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THE NON-LINEAR RELATIONSHIP BETWEEN INFLATION AND ECONOMIC GROWTH

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1. Introduction

Economic growth refers to an increase in a country's real Gross Domestic Product (GDP) over time. According to the World Bank (2023), the global average economic growth rate was 2.6% in 2022.

Inflation, on the other hand, is defined as a sustained increase in the general price level of goods and services in an economy over a period of time. The International Monetary Fund (2023) reports that the average inflation rate for advanced economies was 1.7% in 2022.

The relationship between inflation and economic growth is complex and multifaceted. According to a study by the Organisation for Economic Co-operation and Development (OECD, 2023), there is a positive relationship between low and stable inflation and strong economic growth, while high inflation can lead to lower economic growth.

Threshold effects in the relationship between inflation and economic growth refer to the idea that there is a certain level of inflation beyond which further increases in inflation have a negative effect on economic growth.

1.1. Motivation

The study of the relationship between economic growth and inflation is important for policymakers, as it can provide valuable insights into how to promote sustainable economic development. Understanding the threshold effects in this relationship is crucial for policymakers as it can help them determine the optimal level of inflation that will not only control price stability but also support economic growth.

Moreover, the relationship between inflation and economic growth has important implications for the well-being of citizens, as economic growth leads to increased job opportunities and higher living standards, while high inflation can erode purchasing power and reduce economic stability.

Therefore, by studying the relationship between inflation and economic growth, as well as the threshold effects in this relationship, policymakers can make informed decisions to achieve their economic goals and improve the standard of living for their citizens.

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It is considered a highly debatable issue. Despite the fact that many studies have been carried out on the current topic there is a space for econometric investigation of the non-linear relationship between inflation and economic growth of all 217 countries (selected by World Bank as of 2023).

1.2. Objectives

The objective of this paper is to empirically investigate the non-linear relationship between inflation and economic growth of all 217 countries by Quadratic Regression model using panel data and to find out the threshold level of inflation.

1.3. Literature review

Several researchers examined on this issue. Asaduzzaman (2021) determined non-linear relationship between inflation and economic growth in Bangladesh by OLS method using time series annual data covering the sample period from 1980 to 2017 and found that threshold level of inflation was 7.84% at which the economic growth of Bangladesh was in peak position.

Furthermore, Tarawalie and Kamara (2022) studied the relationship between inflation and economic growth, and determined the threshold level of inflation in Sierra Leone, using a non-linear model with time-series data from 1980 to 2020. They found that there was the presence of a non-linear relationship in the inflation-growth nexus and the threshold level of inflation favorable for economic growth was 10.3%.

Moreover, Azam and Khan (2022) empirically investigated the threshold effect of inflation on economic growth for 27 countries (16 developing and 11 developed economies) over 1975–2018. They showed a significant negative association between inflation and growth above the threshold level of inflation which was 12.3% in developing economies; was 5.4% in developed economies.

In addition, the effects of government effectiveness, credit to private sector, school enrolment and FDI on economic growth have been studied by many researchers.

Anyanwu (2014) determined the positive significant effects of government effectiveness and school enrolment on economic growth using cross-sectional data from 53 African countries between 1996 and 2010.

Additionally, Nistor (2014) found the positive significant effect of FDI on economic growth in Romania using time series annual data for the period from 1980 to 2017.

2. Methodology

To examine the non-linear relationship between inflation and economic growth of all 217 countries using panel data over the period 1997-2021, and to estimate threshold level of inflation I will use the following quadratic model:

$$y_{it} = \beta_0 + \beta_1 inf_{it} + \beta_2 sq\_inf_{it} + other\ control\ variables + \varepsilon$$

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where, y_{it} – gross domestic product growth (GDP), inf_{it} – inflation representing the annual percentage change of the Consumer Price Index (CPI), sq_inf_{it} – the square of inflation, i – 1,2,3,…217 countries, t – 1997,1998,…,2021 years and ε – error term.

As control variables I will use the following variables: government effectiveness, credit to private sector, school enrolment and FDI.

- "fdi" - Foreign Direct Investment (FDI). It refers to the investment made by a foreign entity into a domestic company or establishment, either through the acquisition of a stake in the company or through the establishment of a new business in the domestic market. It is considered a control variable for economic growth because it can bring capital, technology, and job creation to a country. As stated by World Bank (2023), FDI can play a significant role in promoting economic growth and development. It can provide access to capital, technology, and new markets, which can improve the competitiveness of domestic businesses and promote job creation. Besides, Nistor (2014) showed that it had the positive significant effect of FDI on economic growth.

