is any, 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 carried out the pre-tests for non-stationary panel data along with the semi parametric 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 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 does not rely on homoskedasticity. Not rejecting the null hypothesis favors the use of pooled OLS model (Table 2).

The results for the unit root tests in the heterogeneous panels are shown in Table A3 in the Appendix 2. 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, Pesaran, and Shin (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 more reliable inference. As it can be inferred from the results exposed in Table 3, once we allow for more general version of the relation between inflation and the degree of development, no evidence of individual effects in the residuals was found.

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 with and without the lagged dependent variable, to generate information without our selected controls.

From the results shown in 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 statistically significant relation between the degree of development and the inflation rate in the sample of countries. Third, the inclusion

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

***statistically significance at $p = 0.01$ level.
Source: Authors' elaboration.

Table 3. Results for the basic model with lagged dependent variable.

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

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.
Source: Authors' elaboration.

of the lagged dependent variable maintains the sign and the significance of parameters, 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 most complete version of the model, as stated in Equation (15), are shown in Table 4. We used both Pooled OLS and two steps FGLS estimators following Wooldridge (2002), since the 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, to 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 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.

Indeed, the results above contrast with those found by Romer (1993) in a cross-section of countries without controls, in two important aspects. First, a robust negative and significant correlation between inflation and per capita income was found. Second, unlike Romer (1993) and Temple (2002), we did not find statistical evidence of a negative impact of trade openness on inflation when explicit controls are considered.

It is widely known that once we add proper controls the previous results may be difficult to remain. In line with Barro (1991), at first sight the hypothesis that poor countries tend to growth faster than rich countries seems to be inconsistent in a cross-section data analysis for 98 countries. The per capita growth rates have little (and *positive*) correlation with the initial level of output per capita. However, when Barro (1991) added a set of proper controls like human capital and the share of government consumption he finds strong evidence of significant and negative relation between the growth rates of output per capita and the initial

Table 4. Results for extended model.

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

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.
Source: Authors' elaboration.

level of output per capita. Thus, for the same reason, we suggest that those finds of Romer (1993) should be viewed with caution (see Temple 2002 for a critical review).

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 estimate of the individual degree of persistence of inflation, measured by the individual autoregressive coefficient of lagged inflation rate. The results are plotted in 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 three different correlation coefficient estimates are show in Table 5, in which a negative and low correlation was detected. The main conclusion is that there is a low but negative association in all correlation sample statistics relating the degree of development and the inflation persistence.

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 Figure 5 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, which suggests future research that extends the model to include institutional detail, along the lines pointed by Acemoglu and Robinson (2012) and IMF (International Monetary Fund) (2016), may prove illuminating. 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.

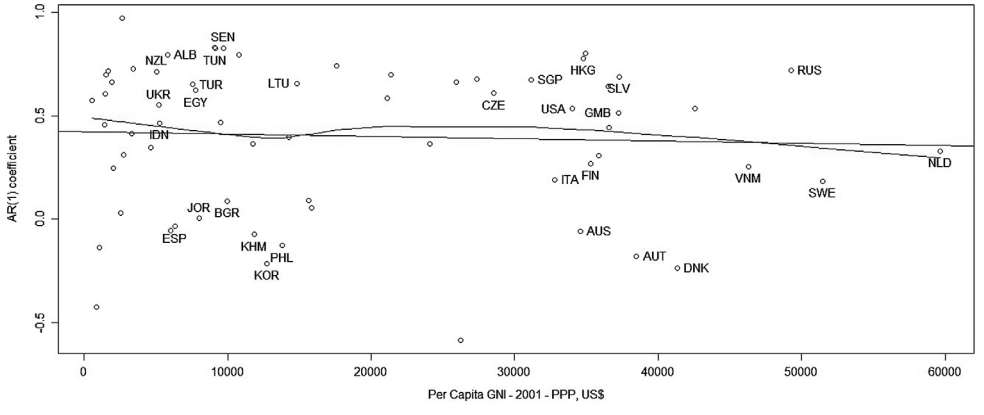

Figure 5. Dispersion between the inflation persistence and the initial per capita income, US$.

