**Analyzing the Relationship Between Inflation and Growth: Policy Implications for Central Banks**

**Srikar Gullapalli**
**Department of Economics**
**Box #H1138 13 Oak Dr. Hamilton NY 13346 sgullapalli@colgate.edu**

**March 2013**

**Abstract**

This paper analyzes the inflation-growth nexus assuming nonlinear effects using data for 214 countries from 1990-2011. A structural break of 20% in the average annual rate of inflation is found for the dataset as a whole, so inflation rates below this have an insignificant effect on growth while inflation rates above this have a significantly negative impact on growth. This analysis is conducted for countries under each of the income categorizations of the World Bank: low-income countries have a threshold of 14.5%, lower middle-income countries have a threshold of 9%, upper-middle income countries have a threshold of 10%, and high income countries have a threshold of 2.25%. The analysis is also conducted for "fast-growing" countries and "slow-growing" countries. Fast-growing countries have an inflation threshold of 16% while slow-growing countries have an inflation threshold of 14%, both of which are statistically significant. The extent of the pernicious effects of excess inflation on economic growth is explored for different conceptions of "developing" and "developed" nations.

**Keywords:** Inflation, Central Bank, Economic Growth, Threshold effects

**JEL Codes:** E31, F43, E58

## 1. Introduction and Background Literature

In 2012, there was a significant policy debate between the Reserve Bank of India (India's central bank) and the Finance Ministry of the Union Government about the interest rates set by the former. The central bank balked at cutting the interest rates because their aim was to bring inflation in control. The Finance Ministry wished to rejuvenate economic activity by having the RBI cut interest rates. To understand this debate, one needs to appreciate the complex relationship between interest rates, inflation, short-run growth and long-run growth. The conventional reasoning goes as such: reduction in interest rates boosts short term economic activity but leads to higher inflation (and vice versa); higher inflation leads to a reduction in long-term growth due to the uncertainty in the economy and the value of currency (and vice versa). An implicit assumption in this debate is that higher inflation always has a significantly negative effect on economic growth. Indeed this is the finding of Barro (1991), De Gregorio (1992), Fischer (1993), Smyth (1994), Sbordone and Kuttner (1994), and Barro(1995).

For instance Barro (1995) finds that "a shift in monetary policy that raises the long-term average inflation rate by 10 percentage points per year is estimated to lower the level of real GDP after 30 years by 4-7%". This, in addition to the hyperinflation crises of the 1980s, led to economists proposing "policy measures and institutional changes to guarantee low inflation", with "independent central banks with a clear mandate to keep inflation levels" low being a "favorite suggestion" (Sarel, 1996). By making price stability the central goal of central banks around the world, economists have tied central banks to policies, such as high interest rates, that have the sole goal of reducing inflation no matter what the cost is to economic growth.

But much of this previous analysis from Fischer to Barro suffers from analytical issues. Bruno & Easterly (1998) argue that much of this past research that correlated inflation and growth "were influenced by outliers", viz. countries with extreme values of inflation. They argue that these cases bias the results because during such cases of discrete high-inflation, growth falls during the inflation crisis

and rises sharply after the crisis is resolved. Mallik & Chowdhury (2001) point out that there can be significant feedback effects between inflation and economic growth. Using panel data for four developing South Asian countries (Bangladesh, India, Pakistan, and Sri Lanka) from the IMF International Financial Statistics, they find that moderate inflation is helpful to growth, but faster economic growth feeds back into inflation. The former finding fits more in the structuralist school of macroeconomic thinking in this field, but Mallik & Chowdhury (2001) make the unique argument that these economies can overheat very quickly and get to the point where inflation is harmful, even if inflation does boost growth initially. For the sake of simplicity, this research does not formally analyze feedback effects between inflation and growth but does differentiate between fast growing countries and slow growing countries.

Another problem among these previous economists is that they assume a linear relationship between inflation and growth prima facie. Later economists including Sarel (1996), Ghosh and Phillips (1998) and Khan and Senhadji (2001) have questioned this assumption and have found it to be faulty. These economists assumed that there is a threshold level of inflation below which inflation might have a positive to negligible effect on growth and above which inflation might have a negative effect on growth. Their results confirm the presence of a "structural break", on either side of which inflation has different effects on economic growth. Hence at the very least the orthodoxy of linear relationships between inflation and growth deserves to be questioned. This is even more important when making the value judgment about the trade-off between interest rates, inflation, and growth. Since high interest rates have a negative impact on economic activity, the justification given for high interest rates is especially important to test vigorously.

If a threshold value of inflation can be found, and if the inflation in a particular country is below that threshold then there is little justification for continued high interest rates by central banks that are

tied to the orthodoxy of price stability. When it comes to the context of developing nations, this value judgment enables a much more detailed discussion of the relationship between the central bank (which sets monetary policy and interest rates) and the government in the pursuit of long-term economic growth. Sarel (1996) found that the threshold value of inflation is 8%, below which the effect of inflation on growth in insignificant and above which it is significantly negative. Khan and Senhadji (2001) used a dataset of 140 countries divided into industrialized and developing nations. They found an inflation threshold of 1-3% for developed countries and 11-12% for developing countries. Pollin and Zhu (2006) found the threshold to be around 15-18%. These results are especially important.

Just an example, India's current CPI inflation is 12.06%. This is below the thresholds found in Pollin and Zhu (2006), so the central bank should reasonably ease up on their rigid price stability stance. But then again, Burdekin et al. (2004) found two inflation thresholds for developing countries: one at 3% after which inflation started retarding growth and one at 50% after which there was a sudden amplification of this negative effect. Under this, India's central bank is justified in continuing its current policy of keeping policy rates high. So clearly, a more detailed analysis is required.

This paper uses new panel data from 214 countries from 1990-2011 to attempt to answer this question. Assuming a nonlinear relationship, a threshold analysis similar to Sarel (1996) is conducted. This paper also divides the set of countries into two sets of categorizations and conducts the threshold analysis for the inflation-growth nexus in each of these groups. Firstly, the countries are divided into low income, lower-middle income, upper-middle income, and high income countries using the World Bank's definition (World Bank, 2013). The World Bank calculates GNI per capita using the Atlas method: Countries with GNI per capita below $1025 are low income countries, countries with GNI per capita between $1026 and $4035 are lower middle income countries, countries with GNI per capita between

$4036 and $12475 are upper middle income countries, countries with GNI per capita $12,476 and above are high income countries.

Secondly, the countries are divided into fast-growing and slow-growing nations, with countries that grow faster than 4% per year on average over the entire time period falling into the former group. Since fast-growing countries tend to have higher inflation as a result of the high growth, which then feeds back to retard growth (Mallik and Chowdury, 2001), this categorization is important to explore. Trying to understand these different relationships is very important because it is impossible to make uniform policy prescriptions for all countries without accounting for their context.

The results found are very interesting. The inflation threshold value found for the dataset as a whole is 20% above which inflation has significant negative effects on growth and below which the effect is not significant. Within the first categorization: the inflation threshold for high-income countries is found to be 2.25%, the inflation threshold for lower middle-income countries is found to be 9%, the inflation threshold for upper middle-income countries is found to be 10%, and the inflation threshold for low-income countries is found to be 14.5%. This shows the necessity for a more detailed analysis by context with the nonlinear approach. Within the second categorization: the inflation threshold for fast-growing countries is found to be 16% and the inflation threshold for slow growing countries is found to be 14%.

Policy debates around the world are often mired in rigidity and orthodoxy. Nowhere is this truer than with the “appropriate” goals for a central bank and its relationship with the government. The conventional view in the context of developing nations is “central bank independence removes monetary policy from the day-to-day control of politicians and therefore enhances credibility of anti-inflationary policies” (Rodrik, 2008). Central bank independence, it is argued, lends credibility to the bank’s anti-inflationary stance. Polillo (2005) argues that the concept of central bank independence

spread primarily due to “globalization pressures”. Blinder (1991) conducts a survey of central bankers and finds that the primary reason central bankers believe their credibility is important is “to keep inflation low”. There are economists, such as Loungani (1997), who argue that lower central bank independence increases inflation and reduces growth in transition economies.