- "hc" - School enrolment. It is considered a control variable for economic growth because it has a direct impact on the human capital development of a country. As reported by the World Bank (2023), the quality and quantity of education are key determinants of economic growth. Higher levels of school enrolment can lead to increased human capital development, which can result in improved productivity and innovation. In addition, Anyanwu (2014) found that it had a positive significant impact on economic growth.

- "credit" - Credit to private sector. It refers to the flow of financing from banks and financial institutions to businesses and households in the form of loans, mortgages, and other forms of credit. It is considered a control variable for economic growth because it can have a significant impact on the level of investment and consumption in an economy. As indicated by (2023), access to credit is a crucial factor in promoting economic growth. It allows businesses to invest in new projects and expand their operations, which drives job creation and increases productivity. It also enables households to finance their consumption and investment in education and housing, which boosts overall economic activity.

- "gov_eff" - Government effectiveness. It refers to the ability of a government to formulate and implement policies and regulations that promote economic growth and development. It is considered as a control variable for economic growth because it has a significant impact on the ability of a country to achieve sustainable and inclusive economic growth. According to the World Bank (2023), government effectiveness is a crucial factor in determining the level of economic growth in a country. An effective government can create a favorable business environment by reducing corruption, ensuring property rights, and promoting competition. This can lead to increased investment, innovation, and job creation, which drives economic growth. Based on the finding of Anyanwu (2014) it had a positive significant impact on economic growth.

Hence, the model I will use as follows:

$$y_{it} = \beta_0 + \beta_1 inf_{it} + \beta_2 sqr\_inf_{it} + \beta_3 fdi_{it} + \beta_4 hc_{it} + \beta_5 credit_{it} + \beta_6 gov\_eff_{it} + \varepsilon$$

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Data on both dependent and independent variables are gathered from the available cite https://databank.worldbank.org/source/world-development-indicators# and data descriptive is shown table 1 (appendix).

3. Results

3.1.Estimation tests

In general, the following section highlights some prior insight of those included variables in the models and the results of specific empirical techniques to address the appropriate models as stated in the previous section.

Moving on to the detection of heteroskedasticity, the absence of the following condition Vj (ε)= for all j in the panel data, Breusch-Pagan / Cook-Weisberg can be applied. According to the results of test (see table 2 Appendix), there is sufficient evidence to confirm the presence of heteroskedasticity as seen significant p-value of the test. It affirms the null hypothesis refers to constant variances across the panel, which is not desirable for all econometric analyses. It may lead to deriving biased standard errors of the coefficients.

Another specific test to be considered is Wooldridge test for autocorrelation in panel data or Cumby-Huizinga test for q-ordered autocorrelation. The reason why there is a need to apply this test is that serial correlation (also called autocorrelation) may result in a number of issues in terms of estimation. For example, it may lead to the standard errors of the coefficients to be smaller or larger than they actually are. At the same time, it may cause regression coefficients to be statistically significant when they actually are not. When it is tested against autocorrelation, it is found that there is evidence at 5% significance level to confirm the presence of autocorrelation as shown table 3 (appendix).

For simplicity at this level, we have not applied any specific panel models, instead running simple pooled OLS. Therefore, to relax the presence of heteroskedasticity we presented the regression results with robust option.

3.2.Discussion of empirical results

The following tables indicate the corresponding coefficients of each regressor included in the model and their robust standard errors in the parentheses. Significance levels are depicted by the stars, * p<0.1, ** p<0.05, *** p<0.01 respectively.

	(1)	(2)
VARIABLES	I	II (robust std. e)
inf	0.0606***	0.0635***

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	(0.00978)	(0.00965)
sqr_inf	-0.000870***	-0.000892***
	(0.000170)	(0.000173)
fdi	0***	0***
	(0)	(0)
hc	0.0279***	0.0272***
	(0.00188)	(0.00184)
credit	0.00732***	0.00716***
	(0.00150)	(0.00149)
gov_eff	0.00383*	0.00455**
	(0.00211)	(0.00203)
Time	-0.0105	
	(0.00647)	
Constant	43.75***	22.59***
	(13.02)	(0.0895)
Observations	2,137	2,137
R-squared	0.409	0.408

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Before turning to the discussion of findings, it is highly essential to note that the interpretations of the obtained results will be based OLS estimation technique as evaluated their appropriateness it in the previous part. Overall, it is important to highlight some general features of the constructed model. The variables included in the model as regressors explains around 41% variation in GDP.

