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Reexamining the relationship between inflation and growth: Do institutions matter in developing countries?☆

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ABSTRACT

Using a large panel of countries during the period 1950–2009, we estimate the inflation thresholds above which its association with economic growth is expected to be negative, taking into account differences in institutions across countries. First, in line with previous literature, we find that the estimated threshold is substantially higher for developing countries compared to that of developed countries. However, we further show that the inflation threshold in developing economies falls when we consider reduced groups that exceed certain levels of institutional quality. We also find that the cost of inflation increases with the quality of institutions.

1. Introduction

A crucial objective of monetary policy is to achieve high and sustainable rates of economic growth along with low and stable rates of inflation. Therefore, the debate about the relationship between inflation and economic growth is important for the conduction of monetary policy. According to the studies by Barro (1991); Fischer (1983, 1993) and Bruno and Easterly (1998), inflation has a negative effect on economic growth, thus the monetary authority should aim at achieving a low level of inflation. In the past years, indeed, central banks in several countries have adopted an inflation targeting regime. An important question is what should be the inflation target. To answer this question, it would be useful to understand from what level inflation has a negative relationship with economic growth. The appropriate level of the inflation target, especially for developing economies, is still under debate.

Given the relevance of this topic, an important number of theoretic models in the macroeconomic literature analyze the impact of inflation on growth in the long run. Sidrauski (1967) finds that there are no effects of inflation on growth (money is superneutral). However, Tobin (1965) finds that inflation has a positive effect on growth, assuming that money is a substitute for capital. Stockman (1981) proposes a model in which money is a complement to capital, so inflation generates negative effects on growth. Finally, more recent models find threshold effects in the relationship between inflation and growth (Huybens and Smith, 1998). In these models, high inflation rates exacerbate the frictions on financial markets, as they reduce the real returns to savings. Such financial frictions may cause credit rationing, limiting investment level, reducing investment efficiency and hence decreasing economic growth.

The primary goal of this paper is to highlight the importance of taking account of institutions for the understanding of the inflation–growth nexus, especially for developing countries. Most of the related literature on institutions has either examined the relationship between institutions and growth (Glaeser et al., 2004; Knack and Keefer, 1995) or the relationship between institutions and inflation (Aisen and Veiga, 2006; Narayan et al., 2011a). To examine the role of institutions in the inflation–growth relationship, we first estimate for both developed and developing countries the inflation thresholds above which its nexus with economic growth is expected to be negative, allowing for a smooth transition between the low and the high inflation regimes. Then, we focus on the (highly heterogeneous) group of developing countries and control for differences in the quality of their institutions. In particular, we work sequentially with reduced groups of developing economies whose compositions depend on identifiable

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levels of a measure for institutional quality. For these groups of countries, we estimate the inflation thresholds in order to provide useful information regarding the appropriate location of the targeting bands, and assess how quicky inflation appears to affect growth around the threshold.

We consider three proxies for institutions. First, we use the Polity IV dataset which contains information on the level of democracy on an annual basis (Jaggers and Marshall, 2000). Second, based on Acemoglu et al. (2001) we consider a proxy related to the mortality rates faced by European settlers in the colonial origins, which in turn appeared to determine the colonization policies and the institutions created. Third, we construct an indicator from the International Country Risk Guide (ICRG) database based on several components of political risk. We use a panel data of over 130 countries, during the period 1950–2009. As it is standard in the empirical literature on economic growth, we work with non-overlapping five-year averages of the data.

The paper by Fischer (1993) is one of the first studies examining the possibility of nonlinearities, i.e., threshold effects, in the relationship between inflation and growth. Using panel data for a set of developed and developing countries, Fisher finds a non-linear negative relationship between inflation and growth. Bullard and Keating (1995) apply structural VAR models to estimate the response of real output to permanent inflation shocks in each economy, for a sample containing 16 countries. They find that increases in long run inflation have positive (negative) effects on growth if the initial level of inflation is sufficiently low (high).

Additionally, Khan and Senhadji (2001) estimate threshold levels of annual inflation between 1 and 3% for industrialized countries, and between 11 and 12% for developing countries – the groups defined according to the IMF classification. They find that inflation significantly reduces growth above these thresholds. The high threshold for non-industrialized countries can be to some extent explained by the adoption of indexation systems which reduce the variations in relative prices and, thus, the negative effects of inflation on growth.

More recent literature has found similar results regarding the ranges of the inflation thresholds for both industrialized and developing countries. In particular, Drukker et al. (2005) solve some of the limitations of Khan and Senhadji (2001) using the econometric methods developed by Hansen (1999, 2000) and Gonzalo and Pitarakis (2002) in order to estimate the number of thresholds, their values and the model coefficients. They find two inflation thresholds in industrialized countries, 2.6% and 12.6%, and one threshold of 19.2% in non-industrialized economies. On the other hand, Vaona and Schiavo (2007) provide evidence about the nonlinear relationship between inflation and growth using nonparametric methods. They find the existence of an inflation threshold of 12% in the full sample that includes both industrialized and non-industrialized countries. Splitting the sample between developed and developing countries, they show that the inflation threshold for developed countries sticks at 12% while there is no clear inflation threshold for developing countries.

In a recent paper, Kremer et al. (2013) introduce a dynamic panel model with threshold effects, finding results that are consistent with the existing literature. The study finds an inflation threshold of 2% for industrialized countries, which represents the inflation target set by several of these countries. An inflation threshold of 17% is estimated for non-industrialized countries. On the other hand, López-Villavicencio and Mignon (2011) estimate the inflation–growth nexus using a smooth transition regression model, finding an inflation threshold of 2.7% for industrialized countries and 17.5% for non-industrialized countries. Espinoza et al. (2010) also find that the threshold for advanced economies is much lower than the one for developing countries. Similarly, Omay and Kan (2010) find a threshold for industrialized countries between 2.4% and 3.2%, depending on the estimation method, which in turn controls for cross section dependency in a non-linear model. For the case of the Southern African Development Community, Seleteng et al. (2013) find a threshold level of 18.9%, using a smooth transition regression model.

Although the inflation thresholds found in the literature for industrialized countries seem consistent with the targets that have been implemented, the evidence for developing countries indicates inflation thresholds that are higher than the inflation targets that have been adopted by those countries. In particular, the estimated thresholds are in the range of 12–19%, while the inflation targets in many developing countries are usually in the range from 1 to 5%. A possible reason for this gap, indeed, might be the high level of heterogeneity in the sample used in most empirical studies. Our contribution is important because it addresses this issue by taking into account the highly different levels of institutional development across countries. For comparison with the previous empirical literature, we also estimate the model using the entire available sample of developing and developed economies.

Our empirical results confirm the importance of including a measure of institutional quality from an economic perspective. In particular, we find that the inflation threshold falls from 19.1% for the entire sample of *developing countries*, to levels well below the two-digit figures for reduced groups that satisfy certain degrees of institutional development. We also find that the estimated (negative) association between inflation and growth becomes higher with the level of institutional quality. Moreover, we find that such association is relatively higher after reaching the two digit levels.

Economies with weaker institutions could have high inflation rates without experiencing negative effects of growth. Narayan et al. (2011a) examine the relationship between inflation and institutional particularly government stability, military in politics, law and order and democratic accountability using a dataset of 54 developing countries during the 1995–2004 period. They find that improvements in democracy and in reductions in the level of participation of military in politics reduce inflation rates in the long run. Similarly, Aisen and Veiga (2006) find that lower levels of political instability result in lower inflation levels using a panel of 75 developing countries. Economies with weak institutions tend to have inefficient tax systems and use seigniorage as a source of revenues (Cukierman et al., 1992). Fatton (1992) argues that non-democratic leaders tend to use repression to maintain themselves in power and spend public revenues to build patronage networks, which results in higher levels of inflation. In addition, weak institutions could be associated with lower levels of central bank independence (de Haan and Kooi, 2000; Loungani and Sheets, 1997), lower probability of having inflation targeting regimes (Bernanke et al., 1999; Capistrán and Ramos-Francia, 2009) and lower levels of central bank transparency (Faust and Svensson, 2001; Walsh, 1995), which results in higher levels of inflation.

Regarding the sample of *developed countries*, the estimation results obtained are in line with the previous literature. In particular, the estimated threshold for that group is 4.5%. For both developed and developing economies, once the thresholds are reached, the association between inflation and growth is negative and statistically significant. However, if the inflation level is below the threshold, inflation has no significant relationship with growth. The speed of transition is relatively smooth for the group of industrialized countries while, for the full group of non-industrialized countries, inflation quickly appears to affect growth when it exceeds the threshold. For those groups of non-industrialized countries which are identified by the proxies as having relatively "good" institutions, however, the speed of transition falls to the levels found for industrialized countries.

The paper is organized in the following way. Section 2 describes the data. Section 3 introduces the econometric model. Section 4 discusses the set of baseline results, including the linearity tests, the estimation results for both the developed and the entire sample of developing countries, and a number of robustness checks. Section 5 shows the estimation results controlling for institutions. Finally, Section 6 presents concluding remarks.

2. Data

We use an unbalanced panel of 138 countries, for the period 1950–2009. The sample period is chosen due to data availability, as our last entire five-year period available is 2005–2009. Countries are classified as industrialized and non-industrialized, according to the *IMF* (see the lists of countries in Tables A.3 and A.4 in the Appendix A). The growth rate of real per capita GDP at 2005 prices is obtained from the Penn World Table 7.0 data base, while inflation is obtained from the IMF's *International Financial Statistics* as the annual percent change of the consumer price index. Following the empirical growth literature (Temple, 2000), the time span is divided in five-year non-overlapped intervals to study a long run relationship between inflation and growth. The growth rates for each interval are then calculated as five-year annual averages.

The control variables introduced are standard in the empirical growth literature (see, e.g., Sala-i-Martin (1997)). The set of control variables includes investment as the share of GDP, the rate of population growth, the initial level of income (measured as the real per capita GDP at the previous quinquennium), the degree of openness to trade (measured by adding exports and imports as the share of GDP), the terms of trade measured as exports divided by imports and the standard deviations of the terms of trade (calculated as the standard deviation within the five-year interval). These data were obtained from the Penn World Table.

We make use of three alternative proxies for institutions. First, we use the Polity IV dataset which contains information on the level of democracy on an annual basis. In particular, we take the '*polity 2*' series, a measure which ranges from -10 (hereditary monarchy) to $+10$ (consolidated democracy), based on political competition, constraints on political authority and executive recruitment at each country. The advantage of using this variable is that it is available for all countries and time periods in our sample. A description of the Polity dataset can be found in the Appendix A. In addition, we also consider the mortality rates faced by European settlers in the colonial origins, used by Acemoglu et al. (2001) as a proxy for later institutions. There are a number of limitations in this sample; for example, only 64 countries appear in it, of which 58 match with our working sample of 130 countries. However, the great advantage of Acemoglu et al. (2001)'s data is that the information contained in it serves as a good instrument for our purposes. It is exogenous to growth and, thus, useful to characterize different groups of countries according to their institutional quality. Our third measure of institutions is obtained from ICRG, a private international investment risk service. This database is available for 93 out of 113 non-industrialized countries in our sample and has been previously used in the literature as an indicator of institutional quality by Knack and Keefer (1995); Hall and Jones (1999); Narayan et al. (2014); Narayan et al. (2015), among others. Compared to the Polity dataset, which focuses on the level of democracy, this database contains information on several dimensions of institutional quality. In particular, we use the following ten components of political risk of a country from the database: government stability, internal and external conflict, corruption, military in politics, religious tensions, law and order, ethnic tensions, democratic accountability and bureaucracy quality.[1] A description of the ICRG database and each of its components employed in the analysis is provided in the Appendix A. Following Knack and Keefer (1995), to construct an indicator for each country, we add the number of points corresponding to these ten variables and compute the proportion of the resultant sum of points out of the maximum score. Thus, our indicator ranges from 0 to 1, where higher values indicate better institutional conditions.[2] Tables A.3 through A.5 in the Appendix A report the list of industrialized and non-industrialized countries and their corresponding levels of institutional quality. In addition, Figs. A.5 through A.7 show the distribution of these variables across non-industrialized countries.

Other measures of institutional quality have been used in the empirical growth literature (see, e.g., Glaeser et al. (2004), and the references therein). However, the data sets mentioned above serve well to our purposes and complement each other, in a way to check for robustness as we discuss below.

