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Inflation-Growth Nexus: Evidence from Panel Smooth Threshold Model Analysis in Different Geographical Region Countries

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ABSTRACT

The relationship between inflation-growth has long been debated and it is inconclusive if there is a trade-off between inflation and growth. The main objective of this study is to model the threshold effect of inflation on growth, in addition to testing on the existence of the trade-off relationship. For this purpose, the Panel Smooth Transition Regression (PSTR) model analysis is conducted. The results are compared among three panel groups, namely the EU, ASEAN and African countries. These three different geographical regions have different inflation experiences and country-specific characteristics separately over the period 1980–2017. Inflation is treated as the threshold variable and other variables as treated as control variables (exchange rate, trade-openness, government final consumption and population growth rate). The results reveal a nonlinear relationship between growth and inflation in all three different geographical regions. The trade-off relationship is detected in the first regime in all three panel groups. The PSTR model has detected the optimal threshold of inflation rate to be 4.17%, 6.02% and 0.94% to 14.51% respectively. Africa has a higher inflation tolerance range, 0.94 to 14.52 % compared to the EU and ASEAN groups. Overall, the inflation-growth relationship is positive (trade-off) below the reported threshold levels and the relationship is negative once the inflation rate exceeds the threshold levels. These imply that our results reveal that the relationship between inflation-growth is non-linear in the company of an existence of a threshold level of inflation.

Keywords: Growth, Inflation threshold, Panel smooth transition regression.

1 INTRODUCTION

One of the most important that widely affect an economy is the inflation rate. High growth associated with low inflation is the ultimate goal to be achieved in macroeconomic policy making ([1]; [2] and [3]). Hence, loads of studies have been focusing on the inflation and growth relationship, both theoretically and empirically. Some studies have shown that this is a deleterious impact on long-run economic growth by inflation ([1], [4], [5], and [6]). Contritely, some of the researcher finds that inflation is vital at a certain rate in order to foster the development of economy ([7] and [8]). Besides, various elements are being considered as important forces that affecting inflation should be taken into research consideration. According to [9], wage rate, trade openness, money supply, interest rate, potential output, and the exchange rate are the factors that should be considered. The factors that cause inflationary pressure may transmit one country into various economic channels and implications.

The relationship of inflation-growth remains a contentious issue in both theoretical and empirically even though it has long been studied. The history of inflation and growth begins with Philip curve. Historically, Phillips curve model managed to illustrate the relationship between inflation adequately. It describes the unemployment and positive/negative inflation relationship (output-growth relationship). The relationship is negative once decrement happens in unemployment which lead to lower inflation or the other way around. Contrariwise, trade-off is an inverted connection between unemployment-inflation. The Phillips curve is adequate in explaining the economy until the 1970s, where both inflation and unemployment are shockingly high which named as the stagflation phenomena. According to [10], the breakdown of the Phillips curve created more arguments and debates.

The trade-off relationship which failed to exist during stagflation has evoked the interests of many researchers. Thus, numerous empirical findings have been performed to investigate the relationship. However, various results were obtained due to vary estimation approaches, country-specified characteristics and different range of data applied. [11] conclude that relationship of inflation-growth reacts differently due to the variations of nation background, application of alternative variables and procedures while making measuring. Hence, both theoretically and empirically, inflation-growth remains as a debatable concern if there exists a relationship of trade-off within.

Research that relates the growth and inflation relationship using Panel Smooth Transition Regression (PSTR) model is very inadequate as mentioned in [7]. To our best knowledge, there are only two research that used PSTR to test the inflation and growth relationship: [12] applied PSTR in developed and developing countries, while [13] focused on 5 ASEAN countries. Thus, this study may provide more empirical proofs of PSTR model in linking to the influence of inflation on the growth of economic. We may also distinguish whether there is a trade-off connection between the two variables with respect of different inflation experiences and country-specific characteristics and finally the results obtain can fulfill the gap in the literature in PSTR.