Then there are economists on the other side of the debate, such as Epstein (2008), who argues that the central bank should focus on employment/output targeting in conjunction with the government instead of focusing simply on price targeting. There is also no clarity as to the theoretical effect of inflation on growth, with the structuralists saying inflation has a positive effect and the monetarists saying it has a negative effect. But since it has been shown in a context-specific manner that there are certain levels of inflation that have a negligible effect on growth and certain levels of inflation that have a negative effect on growth, each country’s central bank and government needs to examine this question more thoroughly and on a consistent empirical basis. Their decisions – whether made independently or jointly – to tamp down on inflation or boost economic activity, to focus on employment targeting or price targeting, should rely on empirical tests of inflation-growth effects instead of rigid orthodoxy.

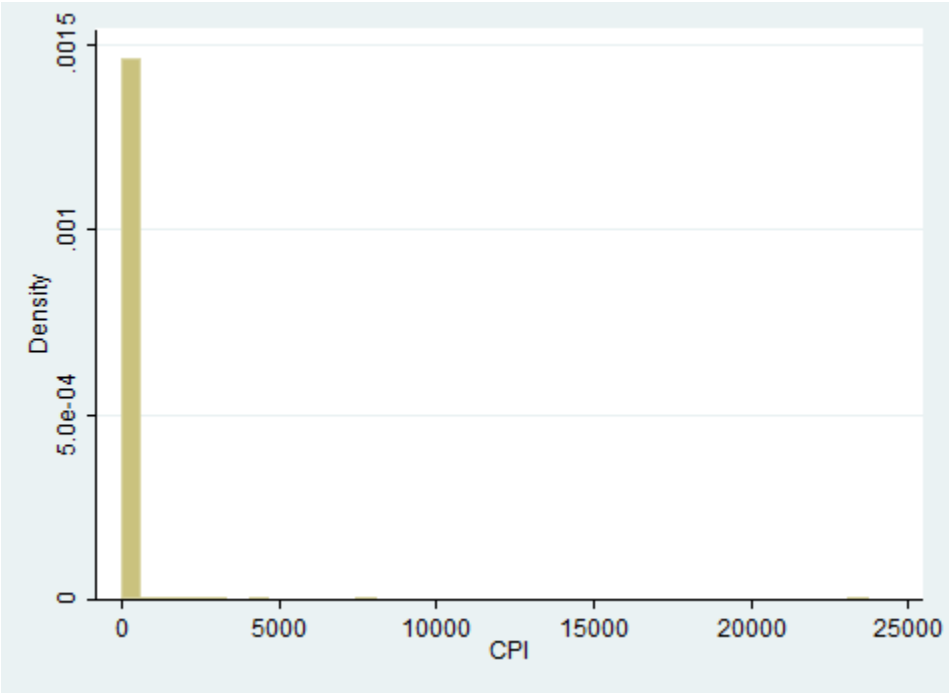
## 2. Data

The dataset comprises observations from 214 countries in the time period from 1990-2011. All data is obtained from the World Bank Databank. The main variables of interest collected are as follows: to measure economic performance, GDP per capita levels, GDP per capita growth, and initial GDP per capita are used; to measure inflation, the CPI is used as opposed to the GDP deflator; to measure economic activity, real exchange rates (indexed to 100 in 2005), investment rates (as a % of GDP), and terms of trade measured at constant prices are used; finally, independent variables that can explain long-term growth on economic growth such as population growth, government expenditures as a % of

GDP, savings rate (gross national savings as a % of GDP), and life expectancy are used. Summary statistics are reported in Table 1.

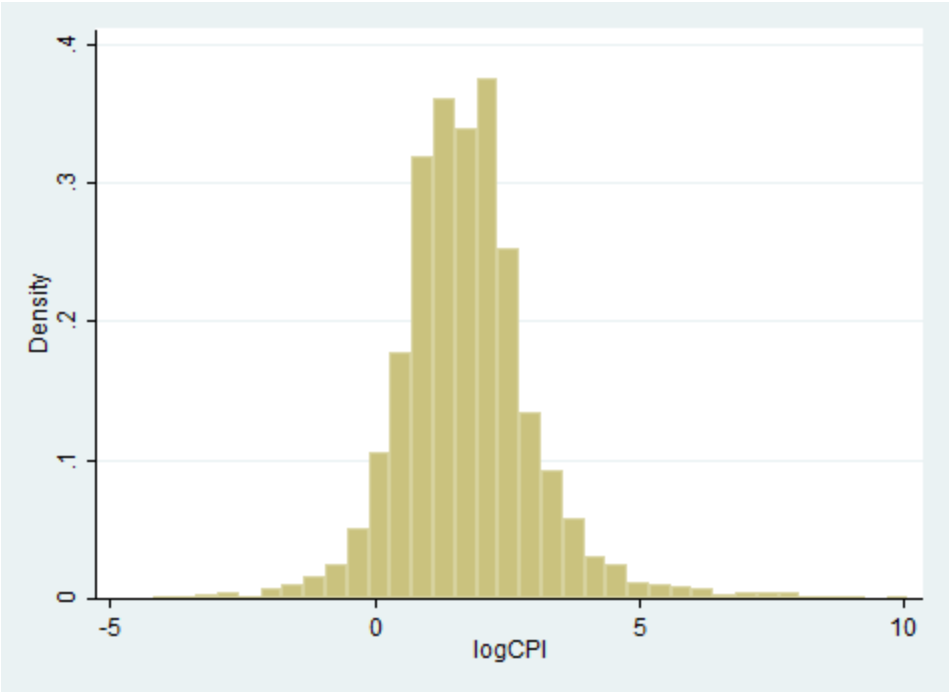
The Consumer Price Index is used instead of the GDP deflator to measure inflation because "changes in GDP deflators are, by construction, negatively correlated with growth rates" (Sarel, 1996). With regard to inflation rates, as Bruno and Easterling (1998) point out, most empirical analysis is influenced by outliers. The same was seen with this data as well as shown in Figure 1, the histogram of inflation rates.

**Figure 1**




To account for this, a method similar to Khan and Senhadji (2001) is adopted, viz. a logarithmic transformation of π is used. The new distribution of π is as shown in figure 2:

**Figure 2**




There are also negative values for π in the dataset for which absolute values are taken in this analysis. If the goal of this paper is to test the appropriateness of price stability as the aim for central banks, then negative or positive inflation should have similarly negative impacts on efficiency and productivity (Sarel, 1996).

To make distributions normal and to make interpretation simpler, logarithmic transformations are conducted for GDP per capita (y), population (pop), and the terms of trade(TOT). Hence the first difference of the log values of each of these variables is used in the empirical models, which are calculated as follows:

$dLog(y_{it}) = log(y_{t+1}/y_t)$

$dLog(pop_{it}) = log(pop_{t+1}/pop_t)$

$dLog(TOT_{it}) = log(TOT_{t+1}/TOT_t)$

These growth rates in y, pop, and TOT are expressed in percentages rather than decimals in the regressions by multiplying the values by 100. Similar to Sarel (1996), the "terms of trade data are used to eliminate the negative correlation between growth and inflation that is caused by external supply shocks" in this analysis. Investment rates, real exchange rates, and levels of government expenditures would have an impact on inflation as well as on growth and hence are accounted for to reduce endogeneity. Initial level of per capita GDP is controlled for by using the GDP per capita five years prior as a proxy. This is done to control for the catch-up effect where countries that start off poorer tend to grow faster than countries that start rich (Barro, 1995). Life expectancy is a proxy for health which plays a very important role in the creation of human capital which in turn helps an economy "approach its long-run position more rapidly" (Barro, 1995). Investment as a share of GDP is controlled for because changes in inflation might affect investment levels which in turn might have an effect on growth (Barro, 1995).