Table 5. Correlation coefficient estimates – results.

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

Source: Authors' elaboration.

Finally, the Figure 5 above plots the correlation between the initial degree of development and the inflation persistence.[6]

The curve line is a smoothed nonlinear function adjusted to the data, and the straight line is the trend line of the regression, in which the initial level of income plus a constant explain persistence. From the result above, we may conclude that there are sound reasons helping to explain why a number of countries may endure a higher level of inflation conditioned upon its degree of development. These theoretical expected results were partially corroborated by a detailed empirical examination through a cross-section, panel data analysis.

5. Concluding remarks

This work 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, GTT, 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. As a consequence, 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.

Furthermore, 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, to the best of our knowledge, the empirical fact that undeveloped 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.

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 while 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.

Lastly, it is worth remarking that our work is but a preliminary investigation on the links between inflation and economic development and, as such, it is certainly not meant to be the final word on this issue. Admittedly, there are multiple areas in which our theoretical and empirical models can be extended, improved or even challenged through the incorporation of additional transmission channels and the employment of different econometric techniques and data sets. Given the complexity of this topic, we decided to leave some important questions for future research, to which we invite the readers to stay tuned.

Notes

1. Two papers back in the late 1950s undertook this task. Wai (1959) and Bhatia (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.
2. 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 undeveloped 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'.
3. The premise behind this assertion is that countries should – and would be able to – achieve such a goal, if they simply follow 'widely accepted' central banking good practices. It is yet to be demonstrated that there exists such gravitational force pulling economies onto 1–3% inflation levels.
4. Woo (2012) and Blanchard and Johnson (2013) work out one specific channel through which high-tech exports can affect inflation, that is, as the production structure moves toward 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, being China a clear-cut historical experience of an economy switching from a commodity export based to the largest exporter of high-technology products in the world. This result concurs with the general claim, made by Rogoff (2003), that increases in productivity have been a major force behind global disinflation from the 1990s onward.
5. All computations and plots were done in *R* (R Core Team 2015).
6. 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 postwar era. In fact, the European Central Bank has setup its own institutional branch to oversee the phenomenon: the *Eurosystem Inflation Persistence Network* (see Marques 2004; O'Reilly and Whelan 2004).

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ORCID

André Roncaglia de Carvalho http://orcid.org/0000-0003-4873-3433
Rafael S. M. Ribeiro http://orcid.org/0000-0002-2355-2460
André M. Marques http://orcid.org/0000-0002-6762-8439

References

Acemoglu, D., S. Johnson, and J. A. Robinson. 2001. "Colonial Origins of Comparative Development: An Empirical Investigation." *American Economic Review* 91: 1369–1401.

Acemoglu, D., S. Johnson, J. Robinson, and Y. Thaicharoen. 2003. "Institutional Causes, Macroeconomic Symptoms: Volatility, Crises and Growth." *Journal of Monetary Economics* 50: 49–123.

Acemoglu, D., and J. A. Robinson. 2012. *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. New York: Crown.

Barro, R. 1991. "Economic Growth in a Cross-section of Countries." *The Quarterly Journal of Economics* 106 (2): 407–443. doi:10.2307/2937943.

Bhatia, R. J. 1960. "Inflation, Deflation, and Economic Development." *Staff Papers – International Monetary Fund* 8: 101–114. doi:10.2307/3865999.

Blanchard, O., and D. R. Johnson. 2013. *Macroeconomics*. New York: Pearson Education.

Bruno, M., and W. Easterly. 1998. "Inflation Crises and Long-Run Growth." *Journal of Monetary Economics* 41 (1): 3–26. doi:10.3386/w5209.

Fischer, S. 1997. "Financial System Soundness". *Finance & Development*. 34 (1): 14–16. International Monetary Fund. https://www.imf.org/external/pubs/ft/fandd/1997/03/pdf/fischer.pdf.

Goodfriend, M., and R. King. 1997. "The New Neoclassical Synthesis and the Role of Monetary Policy." In *NBER Macroeconomics Annual 1997*, edited by B. Bernanke and J. Rotemberg, 231–283. Cambridge: MIT Press. https://www.journals.uchicago.edu/doi/pdfplus/10.1086/654336.