In summary, by taking into consideration of countries-specific characteristics as mentioned in [14], the Panel Smooth Transition Regression (PSTR) model are initiated by [15] and [16] to evaluate whether there is an optimal inflation level within three different geographical regions: the EU, ASEAN and Africa are applied. The objectives are divided into three-fold: (1) employ PSTR model to confirm a nonlinear connection among inflation-growth and seek to discover existence of the trade-off relationship within regimes switching process; (2) set different control variables according to previous studies and find out which variable is significant to the inflation and growth relationship (3) to explore the relationship by comparing at which point that inflation is boosting the economic growth of these three regions respectively. (4) Given the involvement of various determinants other than inflation rate such as the population growth rate, trade openness, government consumption and exchange rate, a new potential significant variable may take place in affecting the economic growth.

The plan of this study proceeds as following: Part 2 is the related literature reviews. Part 3 is the data and methodology which briefly review the PSTR model and introduces the data used in our study. Part 4 illustrates the empirical results and discussion. Part 5 is the conclusions and remarks.

2 LITERATURE REVIEW

What is inflation? According to [17], inflation is identified as an overall continuous raise in costs of goods and services plus the decrease cost of money in the purchasing over time. Phillips studied the connection among the rate of unemployment and the changes in money wage in the year of 1954. Then, his studies of the changes in earnings and output were linked to the alteration in the price level, explicitly named as Phillips curve as mentioned in [10]. The price is proxy by inflation and unemployment proxy by economic growth. Yet, some of the researchers who detected the trade-off within the relationship of inflation and growth in the Phillips curve did not support agree to Phillips studies. Therefore, more debates and studies are carried out when stagflation happened.

Basically, from all the literature reviews and studies of the connection between inflation and economic growth, we managed to categorize the theoretical opinions of the relation into four types as well as followed by a series of empirically studies accordingly. Firstly, some think there is no such relationship. [18] and [19] agreed that inflation does not influence the growth of economic. Instead, the growth of economic is affected by other factors. Next, [7], [8] and [20] agreed that an encouraging impact on long-run economy growth is induced by the inflation. The third theory is inflation has a harmful influence upon long-run economic growth, which also agreed by [4], [5] and [6]. Finally, taken all opinions and theories into account included the breakdown of the Phillips curve, some think that inflation has a damaging shock on long-run economic growth when achieved specific inflation threshold level. Once over this threshold level, inflation is detrimental to economic growth where the trade-off relationship is gone and further rise in inflation rate is damaging the growth of the economy ([1]; [21]; [22]). Recent studies such as [2], [3], [14], [23] and [24] agreed that the connection among inflation and growth is non-linear. The influence of inflation has switched from positive to negative once the threshold level of inflation is reached.

Our study seeks to discover the nexus of inflation and growth, according to three different geographical regions with a PSTR model. The countries involved are 15 EU countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom of Great Britain; 5 ASEAN countries: Indonesia, Malaysia, Philippines, Singapore and Thailand; and 27 Africa region: Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo-Democratic, Côte d'Ivoire, Egypt, Gabon, Gambia, Ghana, Guinea-Bissau, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Niger, Rwanda, Senegal, Seychelles, South Africa, Sudan, Uganda and Zimbabwe.

3 DATA AND METHODOLOGY

Annually data from year 1980 until 2017 is taken from World Development Indicator (WDI) database, International Monetary Fund (IMF) and Thomson Reuters Datastream Professional. Table 1 is the definitions of variables that involve in testing the inflation threshold corollary on economic growth. The inflation-growth modelling relationship began by setting gross domestic product (DLGDP) as dependent variable, inflation (INF) as threshold variable and the rest as control variables.

