A Study on the Non-Linearity Hypothesis Between Various Macroeconomic Variables and Economic Growth in Developing Countries.

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by

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Abstract

This thesis comprises three empirical chapters on the non-linear relationship between different macroeconomic variables and economic growth and employs new developed econometrics techniques.

After a short introductory chapter, the second chapter investigates the relationship between inflation and economic growth for 35 countries in the Middle Eastern and Sub-Sahara African countries between 1986 and 2011. We have employed a Panel Smooth Transition Regression (PSTR) approach to estimate a precise threshold level of inflation. We consider, also, the impact of inflation threshold levels between the finance-growth nexus. Additionally we explore whether or not the relationship between inflation and economic growth varies according to the level of institutional quality. The results indicate that, indeed, the inflation-growth nexus relies on the level of inflation. Moreover we confirm the importance of institutional quality level in determining the relationship between inflation and economic growth. Further, we find that the finance-growth nexus varies according to the threshold level of inflation.

The third chapter introduces a new estimation approach to the PSTR model; it is defined in the form of State Space system equations. We developed this approach to estimate two different threshold variables simultaneously and to consider the existence of a static and stochastic transition function. We employed this panel econometric investigation to identify the non-linear relationship between government size and economic growth for 5 countries in the Middle East and North Africa (MENA) region, during the period from 1970 to 2014. This chapter's main finding asserts the existence of a threshold level of government size below which it hurts economic growth.

The fourth chapter develops the employed model in the third chapter to provide a new insight into the relationship between foreign aid and economic growth. We developed this model in order to consider the time varying effects of the explanatory variables and to examine further the multiple regime threshold models. In this chapter we study the role of income in determining the non-linear relationship between foreign aid and economic growth for 25 developing countries during the period from 1984 to 2008. Additionally, we detect whether or not corruption levels matter for the effectiveness of aid in the aid recipient countries. Generally, based on their income levels, we recognize various threshold levels of foreign aid for each group of developing countries.

Dedication

This thesis is dedicated to the memory of my father, ***Mohamed Harb****.*

To my husband ***Mohamed*****.**

&

My lovely daughter ***Farida*****.**

"And indeed your Lord will soon grant you so that you shall be well-pleased".

[Holly Quran: Surah Al Duha 93:5]

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Declaration

An earlier version of Chapter 4, entitled “Does Foreign Aid Play A Role in the Maintenance of Economic Growth? A Non-Linear Analysis: has been accepted for presentation at the following conferences:

- Econometric Society Conference, South Africa, July 2016.
- Middle East Economic Association Conference, Doha-Qatar, March 2016.

The final version of chapter 3, Does Government Size Matter for Economic Growth? A Non-Linear Analysis Using State Space Model, is submitted and currently under review by Empirical Economics.

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An earlier draft of Chapter 2 entitled, “Does Inflation Really Matter for Economic Growth? Evidence from the Middle East; has been accepted for poster presentation at the:

- Festival of Postgraduate Research, University of Leicester- June 2014.

Table of Contents

List of Tables

List of Figures

List of Abbreviations:

B. Quality	Bureaucratic Quality
D. Accountability	Democratic accountability
EDA	Effective development assistance
ESTR	Exponential smooth transition regression
E. Tension	Ethnic tension
Execorr	Executive corruption index
Fh_ipolity	Level of democracy
Fh_pr	Political rights
FODA	Fitted official development assistance
Gfce	General government final consumption expenditures
GMM	Generalised method of moments
GLS	Generalised least squares
Hci	Human capital index
ICRG	International country risk guide
Inf	Inflation
Inv	Gross fixed capital formation
IV	Instrumental Variable
LSTR	Logistic smooth transition regression
MENA	Middle East and North Africa
ODA	Official development Assistance
Pop	Population Growth
PSTR	Panel smooth transition regression
PTR	Panel transition regression
Qog	Quality of government
ROAA	Return on Assets
SSA	Sub-Sahara Africa

Chapter 1

Introduction

1.1 Background and Motivation

While linear models have been widely used in empirical research, nevertheless, specific issues of economic and financial data remain unexplained. This is because the behaviour of many financial and economic time series experience incidents which vary quite dramatically. The behaviour either alters suddenly (i.e. known as a structural break) or may vary for a period of time before either it returns back to its original position or changes to another behaviour, namely, as a regime switch (Brooks, 2014). Recently, there has been a huge amount of interest of non-linear models. In particular, the regime switching or state dependant variable model has become the most prominent. The Smooth Transition Regression model belongs to the non-linear autoregressive model categories. Chan and Tong (1986) are the pioneers who introduced the Logistic STAR (LSTAR) model in time series analysis. Afterwards, Haggan and Ozaki (1981) introduced the exponential STAR (ESTAR). Later, Terasvirta (1994) defined a new class of STAR models that combined both LSTAR and ESTAR in one family. Afterwards, Gonzalez et al. (2005) have developed a non-dynamic STAR model within a panel data framework (known as Panel Smooth Transition Regression approach).