Gruen, D., and J. Dwyer. 1995. "Are Terms of Trade Rises Inflationary?" *Research Discussion Paper 9508*, Reserve Bank of Australia.

Im, K. S., M. H. Pesaran, and Y. Shin. 2003. "Testing for Unit Roots in Heterogeneous Panels." *Journal of Econometrics* 115: 53–74.

IMF (International Monetary Fund). 2016. "Subdued Demand: Symptoms and Remedies". *World Economic Outlook*, October. https://www.imf.org/external/pubs/ft/weo/2016/02/#ch3.

Kaldor, N. 1966. *The Causes of the Slow Rate of Economic Growth of the United Kingdom*. Cambridge: Cambridge University Press. doi:10.1017/S0770451800040616.

León-Ledesma, M. A. 2002. "Accumulation, Innovation and Catching-up: An Extended Cumulative Growth Model." *Cambridge Journal of Economics*. 26: 201–216. doi:10.1093/cje/26.2.201.

Lucas, R. E. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics*. 22: 3–42. doi:10.1016/0304-3932(88)90168-7.

Marques, C. R. 2004. "Inflation Persistence: Facts or Artefacts?" *European Central Bank – Working Paper Series*, no. 371, June. https://ssrn.com/abstract_id=533131.

McCombie, J. S. L., and A. P. Thirwall. 1994. *Economic Growth and the Balance-of-payments Constraint*. New York: St. Martin's.

O'Reilly, G., and K. Whelan. 2004. "Has Euro-area Inflation Persistence Changed over Time?" *European Central Bank – Working Paper Series*, no. 335, April.
R Core Team. 2015. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. https://www.R-project.org/.
Rogoff, K. 2003. "Globalization and Global Disinflation." In *Monetary Policy and Uncertainity: Adapting to a Changing Economy*, 77–112. Kansas City, MO: Federal Reserve Bank of Kansas City.
Romer, P. M. 1986. "Increasing Returns and Long-run Growth." *Journal of Political Economy* 94: 1002–1037. doi:10.1086/261420.
Romer, D. 1993. "Openness and Inflation: Theory and Evidence." *The Quarterly Journal of Economics* 108: 869–903.
Romer, C., and D. H. Romer. 1997. "Institutions for Monetary Stability." In *Reducing Inflation: Motivation and Strategy*, edited by C. Romer and D. Romer. Chicago, IL: University of Chicago Press.
Temple, J. 2002. "Openness, Inflation, and the Phillips Curve: A Puzzle." *Journal of Money, Credit, and Banking*. 34 (2): 450–468.
Wai, U. T. 1959. "The Relation between Inflation and Economic Development: A Statistical Inductive Study." *Staff Papers – International Monetary Fund*. 7 (2): 302–317.
Woo, J. 2012. "Technological Upgrading in China and India: What Do We Know?" *Working Paper No. 308*. OECD Development Centre.
Wooldridge, J. M. 2002. *Econometric Analysis of Cross-Section and Panel Data*. Cambridge, MA: MIT PRESS.
Wynne, M. A., and M. K. Kersting. 2007. "Openness and Inflation." *Staff Papers*. Federal Reserve Bank of Dallas. n. 2.

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,

$$q = \nu_T q_{Tt} + \nu_S q_{St} + \nu_{SM} q_{SMt}$$

where $\nu_T = Q_{Tt}/Q$, $\nu_S = Q_{St}/Q$ and $\nu_{SM} = Q_{SMt}/Q$. In other words, the parameter ν stands for the share of labor productivity of each sector in the total labor productivity. In equilibrium, the values of ν_T, ν_S and ν_{SM} must be constant otherwise there is a growing sectoral imbalance in the economy. More formally, if the shares ν 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 A1 below describes the sample countries used in the study. Tables A2 and A3 present, respectively, the summary statistics of variables and the results for unit root tests on variables.

Table A1. 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 A2. 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 A3. 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 using the AIC criterion and fixing the p max = 3 following the suggestion of Im et. al. (2003).