Following the objective of the study, it is plausible to note the impact of inflation on GDP. As seen by the table, we report the evidence for a non-linear effect of inflation on the regressand.

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This is evident from the significance of the associated coefficients of inflation rate and squared inflation. Calculating the threshold based on the formula below, we may derive the value of threshold is equal to about 34,8% meaning that the impact of inflation of GDP is positive until the point where the rate of inflation is below the threshold.

$$infl^* = -\frac{\beta_1}{2\beta_2} = \frac{0.0606}{2 * (-0.000870)} = 34{,}8\%$$

However, as the rate of inflation increases beyond 34,8%, then its impact becomes negative. It implies the fact that a higher rate of inflation (beyond moderate rate of inflation to hyper-inflation) severely affects the activity of the economy, namely the transaction. It could be somehow explained by the loss of investment confidence during the course of high inflation.

Moving on the discussion of control variables, as confirmed with significant corresponding p-values in the table above, there is statistically sufficient evidence to conclude that the impact of human capital on GDP is significant and positive. Namely, 1% increase of unitary schooling coverage is found to lead to 2.7% rise in real GDP level. In fact, our results do correspond with the result of Anyanwu (2014).

Another determinant of GDP, foreign direct investment is also estimated to positively affect GDP at 1% significance level. In particular, it was found that inflow of FDI at amount of $1 billion into host economy on average keeping other factors constant resulted in 1.39% increase real GDP during the analyzed period. Expectedly, our findings highly confirm the positive relationship between FDI and GDP in the same line with other studies such as Nistor (2014).

Hypothetically, as a proxy for the quality of institution, the government effectives should be positively correlated with GDP. The results of this study also found the evidence to support it at 5% significance level.

The last but not the least, crediting economy was also estimated to contribute real GDP. In particular, the increase of private credit stock ratio to GDP by 1% unit was found to lead 0.7% rise in real GDP during the period of the estimation.

In short, the study found a significant non-linear effect of inflation real GDP. Besides, we also found the evidence to reclaim that human capital, FDI, institutional quality and crediting the economy have been also important determinants for GDP growth.

4. Potential sources of bias

One can be acknowledged that every econometric model is not possibly free from deriving bias estimates. It could happen due to a number of reasons ranging from estimations techniques used.

Turning to the potential sources of bias that can appear in our empirical work, the first source might be the heterogeneity bias that occurs when there is a noticeable association between country-specific fixed effects and explanatory variables. This bias, in turn, might cause to derive inconsistent pooled OLS estimates. In this case, the use of the Fixed-effect model can address the underlying issue.

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The second potential issue could be the endogeneity problem that arises owing to the possible relationship between independent variables and error terms. This issue also causes to led inaccurate and biased estimates of Fixed-effects models. Employing the GMM model (Arellano-Bond, 1991) or two-step GMM in our research work might solve the issue to some extent.

However, it is beyond the scope of the course so far.

Appendix

Table 1. Data Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
country	5425	109	62.648	1	217
year	5425	2009	7.212	1997	2021
gdp	5028	3.153e+11	1.398e+12	25909153	2.053e+13
ln gdp	5028	23.902	2.359	17.07	30.653
inf	4412	7.077	26.575	-10.067	1058.374
fdi	4868	8.681e+09	3.538e+10	-3.444e+11	7.338e+11
hc	3038	36.57	27.357	.092	150.876
credit	3734	49.209	43.691	0	304.575
gov eff	4337	49.054	28.904	0	100

Table 2.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of ln_gdp

chi2(1) = 25.21

Prob > chi2 = 0.0000

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Table 3.

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 150) = 1618.638
Prob > F = 0.0000

Table 4.

Variable	VIF	1/VIF
inf	3.12	0.320773
sqr_inf	2.81	0.355948
gov_eff	2.52	0.396387
credit	2.35	0.425393
hc	1.81	0.552753
fdi	1.15	0.867687
Mean VIF	2.29	

Table 5.

Jarque-Bera normality test: 5.254 Chi(2) .0723
Jarque-Bera test for Ho: normality:

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