Motivated by these facts, this thesis examines generally the non-linear relationship between various macroeconomic variables and economic growth. Firstly, we employ the panel smooth transition regression model to determine the threshold level of inflation for a group of countries in the Middle East and Sub-Sahara African countries. Secondly, we introduce a new estimation technique for the panel smooth transition regression by employing the state space model and, hence, we determine a precise threshold level of government size for a group of countries in the Middle East and North Africa region. Thirdly, we extend the new estimation method to determine the foreign aid-economic growth nexus for a group of developing countries. One way of justifying interest in these areas is the critical role played by the modern central banks in terms of primary objective of price stability (inflation) and the increasingly important responsibility for sustaining the rate of economic growth. These roles involve the ability by central banks to moderate aid inflows or mitigate the adverse effects of government spending. A brief introduction for each chapter is presented as follows.

1.1.1 Threshold level of Inflation and Economic Growth: A Panel Smooth Transition Regression Approach.

The policy makers' target is to achieve high rates of growth accompanied by low rates of inflation. There is still debate about the clear identification of the inflation-growth nexus. Theoretically, various points of views dominate the debate in the literature. Firstly, Tobin (1965) supposes that money is a substitute for capital and, thereby, inflation enhances the rate of economic growth through inducing savings. Secondly, Sidrauski (1967) argues that money is super-neutral (Neutralist point of View), i.e. there is no causal relationship between inflation and economic growth. Thirdly, Stockman (1981) suggests that inflation has a deleterious effect on economic growth as he imposes the cash in advance constraint whereby money is required for both consumption and investment. Lastly, a new class of models highlights the fact that inflation has only a negative effect on economic growth if it surpasses a specific level. Recent empirical literature mentions the existence of a non-linear relationship between inflation and economic growth (e.g. Khan and Senhadji, 2001; Vaona and Schiavo, 2007; Buredekin et al., 2004 and Espinoza et al., 2012). Accordingly, there exists a threshold level above which inflation has a negative effect on economic growth. On the other hand, below this threshold level, inflation has either positive non-significant, negative or no effect on economic growth.

According to the foregoing discussion, from the theoretical and empirical point of view, it is clear that inflation's impact on economic growth is still mixed. Although there is a consensus that the inflation-growth nexus is non-linear, they cannot estimate a precise threshold level. Furthermore, a huge difference has been realised between the threshold levels of both developed and developing countries. Indeed, due to miscellaneous economic factors and levels of financial development, the threshold level varies from one country to another. There exists an argument which states that the threshold level in developing countries is much higher than in the developed ones. Financial and goods market of the developing countries are exposed to government intervention and supply shocks, leading to highly volatile rates of inflation, which consequently affect the behaviours of consumption, investment and production. Also, in developing countries, there is still a debate about the role of the independent central banks' legitimacy and their effectiveness in administrating the monetary policy, (Bittencourt, 2012). On the contrary, when compared to the developed countries, there are fewer intervention in the financial and goods markets of the developed countries. Therefore, it is interesting to understand the inflation-growth nexus in a broad range of developing countries (Singh and Kalirajan, 2003). Another reason for the existing debate among the empirical studies relates to the fact that most of the previous studies employ either inappropriate linear or non-linear models. In particular, they either determine the threshold level exogenously (i.e. arbitrary using breaks) or employ the inflation quadratic term as a source of non-linearity. Additionally, a non-linear estimation technique and misspecification tests should be improved in order to control any possible endogeniety bias.

Motivated by these facts, we employ in this chapter a PSTR approach because this approach allows us to estimate the threshold level endogenously and to capture the cross-country heterogeneity and time variability in the inflation-growth nexus. Moreover, it allows us to estimate the smoothness and the speed of transition between regimes. Although the threshold models have not been developed to control the endogeneity problem (more specifically if both slope and threshold variable are endogenous), we employ the fitted values of inflation to circumvent the endogeneity problem. To the best of our knowledge, the non-linear relationship between inflation and economic growth has never been investigated for a large group of the Middle East and Sub- Sahara Africa countries. Moreover, this study attempts to fill the gap in the literature by analysing the role of the inflation rate between finance and economic growth. Hence, we employ a new financial fragility dataset in order to capture whether or not various levels of inflation matter for the finance-economic growth nexus. Additionally, this is the first study to highlight the importance of institutional quality between the inflation-growth nexus. In particular, we employ various measures of institutional quality as threshold variables and we detect whether or not the inflation-growth nexus varies with respect to the level of institutional quality.

