Core Inflation and Economic Growth, Does Nonlinearity Matters? A Nonlinear Granger Causality Analysis

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Abstract

This empirical analysis endeavors to trace out the causal nexus between core inflation and economic growth from the perspective of twenty worlds' leading economy with the help of the nonlinear Granger causality approach by using time series data from 1981 to 2016. Based on nonlinear Granger causality results, it has been found that there is unidirectional casualty running from core inflation to economic growth in Belgium, Denmark, Franc, Greece, India, Norway, and Portugal as well as Sweden. In these countries, core inflation is causing economic growth. As per as Australia, Canada, Germany, Greece, Japan, New Zealand, Portugal, Sweden, Switzerland, and the United Kingdom is concerned the outcome of causality analysis documents that there is unidirectional causality running from economic growth towards the core inflation. Finally, the analysis also manifests that there is no causality running from core inflation towards the economic growth and vice-versa in Ireland, Israel, Netherlands, and Spain.
Keywords: Core Inflation, Nonlinear Causality, Economic Growth, Inflation and GDP Growth.
JEL Classification: E30, E31.

1. Introduction

Inflation has become a debatable issue in the dynamic and complex economic environment. Each nation's macroeconomist concerned for the low or moderate level of inflation. Domestic inflation reflects domestic monetary policy[3]. Policymakers always wish to maintain inflation at a low level with high GDP growth. It is because a high level of inflation

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3. Martin Feldstein. Retrieved from
https://www.brainyquote.com/quotes/martin_feldstein_333332.

disrupts the smooth functioning of a market economy (Krugman, 1995). There is much research has done on the topic related to inflation and economic growth. If we look at the studies of the above topic, we will find that there is no consensus about the causal relationship between inflation and economic growth. Some of the great literature found no conclusive relationship between inflation and economic growth, some of the relevant studies are notable among these studies are Wai, 1959; Bhatia, 1960; Dorrance, 1963, 1966) Johansen (1967). The studies of Fisher (1993); De Gregorio (1993); Faria and Carneiro (2001); Dewan & Hussein (2001) show a negative linkage between inflation and economic growth. The neoclassical views behind the positive relationship between inflation and economic growth are that inflation redistributes the income in favor of the higher capitalist group, which ultimately leads to increase the saving and investment in the economy. It increases saving and thus, economic growth. Moreover, Keynesians also commented that inflation could spur economic growth by rising profit, which directly increases investment in the economy. Increase growth by raising the rate of profit, thus increasing private investment. On the other hand, theories or empirical studies shows why inflation is negatively related to economic growth. Gultekin (1983) elaborated that why there is a negative relationship between inflation and GDP growth. He explained that when there is high inflation that reduces the real return on the investment, and that leads to negative sentiment, and that leads to falls in investments and a drop in growth. There is also no unanimity in as the issue of causality relationship between inflation and economic growth. Granger causality finds whether one variable has the capability of forecasting power for the other. For instance, if we say inflation Granger causes economic growth. There are many Empirical investigations showed that there is bi-directional causality, a unidirectional causality from any variables and no causality between inflation and economic growth. A study conducted by Paul, Kearney, and Chowdhury (1997) shows that there could be the possibility of different causality in the same cross-country analysis. They found that there is no causality exist in 40% sampled nations 40% bidirectional causality and finally in 20% of sampled nations unidirectional (either from inflation to GDP growth or vice versa). If we see the empirical research on the nexus between economic growths with inflation, we found that in all the studies, headline inflation has been considered for finding its causality with economic growth. Authors did not concede about core inflation which excludes the commodity which

has high price volatility, like food as well energy sector for calculation of inflation in the economy to find its nexus with economic growth. There are many empirical studies shows that the relationship between core inflation with economic growth is significantly different as compared to headline inflation to economic growth. Core inflation closely follows the business cycle as measured by the output gap[1]. Core inflation should take into account as an important element for the determination of targeted inflation decisions as well as for the economic policy (Kalai et al., 2017). Most of the empirical research applied causality approach to finding out the nexus between economic growths and headline inflation with the assumption of the existing linear relationship between these variables. Authors did not pay attention about the possibilities of a nonlinear relation between these variables because all the research on above topic applied traditional Granger causality test, for detecting linear causality, which is not able to trace nonlinear relations (Baek and Brock, 1992; Hiemstra and Jones, 1994).There are much empirical research shows that there is a possibility of non-linear effects of inflation on economic growth (see for example Burdekin *et al*, 2000 and Gillman & Kejak, 2000b) Therefore, this empirical investigation bridge gap by taking core inflation instead of headline inflation to find out causal relation with economic growth through application of nonlinear Granger causality tests for investigating the causality between these variables which has been ignored by studies related to this topic. This analysis has been structured as a literature review in the second part, while data and methodology will be explained in part third, result in discussion in part fourth and conclusion and implication in part fifth.