Following Sarel (1996), we transform the inflation rate to logs in order to avoid that the extreme observations distort our regression results. In addition, such a change has the advantage that multiplicative shocks (instead of additive) have the same effects either in high or low-inflation economies. By applying this transformation, we obtain an almost symmetric inflation distribution, comparable to a Normal distribution (see Figs. A.1 through A.4 in the Appendix A). Moreover, Ghosh and Phillips (1998) find that the log function provides a reasonable characterization of the inflation–growth nexus.

Given that the logarithm is not defined for negative values and it approaches negative infinity for inflation levels near zero, we use a semi-logarithmic transformation as in Khan and Senhadji (2001). In particular, we consider the following transformation:

$$\tilde{\pi}_{it} = \begin{cases} \pi_{it}-1 & \text{if } \pi_{it} \leq 1 \\ \ln\pi_{it} & \text{if } \pi_{it} > 1 \end{cases}$$

This function is linear for inflation rates less than unity, and logarithmic for rates larger than unity.

3. Model specification

In order to estimate the association between inflation and growth and, in particular, both the threshold as well as the speed of transition, we specify a panel smooth transition regression (PSTR) model with fixed effects, following González et al. (2005). The growth rate of the real per capita GDP is the dependent variable, while the inflation rate and the control variables aforementioned in Section 2 are the independent variables. The two-regime PSTR model is defined as follows:[3]

$$dy_{it} = \mu_i + \Psi z_{it} + \beta_0'\tilde{\pi}_{it} + \beta_1'\tilde{\pi}_{it}G(\tilde{\pi}_{it}\gamma, \tilde{\pi}^*) + u_{it}, \tag{1}$$

where $i = 1, \ldots, N$ represent countries and $t = 1, \ldots, T$, quinquennia. The variable dy_{it} is the growth rate of real per capita GDP, $\tilde{\pi}_{it}$ is the transformed inflation rate, and z_{it} is the vector of control variables which includes: the initial GDP ($igdp_{it}$), the population growth rate (pop_{it}), investment/GDP (inv_{it}), openness to trade ($open_{it}$), the terms of trade (tot_{it}) and the terms of trade standard deviations ($sdtot_{it}$).

The transition function $G(\tilde{\pi}_{it}; \gamma, \tilde{\pi}^*)$ is continuous in the observable transition variable, $\tilde{\pi}_{it}$. It is a normalized function that takes values

[1] The ten components included in the analysis are selected from a longer list of twelve political risk variables according to their relevance as proxies for institutions. The indicators that we exclude are socioeconomic conditions and investment profile, as we consider that they are majorly related to the economic rather than the institutional conditions of a country. We have also performed robustness exercises including those two variables as well as alternative combinations of the entire set of twelve political risk variables and the results are similar to those reported in this paper.

[2] The institutional indicator was also computed using a principal components analysis of the data. The results are similar to those presented in this paper as its correlation with respect to the indicator based on the sum of components is 0.99.

[3] In the next section, we show that the two-regime model is correctly specified by testing for the presence of non-linearities.

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between 0 and 1, and its extreme values are in turn associated with the regression coefficients β_0 and β_1. More generally, the value of $\tilde{\pi}_{it}$ determines the value of $G(\tilde{\pi}_{it};\gamma,\tilde{\pi}^*)$ and thus the effects of inflation on growth, $\beta_0+\beta_1 G(\tilde{\pi}_{it};\gamma,\tilde{\pi}^*)$, for country i in period t. Notice that the estimated marginal effects of inflation on growth will be allowed to vary across time.[4] Finally, μ_i represents country fixed effects.[5]

Following González et al. (2005), G is specified as the following logistic function:

$$G(\tilde{\pi}_{it}\gamma,\tilde{\pi}^*)=\frac{1}{1+\exp(-\gamma(\tilde{\pi}_{it}-\tilde{\pi}^*))}, \quad (2)$$

where the slope parameter of the logistic function, $\gamma>0$, determines the speed of transition, and $\tilde{\pi}^*$ is the inflation threshold. For $\gamma\to\infty$, the logistic transition function approaches an index function $I(\tilde{\pi}_{it}>\tilde{\pi}^*)$ that takes the value of 1 if $\tilde{\pi}_{it}>\tilde{\pi}^*$. For $\gamma\to 0$, the transition function approaches a constant and the model becomes homogenous or a linear panel regression model with fixed effects.

Notice that, for γ sufficiently high, the PSTR model reduces to a threshold model with two regimes as in Khan and Senhadji (2001). In such a case, the direct effect of inflation on real GDP growth will be given by β_0 for those countries with inflation less than or equal to $\tilde{\pi}^*$, and by $(\beta_0+\beta_1)$ for those countries where inflation exceeds $\tilde{\pi}^*$. However, in general, the effect of inflation on growth can be defined as a weighted average of the parameters β_0 and β_1. Therefore, it is generally difficult to directly interpret the values of these coefficients. We can, however, interpret the signs of these parameters, as they indicate the direction of the effect of inflation on growth.

The set of control variables enter linearly (state independent) in the growth equation, in order to emphasize only the threshold effects of inflation. Moreover, it allows us to compare our results with the previous literature, which introduces the control variables linearly (e.g., Khan and Senhadji, 2001).[6]

The estimation procedure for the PSTR model consists of eliminating the individual effects μ_i by removing country-specific means and applying nonlinear least squares to the transformed model.[7] In what follows, we describe the test for linearity against the PSTR model and determine the number r of transition functions. For the linearity test, the null hypothesis can be written as H_0: $\gamma=0$ or H_0: $\beta_1=0$. However, in both cases the test is non-standard, since the PSTR model contains unidentified nuisance parameters under the null hypothesis. A possible solution is to replace the transition function $G(\tilde{\pi}_{it};\gamma,\tilde{\pi}^*)$ by its first-order Taylor expansion around $\gamma=0$ and to test an equivalent hypothesis based on the following auxiliary regression:

$$dy_{it}=\mu_i+\Psi z_{it}+\theta_0'\tilde{\pi}_{it}+\theta_0'\tilde{\pi}_{it}^2+u_{it}^* \quad (3)$$

In this way, testing $H_0:\gamma=0$ in Eq. (1) is equivalent to testing the null hypothesis $H_0:\theta_1=0$. Following Colletaz and Hurlin (2006), we can define the Wald, Fisher and Likelihood Ratio Tests. The Wald (LM) test can be written as:

$$LM=NT(SSR_0-SSR_1)/SSR_0 \quad (4)$$

where SSR_0 is the panel sum of squared residuals under H_0 (linear panel model with individual effects) and SSR_1 is the panel sum of squared residuals under H_1 (PSTR model with two regimes). The Wald statistic is distributed as $\chi^2(K)$ under the null hypothesis. The Fisher (LM_F) test can be written as:

$$LM_F=[(SSR_0-SSR_1)/K]/[SSR_0/(NT-N-K)] \quad (5)$$

where K is the number of explanatory variables, and it has an approximate $F(K, NT-N-k)$ distribution. Finally, the likelihood ratio test is defined as:

$$LRT=-2[\log(SSR_1)-\log(SSR_0)] \quad (6)$$

which follows a $\chi^2(K)$ under the null hypothesis.

To test the number of transition functions in the model, a similar logic is followed. In particular, we test the null hypothesis of no remaining non-linearity in the transition function. For instance, suppose that we want to test whether there is one transition function, (H_0: $r=1$) versus there are at least two transition functions (H_0: $r=2$). Thus, consider the model:

$$dy_{it}=\mu_i+\Psi z_{it}+\beta_0'\tilde{\pi}_{it}+\beta_1'\tilde{\pi}_{it}G_1(\tilde{\pi}_{it};\gamma_1,\tilde{\pi}_1^*)+\beta_2'\tilde{\pi}_{it}G_2(\tilde{\pi}_{it};\gamma_2,\tilde{\pi}_2^*)+u_{it,} \quad (7)$$

The null hypothesis of no remaining heterogeneity can be formulated as $\gamma_2=0$. As before, the identification problem is solved by using a first order Taylor approximation of $G_2(\tilde{\pi}_{it};\gamma_2,\pi_2^*)$, leading to the following auxiliary regression:

$$dy_{it}=\mu_i+\Psi z_{it}+\beta_0'\tilde{\pi}_{it}+\beta_1'\tilde{\pi}_{it}G_1(\tilde{\pi}_{it};\gamma_1,\tilde{\pi}_1^*)+\theta_1'\tilde{\pi}_{it}^2+u_{it}^*, \quad (8)$$

The null hypothesis of no remaining non-linearity can thus be defined as $H_0:\theta_1=0$. The Wald, Fisher and Likelihood Ratio Tests can be computed as before. The testing procedure is as follows. Given a PSTR model, we test the null hypothesis that the model is linear. If the null is rejected, we estimate a two-regime PSTR model. Then, we test the null hypothesis of no remaining non-linearity in this model. If it is rejected, estimate a three regime model. The testing procedure continues until we fail to reject the null hypothesis of no remaining heterogeneity. At each step of the sequential procedure, the significance level must be reduced by a factor $0<\tau<1$ to avoid excessively large models.

4. Baseline results

This section presents the results of estimating our model for the two groups of countries considered. First, we present the tests for non-linearity in the relationship between inflation and growth to investigate the adequacy of the model. Then, we estimate our model for the entire group of industrialized and non-industrialized countries. Finally, we compare our results with those from the previous literature and provide several robustness tests. Before presenting our results, we should note that our estimates of the relationship between inflation and growth cannot be interpreted as a causal relationship but rather as representing conditional correlations.

4.1. Tests of linearity

For both industrialized and non-industrialized countries, the null hypothesis that the model is linear is rejected at the 1% level with the three tests (see Table 1).

[4] González et al (2005), propose a time varying PSTR where the regression coefficients are allowed to change as a function of time, which is suited for a relatively large time dimension T. Given our sample limitations, we estimate our PSTR model assuming that the threshold and gamma parameters are constant over time. However, as it is mentioned above, the inflation coefficient is allowed to change over time according to the level of inflation. In other words, as the inflation rate in a particular country is changing over time, the country can fluctuate between high and low inflation regimes, and so does the association between inflation and growth.

[5] Time fixed effects were also considered in the estimations. The main conclusions of the paper remain if those variables are included. The estimations reported in this paper exclude those variables as they are not statistically significant.

[6] In an earlier version of this paper, we estimated our model with the control variables appearing non-linearly, i.e., state dependent. The main results, especially the thresholds and the speeds of transition, remain.

[7] For more details about the estimation, see González et al. (2005).

Table 1
Linearity tests.

	Industrialized		Non-industrialized	
Tests	Statistic	p value	Statistic	p value
Wald test	10.085	0.001	18.332	0.000
Fisher test	9.164	0.003	16.019	0.000
LRT test	10.294	0.002	18.539	0.000

H_0: Linear model. H_1: PSTR model with at least one threshold.

Further, we test whether there is remaining non-linearity after assuming a two-regime model. In these tests, the null hypothesis indicates that the PSTR model has only one threshold, while under the alternative the model contains at least two thresholds. This type of models requires a sufficiently high value of the test statistic to select a higher number of thresholds. That is, selection criteria penalize the cost of increasing the number of thresholds associated with the curse of dimensionality. From the results presented in Table 2, we observe that the null hypothesis cannot be rejected, indicating that one threshold properly captures the non-linearity in the model.

4.2. Estimation results for industrialized and non-industrialized countries

We proceed to estimate the PSTR model with one threshold given that it seems to properly capture the nonlinearity in the specification. Table 3 shows the model parameters estimated for the two available samples of developed and developing countries. As expected, the thresholds exhibit the important differences between both groups: 4.5% for the developed countries and 19.1% for the developing countries. These results are similar as those of Drukker et al. (2005), although higher than those of Khan and Senhadji (2001).

Note that, for both sets of countries, the estimated coefficient of β_0 is not significantly different from zero at the 5% level. This indicates that inflation does not appear to have significant effects on growth when it is sufficiently below the threshold such that the transition function G approaches 0 (see Eq. (1)). On the other hand, consistent with the theory, the estimated β_1 is negative and statistically significant at the 1% in both groups of countries. This means that the (negative) association between inflation and growth do become significant when it is sufficiently above the threshold such that the transition function G approaches 1. It is worth highlighting that the estimate of β_1 for developed economies ($\hat{\beta}_1 = -1.24$) is substantially higher in absolute value than the one for developing economies ($\hat{\beta}_1 = -0.68$) However, we should notice that the negative and significant association between inflation and growth above the threshold would become comparable between the two groups, as the estimate of $\beta_0 + \beta_1^* G(\tilde{\pi}_{it}; \gamma, \tilde{\pi}^*)$ approaches -0.66 in the case of the former and -0.85 in the case of the latter, as $G(\tilde{\pi}_{it}; \gamma, \tilde{\pi}^*)$ approaches 1. We will return to this point below when we discuss the meaning of these results in terms of what the model tells us regarding the cost of inflation.