These variables are collected for 214 countries on an annual basis over the period from 1990-2011. There are 59 low-income countries (viz. per capita GNI below $1025), 53 lower middle-income countries (viz. per capita GNI between $1026 and $4035), 29 upper middle-income countries (viz. per capita GNI between $4036 and $12475), and 73 high-income (viz. per capita GNI above $12475). The number of countries characterized as fast-growing is 32 and the number of countries characterized as slow-growing is 182.

The reasons for the above categorizations are manifold. Countries which grow faster can have potentially higher inflation as a result of that growth as opposed to having inflation retard growth, and hence it is important to isolate inflation-growth effects in that respect (Malik and Chowdhury, 2006). Similarly, it is important to differentiate between countries that have different levels of income because it has been shown through previous empirical research that developed countries and developing

countries have different thresholds of inflation (Khan and Senhadji, 2001). So the orthodoxy of central bank independence and price stability cannot be uniformly applied across all cases. Especially for developing countries, the stakes are higher because a reduction in economic activity due to high interest rates can have real human costs.

## 3. Methodology

This paper begins with a simple Barro model that regresses log(π) against the growth rate of y using fixed effects with the addition of various explanatory variables including: real exchange rates, investment rates, literacy rate, terms of trade, population growth, government expenditures as a % of GDP, life expectancy, and savings rates. This assumes a linear relationship between inflation and growth. Robust standard errors are used in all models to correct for heteroskedasticity in the data.

$$dLog(y_{it}) = \beta_0 + \beta_1 \log(\pi_{it}) + \boldsymbol{\alpha X}_{ijt} + \boldsymbol{\varepsilon}_{it} \qquad (1)$$

Here $\varepsilon_{ij}$ measures idiosyncratic errors and **X** is a vector of the variables enumerated above. The log(π) represents the logarithmic transformation of inflation. $dLog(y_{it})$ represents the first difference of the log of GDP per capita. The expectation is that a significant negative relationship will be found between inflation and growth.

Observations are then divided into eight groups by levels of π. The groups represent observations where π is between 0-2%, between 2-4%, between 4-6%, between 6-8%, between 8-10%, between 10-15%, between 15-20%, and above 20%. The following regression is then run try to analyze econometrically if there is indeed a structural break for the inflation-growth nexus;

$$dLog(y_{it}) = \beta_0 + \boldsymbol{\mu\ inflgrp_{ijt}} + \boldsymbol{\alpha X}_{ijt} + \boldsymbol{\varepsilon}_{it} \qquad (2)$$

Here **inflgrp** is a vector of dummies to represent each of the groups above uniquely. The group of observations between 6-8% is used as a reference and hence not included in the regression to prevent collinearity.

Once the results of regression 2 are obtained, a more systematic threshold analysis is conducted to bolster the results. The estimation technique used is similar to the one used in Sarel (1996). First, a variable $\pi^*$ is defined which represents "the rate of inflation at which the structural break occurs". Then a dummy variable $D_1$ is defined which is equal to 1 if $\pi$ of a given observation is above $\pi^*$ and which is equal to 0 otherwise. Finally, a variable highinfl is defined as:

$$\text{Highinfl} = D_1 [\log(\pi) - \log(\pi^*)]$$

Using these variables, an OLS regression similar to model 1 is conducted once again, except this time it is of the growth rate on log ($\pi$) and highinfl.

$$dLog(y_{it}) = \beta_0 + \beta_1 \log(\pi_{it}) + \beta_2 \text{ highinfl} + \boldsymbol{\alpha X}_{ijt} + \boldsymbol{\varepsilon}_{it} \qquad (3)$$

The interpretation of the results in model 2 is simple. When $\pi$ is below $\pi^*$, then highinfl will be equal to 0. When $\pi$ is above $\pi^*$, the value of highinfl will keep increasing the higher $\pi$ goes. In the former case, the effect of inflation on growth can be ascertained simply from the coefficient on log $\pi$. In the latter case, the effect of inflation on growth can be ascertained as "the sum of two coefficients: the coefficient of log $\pi$ and the coefficient of (highinfl)" (Sarel, 1996). As pointed out by Sarel, the coefficient on highinfl "estimates the difference in the inflation effect on growth between the two sides of the structural break, and its (p-value) tests whether or not the structural break is (statistically) significant" (Sarel, 1996).

But to be able to conduct these regressions, a value for $\pi^*$ is needed. To find this, $\pi^*$ is assigned different incrementally increasing values and the regression is iterated for each value. The structural break point is the "value of $\pi^*$ that minimizes the sum-of-squared residuals from the regression (which)

is equivalent to picking the π* that maximizes $R^2$" (Sarel, 1996). We can do this, because by controlling for all the explanatory variables above, the error variance is reduced and it is safe to assume that it is "equal for the entire inflation range" (Sarel, 1996).

Once a π* that functions as the structural break point is found, the regression in model 3 is run once again and the results reported. If the coefficient on highinfl is statistically significant then the structural break point is significant as well, proving the presence of a significant "threshold value" for inflation. Even if it is not statistically significant, its presence still confirms a nonlinear relationship between inflation and growth.

The regression is then run without the "highinfl" variable as a contrast to analyze the explanatory power of the structural break when analyzing the effect of inflation on growth. The regression in model 3 is run once using fixed effects, once without fixed effects, and is contrasted with the inflation-growth regression with no "highinfl" variable. The former case helps to account for a variety of fixed factors that are constant in each country – such as the laws governing business for instance – and hence provide causal strength to the analysis. The regression with country and year dummies is conducted to test the results when controlling for the log(initial GDP) for each country. Barro (1995), Sarel (1996), Khan and Senhadji (2001) etc concur on the importance of this variable in determining GDP growth because of the "catch-up effect".

Next the observations in the dataset are divided according to the first categorization by income levels, viz. low income countries, lower-middle income countries, upper-middle income countries and high-income countries. The above threshold estimation analysis is conducted for each of these groups. Finally the observations in the dataset are divided according to the second categorization by the speed of growth, viz. fast-growing countries and slow-growing countries. The above threshold estimation analysis is conducted for each of these groups as well. Results are reported in the next section.