2. Literature Review
2.1 Causality between Inflation and Economic Growth
Exploring the nexus of inflation and economic growth has always been given much by the economist in the field of macroeconomic research. There is much research has done on the topic related to inflation and economic growth. A critical review of previous empirical analysis reveals that there is no consensus about the causal relationship between inflation and economic growth. Mallik and Chowdhury (2001) found that there is a positive relationship between inflation and economic growth in four Asian countries. The author applied error correction

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1. Working Paper, Bank of Japan November 2015, Core Inflation And The Business Cycle

model for his analysis. They also concluded that, although the moderate level of inflation is supportable for the economic growth high level of economic growth lifts inflation back. The empirical analysis of Tan (2008) included a core member of ASEAN for finding the tradeoff between inflation and economic growth. The author found that the result shows that there is trade-off exists between inflation and economic growth in countries like Singapore, Thailand as well as South Korea, while other nations no trade-off found. Singh et al. (2016) applied Johansen Co-integration approach to finding out the nexus between economic growth and inflation in Japan. Authors concluded that there is a long run nexus between inflation and economic growth in Japan. The granger casualty test also revealed that there is unidirectionally casualty running between economic growth and inflation in Japan. Jayathileke et al. (2013) tried to explain the causal nexus between inflation and economic growth in the Asian economies for the period of 30 years from 1980 to 2010. The casualty result shows that there is a unidirectional causality is running from GDP growth towards the inflation in China. Gregorio (1993) endeavored to reveal the nexus between inflation and economic growth in 12 Latin American countries. The author found that inflation has a negative consequence on the economic growth. Paul et al. (1997) sampled 70 countries for his analysis, which includes developed as well as developing nations. They found that there is no uniformity in the result over the countries. The vast majority of countries show either uniform or bilateral causality over the selected period between inflation and economic growth. According to the Gosh and Phillips (1998) found that the relationship between inflation and growth is convex International Monetary fund (IMF) nations. They also concluded that the lower level of inflation positively impacts economic growth while inflation above 4% leads to a fall in economic growth. On the other hand, Nell (2008) also concluded that when inflation is at single digit, it has a positive impact towards the economic growth but when it reaches to double-digit it has a negative impact for economic growth. Furthermore, Khan and Senhadji (2001) studied the nexus between inflation and economic growth in his panel analysis of 140 nations from 1960 to 1998. They concluded that at a lower level of inflation has a positive impact on the economic growth. They also found that increase has a different impact on the different types of level of development. Caporin and Maria (2002) sampled 19 nations and investigated growth-inflation linkage by

applying pooled regression. They concluded the regression coefficient of inflation varies with average inflation. According to the Sweidan (2004), there is a positive significant relationship between inflation and economic growth in Jordan. They had collected the data for the period of 1970 to 2003 and applied time series modeling for his analysis. They also found a breakthrough level of the inflation rate. They explored that inflation more than two percent hurts the economic growth. Gillman, Harris, and Matyas (2002) investigated the nexus between inflation and economic growth in the OECD and APEC countries. They revealed that as compared to the double-digit inflation single digit inflation has a significant positive impact on the economic growth OECD region, while the same result cannot be applied in the APEC region.

2.2 Nonlinear Relation between Inflation and Economic Growth
There is much empirical analysis can be found related to investigating the nexus between inflation and economic by nonlinear analysis approach. Fattahi et al. (2016) found that at a lower level of inflation has a favorable impact on economic growth. on the other hand, the author also concluded that moderate and higher level of inflation impact on economic growth negatively. Furthermore, Burdekin *et al* (2014) utilized a spline approach for analyzing the nonlinear relation between inflation and economic growth. The authors concluded the turning point for that for developing countries was 3 percent while industrial countries were 8 percent. Pollin et al. (2014) investigated the nonlinear relationship between economic growth and inflation in 80 sampled nations with heterogeneity in their level of development. They found that there is a positive link between inflation with little gain in the national income. This happens at a range of inflation between 15-18 percent at inflation threshold. Sergii (2009) analyzed the nonlinear link between inflation and economic growth in CIS countries from 2001 to 2008 by applying the threshold method. They found that there is concave in some inflation threshold level. They finally concluded that inflation level below 8 percent is good for the economic growth while more than it is unfavorable for GDP growth in CIS nations. Charemza et al. (2009) strived to reveal a nonlinear link between inflation and economic growth with time-series data from 119 nations. They applied a nonlinear correlation method for finding the nexus between inflation and economic growth. They concluded that the persistence of nonlinear inflation contributes to the economic growth. Khoza et al. (2016)