Table 1 : List and definition of variables

Variables	Definition
DLGDP	Annual growth rate of log Gross Domestic Product (%) [logGDP(t)-logGDP(t-1)]*100
INF	Annual percentage change in log CPI index (%) [logCPI(t)-logCPI(t-1)]*100
LEX	Log exchange rate (US$)
LTO	Log of trade openness (ratio)
LGOV	Log of government consumption (% GDP)
POP	Annual population growth rate (%)

First and foremost, panel unit root tests are performed to establish whether the variables in the model are stationary. In this study, the null hypothesis of unit root is analyzed by the panel data unit root tests of [25], [26] augmented Dickey-Fuller (ADF) ([27]) and PP-Fisher ([28]). We find that all the variables are stationary at I(0) where nulls of the unit root tests are rejected.

Once all variables are stationary, the Panel Smooth Transition Regression (PSTR) model can be estimated:

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} g(q_{it};\gamma, c) + \varepsilon_{it} \tag{1}$$

where i= 1,..., N and t = 1,..., T, and N and T is the cross-section and time dimensions of the panel, correspondingly. y_{it} is the dependent variable, μ_i is the fixed individual effect, x_{it} is the time-varying exogenous variables with a k-dimensional vector, ε_{it} is a residual term, $g(q_{it};\gamma, c)$ is a transition function which is a continuous function defined by the transition variable of q_{it}, c is a vector of location parameters and the slope parameter γdetermines the speed of the transitions happened. Following [29], we have the logistic specification transition function $g(q_{it};\gamma, c)$ formulated as follows:

$$g(q_{it};\ \gamma, c) = \left(1 + \exp\left(-\gamma \prod_{j=1}^{m}(q_{it} - c)\right)\right)^{-1}, \gamma > 0,\ c_1 \le \cdots \le c_m \tag{2}$$

$g(q_{it};\gamma, c)$ is restricted within 0 and 1; these extreme values are connected with regression coefficients $\beta_0'$and $\beta_0' + \beta_1'$' i.e., the effective regression coefficients $\beta_0' + \beta_1' g(q_{it};\gamma, c)$for individual i at time t. $c = (c_1, \dots, c_m)$is a m-dimensional vector. When $\gamma \ge 0$and $c_1 \le \dots \le c_m$is restricted to identification purposes. It is sufficient to consider the cases of m = 1 or m = 2 in this study. For m =1 implies that there are two regimes associated, which is with low and high values of q_{it} with a single monotonic transition of the coefficients from $\beta_0'$to $\beta_0' + \beta_1'$ as q_{it}increases, where the change is centered around c_1. When $\gamma \rightarrow \infty$, $g(q_{it};\gamma,c)$is an indicator function which is equal to 0 or 1. For m=2, the transition function, $g(q_{it};\gamma,c)$ reaches the value of 1 both at low and high values of q_{it} , and has its minimum at$(c_1 + c_2)/2$. When $\gamma \rightarrow \infty$, the model can be defined as the three-regime threshold model with two identical outside regimes and an isolated middle regime. Overall, for m > 1 and $\gamma \rightarrow \infty$, the model contain two discrete regimes and a $g(q_{it};\gamma,c)$ bounded between 0 and 1 at $c_1,\ldots,c_m$. Whether m is equal to 1 or 2, once γ=1, the model develops into a single monotonic smooth transition with fixed effects ([30]).

PSTR model that has more than two different regimes can be formulated as:

$$y_{it} = \mu_i + \beta_0' x_{it} + \sum_{j=1}^{r} \beta_1' x_{it} g_j(q^j{}_{it};\gamma_j,c_j) + \varepsilon_{it} \tag{3}$$

where the transition functions $g_j(q_{it};\gamma,c)$, j = 1, ..., γ depend on the slope parameters γ_j and location parameters c_j. If r = 1, $q_{it}^j = q_{it}$and $\gamma_j \rightarrow \infty$ for all j = 1, ..., γ then the transition function turn out to be an indicator function, with I[A] = 1 when event A occurs, and I[A] = 0 otherwise; If so, the model in Equation (3) develop into a PTR model with r + 1 regimes. Thus, the multi-regimes PSTR model can be considered as a generalization of the multiple regime panel threshold model (PTR) in [31].