The high threshold for non-industrialized countries can be partly explained by the adoption of indexation systems which reduce the negative effects of inflation on growth. These countries could have shown high inflation rates without experiencing adverse effects on growth because their relative prices did not exhibit large changes. Additionally, the level of inflation tolerance may have increased for developing countries, as the high inflation rates may be associated with convergence and their growth experiences. In other words, the Balassa–Samuelson effect that would emerge from their own dynamics of potentially growing productivity seems to lower the negative growth effects of high inflation rates.

The estimate of γ for industrialized countries is such that the transition from the lower regime to the upper regime is quite smooth and relatively slow. Fig. 1 shows the transition function for this group, plotted against the inflation rate. As opposed to the threshold model usually employed in the literature (e.g., Drukker et al., 2005; Khan and Senhadji, 2001), it indicates that the negative relationship between inflation and growth does not necessarily occur as soon as inflation is above the threshold, but well before. Notice that most observations are located *in-between* the two regimes, not *at* the extremes.

In contrast, for the case of non-industrialized economies, the slope of the transition function is extremely high, showing that the expected change in the association between inflation and growth is abrupt

Table 2
Tests of no remaining non-linearity: Tests for the number of regimes.

	Industrialized		Non-industrialized	
Tests	Statistic	p value	Statistic	p value
Wald test	0.793	0.373	0.071	0.789
Fisher test	0.706	0.402	0.061	0.805
LRT test	0.794	0.373	0.071	0.789

H_0: PSTR with one threshold. H_1: PSTR with at least two thresholds.

Table 3
PSTR model estimation with two regimes.

		Industrialized	Non-industrialized
Threshold: π^*		4.47%	19.13%
Slope: γ		1.48	31,380.77
Variable	Parameter		
$\tilde{\pi}_{it}$	β_0	0.5748	−0.1686
		(0.3805)	(0.1076)
$\tilde{\pi}_{it} * G(\pi_{it}; \gamma, \pi^*)$	β_1	−1.2372**	−0.6806**
		(0.3903)	(0.1041)
		−0.6624**	−0.8492**
		(0.1389)	(0.0936)
$igdp_{it}$	ψ_1	−0.0002**	−0.0003**
		(0.0000)	(0.0001)
pop_{it}	ψ_2	−0.9164**	−0.5032*
		(0.2637)	(0.1986)
inv_{it}	ψ_3	0.0797	0.0733**
		(0.0424)	(0.0263)
$open_{it}$	ψ_4	0.0340**	0.0104
		(0.0128)	(0.0083)
tot_{it}	ψ_5	−0.1313	−0.1168
		(0.2818)	(0.0790)
$sdtot_{it}$	ψ_6	3.9936	3.2913
		(22.7064)	(6.2175)

Significance level: (*) 5%, (**) 1%.
Values in parentheses are standard errors corrected for heteroskedasticity.

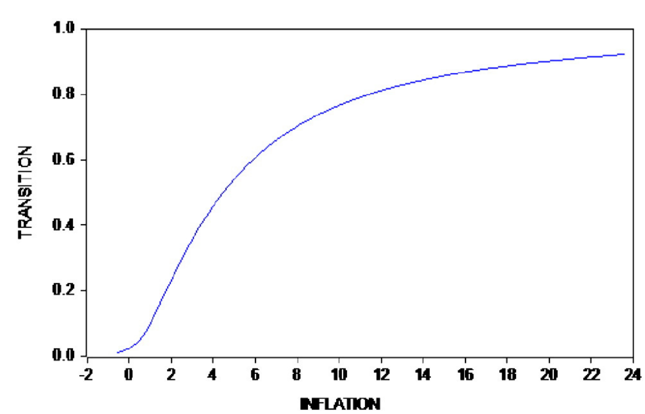

Fig. 1. Estimated transition function: Industrialized countries. Note: Extreme outliers were removed from the figure for a better view.

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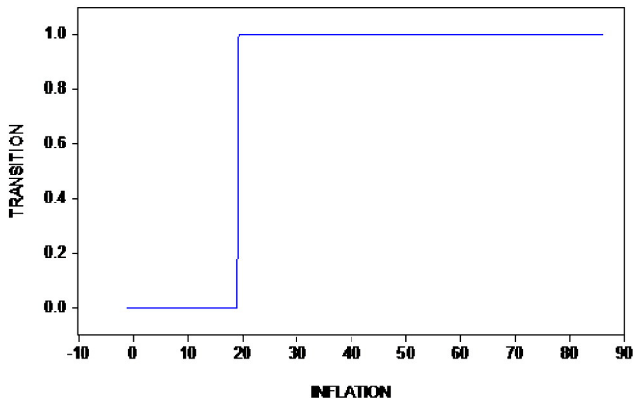


Fig. 2. Estimated transition function: Non-industrialized countries. Note: Extreme outliers were removed from the figure for a better view.

when inflation is near the threshold (see Fig. 2). This indicates that inflation appears to quickly affect growth in developing economies only when it reaches medium/high levels; that is, when relative-price distortions would become significant. We presume that the difference between both groups of countries regarding the slope of the transition function arises for the following reasons. On the one hand, developed countries display generally low-inflation levels and much lower volatility of both inflation and growth. Hence, we expect that the changes in the relationship between inflation and growth be relatively smooth, i.e., with no abrupt threshold effects. On the other hand, developing countries display a higher heterogeneity within sample and both medium/high inflation levels and large volatility. Therefore, we expect not only that just for medium/high levels of inflation its association with growth turns significantly negative but also that the regime change be abrupt.

Regarding the control variables, we find that the results are consistent both with the theory and with the empirical literature on economic growth (see, for example, Levine and Renelt (1992), and Sala-i-Martin (1997)). For industrialized countries, the coefficients associated with initial income and population growth are negative and statistically significant (the first one related to the conditional-convergence result; the second one supporting the pessimistic view of population growth), while the one associated with openness is positive and also statistically significant (reflecting the potential gains from trade). The coefficient related to investment as a share of output is positive (consistent with the well-known positive effect of capital accumulation on growth), although not statistically significant at the 5% level; while the variables associated with the terms of trade do not appear to have significant effects on the rate of growth in these economies.

For developing countries, the effects of initial income and population growth are negative and statistically significant, while the effect associated with investment is positive and also statistically significant. The other controls do not appear to have significant effects on growth in this group.

To analyze whether the results are sensitive to the period used, we estimate the PSTR model for the period 1990–2009, during which some countries have adopted an inflation targeting regime. We find that the threshold and gamma parameters for non-industrialized countries are similar as the baseline estimations. However, the threshold for industrialized countries decreases to 1.8%, as most of the countries that have adopted inflation targeting regimes are industrialized. The results are shown in Table A.10 in the Appendix A.

We also evaluated the sensitivity of our results to marginal changes either on the samples of countries or the variables included in the regressions. Finally, we checked for sensitivity to the exclusion of outliers, in particular regarding the extremely high inflation rates displayed by some countries. None of these changes alterated the main conclusions of our baseline estimations.[8]

5. The importance of controlling for institutions

The inflation threshold found for industrialized countries is not only consistent with the empirical literature but also consistent with the targets that those economies have usually implemented. In contrast, the inflation threshold found for developing countries, although consistent with previous works, turns out to be much higher than the inflation targets that have been adopted by those countries. Indeed, these estimated thresholds are not consistent with the monetary policy adopted in many countries since the inflation targets are usually in the range from 1 to 5%.

A possible explanation for the high threshold observed in the group of developing countries, in addition to the ones suggested above like the adoption of indexation mechanisms, might be the high level of heterogeneity of the sample used in most empirical studies. By reducing the degree of heterogeneity of such group, the estimated inflation threshold will identify more clearly each of these countries' inflection point. We will address this issue by using three measures as control for institutional quality, in order to identify groups of countries with similar degrees of institutional development. In addition, we will present results for income- and region-based panels to show that our main results are not driven by a high level of heterogeneity within the sample of countries.

5.1. Segmentation procedure

We homogenize the sample of non-industrialized economies, on the one hand, according to a proxy for institutional characteristics based on the Polity IV Project. This database measures qualities of autocracy and democracy in governing institutions, ranging from −10 (hereditary monarchy) to +10 (consolidated democracy). Alternatively, we use another proxy for institutional characteristics, following Acemoglu et al. (2001). This proxy relates to the mortality rates faced by European settlers in the colonial origins, which appeared to have determined the colonization policies and, then, the institutions created. To the extent that these institutions have persisted and prevail nowadays, the mortality rates can serve as an exogenous control to disentangle the intrinsic heterogeneity of the set of developing countries. Finally, we use the measure of institutions based on the ICRG database which in turn refers to the political stability of a country. This measure ranges from 0 to 1, where higher values indicate better institutional conditions.

The use of these measures will help us in two different ways. First, we can employ historical information linked to the institutional quality in a group of countries as a control variable in our estimations. Second, this information will serve to segment the sample by countries with similar characteristics, in a different way than the methodology used so far by the literature which simply distinguished groups of countries according to the IMF definition of industrialized/non-industrialized economies or geographically.

The following are the steps applied for the segmentation. First, from the 113-country sample of non-industrialized economies, we calculate the historic average (1950–2009) of the *polity* series for each country, and rank the dataset according to that indicator. Then, we estimate our model sequentially with the groups of countries that exceed certain cut-offs, predetermined for average *polity*.[9]

[8] The details regarding the robustness checks are available upon request.

[9] We took the 1950–2009 average of this series to be able to rank the entire developing-country sample, and then run our estimations for each reduced sub-sample according to the cut-offs set. It is fair to say that the polity average would not be exogenous to the output growth rate, and ultimately the sequence of segmentations would become endogenous. However, this is not an issue for our purposes because, remember, we are not interested in explaining the differences in rates of growth across groups of countries, but the differences in thresholds and transitions. In any case, this potential endogeneity issue is solved by using Acemoglu et al. (2001)'s proxy.

Next, we use the proxy based on the *European-settlers mortality rate*. To that end, we first take from our sample of 113 developing countries those that match with Acemoglu et al. (2001)'s sample, for which we are left with 56 countries. Second, in order to group countries with similar characteristics, we ranked the merged sample according to the mortality rates appearing in the data. Finally, we estimate our model sequentially with the groups of countries that had a settler mortality rate less than a certain, predetermined cut-off.

Similarly, for the ICRG measure, we compute the historic averages for each country for the full available period (1984–2013) and rank the set of countries according to that average.[10] Then, we estimate the PSTAR model sequentially for the groups of countries that exceed certain cut-offs.

5.2. Results

Panel a) in Table 4 shows the estimated inflation thresholds and speeds of transition corresponding to seven *polity* cut-offs, stepped two-by-two from −6 to 6; i.e., a set of seven estimation results for groups of developing economies whose average polity levels exceed the cut-offs indicated. For the group of countries with an average polity greater than −6 (almost the whole sample of developing economies, even including “autocracies”), for instance, we find a threshold as high as the one estimated for the entire sample of non-industrialized nations (19.2%). However, by putting together countries that appear to have relatively “good” institutions, such as those that show a *polity* average greater than zero (governments ranging from ‘*open anocracy*’ to ‘*full democracy*’), we find an inflation threshold of 11.3%, clearly lower than the one estimated for the whole sample. As we take into account only those developing economies that appear to have high-quality institutions, we find that both the estimates for the threshold and the speed of transition approach to those for developed countries, and get in line with the inflation targets adopted in practice. (See Tables 5 and A.1.)

Panel b) in Table 4 shows two estimation results, for countries having mortality rate either less than 300 or 250, a measure over 1000 per year. We have chosen conservative cut-offs that left us with more than 40 countries in each group, which represents more than 75% of the merged sample (Fig. A6 shows the histogram for the distribution of this series).[11] The results based on Acemoglu et al. (2001)'s control turn out to be similar to those found in the case of the *polity* control. We find that, for those developing countries whose institutions appear to be of high-quality, both the estimates for the inflation threshold and speed of transition fall considerably with respect to the entire sample: to an inflation range between 2.8% and 5.4%, and to very low values of γ (in line with developed countries).