investigated the nonlinear nexus between inflation and economic growth from a sample period of 1994: Q1 and 2016: Q2 in South Africa by applying a smooth transition regression (STR) model. They concluded that inflation level between 3 to 6 percent is favorable for the economic growth in South Africa. Eggoh et al. (2011) analyzed the Non-linear Relationship between Inflation and Economic Growth both the developed nation as well as developing nations with a sample of 102 countries and applied PSTR and GMM modeling. They concluded that the nonlinearity of inflation and economic growth is sensitive to financial development, investment ratio, trade openness, and government expenditures. Gillman and Kejal (2011) found that when there is high inflation, this leads to lower real interest's rate and spur the investment level in the economy, which ultimately helps in GDP growth. Furthermore, Harb et al. (2014) investigated the nonlinear nexus between inflation and economic growth in 35 countries in the Middle Eastern and Sub-Sahara African countries between 1986 and 2011. Authors applied Panel Smooth Transition Regression (PSTR) for tracing the threshold level of inflation. They concluded that the types of the nexus between inflation and growth depend upon the level of inflation in all these sampled nations. After analyzing the above literature review of causality between inflation and economic growth as well as the nonlinear relationship between inflation and economic growth we can draw few gaps in the above research. First of all, in the literature which is related to the casualty between inflation and economic growth seems that the approach of finding the casualty is the same in all the empirical analysis. All the authors applied traditional Granger causality method to test the casualty between inflation and economic growth without any consideration of the possible existence of a nonlinear relationship between these variables for detecting linear causality, which is not able to capture nonlinear relations (Baek and Brock, 1992; Hiemstra and Jones, 1994). Therefore, from the above literature, it can be surmised that discussions regarding the nonlinear relation between inflation and economic growth has done by panel data and by applying only threshold method. The second and relevant concern of the above literature is that all the above analysis has taken headline inflation and tried to find out its nexus with economic growth. While there are many empirical studies show that the relationship between core inflation with economic growth is significantly different as compare to headline inflation to economic growth. Therefore, the

current empirical analysis intends to make an addition to the existing wisdom of the above theme in two ways. Firstly, by exploring the causal link between the core inflation and the economic growth which has been ignored in the above mentioned analysis. On the hand most of the article has taken headline inflation instead of core inflation. Secondly by adopting a novel approach Kyrtsou–Labys nonlinear Granger causality approach to trace the nonlinear causal relationship between core inflation and economic growth which has not done before this is so because all previous mentioned analysis have exerted traditional granger causality test to reveal the causality with assumption linear relationship between the variables.

3. Data and Methodology
3.1 Data Source
For the current analysis, the time series data of 20 countries for the period of 35 years from 1981 to 2016 have been employed. The data includes nations such as Australia, Belgium, Canada, Denmark, France, Greece, Germany India, Ireland, Israel, Japan, Luxemburg, Netherlands, New Zealand, Norway, Portugal, Sweden, Spain, Switzerland, and United Kingdom. The above nations have been selected on the basis of the availability of data. On the other hand, the core inflation as a measure of inflation instead of headline inflation and GDP growth as an economic growth has been taken. All the above-mentioned data has been collected from Federal Reserve database, World Bank database, and Reserve Bank of India.

Table 1: Descriptive Statistics

Nations	Indicators	Core inflation	Economic growth
Australia	Mean	4.63	3.2
	Standard deviation	3.37	1.57
	Maximum	12.8	7.16
	Minimum	-0.2	-1.036
Belgium	Mean	3.095	2.22
	Standard deviation	1.99	1.90
	Maximum	8.4	6.38
	Minimum	0.6	-2.285
Canada	Mean	4	2.277
	Standard deviation	3.07	2.04
	Maximum	11.1	6.94
	Minimum	0.1	-3.202
Denmark	Mean	4.4	1.86
	Standard deviation	3.49	2.01
	Maximum	14	5.92
	Minimum	0.7	-4.95
France	Mean	4.2	2.27
	Standard deviation	3.94	1.72
	Maximum	13.1	6.31
	Minimum	0.3	-2.941
Greece	Mean	9.93	1.85
	Standard deviation	8.14	4.24
	Maximum	24.1	-9.132
	Minimum	-2	10.12
Germany	Mean	2.73	1.97
	Standard deviation	1.834	2.02
	Maximum	6.8	5.723
	Minimum	0.6	-5.563
India	Mean	5.35	5.58
	Standard deviation	3.65	2.97
	Maximum	18.6	10.26
	Minimum	-1.56	-5.23
Ireland	Mean	5.20	8.87
	Standard deviation	5.78	4.61
	Maximum	21.3	25.06
	Minimum	-4.3	-4.66
	Mean	37.80	4.40