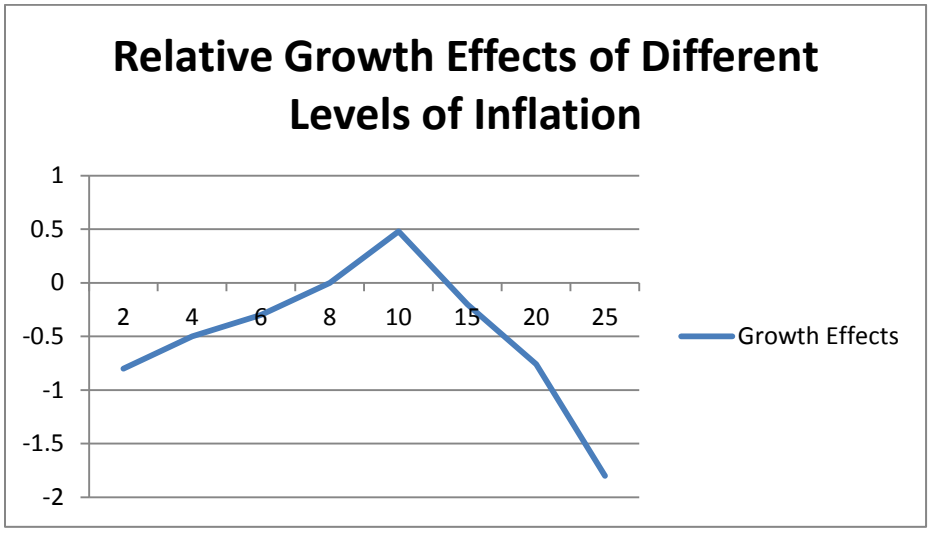
## 4. Results

The results for model 1 which assumes a simple linear relationship between inflation and growth are reported in Table 2. In the reference linear regression with fixed effects, it is found that a 1% increase in inflation rate leads to fall of 0.98% in the growth rate of the economy – a statistically significant result. In the second regression with controls – the controls being average life expectancy, logarithmic transformation of population growth, government expenditure, logarithmic transformation of terms of trade, log of GDP lagged by five years (to control for the catch-up effect), investment as a share of GDP, literacy rate, exchange rate – it is found with statistical significance that a 1% increase in inflation rate leads to a fall of 0.37% in the growth rate of the economy. For instance, the mean value of $\pi$ is 35%. So at the mean, going from 36% to 36.36% $\pi$ (an increase of 1%) lowers the growth rate from the mean of 2% to 1.63%. This is the interpretation of the effect of an increase in $\pi$ on growth in this paper and is reflected in all results.

As expected, an increase of 1 year in average life expectancy adds 0.4% to the growth rate of the economy and a 1% increase in the growth rate of the population leads to a fall of 0.423% in the growth rate of economy. Finally, as expected from the catch-up effect, a 1% increase in GDP per capita five years prior leads to a fall of 0.8% in the growth rate of the economy.

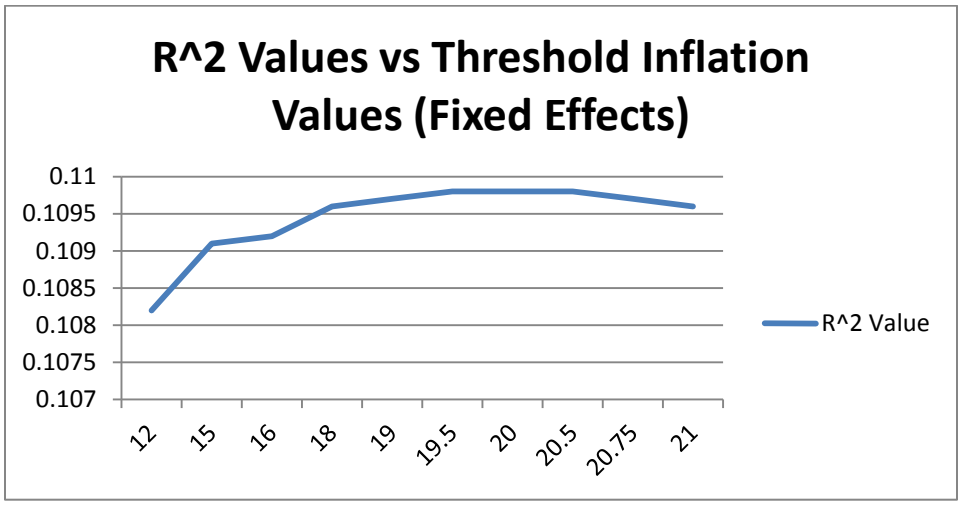
The results of regression 2 presented in Table 3 begin to show us the nonlinear relationship. The estimated coefficients of the variables representing the 7 inflation groups in Table 3 can be interpreted as the effect on growth of each of those groups relative to the $8^{th}$ inflation group (viz. the group where CPI is between 6% and 8%). Figure 3 below graphs the relative growth effects of different levels of inflation with the reference group of 6-8%.

**Figure 3**




Clearly one can see nonlinear inflationary growth effects. The coefficients against most of the groups are not statistically significant at the 5% except in the last group: CPI levels above 20%. This group has a difference in growth effects of 1.8% from the base group. As a result, Sarel's threshold estimation analysis is then conducted for the dataset as a whole. Using a fixed effects analysis, regression 3 was iterated multiple times with incrementally increasing values assigned to the $\pi^*$. Figure 4 shows the R^2 values for the regressions with the different values assigned to $\pi^*$ on the x-axis.

**Figure 4**



As already discussed, the values of $\pi^*$ which maximize R^2 represent the threshold inflation. From the chart above, R^2 is seen to be maximized for values of $\pi^*$ from 19.5% to 20.5%. Hence the threshold value for inflation is estimated to be 20% for the dataset as a whole and the effect of inflation on growth is estimated. The regression results are reported in Table 4. Substituting 20% into $\pi^*$, highinfl is calculated for each observation and model 3 is run for the entire dataset using country and year fixed effects. The results of this regression (regression (2)) are reported next to a reference regression (regression (1)) without the highinfl variable (which assumes a linear relationship between inflation and growth) and a reference regression without year and country fixed effects (regression (3)).

In regression (2), the coefficient on log($\pi$) represents the effect of inflation on growth below the threshold value and is found to be statistically insignificant. Hence an increase of 1% in $\pi$ for all values below $\pi^*$ has an insignificant effect on economic growth. The coefficient on highinfl is -2.6 and is statistically significant hence showing that the structural break at the threshold value is significant. The effect of $\pi$ on growth above $\pi^*$ is given by the sum of the coefficients on log($\pi$) and highinfl: -2.6 + 0.067= -2.533. Therefore a 1% increase in $\pi$ above the threshold value leads to a fall of 2.5% in growth rates that is statistically significant. The other significant effects found are those of life expectancy, government expenditure as a share of GDP, log(initial GDPcap) and log(pop growth). An increase of 1 year in average life expectancy leads to a 0.4% increase in the growth rate of GDP per capita. An increase of 1% in government expenditure as a share of GDP leads to 0.05% increase in the growth rate. A 1% increase in GDP per capita five years prior leads to a 0.7% fall in the growth rate, as is expected from the catch-up effect. A 1% increase in the population growth rate leads to a 0.42% fall in growth rate, as is expected from traditional neoclassical models.

Similar results are found when the regression is run without country and year fixed effects. The effect of π on growth rates is insignificant for values of π below π*. For values of π above π*, the effect is once again estimated by adding the coefficients on log(π) and highinfl: 0.16 – 3.3 = -3.14. Therefore a 1% increase in π leads to 3.1% fall in growth rates for high values of inflation.

The threshold estimation analysis is then conducted for low income countries, lower middle income countries, upper middle income countries, and high income countries. The graphs that show the R^2 values against the iterations of model 3 for different values of π* are shown below. Figure 6 shows the relationship for low-income countries, figure 7 for lower-middle income countries, figure 8 for upper-middle income countries, and figure 9 for high income countries.