Panel c) in Table 4 presents the estimated inflation threshold and speed of transition for countries with ICRG values greater than four cut-offs, in particular, 0.50, 0.55, 0.60 and 0.65. The cut-offs are selected taking into account the resulting distribution of countries such that the number of observations is different for each group and large enough to avoid a high level of parameter uncertainty. The results show that the threshold for countries with an average ICRG measure higher than 0.50 is 19.1%, similar to the estimate of the entire sample of non-industrialized countries. However, if we include only the countries with an average ICRG measure of 0.65, that is, those with better institutions, the threshold decreases to 7.6% and the gamma parameter becomes 1.8, which are estimates that are closer to those of industrialized economies.

Table 4
Estimated threshold – Developing countries, control institutions.

	π^*	γ	$\tilde{\beta}_0$	$\tilde{\beta}_1$	$\tilde{\beta}_0+\tilde{\beta}_1$	N	# Observations
a) Polity							
−6	19.18	17,832.74	−0.23	−0.62**	−0.86**	95	713
−4	17.86	2.84	0.04	−0.86**	−0.82**	84	623
−2	14.09	1.99	0.59*	−1.32**	−0.73**	70	525
0	11.32	1.74	0.7*	−1.4**	−0.7**	58	438
2	11.24	2.63	0.28	−0.96**	−0.69**	49	358
4	10.21	1.66	0.74	−1.51**	−0.78**	35	238
6	5.89	1.55	1.16	−1.91*	−0.76**	20	148
b) Mortality rate							
300	5.41	1.19	0.91**	−1.39**	−0.49**	45	422
250	2.81	1.28	1.36**	−1.81**	−0.45**	40	384
c) ICRG							
0.50	19.13	38,294.11	−0.17	−0.61**	−0.78**	85	651
0.55	15.83	2.58	0.04	−0.77**	−0.74**	75	580
0.60	14.48	2.09	0.67*	−1.38**	−0.71**	56	401
0.65	7.59	1.81	1.42**	−2.06**	−0.64**	37	262

Significance level: (*) 5%, (**) 1%.
The table reports the estimated threshold (π^*), speed of transition (γ), $\tilde{\beta}_0$ and $\tilde{\beta}_1$ parameters for non-industrialized countries with average *polity* above, mortality rate below or ICRG above those indicated in the first column, the sum of $\tilde{\beta}_0$ and $\tilde{\beta}_1$, the number of countries (n), and the total number of observations in each group.

The results for the three indicators of institutions are robust to other sequences of cut-offs.[12] In all cases, the inflation thresholds fall gradually, from 19.1% for the original developing-country sample to one-digit figures for the reduced, less heterogeneous sets of countries. Thus, the inflation threshold gets closer to values mostly identified with developed economies.[13] Although not shown for the sake of brevity, the estimated coefficients for the effects of both inflation and the control variables are in general consistent with the estimation results shown in Table 3 for the entire developing country sample. As an additional exercise, we estimate the inflation thresholds and speed of transition parameters for the same cut-offs, but including the entire sample of developed and developing countries. The results are reported in Tables A.8 and A.9. As expected, the estimated thresholds are generally lower compared to the sample of non-industrialized countries. However, qualitatively, the results are similar. That is, the thresholds fall gradually as we include countries that appear to have better institutions. This result confirms the importance of taking account of institutions to obtain a better understanding of the inflation growth nexus.

The mechanisms through which countries with relatively weak institutions can have higher thresholds are not identified in our model. However, we conjecture that there are several reasons why economies with weaker institutions can bear high inflation rates without experiencing negative effects on growth. First, economies with weaker institutions might be unable to build efficient tax systems leading them to use seigniorage more frequently as a source of revenue (Cukierman et al., 1992). Second, countries with weaker institutions have less healthy bank systems and poorer direct capital access (see, e.g., La Porta et al. (1998)). Thus, these economies display a greater real sensitivity to monetary policy changes than do countries with big healthy banks and deep, well-developed capital markets (Cecchetti, 1999). As found by Narayan et al. (2011a) and

[10] The database is available for the full period for about 75% of the set of countries in our sample. To avoid a possible bias that might arise from considering countries for which the data is available only for part of the period, we have also carried out robustness exercises excluding these countries. The results are consistent with those reported in this paper.

[11] See Acemoglu et al. (2001) for a detailed description of this measure.

[12] In addition, both the non-linearity test and the no-remaining-non-linearity test, applied to the sequence of controlled samples, indicated the presence of non-linearities in the inflation–growth relationship, and did not allow us to significantly reject the specification with two regimes only. These results are available upon request.

[13] It is worth noting that, for the 56 developing countries that match Acemoglu et al. (2001)'s sample, the estimated inflation threshold is 19.2%, i.e., as high as the one reported in Table 3. This indicates that the significant fall in the threshold for the institutionally-controlled group does not depend on Acemoglu et al. (2001)'s sample. Especially, we believe that there are no reasons to expect a selection bias.

Table 5
Estimation results by income group and region.

	π^*	γ	$\tilde{\beta}_0$	$\tilde{\beta}_1$	$\tilde{\beta}_0+\tilde{\beta}_1$	N	# Observations
a) Income group							
High Income	6.58	2.27	0.53	−1.05**	−0.52**	44	386
Middle Income	24.11	2.51	0.35*	−1.08**	−0.73**	70	534
Low Income	49.34	0.92	−0.42**	−1.39**	−1.81**	24	169
b) Region							
Arab States	9.55	22.42	−0.45	0.40	−0.05	15	95
East Asia and Pacific	7.67	2.14	1.27**	−1.94**	−0.67**	14	119
Europe and Central Asia	25.40	2.22	−0.14	−0.99**	−1.13**	34	226
Latin America and the Caribbean	9.49	3.58	0.51	−0.91**	−0.40**	20	204
Middle East and North Africa	27.52	5.64	−0.05	−1.60**	−1.65**	16	106
OECD	9.29	2.03	0.28	−0.76**	−0.48**	32	316
Sub-Saharan Africa	36.94	1.03	−1.18	−1.055**	−1.72**	38	293

Significance level: (*) 5%, (**) 1%.
The table reports the estimated threshold (π^*), speed of transition (γ), $\tilde{\beta}_0$ and $\tilde{\beta}_1$ parameters for non-industrialized countries with average *polity* above, mortality rate below or ICRG above those indicated in the first column, the sum of $\tilde{\beta}_0$ and $\tilde{\beta}_1$, the number of countries (n), and the total number of observations in each group.

Aisen and Veiga (2006), higher levels of inflation also result from weaker institutions, as they tend to be associated with lower levels of central bank independence (de Haan and Kooi, 2000; Loungani and Sheets, 1997), lower probability of having inflation targeting regimes (Bernanke et al., 1999; Capistrán and Ramos-Francia, 2009) and lower levels of central bank transparency (Faust and Svensson, 2001; Walsh, 1995). Moreover, political instability shortens the horizon of the members of government, thus discouraging long term goals such as inflation reduction (Aisen and Veiga, 2006).

There might be an issue with the exogeneity assumption of *initial GDP* as control variable in our growth equation (see Caselli et al. (1996), and Kremer et al. (2013)). Recall, we construct this measure as the five-year lagged real per capita GDP, following most of the empirical growth literature. We also performed estimations removing this variable (as in the threshold model of Drukker et al. (2005)) and found no significant changes neither in the thresholds nor in the speeds of transition. The results are reported in Table A.7 of the Appendix A.

Moreover, the literature has found that accounting for the endogeneity of control variables does not seem to have a major impact on the estimated threshold in the relationship between inflation and growth (Kremer et al., 2013). In addition, Fouquau et al. (2008) have concluded that the PSTR estimation method seems to reduce the potential endogeneity bias.

5.3. On the costs (or benefits) associated with inflation

Based on our model estimation results, we finally calculate the association between inflation and growth for the different groups of countries considered – including the sample of industrialized countries and the sequence of sub-samples of developing countries. As an illustration, we take a number of inflation levels as departure points and calculate the (potential) effect of varying inflation on the rate of growth, according to our estimations. Figs. 3 through 6 summarize these calculations. Fig. 3 refers to the estimation results obtained from the set of industrialized countries, Fig. 4 refers to those non-industrialized countries with average '*polity*' greater than the cut-offs indicated, Fig. 5 refers to those non-industrialized countries with mortality rate lower than 300 and 250 based on Acemoglu et al. (2001), while Fig. 6 shows the cost of inflation based on the ICRG measure. Each of these figures illustrates

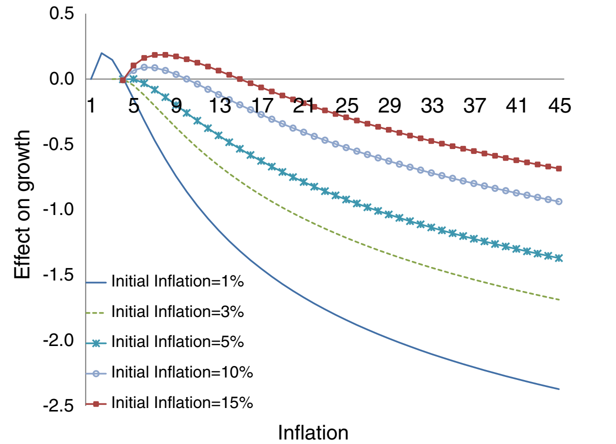


Fig. 3. Effect of inflation on growth: Industrialized countries. Note: The figure shows the effect on growth of gradually varying inflation from initial inflation rates as indicated in each figure.

the real effect of inflation as calculated relative to the following initial inflation levels: 1%, 3%, 5%, 10%, and 15%.[14]

According to our estimations, we find that, rising the (long-run) rate of inflation from 1% to, say, 3% in a typical industrialized country, is associated with a one-fifth of a percentage point (p.p.) increase in the rate of economic growth. The formula applied for these results is obtained by using the estimated marginal effects from inflation and the inflation rate differentials. That is, the growth change is calculated as $[\beta_0+\beta_1 G(\tilde{\pi}_{it};\gamma,\tilde{\pi}^*)](\tilde{\pi}-\tilde{\pi}_0)$; where $\tilde{\pi}$ is actual inflation and $\tilde{\pi}_0$ is the departure level. In contrast, increasing the rate of inflation from 1% to, say, 8% in the long run is related to output losses greater than a half of a p.p. per year. In other words, inflation levels above the 4.47% threshold estimated for developed countries are associated with large losses in terms of growth. Of course, inflation reductions from initial levels as high as 10–15% are expected to improve long-run performance (although not considerably, as we notice from the estimations).[15]

We find the same pattern if we look at the set of developing countries, although notable differences appear depending on the subsample considered. For instance, for a given rate of actual inflation, the estimated cost becomes higher with the level of institutional quality. That is, we note that, departing from an inflation rate of 5%, an inflation close to 25%, say, is associated with losses of 2/3 of a p.p. for the set of economies with average polity greater than −2, while the inflation cost becomes approximately of 1 p.p. for the set of economies with average polity greater than 2. We also find that increases in inflation in developing countries are negatively related to growth only at medium-high levels, say crossing the range 8–12%, depending on the group considered.[16]

[14] Observations to the left of the initial inflation rate which imply costs in terms of growth (inflation reductions from low levels, mostly to the left of the corresponding threshold) are omitted from the figures, for they are considered sub-optimal decisions. The same is not true of inflation levels with real costs to the right of the initial inflation rate, as there might be a trade-off between short-run gains from the inflation tax and long-run losses in terms of growth.

[15] We have to be cautious and take these calculations merely as an illustration. To the extent that they are based on estimates of β_0 and β_1, notice that, while the latter is significantly different from zero in all the estimations, that is not always true of the former (see Table 4).