The PSTR model building step consists of three stages. Firstly, we test the non-linear correlation between inflation and growth. For each specification, we employ the Wald test (LM), Fisher tests (LMF) and LR tests (LRT). With LM, LMF and LRT tests, the statistics for linearity tests and remaining non-linearity tests are revealed. [32] claimed that the F-version test, LMF is more adequate among the LM and LRT tests. It has better size properties in small sample than the asymptotic χ^2 distribution of LM and LRT.

Secondly, we decide the number of transition functions, r or number of regime which is r + 1 of the PSTR model on the ground of non-linear relationship is confirmed in previous step. As suggested in [16] , the optimal transition function (r*) which corresponding to the different tested threshold variables are chosen based on the strongest rejection of the linearity hypothesis. Generally, one or two transition functions are considered sufficient. Even if r = 1, PSTR model allows a "*continuum*" of elasticities (or regimes), with each one associated with a different value of the transition function between 0 and 1. In this study, we seek test the following equation (2) which is $g(q_{it};\ \gamma,c) = \left(1+\exp\left(-\gamma\prod_{j=1}^{m}(q_{it}-c)\right)\right)^{-1}, \gamma > 0,\ c_1 \leq \ldots \leq c_m$ is a suitable specification of the data and the nonlinearity.

The final stage is finding the optimal model with ideal quantity of transition functions (r*) matches with best possible number of location parameter (m*) through a non-linear relationship assessment. In particular, according to [33] , the AIC and BIC principle are used to decide the ideal quantity of location parameter m*. The chosen one has the AIC and BIC values that are reasonably smaller. The residual sum of square (RSS) is considered if and only if the AIC and BIC values are relatively closed. Furthermore, the range of the estimated location parameter must fulfil the condition where it should not surpass the trimming of the observed value of the variable when establishing the initial values of the location parameter and smoothing the parameter by using a grid search technique. Thus, when the location parameter is beyond the trimming of the observed value, the m* is suggested to be aborted by [34] even though the AIC and BIC value is relatively lower. For instance, [34] take on (r, m) = (1, 1) to estimate their model as a replacement for (r, m) = (2, 2).

4 EMPIRICAL RESULTS

The null hypothesis of linearity (r = 0) is evidently rejected whether m = 1 or m = 2 for all three groups of the EU, ASEAN and Africa countries, respectively in Table 2,. These results show evidence of the nonlinear relationship between economic growth and inflation. Next, according to [33], the order of m is determined based on Schwarz and Akaike criteria. AIC and BIC criteria is to decide the amount of location parameter, m. It is recommended to prefer the best m that diminish the AIC and BIC given that the range of the estimated location parameter must not surpass the trimming range. As in all the cases of EU, ASEAN and Africa, where m=2, thus we dropped the selection of m = 2 and adopted m =1. Besides, the specification test of no remaining non-linearity guide to the classification of an ideal quantity of transition functions (regimes). Taking into consideration of 1% significance level, in the models of EU and ASEAN for instance, results illustrate that the optimal number of threshold function is r = 1, which suggests that there are two regimes. On the contrary, given rmax is 2 and significance level of 1%, Africa has the best possible amount of threshold function, r=2, which indicates 3 regimes are involved.