1.1.2 Does Government Size Matter for Economic Growth? A Non-Linear Analysis Using State Space Model.

The impact of government size on economic growth is still a controversial issue among researchers. There is no conclusive outcome on how big the government should be when it comes to its role in determining economic growth. Previous studies make a comparison between the reasons why government has a conducive or a deleterious impact on economic growth (e.g. Hansson and Henrekson, 1994; Obben, 2013; Bergh and Henrekson, 2010; 2011). They show that government spending can exhibit a positive effect on economic growth through avoiding market failure; reducing social inequality and poverty; alleviating the distortionary effect of taxes; and raising productive investment. Additionally, they suggest that larger government size stimulates economic growth through the evolution of the administrative, legal and economic infrastructures; increasing productive investment; establishing rule of law; securing property rights; and providing public goods. On the other hand, they relate the reduction in the marginal effect of government size to the following various reasons: 1) an increase in the distortionary effect of taxes; 2) Crowding out effect; and 3) Rent seeking activities. Another strand in the literature suggests the non-linearity hypothesis between government size and economic growth. They mention that various levels of government expenditures have different effects on economic growth (e.g. Karras, 1996; Pushak et al. 2007; Pevcin, 2004 and Davies 2009).

The above discussion highlights the controversial debate about the government size-economic growth nexus and shows clearly the fact that there exists undoubtedly an interesting gap in the literature. In developing countries, there is still a very limited investigation of the relationship between government size and economic growth. This is because most of the previous studies are concerned only with industrialized countries (e.g. OECD countries) and overlook the developing countries. Herath (2012) confirms the importance of analysing the relationship between government size and economic growth in developing countries. This is because most of these countries suffer from unstable political situations and poverty which stimulates their governments to take part in the economy and to spend money through welfare expenditure. Similarly Abu-Bader and Abu-Qarn (2003) suggest that these countries suffer from large fiscal imbalances. Moreover, their government revenues are very sensitive to any external shocks, a growing population and sustained per capita rates of economic growth are considered to be major challenges. This provides the motivation for this chapter to investigate the non-linear relationship between government size and economic growth within the Middle East and North Africa region.

Specifically, this chapter aims to answer the following questions:

1) How does government size affect economic growth?

2) Does the optimal size of government spending exist?

3) How large should the government be in the Middle East region?

A further shortcoming of most of previous studies relates to employing the squared term to identify the non-linearity hypothesis. Therefore, chapter three of this thesis contributes to the existing literature in several ways: first, our study attempts to answer the above questions by using a newly developed estimation technique for one of the most well-known threshold models (PSTR model) and by using Sate Space system equations. Second, the developed estimation method supersedes and overcomes the limitation of previous studies in determining a precise and significant threshold value. Third, we developed the model that estimates two different threshold variables jointly; as a new contribution to the existing literature. Fourth, the developed estimation method introduces a stochastic transition function for the PSTR model. Fifth, to the best of our knowledge, by covering a long time span from 1970 to 2014, this is the first study to investigate the relationship between government size and economic growth in the Middle East and North Africa region from a non-linear perspective.

1.1.3 Does Foreign Aid Fit All? A Non-Linear Analysis.

Foreign aid is always a debatable issue. During the 1970s, early generation studies were mainly based upon the Harrod-Domar model; they suggest that foreign aid promotes economic growth via savings. Consistently, the second-generation studies affirm the positive impact of foreign aid on economic growth through investment. As better data and new econometric methods become attainable, a new generation of studies has emerged; however their results are inconclusive. The existing literature raises many concerns towards the effectiveness of foreign aid. On the one hand, a group of researchers assert the flourishing effect of foreign aid on economic growth (e.g. Hansen and Tap, 2001; Gyimah-Brompeng et al., 2012 and Moriera, 2005), while they argue that the effect may vary between countries due to the various conditions that they might face. Another strand in the literature suggests that foreign aid is effective only in a good policy environment (e.g. Burnside and Dollar, 1997, 2000 and Collier and Dollar, 2002). On the contrary, other studies claim that foreign aid has a negative effect on economic growth due to the presence of corruption, rent seeking activities and aid dependency problems (e.g. Svensson, 2000; Economides et al., 2008; Djankov et al., 2008 and Moyo, 2009). Recently, a new line of research has incorporated the non-linearity hypothesis between the foreign aid-economic growth nexus. In this respect, some researchers consider the fact that foreign aid promotes economic growth but with diminishing returns (e.g. Hadjimichael et al., 1995; Durbarry et al., 1998, Lensink and White, 2001 and Clemens at al., 2012). In this vein, two points of views dominate the argument in the literature; these are, namely, the big push and the absorptive capacity constraint concepts. It is worth mentioning that raising the amount of foreign aid is vital to enhancing the rate of economic growth for some countries. Nevertheless, donors should consider each country's limited absorptive capacity.