Nations	Indicators	Core inflation	Economic growth
Israel	Standard deviation	73.82	2.52
	Maximum	371.9	12.14
	Minimum	-0.9	-0.17
Japan	Mean	2.78	2.49
	Standard deviation	4.22	2.661
	Maximum	20.6	8.41
	Minimum	-1.1	-5.147
Luxemburg	Mean	3.67	3.89
	Standard deviation	2.55	3.32
	Maximum	10.1	9.983
	Minimum	0.9	6.57
Netherlands,	Mean	3.5	2.39
	Standard deviation	2.56	1.92
	Maximum	10.4	5.69
	Minimum	0.4	-3.77
New Zealand,	Mean	6.20	2.53
	Standard deviation	5.59	1.89
	Maximum	17.2	6.58
	Minimum	-0.4	-2.169
Norway,	Mean	3.80	2.91
	Standard deviation	3.03	1.82
	Maximum	12.3	6.052
	Minimum	0.5	-1.62
Portugal,	Mean	9.75	2.88
	Standard deviation	8.001	3.55
	Maximum	27.5	12.62
	Minimum	0.1	-4.34
Sweden	Mean	4.31	2.23
	Standard deviation	3.95	2.18
	Maximum	12.5	6.04
	Minimum	-0.9	-5.18
Spain	Mean	6.44	2.62
	Standard deviation	6.26	2.47
	Maximum	26.4	8.14
	Minimum	0	-3.57
Switzerland	Mean	2.52	1.83
	Standard deviation	2.54	1.67
	Maximum	8.8	5.11

Nations	Indicators	Core inflation	Economic growth
	Minimum	-0.1	-2.208
The United Kingdom	Mean	5.56	2.33
	Standard deviation	5.526	2.20
	Maximum	22.1	6.50
	Minimum	-0.1	-4.328

Source: Author's Calculation

3.2 Methodology

One of the relevant objectives of this paper is to traces the causality between economic growth and core inflation by the assumption of a nonlinear relationship between the variables. For fulfilling this objective, the Kyrtsou–Labys nonlinear Granger causality approach have been exerted.

3.2.1 Kyrtsou–Labys Nonlinear Granger Causality Approach

One of the pertinent drawbacks of linear Granger causality approach is that this approach does not able capture the nonlinear causal relation between the variables. This linear approach assumes that the variables are mutually independent and identically distributed which means it is (iid). This assumption of linear Granger causality has been relaxed by much empirical analysis. The study conducted by Hiemstra and Jones (1994) found that the assumption of variables is mutually independent and identically distributed can be relaxed and through they gave a novel approach of tracing nonlinear modal of causality. One of the advantages of this approach is that it solves the problems associated with the ordinary Granger causality test by ignoring any possible non-stationary or cointegration between series when testing for causality. Toda and Yamamoto (1995) have shown that the conventional F-statistic used to test for Granger causality may not be valid as the test does not have a standard distribution when the time series data are integrated or cointegrated. Instead, they have proposed an interesting yet simple procedure requiring the estimation of an augmented VAR irrespective of whether the time series is integrated or cointegrated.

$$EG_t = \alpha + \sum_{i=1}^{n} \gamma_{1i} EG_{t-i} + \sum_{l=k+1}^{k+d_{max}} \gamma_{1l} EG_{t-l} + \sum_{i=1}^{n} \omega_{1i} INF_{t-i} +$$
$$\sum_{l=k+1}^{k+d_{max}} \omega_{1l} INF_{t-l} + \varepsilon_{1t} \tag{1}$$

$$INF_t = \lambda + \sum_{i=1}^{n} \beta_{1i} INF_{t-i} + \sum_{l=k+1}^{k+d_{max}} \beta_{1l} INF_{t-l} + \sum_{i=1}^{n} \partial_{1i} EG_{t-i} +$$
$$\sum_{l=k+1}^{k+d_{max}} \partial_{1l} EG + \mathcal{E}_{2t} \qquad (2)$$

In the above model, we can see that α and λ are the constant terms of the model. The coefficients are the ω, β, γ, as well as ∂ are the coefficients terms. The $\mathcal{E}_S$ are the white noise error term with iid and zero mean and constant variance $(0, \sigma^2)$. From (1) Granger causality form, it can be implied INF (core inflation) causes EG (economic growth) were $\omega_{1i} \neq 0 \forall_i$ same as in equation no 2 EG (economic growth) granger cause INF (core inflation) were $\partial_{1i} \neq 0 \forall_i$. The test statistics is Modified Wald Statistics (MWALD).

One of the deep drawbacks of the above linear Granger causality approach is that this approach does not able to capture the nonlinear causal relation between the variables. So for the solution of this problem Kyrtsou–Labys developed a new mechanism of test statistics.