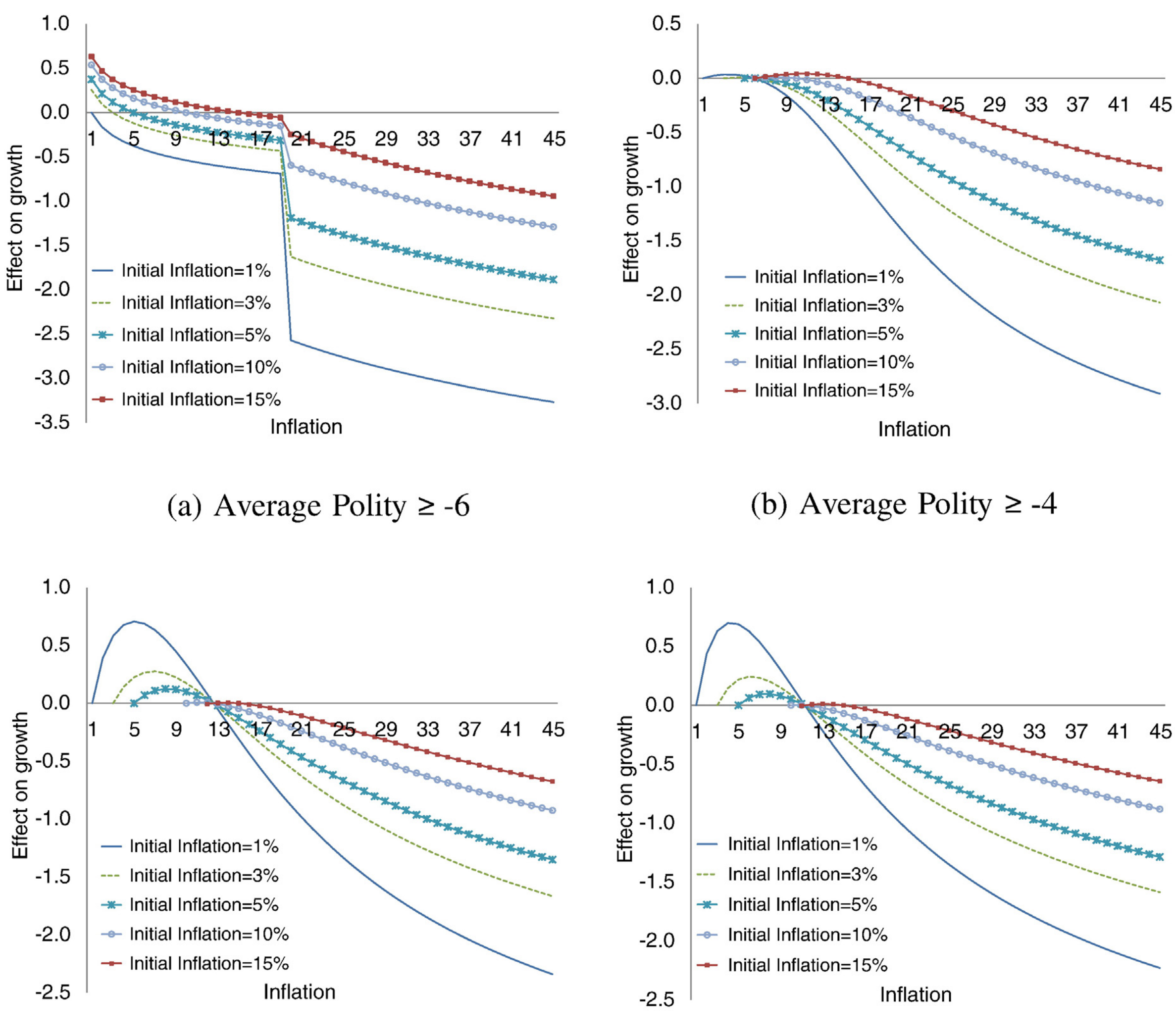
[16] We are aware that, according to the estimation results for the set including all developing countries (as well as that for countries with average polity greater than −6 or ICRG greater than 0.50, as seen in Panel (a) of both Figs. 4 and 6), the real effect of inflation appears to be negative at any level, as the estimates of β_0 and β_1 are both negative. However, also notice that, while the estimate of β_1 is significantly different from zero at the 1% level (see Table 4), the estimated value for β_0 is not statistically significant at the conventional levels, which indicates that the inflation cost below the 19% threshold might be negligible.

It is worth noting that the negative association between inflation and growth might not necessarily begin at the threshold level. Because of the model's 'smooth-transition' nature (characterized by the γ parameter in the transition function G), inflation might begin exerting adverse effects at a rather different level. For instance, except for the estimation from the complete sample of developing countries (where γ is high enough to rule out any smoothness), the rest of the estimations certainly indicate inflection points either below or above the inflation threshold – even quite far in some cases, as can be noted from the figures.

We may summarize the findings regarding developing countries as follows. First, there is a zone of inflation levels, between 1% and 5%, where marginal increases in inflation are generally associated with higher growth. Second, there is another zone, with inflation rates between 5% and 8–9%, for which inflation would not be related to growth, or the relationship would be negligible. Third, there is a zone for inflation rates greater than 9–10% in which inflation is associated with lower growth in most cases. Of course, these results depend upon the kind of countries analyzed, particularly with respect to the institutional quality as we showed above. For example, countries with '*regular*' institutions, i.e., those with average polity between −4 and 2, might see their output growth decrease only for inflation rates above 12–15%. If we take into account the group of countries with '*bad*' institutions, for instance, those with average polity lower than −4, then the threshold approaches the 19% level, and the negative real effects appear only for inflation rates around or above such a level. Finally, countries with relatively '*good*' institutions, such as those with average polity greater than 2, mortality rate less than 250, or ICRG greater than, say, 0.65, might see their growth rate fall for inflation rates above 7–8%.

Further, we may summarize the findings regarding developed countries as follows. On the one hand, we find a zone between 1% and 3% where marginally increasing inflation is positively related to growth. On the other hand, we find a second zone above 4–5%, where rising inflation is associated with a reduction in the rate of growth.

These zones, which of course differ quantitatively depending on the type of country, reflect the common fact that low levels of inflation are desired and, therefore, should be the target (though it also appears that extremely low levels, such as 1–3% of annual inflation, ought to be avoided), while medium-high inflation levels are certainly bad for growth and, thus, should be discarded from the policy set.



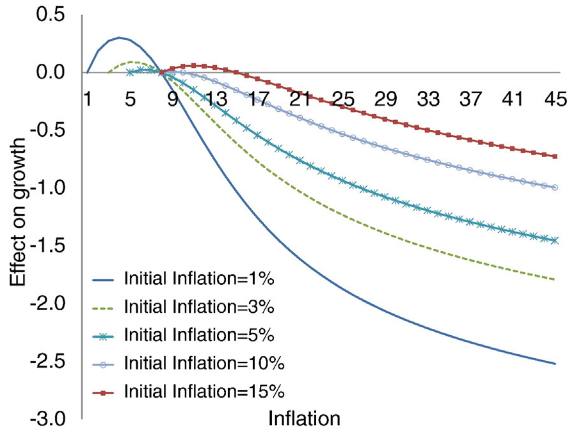
(a) Average Polity ≥ -6

(b) Average Polity ≥ -4

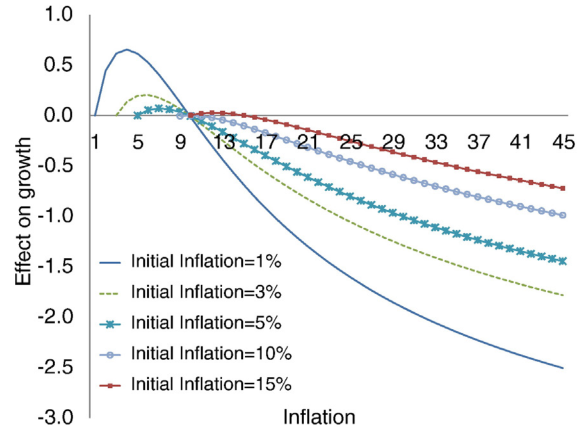
(c) Average Polity ≥ -2

(d) Average Polity ≥ 0

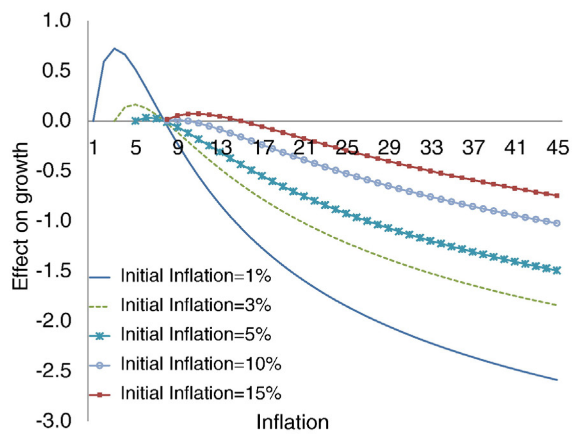
Fig. 4. Effect of inflation on growth: Developing countries segmented by polity. Note: The figures show the effect on growth of gradually varying inflation from initial inflation rates as indicated in each figure. The group of countries considered in the estimation is indicated below each figure.



(e) Average Polity ≥ 2



(f) Average Polity ≥ 4



(g) Average Polity ≥ 6

Fig. 4 (*continued*).

5.4. Robustness

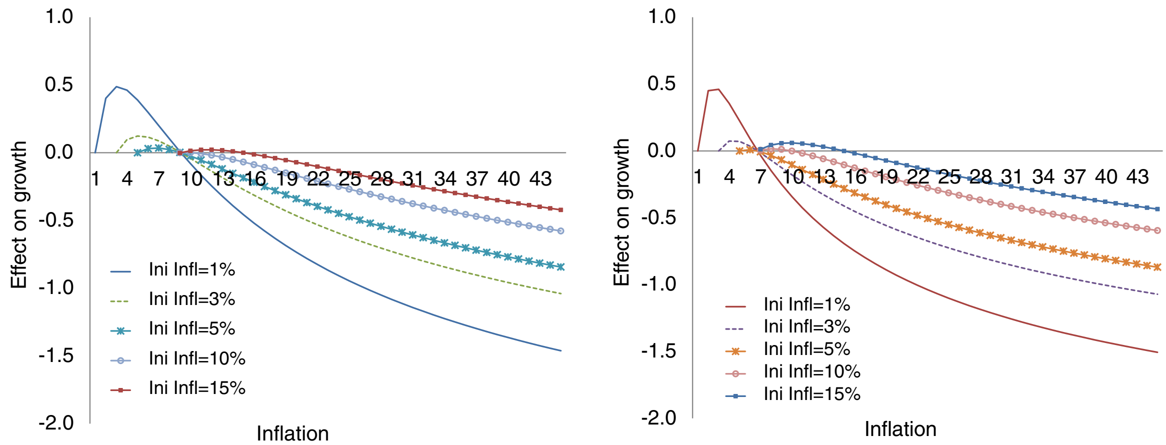
For robustness, we considered other ways of pooling together various (more homogeneous) subsets of developing countries. In particular, we ran income- and region-based panels in order to show that the previous results are not driven by a number of very heterogeneous countries. Following Narayan et al. (2011b), we constructed a series of panels based on the income level of the country and the geographical location, and re-estimated our empirical model. In particular, we estimated the relationship between inflation and growth for the following panels: (i) by income groups according to gross national income (GNI) per capita, calculated using the World Bank Atlas method; and (ii) by geographic regions such as Middle East and North Africa, East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, and Sub-Saharan Africa. Additionally, we estimated our model for a panel of member countries of the OECD, and for the Arab States.[17,18]

As shown in Table 5, the results, in general, are strongly consistent with our main arguments. In particular, the inflation thresholds estimated for all groupings are widely consistent with the set of results obtained using institutions. For instance, the threshold falls from 49.3% for low-income countries to 24.1% and 6.6% for middle-income and high-income countries, respectively. To the extent that the level of institutions/governance is positively associated with economic development, these results support our main predictions. We find that the threshold for the group of countries in the East-Asia and Pacific region is 7.68%, for OECD countries is 9.29%, while that for countries in Latin America and the Caribbean is 9.49%. The estimation results are as expected, as these economies are mostly associated with relatively good institutions (see Tables A.3–A.5 in the Appendix A).[19]

[17] In the Appendix A, Table A.6 we provide the detail of each group's composition. For the results reported by regions, we excluded the outlier countries based on the levels of inflation, as those observations tend to bias the estimations in small samples.

[18] We ran our estimations for other panels such as North America, South Asia, and the Commonwealth of Independent States (CIS), but the small number of observations available for each of these groups was insufficient to perform the standard, non-linearity tests, and to obtain the parameters of our model.

[19] Although we were unable to estimate the model for North America due to the small sample, we conjecture that a threshold for these countries would be in the range (most likely biased downward) of those found for the wider group of the OECD and high-income countries.



(a) Acemoglu et al. (2001)'s Mortality Rate ≤300

(b) Acemoglu et al. (2001)'s Mortality Rate ≤ 250

Fig. 5. Effect of inflation on growth: Developing countries segmented by Mortality Rate. (a) Acemoglu et al. (2001)'s Mortality Rate ≤ 300. (b) Acemoglu et al. (2001)'s Mortality Rate ≤ 250. Note: The figures show the effect on growth of gradually varying inflation from initial inflation rates as indicated in each figure. The group of countries considered in the estimation is indicated below each figure.