One main limitation of previous studies is that either the threshold level of foreign aid has been selected arbitrarily (exogenous determination of the threshold level) or has employed the aid-squared term, which specifies only one specific form of non-linearity. Additionally, one of the main persistent issues between foreign aid-economic growth nexus is the endogeneity problem. Some studies suggest using instrumental variables (e.g. Aurangzeb and Stengos, 2010 and Kalyvitis et al., 2012); however it is difficult to find an instrumental variable, which is not correlated with any other omitted variables. More specifically, in the context of the threshold models, there is no existing solution to estimating a threshold model where both slope and threshold variable are endogenous, (Kourtellos et al., 2007).

By paying particular attention to the non-linear relationship between foreign aid and economic growth, chapter four of this thesis seeks to determine the threshold level of foreign aid across countries with various levels of income. This chapter is motivated to address the role of the income level between foreign aid-growth nexus through our estimation of the threshold level of foreign aid for three different income level countries. Furthermore it aims to understand whether foreign aid should adopt a big push or a limited absorptive capacity constraint concept. Additionally, we investigate whether or not corruption levels of aid recipient countries affects the aid allocation process.

This chapter contribute to the literature by introducing a new insight to estimating the panel smooth transition regression model by using state space system equations to distinguish an appropriate threshold level endogenously. We have developed the model in two ways. First, we propose a time varying effects of explanatory variables and, hence, the parameters of the explanatory variables are expected to vary with regard to the estimated threshold level. Second, we have extended the model to consider a multiple regime threshold model. Additionally we detect the effectiveness of institutional quality for aid recipient countries. In the context of the threshold models, we have employed the fitted values of foreign aid in an attempt to control the endogeneity problem.

1.2 Structure of the Thesis.

The remainder of the thesis is organised as follows: chapter 2 examines the non-linearity hypothesis among inflation-economic growth nexus. Paying particular attention to determine the threshold level of inflation and investigate its impact among finance-growth nexus. Furthermore, we explore whether institutional quality matters for inflation-growth nexus. The estimation method employed in this chapter is mainly, the Panel Smooth Transition Regression Approach (PSTR model).

Chapter 3 focuses on the non-linearity hypothesis between government size and economic growth in respect of a panel of 5 countries within the Middle East and North Africa continent. A new estimation method of the PSTR model has been developed in the form of state space system equation to determine the optimal size of government expenditures endogenously.

Chapter 4 estimates the threshold level of foreign aid for 25 developing countries through the period from 1984 to 2008. The employed method in the third chapter has been extended in the fourth chapter to examine a multiple threshold level of foreign aid and allow for a time varying effects of the explanatory variables.

Finally, chapter 5 presents the conclusion and policy implications, as well as underline the limitations of this study and further research avenues.

Chapter 2

Threshold Level of Inflation and Economic Growth: A Panel Smooth Transition Regression Approach.

2.1 Introduction

Whilst the economic literature agrees that high inflation rates have a negative effect on economic growth, it does not indicate what levels of inflation are considered to be high enough to distort economic growth. Theoretically, there exists a debate about the impact of inflation on economic growth (e.g. Tobin, 1965; Sidrauski, 1967; Stockman 1981). However, empirically, there remains mixed and scant evidence supporting such a debate. Recent literature goes towards examining the inflation-growth nexus from a non-linear perspective (e.g. Khan and Senhadji, 2001; Omay and Kan, 2010; Seleteng et al., 2013). Although, there is a consensus in the literature about the non-linearity hypothesis between inflation and the economic growth relationship, there continues to be great controversy with regard to determining an appropriate threshold level for both developed and developing countries. For instance, the results of the studies by Khan and Senhadji (2001) and Lopez-Villavicencio and Mignon (2011) were challenged by others (e.g. Vaona and Schiavo, 2007; Espinoza et al., 2012). This was because most of the previous studies on the factors impacting on economic growth investigated a heterogeneous group of countries with different income, financial, development and growth levels. This explains the existing discrepancy when estimating an adequate threshold level of inflation.

Against this background, this study aims to test the nonlinear relationship between inflation and economic growth. During the period from 1996 till 2000, inflation rates in the MENA countries declined from 11.5 percent till 2.5 percent. However, in 2001 inflation rates starts to increase again till 2008. Afterwards it has been emerged as a priority issue in the MENA countries as it jumped into double digits, (Crowley, J. (2010).

We attempt to fill the gap in the literature by undertaking a panel econometric investigation of 35 countries in the Middle East and Africa region. Moreover by using a new international database of financial fragility, we test for the presence of a threshold level of inflation and, where appropriate, we consider the effect of inflation threshold levels along the finance-growth nexus. Lastly, we attempt to control and employ various institutional quality indicators as threshold variables in order to determine whether or not institutional quality matter for the inflation-growth nexus.