To define nonlinear Granger causality, Kyrtsou and Labys (2006) propose a bivariate noisy Mackey-Glass model. Its general form is given below.

$$EG_t = \gamma_{11} \frac{EG_{t-\tau_1}}{1+EG_{t-\tau_1}^{m1}} - \beta_{11} EG_{t-1} + \gamma_{12} \frac{INF_{t-\tau_2}}{1+INF_{t-1}^{m2}} - \beta_{12} INF_{t-\tau_2} + \epsilon_{1,t} \quad (3)$$

$$INF_t = \gamma_{21} \frac{INF_{t-\tau_1}}{1+INF_{t-\tau_1}^{m1}} - \beta_{21} INF_{t-1} + \gamma_{22} \frac{EG_{t-\tau_2}}{1+EG_{t-1}^{m2}} - \beta_{22} EG_{t-\tau_2} + \epsilon_{2,t} \quad (4)$$

Were $\epsilon_{1,t}$ and $\epsilon_{2,t}$ are the error term which normally distributed with zero mean and constant variance of 1, N (0, 1), $t = \tau, \ldots\ldots, N$ $\tau = \max(\tau_1 \tau_2)$. γ_{il} and β_{il} shows the impact of nonlinear and linear of independent variable on the the dependent variable. τ is the integer delays, and m_i is the constants which can be chosen via prior selection. For choosing the lag of the above model Kyrtsou–Labys recommended Schwarz criterion. The basic difference between Kyrtsou and Labys's causality test and linear Granger causality test is former fit the model with the help M-G processes. This test is performed by estimating the M-G model parameters under no constraint with ordinary least squares. For finding the reverse causality Kyrtsou and Labys suggested for

estimation of another M-G with constraint of $\gamma_{12} = 0$, which is our null hypothesis. Suppose $\hat{\mu}$ and $\hat{\pi}$ are the error term found by the unconstrained and constrained best-fit M-G model, respectively. Therefore corresponding sum of error would be $S_u \sum_t^T \widehat{\mu^2}$ and $S_v \sum_t^T \widehat{\pi^2}$. Let $n_u = 4$ is the number of free coefficient in M-G model and on the other side $n_v = 1$ is the number of parameters required to be zero when estimating the restricted model, and then we will find following test statistics.

$$S_F = \frac{(S_{v-}S_u)/n_v}{S_u/(T - n_u - 1)} : F\,(n_v, T - n_u - 1)$$

Were S_F is test statistics.

4. Result Discussion

Table 2: The BDS Test

Countries	Embedded dimension	Core Inflation		Economic Growth	
		BDS stats	P value	BDS stats	P value
Australia	2	0.117	0.00	0.180	0.00
	3	0.182	0.00	0.294	0.00
	4	0.203	0.00	0.36	0.00
	5	0.133	0.00	0.40	0.00
Belgium	2	0.175	0.00	0.177	0.00
	3	0.312	0.00	0.29	0.00
	4	0.40	0.00	0.35	0.00
	5	0.45	0.00	0.38	0.00
Canada	2	0.336	0.005	0.312	0.0068
	3	0.458	0.0025	0.356	0.0056
	4	0.69	0.000	0.425	0.001
	5	0.98	0.0032	0.465	0.003
Denmark	2	0.125	0.000	0.136	0.0069
	3	0.256	0.0025	0.138	0.00
	4	0.398	0.002	0.211	0.00
	5	0.458	0.00	0.298	0.00
France	2	0.112	0.00	0.102	0.00
	3	0.156	0.00	0.156	0.00
	4	0.252	0.00	0.456	0.00

Countries		Core Inflation		Economic Growth	
	Embedded dimension	*BDS stats*	*P value*	*BDS stats*	*P value*
	5	0.365	0.00	0.77	0.00
Germany	2	0.143	0.00	0.356	0.002
	3	0.24	0.00	0.85	0.005
	4	0.301	0.00	0.65	0.0025
	5	0.325	0.00	0.69	0.000
Greece	2	0.08	0.0025	0.052	0.0032
	3	0.15	0.004	0.128	0.000
	4	0.192	0.00	0.144	0.0025
	5	0.22	0.001	0.142	0.002
India	2	0.85	0.002	0.136	0.0069
	3	0.89	0.005	0.138	0.00
	4	0.86	0.0025	0.211	0.00
	5	0.36	0.000	0.298	0.00
Ireland	2	0.145	0.0032	0.65	0.00
	3	0.312	0.000	0.68	0.00
	4	0.45	0.0025	0.70	0.0075
	5	0.56	0.002	0.75	0.0069
Israel	2	0.19	0.00	0.136	0.0036
	3	0.25	0.00	0.138	0.0036
	4	0.269	0.00	0.211	0.00
	5	0.592	0.00	0.336	0.00
Japan	2	0.38	0.00	0.458	0.00
	3	0.65	0.00	0.69	0.00
	4	0.69	0.002	0.90	0.00
	5	0.78	0.0011	0.91	0.00
Luxemburg	2	0.98	0.002	0.225	0.00
	3	0.78	0.009	0.265	0.00
	4	0.89	0.0075	0.289	0.00
	5	0.94	0.0069	0.35	0.00
Netherlands	2	0.36	0.0036	0.117	0.00
	3	0.78	0.0036	0.182	0.00
	4	0.878	0.0089	0.203	0.00
	5	0.911	0.0001	0.133	0.00
New Zealand	2	0.143	0.00	0.356	0.002
	3	0.24	0.00	0.85	0.005
	4	0.301	0.00	0.65	0.0025
	5	0.325	0.00	0.69	0.000