**Figure 6**

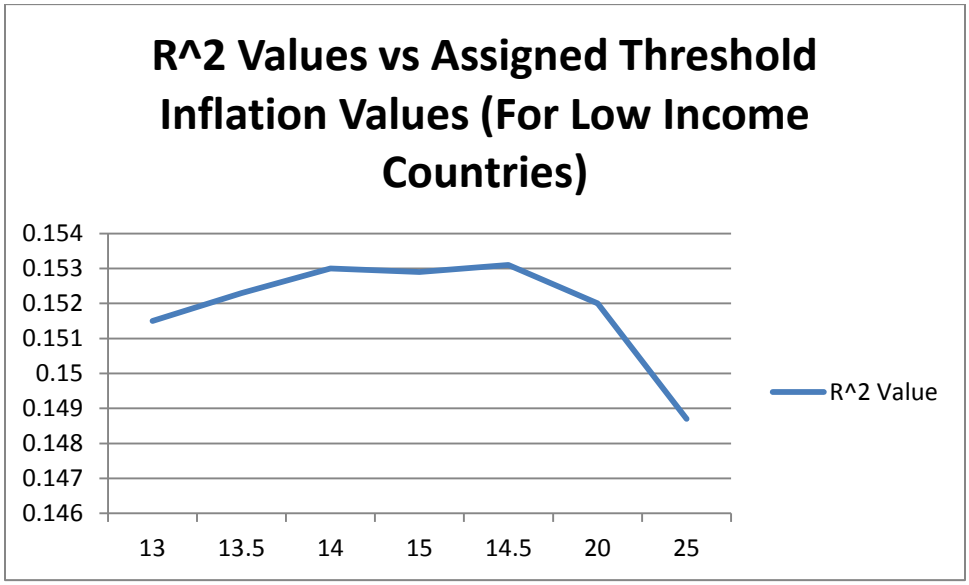


**Figure 7**

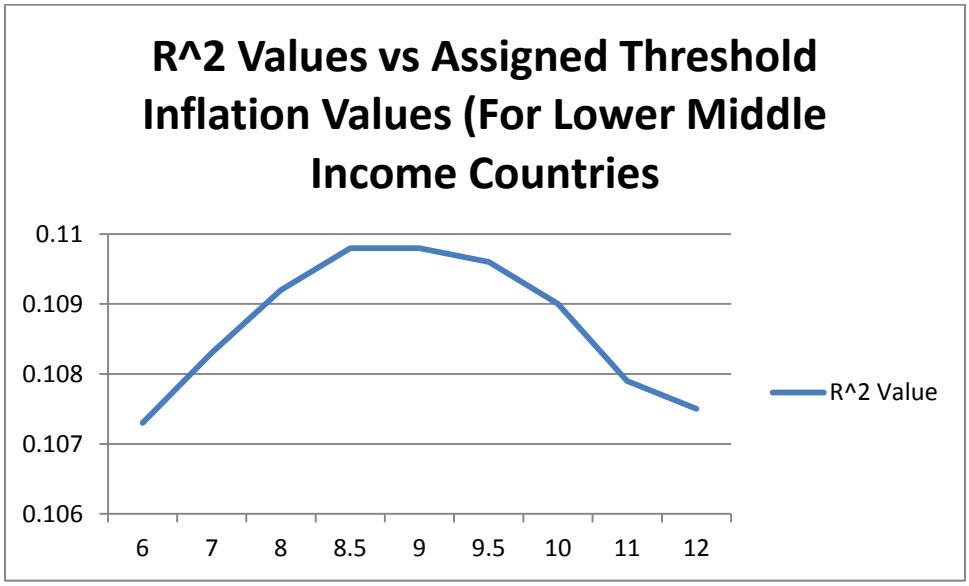



**Figure 8**

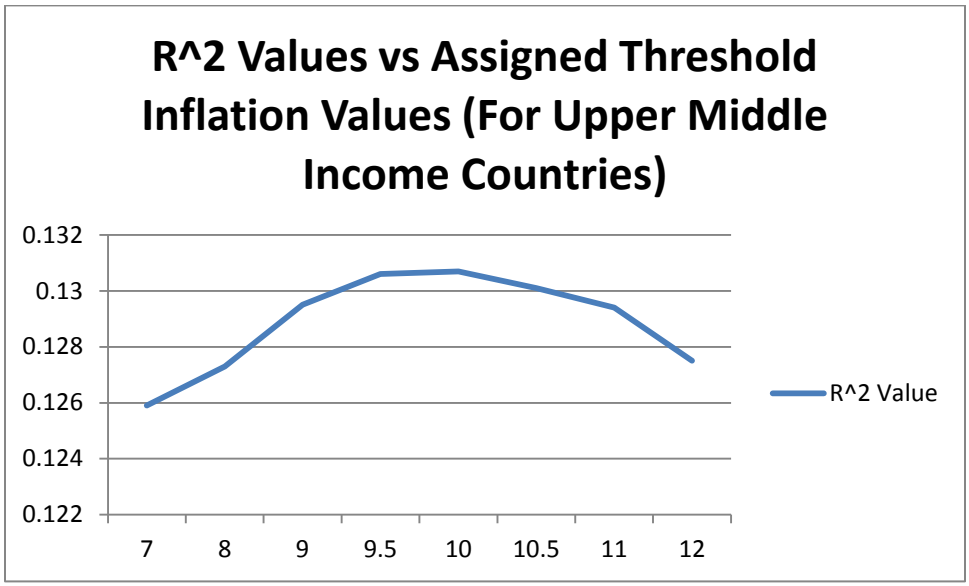
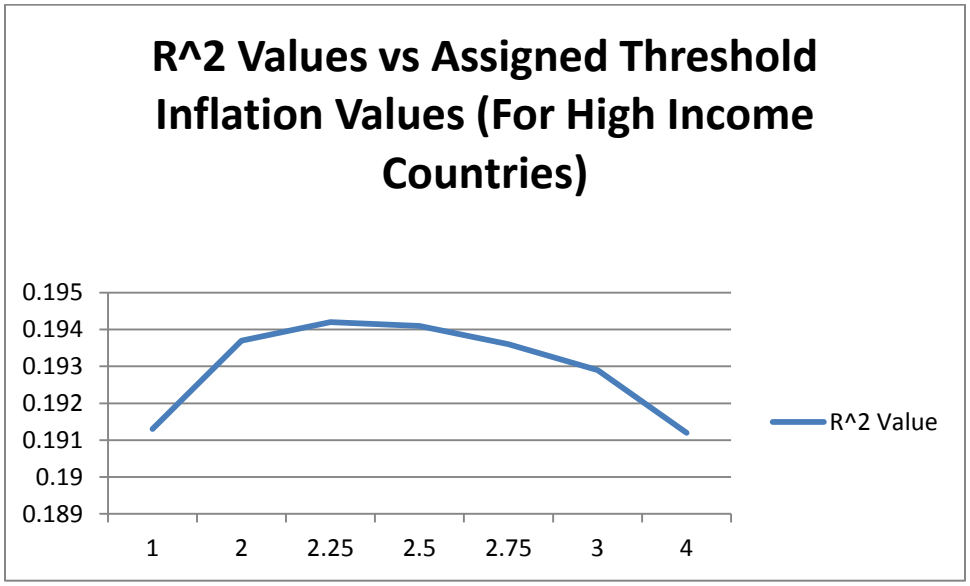


**Figure 9**




The threshold inflation values found from the points that maximize the R^2 values are as follows: 14.5% for low income countries, 9% for lower-middle income countries, 10% for upper-middle income countries, and 2.25% for high income countries. The regression in model 3 is then run for each subset of observations that fit into these respective groups using fixed effects analysis. The results are reported in Table 5 with regression (1) for low income countries, (2) for lower-middle income countries, (3) for upper-middle income countries, (4) for high income countries Once again, the coefficient on log(π) is found to be statistically insignificant in each of the four groups which means that for all values of π below π*, an increase of inflation has an insignificant effect on growth.

In the group of low-income countries, the coefficient on highinfl has a value of -2.81 and is statistically significant while the coefficient on log(π) has a value of 0.3 but is not significant. Hence for values of π below 14.5%, inflation has an insignificant effect. For values of π above 14.5%, the effect of inflation on growth is estimated by the sum of the coefficients on log(π) and highinfl: 0.3 – 2.81 = -2.51. Hence for inflation levels above 14.5%, a 1% increase in π leads to fall of 2.5% in the growth rate of GDP

per capita that is statistically significant. The other significant effects found are log(initGDPcap) – an increase of 1% in GDP per capita levels five years prior leads to a 0.5% fall in the growth rate – and government expenditure – an increase of 1% of government expenditure as a share of GDP leads to a 0.1% increase in the growth rate.