Table 2. Linearity (homogeneity) tests, remaining non-linearity test and m selection tests

Model	**EU**		**ASEAN**		**Africa**	
Location parameter	m=1	m=2 #	m=1	m=2#	m=1	m=2 #
H_0=PSTR with r = 0 versus H_1=PSTR with at least r =1						
Wald Tests (LM)	17.555***	42.912***	45.515***	63.959***	21.890***	52.438***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Fisher tests (LMF)	3.495***	4.441***	11.421***	8.983***	4.333***	5.329***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
LR Tests (LRT)	17.839***	44.661***	52.244***	78.482***	22.133***	53.864***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
H_0=PSTR with r = 1 versus H_1=PSTR with at least r =2						
Wald Tests (LM)	12.182**	23.845***	4.388	3.315	18.064***	40.850***
	(0.032)	(0.008)	(0.495)	(0.973)	(0.003)	(0.000)
Fisher tests (LMF)	2.356**	2.334***	0.802	0.292	3.525***	4.059***
	(0.039)	(0.011)	(0.550)	(0.982)	(0.004)	(0.000)
LR Tests (LRT)	12.318**	23.373***	4.441	3.345	18.229***	41.708***
	(0.032)	(0.008)	(0.488)	(0.973)	(0.002)	(0.000)
RSS	50511	47892	16429	14517	227110	220070
AIC	4.5495	4.5441	4.6570	4.5494	5.4565	5.4309
BIC	4.6410	4.7042	4.8621	4.7716	5.5478	5.5319

Notes: Given the choices of rmax=2, final model for EU is m=1, r = 1; ASEAN is m=1, r =1; Africa is m=1, r=2; The matching p-value are stated in parentheses, # denotes At least one estimated Location Parameter is outside the trimming of the observed variables. ***, ** and * represent the 1, 5% and 10% significance level correspondingly.

Finally, parameter estimates of the ultimate PSTR models are reported in table 3. The expected transition slope parameters are rather small for all models except the EU. This indicates that a continuum situation occurs among the regimes in all three models. The connection between inflation and growth is well switched from one regime to another in the context of the ASEAN and Africa. As for EU, with relatively big transition slope parameter, reveals that the transition speed rate from one regime to another is rapid.

The threshold variable, inflation (INF) has the estimated coefficient (INF_1) statistically significant and positive for all three models, with values of 1.7138, 0.0260 and 0.2429 respectively. Indeed, we managed to capture the existence of a trade-off relation in the regime 1 in all three models. The changes of signs of INF from positive to negative, implying there is a non-linear bond among growth and inflation. In the case of Africa, the coefficient INF_2 of Africa is a higher negative than the first regime and lead to no trade-off relationship in second regime as well as the third regime. The overall force of inflation on economic growth of Africa is depressing. These results are in line with recent studies included [2], [3], [14] and [23], who agreed that the link among growth and inflation is non-linear. It has switched from positive to negative once reached or exceed the threshold level of inflation.

In the circumstance of other control variables instead of INF, we seek to discuss the most impactful control variable in every model. Particularly in EU model, other than INF, all the control variables are significant except for the population growth (POP_1) in regime 1 and once exceed the threshold rate of 4.172% all become not significant. The population growth data are adopted in the models rather than the only employment growth owing to the data availability; hence, the results can be affected where population growth might include the unemployment growth data. When having lower inflationary pressure, economic growth still increases by 11.04% as exchange rate depreciates by 1%. This implies that the strong currency of the EU countries enhances the purchasing power domestically and thus growing the economy. On the other hand, the rising of a unit in LGOV leads to the reductions of economic growth by 35.77 units. LGOV seems to be a big burden to the economic growth of the EU, therefore the current fiscal policy needs to be revised. In ASEAN, LEX is the most impactful variable. As 1% appreciation of LEX, the economic growth will decrease by 0.09% in regime 1. As for regime 2, the economic growth will increase by 0.18% with 1% depreciation in LEX. ASEAN as developing countries (except Singapore), with depreciation in currency under low inflationary pressure will attract more foreign investor as explained in regime 2. The condition might be slightly different under high inflationary pressure, the economic growth positively as the exchange rate appreciate might be due cheaper import goods that boost the economy. The same condition happens in the context of Africa, where the LEX is significant in regime 1 and regime 3. The economic background of ASEAN and Africa countries where the exchange rate more important when come to policy making. The exchange rate is influential as these countries are small but open economies which is weak to external shock exposure.