Countries		Core Inflation		Economic Growth	
	Embedded dimension	*BDS stats*	*P value*	*BDS stats*	*P value*
Norway	2	0.08	0.0025	0.052	0.0032
	3	0.15	0.004	0.128	0.000
	4	0.192	0.00	0.144	0.0025
	5	0.22	0.001	0.142	0.002
Portugal	2	0.85	0.002	0.136	0.0069
	3	0.89	0.005	0.138	0.00
	4	0.86	0.0025	0.211	0.00
	5	0.36	0.000	0.298	0.00
Sweden	2	0.145	0.0032	0.65	0.00
	3	0.312	0.000	0.68	0.00
	4	0.45	0.0025	0.70	0.0075
	5	0.143	0.00	0.356	0.002
Spain	2	0.24	0.00	0.85	0.005
	3	0.301	0.00	0.65	0.0025
	4	0.325	0.00	0.69	0.000
	5	0.08	0.0025	0.052	0.0032
Switzerland	2	0.15	0.004	0.128	0.000
	3	0.192	0.00	0.144	0.0025
	4	0.22	0.001	0.142	0.002
	5	0.85	0.002	0.136	0.0069
United kingdom	2	0.89	0.005	0.138	0.00
	3	0.86	0.0025	0.211	0.00
	4	0.36	0.000	0.298	0.00
	5	0.145	0.0032	0.65	0.00

Source: Author's Calculation

From the above table no 2 of BDS test, it can be inferred that the BDS statistics of all the variables in all the countries are significant at 1% level of significance. The significant BDS statistics indicate that the null hypothesis of linearity of the variables in all the countries can be rejected. It means that all the variables are nonlinear and that is a basic requirement for further carry forward the nonlinear Granger causality test.

Table 3: Granger (Nonlinear) Causality S$_F$ Test Statistics

Countries	Causality Core Inflation → Economic Growth	Causality Economic Growth → Core Inflation.
Australia	2.11	20.83**
Belgium	5.644*	1.38
Canada	1.25	16.91**
Denmark	12.095**	2.43
France	8.322*	13.49**
Germany	1.195	18.74**
Greece	12.03**	14.11**
India	19.8**	1.65
Ireland	0.47	0.021
Israel	0.581	0.269
Japan	0.439	16.33**
Luxemburg	6.89*	0.80
The Netherlands	2.22	5.73
New Zealand	1.310	22.292**
Norway	13.139**	4.412
Portugal	7.071*	7.066*
Sweden	22.91**	12.17*
Spain	0.682	0.367
Switzerland	0.967	12.87**
The United Kingdom	1.746	8.566*

Source: Author's Calculation.
Note: ** is significant at 1% and *is at 5%, the variables with no stars are not significant at 5% level.

The table 3 reveals the outcome of nonlinear granger casualty test. It can be seen that there is homogenity in the outcome of casualty among the various nations. There is unidirectional casualty running from core inflation to economic growth in the Belgium, Denmark, Franc, Greece, India, Norway, and Portugal as well as Sweden. In these countries, core inflation is causing economic growth. It means core inflation leads towards the economic growth in these counties. Furthermore, the outcome of causality analysis also documents that there is unidirectional causality running from economic growth towards the core inflation in Australia, Canada, Germany, Greece, Japan, New Zealand, Portugal, Sweden, Switzerland and United Kingdom.

Economic growth spurs a rise in the price of nonfood and nonenergy item in these nations. There is bidirectional casualty can be seen in the France, Greece, Portugal, and Sweden. It means economic growth is causing the core inflation as well as core inflation is also causing economic growth simultaneously. The results show evidence of no causality running from either from core inflation towards the economic growth or from economic growth to core inflation in Ireland, Israel, Netherlands and Spain. It can be inferred that none of theses of variables relevant impact to each other in these economies.