Our study has the following key objectives:

1) To investigate the non-linearity hypothesis between inflation and economic growth in the Middle East and African continent.
2) To estimate the threshold level of inflation.
3) To estimate the speed of transition between regimes.
4) To examine the impact of the inflation threshold on the finance-growth relationship.
5) To investigate institutional quality effect on inflation-growth nexus.
6) To draw macroeconomic policy implications.

In this chapter, we employ the Panel Smooth Transition Regression (hereinafter referred to as PSTR) model developed by Gonzalez et al. (2005). Instead of the discontinuous transition, this model is considered to be a regime-switching model, which provides a smooth transition from one regime to another. Furthermore, over time and following the changes in the threshold variable, individuals are allowed to switch between groups (Lopez-Villavicencio and Mignon, 2011). The PSTR model supersedes other models in its capacity to determine the threshold level of inflation endogenously and to control the cross-country heterogeneity and time variability of the growth inflation nexus. In addition, it determines the smoothness (speed) of the transition between regimes. This model has not been developed to consider an IV approach and, therefore, we employ a two-stage procedure by using the fitted values of inflation to avert endogeneity.

Our empirical investigation confirms the presence of a non-linear relationship between inflation and economic growth. According to our estimations, 10.8% is the threshold level of inflation for the countries, which we choose to study. This threshold level splits the sample into two regimes and demonstrates that, during high inflation regimes, inflation has a distortionary impact on economic growth, while it has either a positive or negative non-significant impact on economic growth during regimes of low inflation. However, when compared to the SSA countries, there is little evidence of nonlinearity in MENA countries. Moreover, we observe that the finance-growth nexus varies according to the threshold level of inflation. Similarly, the quality of institutions affects the relationship between inflation and economic growth.

The rest of the chapter is organised as follows. Section 2.2 reviews the theoretical and empirical literature concerning the relationship between inflation and economic growth and addresses the empirical problems in estimating the inflation-growth nexus. Section 2.3 discusses the empirical estimation method. Section 2.4 describes the data and variables employed in this chapter. Sections 2.5 and 2.6 display the empirical results. Section 2.7 presents the conclusion.

2.2 Literature Review

2.2.1 Theoretical Background

The objective of macroeconomic policy is to achieve high growth rates accompanied with stable levels of inflation. A certain level of inflation is required in order to grease the wheels of the economy. However, Gylfason and Herbertsson (2001) mention that inflation is a common factor for any imperfect institution and that other factors can weaken both savings and efficiency and can diminish economic growth. Consequently, it is important that policy makers understand the inflation-growth nexus, **(**Seleteng et al., 2013).

Economic theories provide several explanations about the relationship between inflation and economic growth. According to John Maynard Keynes, government intervention in the economy via expansionary policies will enhance both investment and demand to attain the full production level. This is defined as effective demand that maximize the employment of the restricted amount of resources before the full production level. However any excess demand beyond that level is considered as excess demand, (Xiao, J., 2009). The Keynesian vision of the positive relationship between inflation and economic growth prevailed in the literature until the 1970's when Friedman mentions that this positive relationship can hold only in the short run, (Espinoza et al., 2012). The Keynesians fail to provide any explanation for this phenomenon under the Keynesian theory. This is because this period manifests low rates of output growth, high inflation rates and huge unemployment (i.e. the Phillips curve fails to explain stagflation). According to the Monetarism point of view, inflation happens if the growth in money supply is greater than the output growth. Hence, the quantity theory of money underlines the importance of monetary growth in deciding inflation.

The New Keynesian models consider both price and wage rigidities and their implications on the implementation of the monetary policy. Because of the existing rigidities, they suggest that the economic shocks that might arise from either supply or demand side will be overstated. For instance, if the central bank introduces a tightening monetary policy, aggregate demand will decline followed by a reduction in the economic growth rate and a boost in the unemployment level. However inflation levels are expected to be unchanged because prices are supposed to be rigid[1]. They believe that high inflation rates affect economic growth negatively. Additionally, due to the price rigidity phenomenon, they argue that a decrease in money supply to restrain high inflation rates will lead to a recession, (Makuria, 2014).

There is an on-going debate about whether inflation has a positive or a detrimental impact on economic growth. Jung and Marshall (1986) mention the existence of three possibilities for the relationship between inflation and economic growth. The first possibility is that inflation has a positive effect on economic growth through inducing savings (Structuralist point of view). In addition, Keynesians' believe that inflation stimulates economic growth through increasing the rate of profit and, consequently, increases private investment. On the contrary, another point of view suggests that inflation has a detrimental effect on economic growth. This is because those, who support this view, build their ideas upon the fact that high and variable inflation leads to an increase in the risk and cost of productive investment. In turn, this causes a decline in both investment and economic growth. Others believe that there is no causal relationship between inflation and economic growth (Neutralist point of view).