In contrast, we find higher inflation thresholds for countries in the Sub-Saharan Africa (36.94%), the Middle East and North Africa (27.52%), and Europe and Central Asia (25.40%). It might be surprising, particularly, the high threshold estimated for the group of Europe and Central Asia. However, since the γ parameter appears to be relatively low (2.22), and the estimated sum of $\beta_0 + \beta_1$ turns out to be negative and strongly significant (−1.13), the harmful effect of inflation on growth starts acting at low (one-digit) inflation rates.[20]

Overall, the results based on the disaggregation of countries by geographical location and especially income level, are consistent with our main argument. However, there is some heterogeneity among countries of certain regions, such as Europe and Central Asia, which may disappear when we disaggregate countries based on only one dimension such as a normalized (and homogeneous) measure of institutions as previously shown in this section.

6. Concluding remarks

Motivated by the increase in the number of central banks that have adopted an inflation targeting regime in the last years, we revisit the nexus between inflation and economic growth by taking into account the differences in institutions. Using a 'PSTR' model for a panel of 138 countries during the period 1950–2009, we estimate both the threshold above which inflation is harmful for growth and the slope of the function that connects one regime to the other. In addition, we estimate the effect on growth from the control variables that are standard in growth models (initial per capita income, population growth, the investment–output ratio, openness to trade, and the standard deviations of terms of trade), and calculate the effect of varying inflation on the long-run rate of economic growth. Our results can be interpreted as conditional correlations rather than as causal relationships. In that matter, previous literature (e.g., Cukierman et al., 1992, and Fischer, 1993) has found that the causality is more likely to run primarily from inflation to growth.

In line with previous literature, our study indicates that the relationship between inflation and growth is non-linear. The threshold level of inflation above which its association with economic growth is negative is much higher for non-industrialized economies (19.1%) compared to that for industrialized economies (4.5%). In addition, the speed at which inflation affects growth is relatively smooth for the group of industrialized economies, while inflation appears to quickly affect growth when it exceeds the threshold in non-industrialized economies. Notably, the inflation threshold may fall considerably (including levels as low as 3 to 7%) for reduced groups of developing countries that appear to have relatively high levels of institutional quality. Indeed, using proxies for institutions helps us to better understand the relationship between inflation and growth in these types of economies. In addition, it also allows us to find thresholds closer to the targets for monetary policy. Our analysis also suggests that the cost of inflation increases with the level of institutional quality.

In summary, the analysis suggests that central banks could improve economic growth by reducing inflation when it approaches the estimated thresholds. For those developing countries characterized by weaker institutions, the extremely high speeds of transition estimated also suggest that their central banks should act as soon as inflation approaches their (high) threshold levels. For countries with relatively strong institutions (including both characterized as developed and developing), the results suggest that central banks could act gradually but well before inflation reaches their (even lower) thresholds. Such results can be considered, therefore, as consistent with the adoption of inflation targeting regimes. For future work, it would be interesting to study the effect of additional controls such as the presence (or absence) of indexation and dollarization schemes, which are particularly relevant for developing economies. Future research could also examine the nature of political economy in developing countries (e.g., the lobbying process, conflicts in policy making, and the politics of delayed reforms), which could provide further insights regarding the mechanisms governing the relationship between inflation and growth and help in any policy design.

[20] It is worth emphasizing that, if we consider only the western European economies, i.e. leaving out of the sample the Eastern European and Central Asian countries (some of which are associated with weaker institutions and experienced long periods of high inflation before), the threshold goes down to 7.14%.

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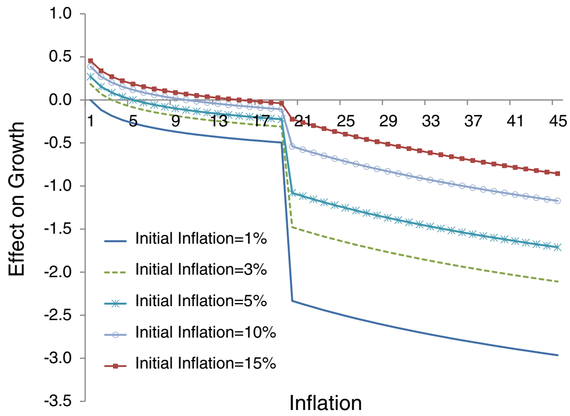
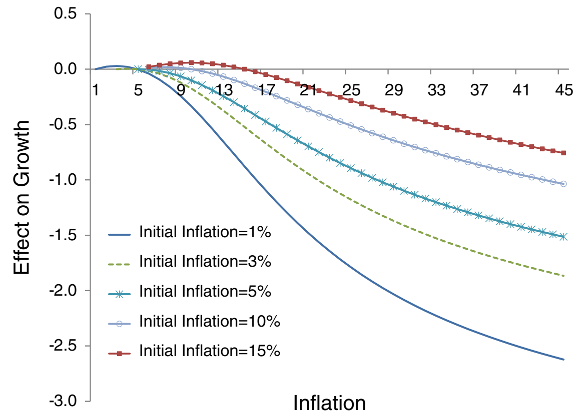
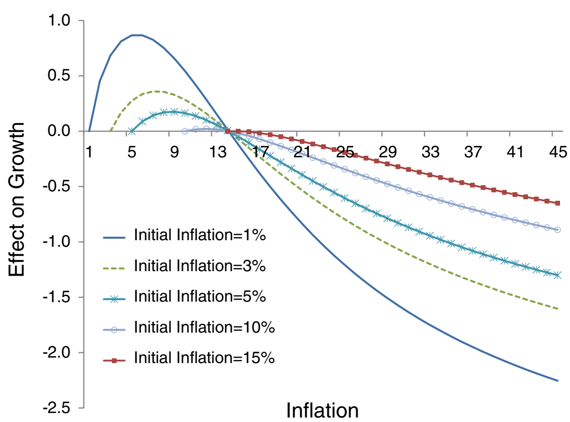


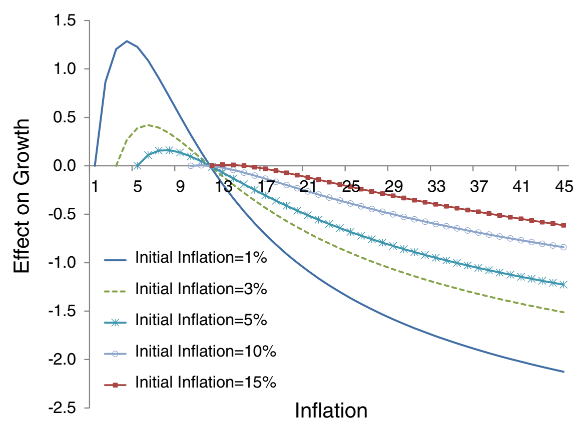
(a) ICRG ≥ 0.50



(b) ICRG ≥ 0.55



(c) ICRG ≥ 0.60



(d) ICRG ≥ 0.65

Fig. 6. Effect of inflation on growth: Developing countries segmented by ICRG. Note: The figures show the effect on growth of gradually varying inflation from initial inflation rates as indicated in each figure. The group of countries considered in the estimation is indicated below each figure.

Appendix A

Polity IV dataset

The Polity IV dataset covers all major, independent states in the global system over the period 1800–2013. Each state has a total population of 500,000 or more in the most recent year. At present, there are 167 countries included. The dataset is updated and revised on an annual cycle and is reexamined whenever new sources of information become available. It includes information only on the institutions of the central government and on political groups acting, or reacting, within the scope of that authority. This project builds on the contribution of Ted Robert Gurr's earlier study of "*Persistence and Change in Political Systems, 1800–1971*".

The Polity conceptual scheme examines concomitant qualities of democratic and autocratic authority in governing institutions (Jaggers and Marshall, 2010). This perspective envisions a spectrum of governing authority that spans from fully institutionalized autocracies through mixed, or incoherent, authority regimes (anocracies) to fully institutionalized democracies. The reliability of the indicators developed depends on the accuracy and consistency of the coding of the constituent authority variables.

The "Polity Score" captures this regime authority spectrum on a 21-point scale ranging from −10 (hereditary monarchy) to +10 (consolidated democracy). The Polity scores can also be converted into regime categories in a suggested three part categorization of "autocracies" (−10 to −6), "anocracies" (−5 to +5 and three special values: −66, −77 and −88), and "democracies" (+6 to +10).

This score depends on two other variables of the dataset: institutionalized democracy and autocracy. Democracy is conceived as three essential, interdependent elements. One is the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders. Second is the existence of institutionalized constraints on the exercise of power by the executive. Third is the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation. Institutionalized autocracy defines in terms of the presence of a distinctive set of political characteristics. Autocracies sharply restrict or suppress competitive political participation. Both indicators are additive eleven-point scales (0–10). The operational indicators of both variables are derived from codings of the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive (see Table A.1).

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The Polity score is computed by subtracting the autocracy score from the democracy score; the resulting unified polity scale ranges from +10 (strongly democratic) to −10 (strongly autocratic).

International Country Risk Guide—Political Risk dataset

The International Country Risk Guide (ICRG), constructed by the Political Risk Services (PRS) Group, comprised a set of three index pillars: Political Risk, Financial Risk and Economic Risk. Howell (2011) explains that essentially, data on financial, economic and political components is collected and transformed into risk points which indicate the extent of the risk structure within a given country. The measure of institutions presented in the paper is based on the political risk component which in turn is constructed from a subjective but consistent analysis of available information of each country.

The Political Risk rating accounts for a total of 100 points which are divided into 12 components: *Government Stability*, *Socioeconomic Conditions*, *Investment Profile*, *Internal Conflict*, *External Conflict*, *Corruption*, *Military in Politics*, *Religious Tensions*, *Law and Order*, *Ethnic Tension*, *Democratic Accountability* and, lastly, *Bureaucracy Quality*. Each component can obtain a total of risk points as shown in Table A.2 where a high score means a low risk level within the category and vice versa.

The first component, *Government Stability*, assesses the extent to which the government can remain in power and also follow its policies. This component in turn has three subcomponents, Government Unity, Legislative Strength and Popular Support. The second and third components are not included within the current analysis as they are considered to be related to economic rather than institutional conditions. Nevertheless, they are worthwhile mentioning: *Socioeconomic Conditions* include the three subcomponents Unemployment, Consumer Confidence and Poverty and *Investment Profile* contains three subcomponents Contract Viability/Expropriation, Profits Repatriation and Payment Delays. Furthermore, two components are related to assessing the risk of either internal or external conflict. On the one hand, the idea behind the *Internal Conflict* component is to infer whether political violence, such as the risk of civil wars or coups, terrorism or political violence and civil disorder, can damage the country's governance. On the other hand, the *External Conflict* risk component includes analyzing the likelihood that the current government may act against another country through war, cross-border conflict and foreign pressures.

The last block of seven components of the Political Risk pillar contains no subcomponents. The *Corruption* component assesses a range of corrupt activities such as bribes in exchange for preferential behavior between politicians and businesses. The next component is *Military in Politics* which inherently analyzes the involvement of military personnel within the government and whether this can affect the direction of national policy. *Religious Tensions* is another component whose objective is to infer the extent to which religious division or involvement in the government may cause social instability. Another related component to the latter is that of *Ethnic Tensions* measuring the extent to which linguistic or ethnic diversity may create tensions. In terms of the judicial system, the *Law and Order* component contains the degree of neutrality of the system as well as the ability to implement the law. Furthermore, the *Democratic Accountability* component creates a range of government structures regarding the degree of responsiveness of the government towards society's needs. Thus, from the most responsive to the least responsive, the five government structures are: an alternating democracy, a dominated democracy, a de facto one-party state, a de jure one-party state and, lastly, an autarchy. Lastly, the *Bureaucracy Quality* component assesses if bureaucracy can act independently of any political shock or pressure.

Once all points are added within the political risk pillar, a risk rate of 0%–49% indicates a Very High Risk, followed by High risk if a score lies in the 50%–59% range, Moderate Risk 60% to 69%, Low Risk from 70% to 79% and Very Low Risk from 80% onwards. Essentially, a high risk rating indicates unstable institutions and a low risk rating points towards robust institutions.

Table A.1
Elements of democracy and autocracy scores. Polity IV dataset.

Democracy		Autocracy	
Authority	Scale weight	Authority	Scale weight
Competitiveness of executive recruitment		*Competitiveness of executive recruitment*	
Election	2	Selection	2
Transitional	1		
Openness of executive recruitment		*Openness of executive recruitment*	
Dual/election	1	Closed	1
Election	1	Dual/designation	1
Constraint on Chief Executive		*Constraint on Chief Executive*	
Executive parity or subordination	4	Unlimited authority	3
Intermediate category	3	Intermediate category	2
Substantial limitations	2	Slight to moderate limitations	1
Intermediate category	1		
Competitiveness of political participation		*Regulation of participation*	
Competitive	3	Restricted	2
Transitional	2	Sectarian	1
Factional	1		
		Competitiveness of participation	
		Repressed	2
		Suppressed	1

Table A.2
Elements of political risk rating of ICRG.