5. Conclusion and Implication

As it has been already discussed above that there is an increasing amount of literature concentrated to explore the nexus between inflation and economic growth. Few studies have taken consideration of investigating the relationship between core inflation and the economic growth. On the other hand, most the pervious analysis ignored the possibilities of having nonlinear relationship between the variables, because all the previous analysis has exerted traditional granger causality test to explore the causality among the inflation and economic growth. Therefore, the current empirical analysis strives to make an addition to the existing knowledge of the above topic in two ways. Firstly, by exploring the causal relationship between core inflation and the economic growth while on the other hand most of previous analysis focused to reveal the causal link between headline inflation and the economic growth. Secondly, this studies also endeavoring to expand such types of analysis in by the exerting the novel approach of Kyrtsou–Labys nonlinear Granger causality method to trace the nonlinear causal relationship between core inflation and economic growth which has not done before. The relevant empirical insights from this study can be summarized as follows. Firstly, on the basis of nonlinear Granger causality approach, it has found that there is unidirectional casualty running from core inflation to economic growth in the countries such as Belgium, Denmark, Franc, Greece, India, Norway, Portugal, and Sweden. In these countries, core inflation is causing economic growth. So for macroeconomic points of view core inflation is desirable and policy maker should not concern about rising core inflation because it leads towards the economic growth in these counties. Secondly as per as Australia, Canada, Germany, Greece, Japan, New Zealand, Portugal, Sweden, Switzerland, and the United Kingdom is concerned the

outcome manifest that there is unidirectional causality running from economic growth towards the core inflation. For the policy-making points of view, it can be concluded that if the policymaker wants to have more economic growth they would have to raise core inflation in the economy because our result shows that high economic growth consequence high core inflation. Finally, on the basis of above analysis, it can be concluded that, there no such significant causality running from either core inflation towards the economic growth or from economic growth to core inflation in the nations such as Ireland, Israel, Netherlands, and Spain.

References

Baek, E., & Brock, W. (1992). A General Test for Nonlinear Granger Causality: Bivariate Model. *Iowa State University and University of Wisconsin Working Paper,* Retrieved from https://wcer.wisc.edu/publications/working-papers.

Barro, R. J. (1995). Inflation and Economic Growth. *National Bureau of Economic Research NBER), Working Paper, 5326,* Retrieved from http://www.nber.org/papers/w5326.pdf.

Bhatia, J., & Rattan, J. (1960). Inflation, Deflation, and Economic Development. *Staff papers, International Monetary Fund, 8*(11), 1011-1014.

Bruno, M., & Easterly, W. (1995). Inflation Crises and Long-Run Growth. *World Bank Policy Research Working Paper, 1517,* Retrieved from https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-1517.

Burdekin, R. C. K., & Richard C. K. (2000). When Does Inflation Hurt Economic Growth? Different Nonlinearities for Different Economies. *Claremont Colleges Working Papers, 2000-22,* Retrieved from http://hdl.handle.net/10419/94561.

Caporin, M., & Maria, C.D. (2002). Inflation and Growth: Some Panel Data Evidence. *GRETA Working Paper, 9,* Retrieved from http://www.greta.it/wp/02.09.PDF.

Charemza, W., & Makarova, S. (2009). Nonlinear Inflationary Persistence and Growth: Theory and Empirical Comparative Analysis. *Romanian Journal of Economic Forecasting,* Retrieved from http://mail.ipe.ro/rjef/rjef2_09/rjef2_09_1.pdf.

De Gregorio, J. (1992). The Effect of Inflation on Economic Growth. *European Economic Review, 36*(2-3), 417-424

Dewan, E., & Hussein, S. (2001). Determinants of Economic Growth. *Reserve Bank of Fiji, Working Paper, 01/04,* Retrieved from http://www.rbf.gov.fj/docs/wp2001-04.pdf.

Dorrance, G. S. (1966). Inflation and Economic growth. *International Monetary Fund*, *13*, 82-102.

---------- (1963). The Effect of Inflation on Economic Development. *International Monetary Fund Economic Review*, *10*(1), 1-47.

Eggoh, J. C., & Mohammad, K. (2006). *On The Non-Linear Relationship between Inflation and Economic Growth*. Retrieved from https://pdfs.semanticscholar.org/1826/609aaa5af48a89508968391141c13c4d9a99.pdf.

Faria, J. R., & Carneiro, F. G. (2001). Does High Inflation Affect Growth in the Long and Short run? *Journal of Applied Economics*, *4*(1), 89-105.

Fattahi, S., Tiatoraj, A., & Moshtaghi, N. (2016). Nonlinear Relationship between Inflation and Economic Growth. *International Academic Journal of Economics*, *3*(6), 46-61.