For lower-middle income countries, the coefficient on highinfl has a value of -2.34 and is statistically significant while the coefficient on log(π) has a value of 0.19 but is not significant. Hence for values of π below 9%, inflation has an insignificant effect. For values of π above 12%, the effect of inflation on growth is estimated by the sum of the coefficients on log(π) and highinfl: 0.19 – 2.34 = -2.15. Hence for inflation levels above 9%, a 1% increase in π leads to 2.15% fall in the growth rate that is statistically significant. The example outlined in the beginning of this paper, India, is classified as a lower-middle income country by the World Bank. The most recent CPI inflation rate in India for the month of March 2013 was found to be 10.39%[1] which is above the threshold value of 9%. Hence the Central Bank of India is justified in being hawkish about interest rates and keeping them high in the short run. On the other hand, the RBI's medium-term inflation target is 4-5% (Misra, 2012). Clearly this inflation target can be relaxed to some degree to enable greater economic activity and growth from the loosening of the monetary stance given that the threshold value for inflation is 9%.

For upper-middle income countries, the coefficient on highinfl has a value of -2.65 and is statistically significant while the coefficient on log(π) has a value of 0.3 but is not significant. For π values below 10%, inflation has an insignificant effect on growth rates. For π values above 8%, the effect of inflation on growth is estimated by the sum of the coefficients on log(π) and highinfl: 0.3 – 2.65 = -2.35. Hence for an increase of 1% in π for high values of inflation, there is a fall of 2.35% in the growth rate of the GDP per capita of the economy.

[1] http://mospi.nic.in/mospi_new/upload/t4.pdf

For high-income countries, the coefficient on highinfl has a value of -0.9 and is statistically insignificant while the coefficient on log(π) has a value of -0.18 and is statistically insignificant. Hence for high income countries, the structural break is not statistically significant and no clear statement can be made about the effect of inflation on growth.

Interestingly inflation values above the threshold are most pernicious for low income countries and least pernicious for lower-middle income countries in terms of their effect on growth rates. Since there are "developing nations" like Chad that fall into the former category and "developing nations" like India that fall into the latter category, these results are particularly interesting. This is especially true in light of a variety of research that even attempts to offer policy prescriptions uniformly across all "developing nations". For instance, Bick (2010) claims that developing nations are characterized by certain regime types which determine the pernicious growth effects of allowing inflation rates to rise above the threshold. Bick's analysis does not allow for the fact that developing nations at different levels of income will suffer different consequences for going above the threshold value of inflation as shown by this paper. Pernicious growth effects for breaching threshold inflation in upper-middle income countries are in between the effects for low-income and lower-middle income countries. "Developing nations" like China fall into this category. Hence these results show that there are different threshold values inflation and pernicious growth effects of breaching the threshold for different types of developing nations.

The threshold estimation analysis is then conducted for the second categorization, viz. slow-growing and fast-growing countries. This is done because there are some developing nations growing very fast such as China or India, and some developing nations which are growing very slowly such as Yemen and Gambia. By controlling for initial GDP per capita five years prior, these results are able to control for the income effects that have been shown above to explain some inflation-growth trends.

Hence controlling for income level, the threshold values of inflation for slow-growing countries and fast-growing countries are calculated. The graphs that show the R^2 values against the iterations of model 3 for different values of π* are shown below. Figure 10 shows the relationship for slow-growing countries and figure 11 for fast-growing countries.

**Figure 10**

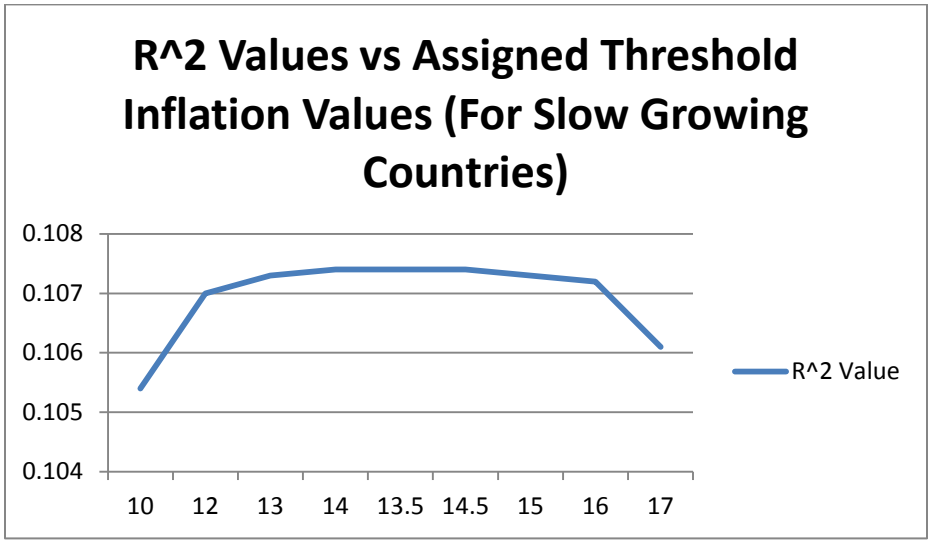
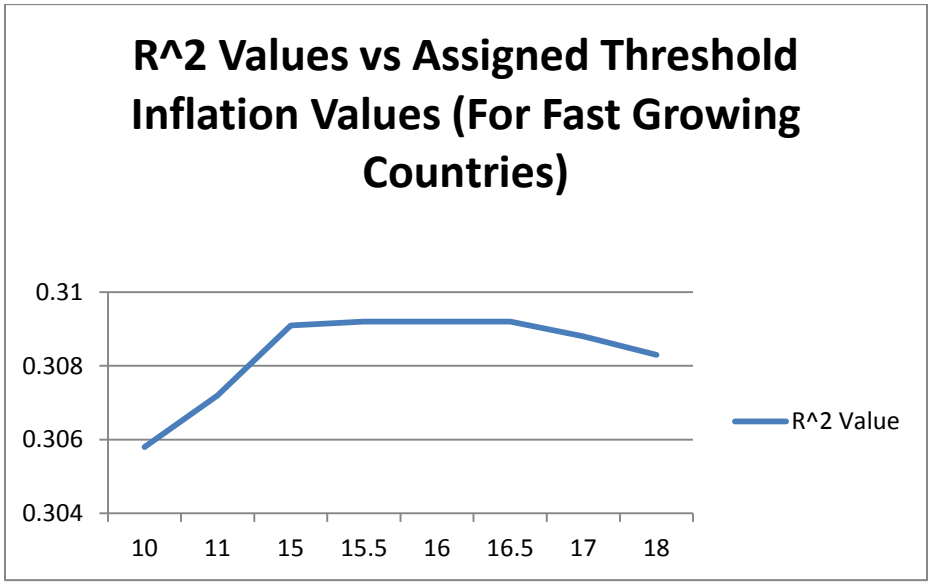



**Figure 11**



The threshold inflation values found from the points that maximize the R^2 values are as follows: 14% for slow-growing countries and 16% for fast-growing countries. The regression in model 3 is then run for each subset of observations that fit into these respective groups using fixed effects analysis. The results are reported in Table 6. Once again, the coefficient on log(π) is found to be statistically insignificant in each of the two groups. For fast-growing countries, the coefficient on highinfl is -0.047 and is statistically significant. Hence the growth effects of π above the threshold of 16% are significantly negative to the tune -4.7 - 0.06 = -4.76, or a fall of 4.7% in growth rates for every increase of 1% in π. For slow-growing countries, the coefficient on highinfl is -2.04 and is statistically significant. The growth effects of π above the threshold of 14% are significantly negative to the tune of 0.11 - 2.04 = -1.93, or a fall of 1.93% for every increase of 1% in π.

These results show that the pernicious growth effects of inflation above the threshold are more pronounced for fast-growing countries than for slow-growing countries, perhaps because the former are also starting off at a lower level of income and hence their productivity levels are more sensitive to high inflation; or perhaps because fast-growing countries have additional feedback complications as pointed out by Mallik & Chowdhury (2001).