Component	Subcomponent	Total risk points
Government stability	Government unity Legislative strength Popular support	12
Socioeconomic conditions	Unemployment Consumer confidence Poverty	12
Investment profile	Contract viability/expropriation Profits repatriation Payment delays	12
Internal conflict	Civil War/Coup threat Terrorism/political violence Civil disorder	12
External conflict	War Cross-border conflict Foreign pressures	12
Corruption		6
Military in politics		6
Religious tensions		6
Law and order		6
Ethnic tensions		6
Democratic accountability		6
Bureaucracy quality		4

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Table A.3
List of industrialized countries with their average polity levels and ICRG rating.

Country	Polity	ICRG
Australia	10.00	0.88
Austria	10.00	0.90
Belgium	9.89	0.85
Canada	10.00	0.89
Cyprus	8.52	0.71
Czech Republic	9.47	0.82
Denmark	10.00	0.90
Estonia	8.07	0.76
Finland	10.00	0.95
France	7.95	0.81
Germany	10.00	0.87
Greece	5.96	0.75
Iceland	9.89	0.93
Ireland	10.00	0.87
Italy	10.00	0.80
Japan	10.00	0.86
Netherlands	10.00	0.91
New Zealand	10.00	0.91
Norway	10.00	0.91
Portugal	3.31	0.84
Spain	3.25	0.77
Sweden	10.00	0.92
Switzerland	10.00	0.93
United Kingdom	10.00	0.84
United States	10.00	0.84

Table A.4
List of non-industrialized countries with their average polity levels and ICRG rating.

Country	Polity	ICRG	Country	Polity	ICRG
Albania	5.65	0.69	Lesotho	−1.28	NA
Algeria	−5.33	0.55	Liberia	−6.27	0.43
Angola	−2.35	0.53	Libya	−7.00	0.59
Argentina	1.49	0.73	Lithuania	10.00	0.75
Armenia	3.40	0.62	Macedonia	7.80	NA
Azerbaijan	−6.80	0.61	Madagascar	0.58	0.63
Bahrain	−9.03	0.66	Malawi	−0.63	0.61
Bangladesh	2.28	0.51	Malaysia	4.67	0.73
Belarus	−6.53	0.66	Mali	3.72	0.55
Benin	5.90	NA	Mauritania	−5.26	NA
Bhutan	−8.73	NA	Mauritius	9.64	NA
Bolivia	2.05	0.59	Mexico	−0.75	0.72
Botswana	7.03	0.76	Moldova	7.67	0.69
Brazil	6.00	0.71	Mongolia	9.40	0.74
Bulgaria	5.36	0.74	Morocco	−7.04	0.67
Burkina Faso	−4.16	0.58	Mozambique	1.28	0.62
Burundi	−3.62	NA	Namibia	6.00	0.79
Cambodia	1.27	NA	Nepal	−1.87	NA
Cameroon	−6.20	0.57	Nicaragua	1.92	0.61
Cape Verde	4.43	NA	Niger	−2.32	0.56
Central African Republic	−1.53	NA	Nigeria	−0.20	0.49
Chad	−3.17	NA	Oman	−8.10	0.70
Chile	2.62	0.72	Pakistan	0.38	0.45
Colombia	7.02	0.59	Panama	1.87	0.65
Congo, Republic of	−3.40	0.56	Papua New Guinea	4.00	0.65
Costa Rica	10.00	0.77	Paraguay	−2.35	0.60
Croatia	4.40	0.78	Peru	3.00	0.57
Dem Rep Congo	−4.44	0.36	Philippines	2.73	0.60
Djibouti	−3.00	NA	Poland	3.00	0.76
Dominican Republic	2.47	0.66	Qatar	−10.00	0.67
Ecuador	4.04	0.63	Romania	7.40	0.70
Egypt	−6.11	0.60	Russia	4.60	0.64
El Salvador	2.20	0.61	Saudi Arabia	−10.00	0.63
Ethiopia	−4.07	0.51	Senegal	−0.78	0.59
Fiji	5.30	NA	Sierra Leone	−2.38	0.53
Gabon	−6.53	0.64	Singapore	−2.00	0.84
Gambia, The	3.07	0.66	Slovak Republic	8.40	0.80
Georgia	5.60	NA	Slovenia	10.00	0.81
Ghana	−1.29	0.63	Solomon Islands	6.71	NA
Guatemala	0.85	0.57	South Africa	5.60	0.68
Guinea	−3.08	0.51	Sri Lanka	6.16	0.52

Table A.4 (*continued*)

Country	Polity	ICRG	Country	Polity	ICRG
Guinea-Bissau	0.00	0.52	Sudan	−5.09	0.34
Guyana	6.00	0.61	Swaziland	−9.51	NA
Haiti	−4.13	0.46	Syria	−8.33	0.59
Honduras	2.80	0.57	Tajikistan	−2.40	NA
Hungary	3.17	0.82	Tanzania	−4.27	0.66
India	8.60	0.58	Thailand	1.09	0.64
Indonesia	−3.44	0.54	Togo	−5.16	0.51
Iran	−6.04	0.56	Trinidad &Tobago	8.78	0.68
Israel	9.42	0.59	Tunisia	−4.87	0.69
Jamaica	9.69	0.74	Turkey	6.47	0.60
Jordan	−5.80	0.66	Uganda	−2.90	0.50
Kenya	−2.36	0.60	Ukraine	6.60	0.69
Kuwait	−7.13	0.64	Uruguay	5.18	0.72
Kyrgyzstan	−1.07	NA	Venezuela	6.85	0.65
Laos	−7.00	NA	Zimbabwe	−1.09	0.56
Lebanon	0.00	0.47			

Note: NA indicates not available.

Table A.5
Sample of non-industrialized countries matched with Acemoglu et al. (2001)'s, with their Mortality Rates.

Country	Mortality Rate	Country	Mortality Rate
Algeria	78.20	Jamaica	130.00
Angola	280.00	Kenya	145.00
Argentina	68.90	Madagascar	536.04
Bangladesh	71.41	Malaysia	17.70
Bolivia	71.00	Mali	2940.00
Brazil	71.00	Mexico	71.00
Burkina Faso	280.00	Morocco	78.20
Cameroon	280.00	Nicaragua	163.30
Chile	68.90	Niger	400.00
Colombia	71.00	Nigeria	2004.00
Congo, Republic of	240.00	Pakistan	36.99
Costa Rica	78.10	Panama	163.30
Dominican Republic	130.00	Paraguay	78.10
Ecuador	71.00	Peru	71.00
Egypt	67.80	Senegal	164.66
El Salvador	78.10	Sierra Leone	483.00
Ethiopia	26.00	Singapore	17.70
Gabon	280.00	South Africa	15.50
Gambia, The	1470.00	Sri Lanka	69.80
Ghana	668.00	Sudan	88.20
Guatemala	71.00	Tanzania	145.00
Guinea	483.00	Togo	668.00
Guyana	32.18	Trinidad & Tobago	85.00
Haiti	130.00	Tunisia	63.00
Honduras	78.10	Uganda	280.00
India	48.63	Uruguay	71.00
Indonesia	170.00	Venezuela	78.10

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Table A.6
List of countries by region and income.

Country	Income level
a) East Asia and Pacific	
Australia *	High income
Cambodia	Low income
Fiji	Middle income
Indonesia	Middle income
Japan *	High income
Laos	Middle income
Malaysia	Middle income
Mongolia	Middle income
New Zealand *	High income
Papua New Guinea	Middle income
Philippines	Middle income
Singapore	High Income
Solomon Islands	Middle income
Thailand	Middle income
b) Europe and Central Asia	
Albania	Middle income
Armenia ***	Middle income
Austria *	High income
Azerbaijan ***	Middle income
Belarus ***	Middle income
Belgium *	High income
Bulgaria	Middle income
Croatia	High income
Cyprus	High income
Czech Republic *	High income
Denmark *	High income
Estonia *	High income
Finland *	High income
France *	High income
Georgia ***	Middle income
Germany *	High income
Greece *	High income
Hungary *	High income
Iceland *	High income
Ireland *	High income
Italy *	High income
Kyrgyzstan ***	Middle income
Lithuania	High income
Macedonia	Middle income
Moldova ***	Middle income
Netherlands *	High income
Norway *	High income
Poland *	High income
Portugal *	High income
Romania	Middle income
Russia ***	High Income
Slovak Republic *	High income
Slovenia *	High income
Spain *	High income
Sweden *	High income
Switzerland *	High income
Tajikistan ***	Middle income
Turkey *	Middle income
Ukraine ***	Middle income
United Kingdom *	High income
c) Latin America and the Caribbean	
Argentina	High income
Bolivia	Middle income
Brazil	Middle income
Chile *	High income
Colombia	Middle income
Costa Rica	Middle income
Dominican Republic	Middle income
Ecuador	Middle income
El Salvador	Middle income
Guatemala	Middle income
Guyana	Middle income
Haiti	Low income
Honduras	Middle income
Jamaica	Middle income
Mexico *	Middle income
Nicaragua	Middle income
Panama	Middle income
Paraguay	Middle income
Peru	Middle income
Trinidad & Tobago	High income
Uruguay	High income
Venezuela	High income
d) Middle East and North Africa	
Algeria **	Middle income
Bahrain **	High income
Djibouti **	Middle income
Egypt **	Middle income
Iran	Middle income
Israel *	High income
Jordan **	Middle income
Kuwait **	High income
Lebanon **	Middle income
Libya **	Middle income
Morocco **	Middle income
Oman **	High income
Qatar **	High income
Saudi Arabia **	High income
Syria **	Middle income
Tunisia **	Middle income
e) North America	
Canada *	High income
United States *	High income
f) South Asia	
Bangladesh	Middle income
Bhutan	Middle income
India	Middle income
Nepal	Low income
Pakistan	Middle income
Sri Lanka	Middle income
g) Sub-Saharan Africa	
Angola	Middle income
Benin	Low income
Botswana	Middle income
Burkina Faso	Low income
Burundi	Low income
Cameroon	Middle income
Cape Verde	Middle income
Central African Republic	Low income
Chad	Low income
Congo, Republic of	Middle income
Dem Rep Congo	Low income
Ethiopia	Low income
Gabon	Middle income
Gambia, The	Low income
Ghana	Middle income
Guinea	Low income
Guinea-Bissau	Low income
Kenya	Middle income
Lesotho	Middle income
Liberia	Low income
Madagascar	Low income
Malawi	Low income
Mali	Low income
Mauritania **	Middle income
Mauritius	Middle income
Mozambique	Low income
Namibia	Middle income
Niger	Low income
Nigeria	Middle income
Senegal	Middle income
Sierra Leone	Low income
South Africa	Middle income
Sudan **	Middle income
Swaziland	Middle income
Tanzania	Low income
Togo	Low income
Uganda	Low income
Zimbabwe	Low income

Notes: (i) * indicates that the country is a member of the OECD, (ii) ** indicates an Arab state; (iii) *** indicates that the country is a member of the CIS.

Table A.7
Estimated threshold – Developing countries, control institutions. Excluding initial GDP.

	π^*	γ	$\tilde{\beta}_0$	$\tilde{\beta}_1$	$\tilde{\beta}_0+\tilde{\beta}_1$	*N*	*Observations*
a) Polity							
−6	19.17	13,987.3	−0.24*	−0.64**	−0.88**	95	713
−4	17.50	2.66	0.05	−0.89**	−0.84**	84	623
−2	13.81	1.95	0.63**	−1.37**	−0.75**	70	525
0	11.35	1.76	0.64*	−1.39**	−0.75**	58	438
2	10.50	2.54	0.31	−1.01	−0.71	49	358
4	7.76	1.48	0.91	−1.74**	−0.83**	35	238
6	5.46	1.53	1.44	−2.2*	−0.77**	20	148
b) Mortality rate							
300	4.84	1.20	0.95**	−1.47**	−0.52**	45	422
250	2.97	1.36	1.36**	−1.82**	−0.46**	40	384
c) ICRG							
0.50	15.86	2.77	−0.04	−0.79**	−0.83**	85	651
0.55	14.23	2.30	0.05	−0.83**	−0.78**	75	580
0.60	12.97	1.82	0.79**	−1.54**	−0.75**	56	401
0.65	6.18	1.60	1.71**	−2.38**	−0.66**	37	262

Significance level: (*) 5%, (**) 1%.
The table reports the estimated threshold (π^*), speed of transition (γ), $\tilde{\beta}_0$ and $\tilde{\beta}_1$ parameters for non-industrialized countries with average *polity* above, mortality rate below or ICRG above those indicated in the first column, the sum of $\tilde{\beta}_0$ and $\tilde{\beta}_1$, the number of countries (n), and the total number of observations in each group.