De Gregorio (1996) consider the following production function to explain inflation's impact on economic growth in the long-run:

$$y_t = \mu f(k_t, l_t) \qquad (2.1)$$

[1] Additionally, they argue that output levels will vary even if prices were flexible, due to the existing uncertainty with prices.

As y_t represent the output at time t, μ shows the technological progress parameter and k_t, l_t display the capital stock and labor at time t respectively. By log-differentiating equation (2.1) the rate of growth of an economy displayed as follows:

$$\gamma = \mu f'(k_t, l_t) i \qquad (2.2)$$

According to equation (2.2), γ represent the growth rate of output, whereas $\mu f'(k_t, l_t)$ display the marginal productivity of capital and i shows the rate of investment. According to the traditional neoclassical growth theory, the economic growth cannot be accomplished without technological progress (i.e. μ is not constant)[2]. On the other hand with respect to the new endogenous growth models, μ is no longer a source of output growth. According to equation (2.2) an increase in output growth is expected either through a boost in investment or a rise in the marginal productivity of capital. Another scenario proposes that inflation could affect economic growth through deforming the optimal choice among consumption and leisure. Therefore, since capital accumulation turns out to be less efficient, a decline in the marginal productivity of capital $f'(k_t, l_t)$ will lead to a fall in the rate of economic growth. Since money is required for consumption and people have to choose between consumption and leisure. Thus a boost in the rate of inflation will motivate people to substitute from consumption to leisure due to a rise in the price of goods, (De Gregorio, 1996).

Theoretically, the impact of inflation on economic growth is mixed and depends mainly on the way in which money is inserted into the models. For instance, Tobin (1965) assumes that money is a substitute for capital. Therefore, in the long run, any increase in the inflation rate induces individuals to hold capital instead of money. Consequently, as the long-run real interest rate falls, the long-run investment increases and output growth increases. Therefore, high levels of inflation diminish the real return on monetary assets and, thus, high levels of inflation encourage people to substitute money for real investment[3].

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[2] Furthermore they assume the diminishing returns of capital accumulation.

[3] Ahmed and Rogers (2000) mention that the general idea behind the Tobin effect originates from the inclusion of a fixed saving rate. Thus, a high rate of inflation increases the opportunity cost of holding money. Therefore, it stimulates savers to hold more physical capital instead of real balances. Hence, it reduces the marginal product of capital and, consequently, the real rate of interest falls. Moreover, since individuals tend to hold more capital than money, Gillman and Kejak (2011) use capital intensity to define the broader framework of the Tobin Effect and this leads to an increase in the capital to labour ratio. Thereby, in the long run, inflation exhibits positive effect on economic growth (Tobin Effect)

However, Sidrauski (1967) proposes a considerable change within the neoclassical structure because he assumes that money is super neutral. He uses infinitely lived agents, which have preferences for both consumptions and real balances. In this model, the saving and demand function originates from optimization behaviour, while saving rate is considered to be a fixed in the Tobin model. Thus, the long-run capital stock relies mainly on its rate of depreciation, rate of population growth and rate of agents' discount. In this model, capital stock is considered to be super-neutral since the rate of growth of money and inflation do not affect both steady state capital stock and output.

On the other hand, Stockman (1981) argues that individuals use money to finance their real purchases (consumption) and investment. He imposes cash in advance as a constraint, he suggests that a rise in the rate of inflation minimises individuals' desire to hold real money. Since money is a prerequisite for both consumption and investment goods, there is a decline in both consumption and investment due to the diminishing rate of holding money. Likewise, there is a declining return from investment because it is too costly to hold money at higher rates of inflation. Therefore, since inflation acts as a tax on investment, there is a diminution in both investment and steady state of capital stock and, thereby; people prefer to spend their money instead of keeping it. This result does not echo with the Tobin effect theory.

Lately, a new class of model has been introduced in which inflation has a negative effect on economic growth only when it exceeds a certain level. In this class of model, high rates of inflation hamper efficient allocation of resources and hinder financial development. Therefore, recent theoretical studies have started to consider the non-linearity hypothesis between the inflation-growth nexus via money elasticity demand (e.g. Gillman and Kejak; 2005 and Hung 2008). Hence, they introduce the monetary endogenous growth model, which employs both human and physical capital.