## 5. Conclusions

This paper has analyzed the inflation-growth nexus assuming nonlinear effects using data for 214 countries from 1990-2011. A structural break of 20% in the average annual rate of inflation was found for the dataset as a whole, so inflation rates below this had an insignificant effect on growth while inflation rates above this threshold had a significantly negative impact on growth. The set of countries was then divided by the income categorizations of the World Bank. It was found that low-income countries had an inflation threshold of 14.5% that was statistically significant, lower middle-income countries had an inflation threshold of 9% that was statistically significant, upper-middle income

countries had an inflation threshold of 10% that was statistically significant, and high income countries had an inflation threshold of 2.25% that was not statistically significant. These thresholds mirror the results in earlier research. The set of countries was finally divided into fast-growing countries and slow-growing countries. It was found that fast-growing countries had an inflation threshold of 16% while slow-growing countries had an inflation threshold of 14%, both of which were statistically significant. The pernicious effects of excess inflation on economic growth were measured for different conceptions of “developing” and “developed” nations and very interesting results were found.

The empirical results of this paper tell us that price stability doesn’t have to be a noose around central banks attempting to make monetary policy to enable growth in the economy. There are many levels of inflation that have been found to have little effect on economic growth; in some cases even a weakly positive effect on growth. But the threshold levels of inflation where the structural break occurs are significant and hence central banks should use their policy tools (including interest rates) to ensure that inflation levels stay below the threshold. Many central banks around the world have settled on really low inflation targets, from 2-5%, with no regard for the economic context of their country. This was primarily because of the orthodoxy of price stability and central bank independence coming out of the hyperinflation scares of the 1980s and empirical literature like Barro (1991) which assumes a linear relationship between inflation and growth. Such low inflation targets lead to unnecessary monetary tightening and drying up of economic activity. Central banks would be justified in monetary easing and even working with the government to spur economic growth given the high inflation thresholds that have been found in this research.

**TABLES**

**Table 1 (Summary Statistics)**

| **Summary Statistics** | | | | | |
|---|---|---|---|---|---|
| Variable | N | Mean | Std. Dev | Min | Max |
| CPI | 3576 | 35.99195 | 461.4123 | -16.1173 | 23773.13 |
| GDP per capita | 4182 | 7637.349 | 12138.25 | 54.50519 | 108111.2 |
| Government Expenditure | 3727 | 139.3354 | 1444.367 | 29.18065 | 63368.5 |
| GDP growth | 4188 | 2.008984 | 6.158349 | -50.2904 | 92.58597 |
| Population growth | 4683 | 1.507385 | 1.581731 | -10.9552 | 18.58832 |
| Life expectancy | 4184 | 66.85974 | 10.44224 | 26.81871 | 83.15938 |
| GDP Initial levels | 3982 | 6538.727 | 10212.82 | 127.8881 | 70463.66 |
| δ(Terms of Trade) | 2817 | -3.19E+11 | 1.64E+13 | -7.02E+14 | 3.45E+14 |

**Table 2 (Model 1 Results)**

| **Dependent Variable: dlog(GDPcap)** | (1) | | (2) |
|---|---|---|---|
| Log(CPI) | -0.98*** | | -0.37*** |
| Standard Errors | 0.08 | | 0.13 |
| Life expectancy | | | 0.4*** |
| Standard Errors | | | 0.07 |
| dLog(popn growth) | | | -0.423* |
| Standard Errors | | | 0.253 |
| Govt expenditure | | | 0.05*** |
| Standard Errors | | | 0.01 |
| dLog (δ(Terms of Trade)) | | | 0.0002 |
| Standard Errors | | | 0.0004 |
| Log(initialGDPcap) | | | -0.8*** |
| Standard errors | | | 0.03 |
| | | | |
| Year Fixed Effects | Yes | | Yes |
| Country Fixed Effects | Yes | | Yes |
| R-Sq | 0.0428 | | 0.0860 |
| Number of Observations | 3150 | | 1563 |

Notes: 1) *** represents significance at the 1% level, ** represents significance at the 5% level, * represents significance at the 10% level.

2) The dependent variable for all regressions is dLog(GDPcap)

3) Standard errors reported are all robust

4) The variables dLog(GDPcap), dLog(popn growth), dLog(δ(Terms of Trade)) are logarithmic transformations as outlined in the paper

5) Additional controls included are investment/GDP, literacy rate, exchange rate, savings rate

**Table 3 (Model 2 Results)**

| **Dependent Variable dlog(GDPcap)** | **(1)** |
|---|---|
| Life expectancy | 0.12* |
| Standard Errors | 0.06 |
| dLog(popn growth) | -1.06*** |
| Standard Errors | 0.195 |
| Govt expenditure | 0.03*** |
| Standard Errors | 0.01 |
| dLog (δ(Terms of Trade)) | -0.0002 |
| Standard Errors | 0.0004 |
| Log(Initial GDP) | -0.67*** |
| Standard Errors | 0.07 |
| CPI<=2 | -0.8 |
| Standard Errors | 2.24 |
| CPI>2 and CPI <=4 | -0.5 |
| Standard Errors | 0.4 |
| CPI>4 and CPI<=6 | -0.3 |
| Standard Errors | 0.4 |
| CPI>8 and CPI<=10 | 0.48 |
| Standard Errors | 0.46 |
| CPI>10 and CPI<=15 | -0.2 |
| Standard Errors | 0.5 |
| CPI>15 and CPI<=20 | -0.76 |
| Standard Errors | 0.6 |
| CPI>20 | -1.8*** |
| Standard Errors | 0.5 |
| | |
| Year Fixed Effects | Yes |
| Country Fixed Effects | Yes |
| R-Sq | 0.0844 |
| Number of Observations | 1776 |

Notes: 1) *** represents significance at the 1% level, ** represents significance at the 5% level, * represents significance at the 10% level.

2) The dependent variable for all regressions is dLog(GDPcap)

3) Standard errors reported are all robust

4) The variables dLog(GDPcap), dLog(popn growth), dLog(δ(Terms of Trade)) are logarithmic transformations as outlined in the paper

5) Additional controls included are investment/GDP, literacy rate, exchange rate, savings rate

**Table 4 (Model 3 Results for entire dataset)**

| **Dependent Variable dlog(GDPcap)** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Log(CPI) | -0.37*** | 0.067 | 0.16 |
| Standard Errors | 0.12 | 0.15 | 0.12 |
| Life expectancy | 0.4*** | 0.27*** | 0.062*** |
| Standard Errors | 0.07 | 0.07 | 0.02 |
| dLog(popn growth) | -0.423* | -0.538** | -0.642*** |
| Standard Errors | 0.253 | 0.25 | 0.114 |
| Govt expenditure | 0.05*** | 0.05** | -0.02**** |
| Standard Errors | 0.01 | 0.01*** | 0.007 |
| dLog (δ(Terms of Trade)) | -0.0002 | -0.0002 | 0.00007 |
| Standard Errors | 0.0003 | 0.0003 | 0.0004 |
| Log(Initial GDP) | -0.8*** | -0.72*** | -0.84*** |
| Standard Errors | 0.08 | 0.08 | 0.12 |
| Highinfl | | -2.57*** | -3.3*** |
| Standard Errors | | 0.4 | 0.4 |
| | | | |
| Year Fixed Effects | Yes | Yes | No |
| Country Fixed Effects | Yes | Yes | No |
| | | | |
| R-Sq | 0.0860 | 0.1098 | |
| Number of Observations | 1563 | 1563 | |

Notes: 1) *** represents significance at the 1% level, ** represents significance at the 5% level, * represents significance at the 10% level.