Table A.8
PSTR model estimation with two regimes. Developed and developing countries.

Threshold: π^*		19.15%
Slope: γ		36,410.04
Variable	Parameter	
$\tilde{\pi}_{it}$	β_0	−0.2219*
		(0.0939)
$\tilde{\pi}_{it} * G(\pi_{it};\gamma,\pi^*)$	β_1	−0.6455**
		(0.0976)
	$\beta_0+\beta_1$	−0.8674**
		(0.0879)
$igdp_{it}$	ψ_1	−0.0002**
		(0.0000)
pop_{it}	ψ_2	−0.4939**
		(0.1790)
inv_{it}	ψ_3	0.0764**
		(0.0230)
$open_{it}$	ψ_4	0.0105
		(6.0066)
tot_{it}	ψ_5	−0.1213
		(0.0779)
$sdtot_{it}$	ψ_6	3.1088
		(6.1474)

Significance level: (*) 5%, (**) 1%.
Values in parentheses are standard errors corrected for heteroskedasticity.

Table A.9
Estimated threshold – Developed and developing countries, control institutions.

	π^*	γ	$\tilde{\beta}_0$	$\tilde{\beta}_1$	$\tilde{\beta}_0+\tilde{\beta}_1$	*N*	*Observations*
a) Polity							
−6	16.73	1.83	−0.03	−0.90**	−0.92**	120	963
−4	15.50	2.17	0.05	−0.90**	−0.85**	109	873
−2	11.70	1.67	0.49*	−1.28**	−0.79**	96	784
0	8.62	1.48	0.59*	−1.37**	−0.78**	85	696
2	8.62	2.02	0.32	−1.05**	−0.73**	74	608
4	6.42	1.27	0.67*	−1.55**	−0.89**	59	474
6	5.68	1.44	0.66	−1.48**	−0.82**	45	376

Table A.9 (*continued*)

	π^*	γ	$\tilde{\beta}_0$	$\tilde{\beta}_1$	$\tilde{\beta}_0+\tilde{\beta}_1$	N	Observations
b) Mortality rate							
300	4.03	1.16	1.05**	−1.56**	−0.51**	49	466
250	2.93	1.37	1.34**	−1.79**	−0.45**	44	428
c) ICRG							
0.50	14.52	2.41	−0.02	−0.80**	−0.82**	110	901
0.55	12.47	2.02	0.07	−0.84**	−0.77**	100	830
0.60	11.19	1.57	0.57**	−1.36**	−0.79**	81	651
0.65	7.21	1.62	0.87**	−1.59**	−0.72**	62	512

Significance level: (*) 5%, (**) 1%.
The table reports the estimated threshold (π^*), speed of transition (γ), $\tilde{\beta}_0$ and $\tilde{\beta}_1$ parameters for non-industrialized countries with average *polity* above, mortality rate below or ICRG above those indicated in the first column, the sum of $\tilde{\beta}_0$ and $\tilde{\beta}_1$, the number of countries (n), and the total number of observations in each group.

Table A.10
PSTR model estimation with two regimes. Period 1990–2009.

		Industrialized	Non-industrialized
Threshold: π^*		1.76%	19.14%
Slope: γ		45.68	4307.15
Variable	Parameter		
$\tilde{\pi}_{it}$	β_0	−0.7867*	−0.0240
		(0.3550)	(0.2143)
$\tilde{\pi}_{it} * G(\pi_{it};\gamma,\pi^*)$	β_1	−0.6638	−0.8550**
		(0.3957)	(0.1604)
	$\beta_0+\beta_1$	−1.4505**	−0.8790**
		(0.2306)	(0.1871)
$igdp_{it}$	ψ_1	−0.0004**	−0.0001
		(0.0000)	(0.0002)
pop_{it}	ψ_2	−1.3202**	−0.3700
		(0.2601)	(0.3783)
inv_{it}	ψ_3	0.1785**	0.1242**
		(0.0430)	(0.0406)
$open_{it}$	ψ_4	0.0773**	0.02160
		(0.01320)	(0.0140)
tot_{it}	ψ_5	0.9264**	−0.1011
		(0.1975)	(0.1055)
$sdtot_{it}$	ψ_6	−8.9316	11.1856
		(29.0065)	(11.1829)

Significance level: (*) 5%, (**) 1%.
Values in parentheses are standard errors corrected for heteroskedasticity.

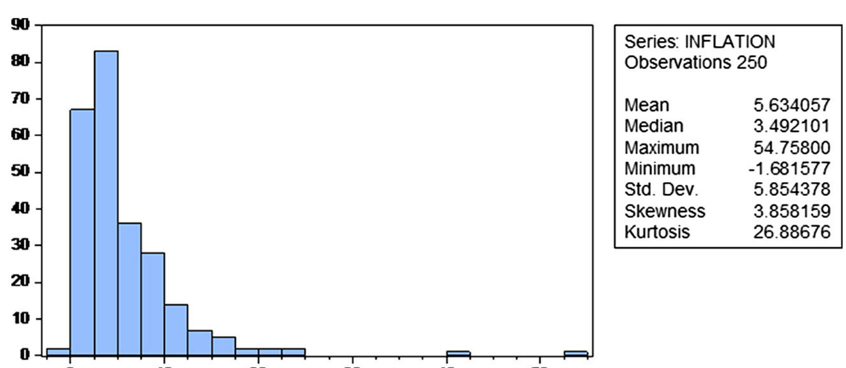

Fig. A.1. Inflation distribution – Industrialized countries. Note: Five-year average of annual inflation, in percentage points, 1955–2009. Source: IFS, IMF.

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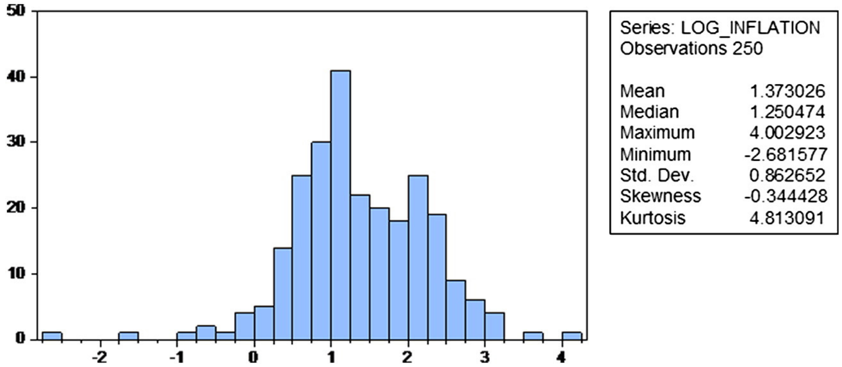

Fig. A.2. Transformed inflation distribution – Industrialized countries. Note: Five-year average of annual inflation, semi-log transformation, 1955–2009. Source: IFS, IMF.

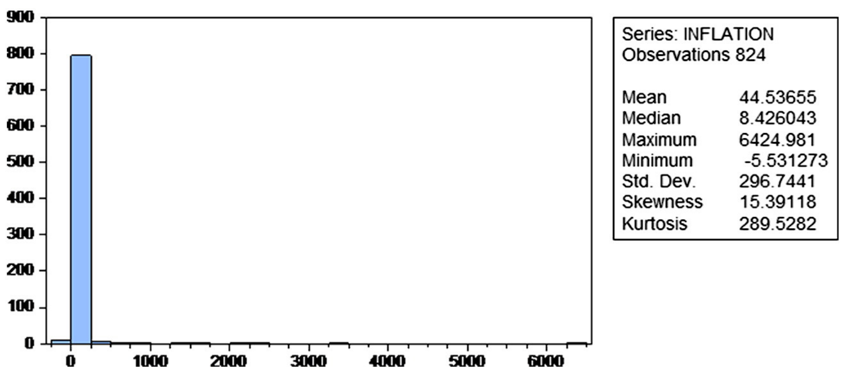

Fig. A.3. Inflation distribution – Non-industrialized countries. Note: Five-year average of annual inflation, in percentage points, 1955–2009. Source: IFS, IMF.

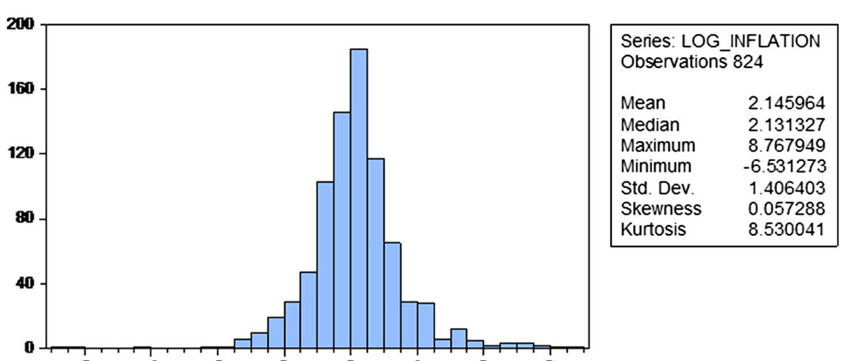

Fig. A.4. Transformed inflation distribution – Non-industrialized countries. Note: Five-year average of annual inflation, semi-log transformation, 1955–2009. Source: IFS, IMF.

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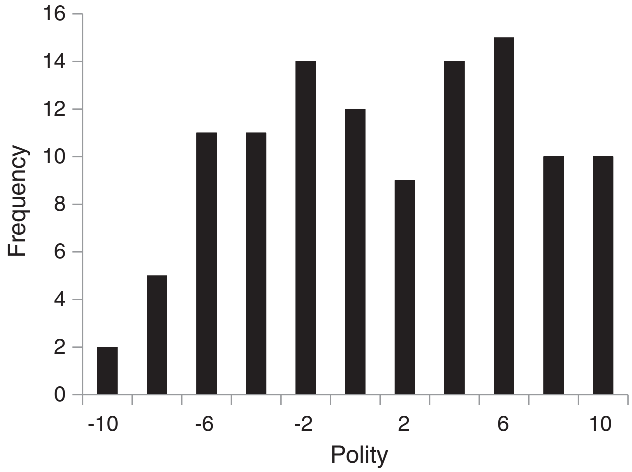

Fig. A.5. Developing countries by Polity.

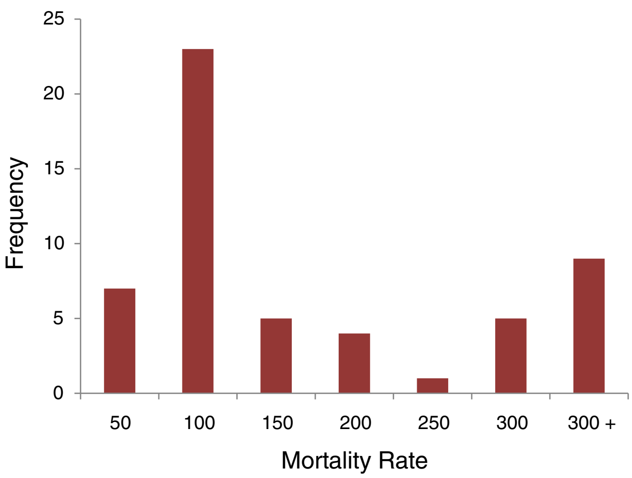

Fig. A.6. Developing countries by Mortality Rate.

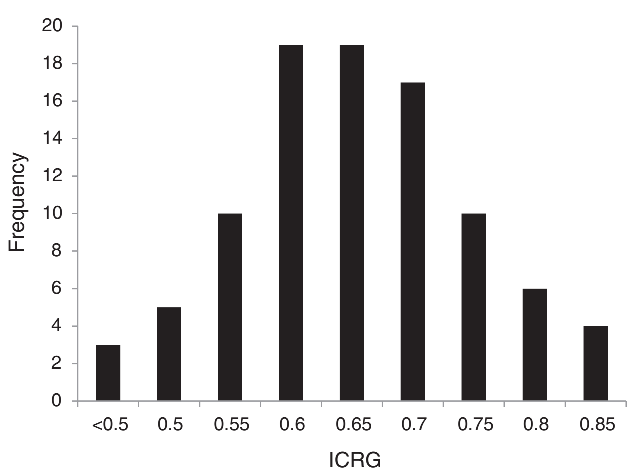

Fig. A.7. Developing countries by ICRG.

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