Furthermore, the optimal inflation rate is important in order to have an optimal economic growth. Taking the EU countries as an example where their inflation optimal rate is 4.172%. In regime 1 (below the rate), since the inflation rate is low, increasing inflation can stimulate economic growth till reaching the optimal rate. Regime 1 is not yet optimal and exhibit the trade-off relationship. The optimal rate is the level where the inflation is associated with the max growth. After this rate (regime 2), increasing the inflation will deteriorate the economic growth. Regime two is also not optimal, although no more trade-off, the economic growth will drop with higher inflation. Therefore, it is advised to maintain the economy at the optimal stage.

Table 3. Parameter estimation results for PSTR model

Model (m, r)	**EU (1,1)**	**ASEAN (1, 1)**	**Africa (1, 2)**
INF_1	1.7138***	0.0260**	0.2429***
	(0.4641)	(0.0104)	(0.0752)
LEX_1	11.0427***	-0.0922**	-1.3990***
	(2.4352)	(0.0396)	(0.5311)
LTO_1	-12.9096***	0.1834	-1.4831
	(2.8745)	(0.1745)	(3.2325)
$LGOV_1$	-35.7697***	0.7177	-2.7269
	(5.2237)	(0.6367)	(3.6306)
POP_1	0.4138	0.1085	-1.8094
	(1.1116)	(0.1302)	(1.2909)
INF_2	-0.0519***	-0.0519**	-0.7371***
	(0.5300)	(0.0208)	(0.2136)
LEX_2	0.1844	0.1844**	-0.4061
	(1.3290)	(0.0793)	(0.6069)
LTO_2	-0.3667	-0.3667	-4.5707
	(2.4020)	(0.3490)	(3.2869)
$LGOV_2$	-1.4355	-1.4355	4.2836
	(3.2447)	(1.2734)	(4.9307)
POP_2	-0.2171	-0.2171	-0.0464
	(2.8348)	(0.2605)	(2.8413)
INF_3			0.4412**
			(0.2149)
LEX_3			1.6251***
			(0.4383)
LTO_3			-0.0328
			(2.7589)
$LGOV_3$			-1.4894
			(3.6887)
POP_3			3.8246***
			(1.3794)
Location parameter, c	4.172	6.0207	14.5188; 0.9362
Transition slope, γ	2920	$5.42*10^{-06}$	0.0004; 2.2301

Notes: The standard errors in parentheses are corrected for heteroskedasticity. ***, ** and * denote the 1, 5% and 10 % significance level, correspondingly.

5 CONCLUSION

This study examines whether the inflation influences economic growth with the estimation of PSTR model in the context of three different geographical countries, which are the EU, ASEAN and Africa respectively. We seek to discover whether there is an ideal rate of inflation at which point the countries may possibly maximize their economic growth. Strong evidence show that the inflation has non-linear impacts on the growth of economic in all three tested regions. The trade-off relationships are found in all three models. The threshold value is strongly differed among these three models. i.e., 4.17% for the EU, 6.02% for ASEAN and 0.94% ~ 14.52% in Africa. Africa has a higher inflation tolerance range, 0.94% ~ 14.52% compared to EU model. Various factors like the Balassa-Samuelson effect, the exchange rate policies as well as the indexation system may influence the range. Given that the exchange rate is highly significant in the ASEAN and Africa, monetary policy (money supply) may possibly have distinct outcome on the growth of economic due to different level of inflation. The EU countries, on the other hand have the LGOV as a big burden to the economy. It is advised that the EU can have the current fiscal policy revised to enhance the economic growth. Hence, as an extension of this paper, based on our empirical results, other than the inflation rate, we may suggest some potential non-linearities determinants that may influence the economic growth. i.e., the impact of LEX on the ASEAN and Africa growth model as threshold variable instead.

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