2.2.2 Empirical Background

2.2.2.1 The Linear Inflation-Growth Nexus.

Inflation is not the sole reason for countries' poor performance; some countries react to high rates of inflation by printing more money, (Guerrero, 2006). Existing empirical studies provide contradictory evidence about how inflation affects economic growth. On the one hand, in order to give a theoretical explanation for the discrepancy concerning the Tobin effect on both investment and real interest rate, Ahmed and Rogers (2000) employ US data from 1889 to 1995 and Gillman and Kejak (2011) employ post war US data and augment stockman constraint. Consistent with the Tobin effect, they both indicate the existence of long-run evidence in which inflation leads to a decline in the real rate of interest. Along the same lines, by using a structural vector auto-regression model, Rapach (2003) analyses the long-run response of the real rate of interest and real output to permanent changes in the rates of inflation of 14 industrialised countries (OECD countries). He argues that, in the long run, an increase in each country's rate of inflation reduces the rate of interest and raises the level of real output.

On the other hand, Gillman and Nakov (2003) introduce endogenous growth through the cash in advance model with human and physical capital. They contribute to the literature by employing the finance sector since it enables them to produce credit services in order to avert inflation tax. Their idea is stimulated by the Tobin effect and they expand it further to include both capital and labour, the result suggests a decline in economic growth rates. From this, they are able to show that an increase in the rate of inflation leads to a rise in the ratio of real wages to the real rate of interest. In the same vein, Gillman et al. (2004) develop Gillman and Nakov's (2003) idea by introducing the credit sector to monetary model of endogenous growth, namely, human capital along with credit production. As in Gillman and Nakov (2003) they employ both money and credit to buy goods rather than using only cash. Their novelty is based on employing a new panel of data for both APEC[4] and OECD countries; they use the growth rate of money supply as an instrumental variable for inflation. Generally, they conclude that inflation has a dampening effect on economic growth.

[4] APEC: Asia-Pacific economic cooperation, they are 21 countries most of them on the Pacific Ocean. Their aim is to enhance trade and economic cooperation.

2.2.2.2 What Levels of inflation is harmful to economic growth? (Threshold effects)

The above-mentioned studies manifest contradictory evidence about how inflation affects economic growth (e.g. Structuralist and Neutralist). Their concerns are based mainly on determining the sign of the impact; they take no account of the possibility of an existing kink in the rate of inflation, which splits the sample into two or more regimes. Thereby, at different levels of inflation, we may capture its various impacts on economic growth. Moreover, some of these studies overlook the indirect channels, which may affect growth in the presence of inflation, for example: the level of financial development; openness to trade; and population growth.

2.2.2.2.1 Exogenous Determination.

We can consider the non-linear relationship between inflation and economic growth from two aspects. Firstly, there is a positive relationship at low rates of inflation. Secondly, higher rates of inflation reduce the marginal effect of the rate of inflation on economic growth, (Ghosh and Phillips, 1998). However, misleading results are expected if we take no account of the non-linearity hypothesis. Fischer (1993) is the pioneer who identifies the non-linear relationship between inflation and economic growth by using the spline function. His results show that, at all levels of inflation, a negative relationship occurs between inflation and economic growth. Similarly, Sarel (1996) investigates the nonlinearity hypothesis for a group of both developed and developing countries. His assertions are based on the existence of a structural break at 8% and, hence, below this rate, inflation exhibits either a positive or an insignificant impact on economic growth. However, beyond this rate, there is a negative association with economic growth. In this respect, the main limitation is that the threshold level of inflation is located exogenously because, by using breaks, the sample is split in order to clarify the thresholds.

Additionally, Bruno and Easterly (1998) mention that a crisis of high inflation does not damage economic growth permanently because they show that some countries recovered to their pre-crisis rates of inflation. They detect a long-run relationship between inflation and economic growth. Also, they emphasise that such a relationship does not occur if the rate of inflation is below 40%. However, if it exceeds the 40% threshold level, it can be detrimental to growth. Similarly, Ghosh and Phillips (1998) employ large panel data during the period from 1960 to 1996. They suppose that the kink of the spline is 2.5%

and, furthermore, they support the existence of a negative correlation between the rates of inflation and economic growth.

In the same vein, Burdekin et al., (2004) employ GLS with fixed effect to assess inflation's non-linear impact on economic growth among different groups of developed and developing countries in the period from 1965 to 1992[5]. Unlike previous studies, their empirical results show that, for developing countries, inflation has a positive and significant impact on economic growth until it reaches the 3% threshold level. Beyond this level, inflation has a detrimental effect on economic growth. On the other hand, they observe an 8% threshold level of inflation for industrialised countries. These findings contradict most existing studies, which provide evidence of a higher threshold level for developing countries when compared to the developed ones (e.g. Khan and Senhadji, 2001; Lopez-Villavicencio and Mignon, 2011).