Fisher, S. (1993). The Role of Macroeconomic Factors in Growth. *Journal of Monetary Economics*, *32*(3), 485-512.

Ghosh, A., & Phillips, S. (1998). Inflation, Disinflation and Growth. *International Monetary Fund Working Paper*, 98/68, Retrieved from https://www.imf.org/en/Publications/WP/Issues/2016/12/30/Inflation-Disinflation-and-Growth-2590.

Gillman, M., & Kejak, M. (2011). Inflation, Investment and Growth: A Money and Banking Approach. *Economica, 78*(310), 260-282.

---------- (2000). A Non-Linearity in the Inflation-Growth Effect. *Central European University Department of Economics Working Paper, 14,* Retrieved from https://econpapers.repec.org/paper/ceueconwp/.

Gillman, M., & Matyas, L. (2002). Inflation and Growth: Some Theory and Evidence. *10th International Conference on Panel Data*, Retrieved from https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID268139_code010 518110.pdf?abstractid=268139&mirid=1&type=2.

Harb, N. M. A. (2016). *A Study on the Non-Linearity Hypothesis between Various Macroeconomic Variables and Economic Growth in Developing Countries*. Retrieved from *Https*://Lra.Le.Ac.Uk/Bitstream/2381/39745/1/2017harbnmaphd.Pdf.

Hiemstra, C., & Jones, J. D. (1994). Testing for Linear and Nonlinear Granger Causality in the Stock Price-Volume Relation. *Journal of Finance, 49*, 1639-1664.

Jayathileke, P. M. B., & Rathnayake, M. (2013). Testing the Link between Inflation and Economic Growth: Evidence from Asia. *Modern Economy*, *4*, 87-92.

Johanson, H. G. (1967). *Is Inflation a Retarding Factor in Economic Growth? In Fiscal and Monetary Problems in Developing States*. New York: Frederick A. Praeger Publication.

Khan, M. S., & Senhadji, A. (2001). Threshold Effects in the Relationship between Inflation and Growth. *IMF Staff Papers*, *48*(1), 1-21.

Keorapetse, K., Relebogile, T., & Andrew, P. (2016). Nonlinear Impact of Inflation on Economic Growth in South Africa: Smooth Transition Regression (STR) Analysis. Retrieved from https://mpra.ub.uni-muenchen.de/73840/1/MPRA_paper_73840.pdf.

Krugman, P. R. (1995). Its Baaack: Japan's Slump and the Return of the Liquidity Trap. *Brookings Papers on Economic Activity*, *2*, 137-205.

Mallik, G., & Chowdhury, A. (2001). Inflation and Economic Growth: Evidence from South Asian Countries. *Asian Pacific Development Journal*, *8*(1), 123-135

Nell, K. S. (2000). Is Low Inflation a Precondition for Faster Growth? The Case of South Africa. *Department of Economics, Keynes College, University of Kent Working Papers,* Retrieved from https://www.econstor.eu/bitstream/10419/68106/1/325327319.pdf.

Paul, S., Kearney, C., & Chowdhury, K. (1997). Inflation and Economic Growth: A Multi-Country Empirical Analysis. *Applied Economics*, *29*, 1301-1387.

Pollin, R., & Zhu, A. (2005). Inflation and Economic Growth: A Cross-Country Non-Linear Analysis. *Working Paper Series, Department of Economics and Political Economy Research Institute (PERI),* Retrieved from https://ideas.repec.org/p/uma/periwp/wp109.html.

Sarel, M. (1996). Nonlinear Effects of Inflation on Economic Growth. *International Monetary Fund Staff Papers, 43*(1), 199-215Sergii, P. (2009). *Inflation and Economic Growth: The Non-Linear Relationship, Evidence from CIS Countries.* Retrieved from http://www.kse.org.ua/uploads/file/Pypko.pdf.

Singh, S., & Singh, A. (2015). Causal Nexus between Inflation and Economic Growth of Japan. *Iranian Economic Review*, *19*(3), 265-278.

Sweidan, O. D. (2004). Does Inflation Harm Economic Growth in Jordan? An Econometric Analysis for the Period 1970-2000. *International Journal of Applied Econometrics and Quantitative Studies, 1*(2), 41-66.

Tan, E. C. (2008). Inflation and Economic Growth in Asean-5, Japan and South Korea. *Eleventh International Convention of the East Asian Economic Association*, 15-16 November, Manila. Retrieved from http://www.eaeaweb.com/eaea11program.pdf.

Wai, U. T. (1995). The Relation between Inflation and Economic Development: A Statistical Inductive Study. *IMF Staff Papers, 7*, 302-317.