2) The dependent variable for all regressions is dLog(GDPcap)

3) Standard errors reported are all robust

4) The threshold inflation value is 20%

5) The variables dLog(GDPcap), dLog(popn growth), dLog(δ(Terms of Trade)) are logarithmic transformations as outlined in the paper

6) Additional controls included are investment/GDP, literacy rate, exchange rate, savings rate

**Table 5 (Model 3 results for different income groups)**

| **Dependent Variable log(growth)** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Log(CPI) | 0.3 | 0.19 | 0.3 | -0.18 |
| Standard Errors | 0.33 | 0.3 | 0.5 | 0.33 |
| Life expectancy | 0.13 | 0.34** | -0.4 | 0.3 |
| Standard Errors | 0.12 | 0.17 | 0.4 | 0.2 |
| dLog(popn growth) | -0.182 | -1.295** | -0.992 | -0.27 |
| Standard Errors | 0.593 | 0.579 | 0.734 | 0.337 |
| Govt expenditure | 0.11*** | 0.0146 | 0.2*** | -0.008 |
| Standard Errors | 0.02 | 0.03 | 0.05 | 0.02 |
| dLog (δ(Terms of Trade)) | -0.0007 | -0.0005 | 0.0019 | 0.0002 |
| Standard Errors | 0.001 | 0.0005 | 0.0013 | 0.0005 |
| Log(Initial GDP) | -0.51*** | -0.71*** | -0.495 | -1.26*** |
| Standard Errors | 0.17 | 0.19 | 0.38 | 0.23 |
| Highinfl | -2.81*** | -2.34*** | -2.65** | -0.9 |
| Standard Errors | 0.73 | 0.5 | 1.08 | 0.7 |
| | | | | |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Country Fixed Effects | Yes | Yes | Yes | Yes |
| | | | | |
| R-Sq | 0.1531 | 0.1098 | 0.1307 | 0.1942 |
| Number of Observations | 427 | 490 | 261 | 385 |

Notes: 1) *** represents significance at the 1% level, ** represents significance at the 5% level, * represents significance at the 10% level

2) The dependent variable for all regressions is dLog(GDPcap)

3) Standard errors reported are all robust

4) Regression (1) is for low income countries, (2) is for lower-middle income countries, (3) is for upper-middle income countries, (4) is for high income countries

5) Threshold value of inflation is 14.5% for low income countries, 9% for lower-middle income countries, 10% for upper-middle income countries, and 2.25% for high income countries

6) The variables dLog(GDPcap), dLog(popn growth), dLog(δ(Terms of Trade)) are logarithmic transformations as outlined in the paper

7) Additional controls included are investment/GDP, literacy rate, exchange rate, savings rate

**Table 6 (Model 3 results for countries growing at different rates)**

| **Dependent Variable dLog(GDPcap)** | **(1)** | **(2)** |
|---|---|---|
| Log(CPI) | -0.06 | 0.11 |
| Standard Errors | 0.6 | 0.15 |
| Life expectancy | 1.04*** | 0.16** |
| Standard Errors | 0.4 | 0.07 |
| Log(popn growth) | .5 | -0.605** |
| Standard Errors | 1.1 | 0.253 |
| Govt expenditure | -0.06 | 0.08*** |
| Standard Errors | 0.05 | 0.01 |
| Log (δ(Terms of Trade)) | 0.001 | -0.0002 |
| Standard Errors | 0.002 | 0.0003 |
| Log(Initial GDP) | -0.84*** | -0.72*** |
| Standard Errors | 0.21 | 0.089 |
| Highinfl | -4.7*** | -2.04*** |
| Standard Errors | 1.8 | 0.4 |
| | | |
| Year Fixed Effects | Yes | Yes |
| Country Fixed Effects | Yes | Yes |
| R-Sq | 0.3092 | 0.1074 |
| Number of Observations | 145 | 1418 |

Notes: 1) *** represents significance at the 1% level, ** represents significance at the 5% level, * represents significance at the 10% level.

2) The dependent variable for all regressions is dLog(GDPcap)

3) Standard errors reported are all robust

4) Regression (1) is for fast growing countries, (2) is for slow-growing countries

5) Threshold value of inflation is 16% for fast growing countries and 14% for slow growing countries

6) The variables dLog(GDPcap), dLog(popn growth), dLog(δ(Terms of Trade)) are logarithmic transformations as outlined in the paper

7) Additional controls included are investment/GDP, literacy rate, exchange rate, savings rate

**References:**

Barro, Robert J. 1991. "Economic Growth in a Cross Section of Countries". *Quarterly Journal of Economics*. Vol. 106 (May), pp. 407-43.

Barro, Robert J. 1995. “Inflation and Economic Growth”. *NBER Working Papers Series*: No. 5326.

Bick, Alexander. 2010. “Threshold effects of inflation on economic growth in developing countries”. *Economics Letters.* Vol. 108, No. 2, pp 126-129.

Bruno, M., & Easterly, W. (1998). “Inflation crises and long-run growth”. *Journal of Monetary Economics*, Vol. 41, pp 3–26.

Burdekin, R.C.K., Denzau, A.T., Keil, M.W., Sitthiyot, T. & Willett, T.D. (2004). “When Does Inflation Hurt Economic Growth? Different Non-linearities for Different Economies”. *Journal of Macroeconomics*. Vol. 26, pp 519–532.

De Gregorio, José, 1992, “Effects of Inflation on Economic Growth: Lessons from Latin America,” *European Economic Review*, Vol. 36 (April), pp. 417–25.

Fischer, Stanley. 1993. "The Role of Macroeconomic Factors in Growth". *Journal of Monetary Economics.* Vol. 32 (December), pp. 485-512.

Ghosh, Atish, and Steven Phillips. 1998. “Warning: Inflation May Be Harmful to Your Growth”. *IMF Staff Papers*, International Monetary Fund, Vol. 45, No. 4, pp. 672–710.

Ghosh, Atish. 2000. “Inflation and Growth”. *IMF Research Bulletin*. Vol. 1, pp. 1–3.

Loungani, Prakash and Nathan Sheets. 1997. “Central bank independence, inflation, and growth in transition economies”. *Journal of Money, Credit and Banking.* Vol 29, no 3, pp 381-399.

Khan, M. S., & Senhadji, A.S. 2001. “Threshold Effects in the Relationship Between Inflation and Growth,” *IMF Staff Papers*. Vol. 48, pp 1–21.

Mallik, Girjiasankar and Anis Chowdhury. 2001. “Inflation and Economic Growth: Evidence from Four South Asian Countries”. *Asia-Pacific Development Journal.* Vol. 8, no. 1, pp 123-135.

Mohanty, Deepak, A B Chakraborty, Abhiman Das, and Joice John. 2011. “Inflation Threshold in India: An Empirical Investigation”. *RBI Working Paper Series.* Vol. 18 (September).

Polillo, Simone and Mauro F. Guillen. “Globalization Pressures and the State: The Worldwide Spread of Central Bank Independence”. *American Journal of Sociology. Vol.* 110, no. 6, pp 1764-1802.

Pollin, R., & Zhu, A. (2006). “Inflation and Economic Growth: A Cross-Country Non-linear Analysis,” *Journal of Post Keynesian Economics*, Vol. 28, 593–614.

Rodrik, Dani. 2008. “Second-Best Institutions”. *NBER Working Papers.* Working Paper no 14050. Available online at http://www.immagic.com/eLibrary/ARCHIVES/GENERAL/NBER_US/N080603R.pdf

Sarel, M. (1996). “Non-linear effects of inflation on economic growth”. *IMF Working Staff Papers*, Vol. 43, 199–215.

Sbordone, Argia and Kenneth Kuttner. 1994. "Does Inflation Reduce Productivity?" Economic Perspectives, Vol. 18 (November - December), pp. 2-14.

Smyth, David J. 1994. "Inflation and Growth," *Journal of Macroeconomics*, Vol. 16 (Spring), pp. 261-70.