The results of the foregoing studies (e.g., Fischer, 1993; Sarel, 1996; Bruno and Easterly, 1996; Bullard and Keating, 1995 and Ghosh and Phillips, 1998) confirm that, for various time intervals, inflation has a negative effect on economic growth. They rely on either the linear or non-linear models, which are inappropriate when modelling the non-linearities. The inadequacy of these models stems from determining threshold levels of inflation exogenously and from employing inflation's quadratic term[6]. This imposes only a specific form of non-linearity that fails to capture the true non-linear impact of inflation on economic growth. Additionally, there is a lack of consensus regarding the critical value of the threshold level of inflation. Thereby, more advanced estimation techniques are required in order to allow them to control heterogeneity at both the country and time levels, (Omay and Kan, 2010).

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[5] They consider the data separately for both groups of countries because they argue that mixing both industrial and developing countries may produce unreliable results. This is because both types of countries have different characteristics and various levels of financial development.

[6] Other studies criticise the strategy of employing the interaction term (e.g. Law and Singh, 2014; Law et al., 2013). They suggest that the square term of inflation proposes a priori constraint in which the effect of inflation on economic growth increases and decreases monotonically with respect to the inflation level. Also, they claim that a specific level of inflation may need to be achieved prior to distinguishing its impact on economic growth.

2.2.2.2.2 Endogenous Determination

There has been criticism of previous studies due to their estimating the threshold level of inflation exogenously. Since they split the sample arbitrary, they take no account of the heterogeneity at the country and time levels. Consequently, there is an expectation that the results are biased. Thereby, more advanced econometric methods have been employed to determine endogenously a precise threshold level. Hansen (1999) introduces the starting point for the empirical analysis of the threshold level of inflation, (Kremer et al., 2013). This suggests that, all regressors have to be exogenous, but it is difficult to satisfy the exogeneity assumption.

In the same context, David, D., et al., (2005) use a non-dynamic panel model for a sample of 138 countries in the period from 1950 to 2000. Interestingly, their empirical results emphasise the existence of two threshold levels for industrialised countries at 2.52% and 12.6% respectively. Consistently, Khan and Senhadji (2001) use a discrete threshold model in order to investigate whether or not the threshold is similar across both developed and developing countries. They detect a lower 1% threshold level of inflation for industrial countries compared with 11% for developing countries. Nevertheless, Vaona (2012) argues that the threshold level found by Khan and Senhadji (2001) is unconvincing. This is because below this threshold level, the observations are very small and, consequently, it may be representing only a temporary incident, which may have a small effect on long-term economic growth.

Similarly, by using a generalised Panel Threshold Regression (PTR)[7] Model and taking account of the regime intercept, Bick (2010) revisits the relationship between inflation and economic growth. The empirical results assert the importance of including regime intercept from the statistical and economic perspective. With the inclusion of regime intercept, he finds that the threshold level of inflation declines from 19% to 12% and that, above this level of inflation, there is a detrimental impact on the rate of economic growth. Alike, Kremer et al., (2013) extend Caner and Hansen's (2004) model to a dynamic panel threshold model with instrumental variables. They observe the detrimental impact of inflation on industrialised and developing countries' economic growth beyond 2% and 17% respectively. They assert that for industrialised countries, the threshold level is

[7] Developed by Hansen (1999)

consistent with some central banks' target levels of inflation. However, in developing countries the target of an adequate level of inflation is still ambiguous.

In response to the global inflation episodes in 2007, Vaona and Schiavo (2007) use a non-parametric and a semi parametric IV-estimator to deal with the endogeneity of inflation during the period from 1960 to 1999. Their results show that, in developed countries, inflation does not have a substantial impact on economic growth when it is below 12%. On the other hand, due to the developing countries' high variability of growth performance, they cannot find a precise threshold level of inflation. Alternatively, Vaona (2012) investigates theoretically and empirically inflation's influence on economic growth through the existence of staggered wages in the labour market. Unlike the findings of previous existing studies, they detected no evidence of threshold levels of inflation. In contrast, Espinoza et al., (2012) cannot find a specific threshold level of inflation for the developed countries. However, they detected a 10% threshold level of inflation for developing countries. This result contradicts other studies (e.g. Khan and Senhadji, 2001; Omay and Kan, 2010; Vaona and Schiavo, 2007 and Burdekin et al., 2004) that find that the threshold levels for developed countries are 1%, 2.52%, 12% and 8% respectively. Despite the seeming acceptance of the non-linearity of the inflation-growth nexus, it is seen obviously that, due to the sensitivity of the non-linear relationship to the frequency of the data, the determination of a precise threshold level of inflation is still a debatable issue, (Lopez-Villavicencio and Mignon, 2011).

2.2.2.3 More advanced estimation techniques

With it being unconvincing to assume that inflation's behaviour changed suddenly, the threshold models has been developed to consider a gradual transition between regimes. Hence, they replace the discontinuity in the threshold model with the smooth transition function (PSTR model). This model allows heterogeneity to be captured between individuals and over time and determines the speed of transition between the regimes. Additionally, these can be extended in order to examine a multiple regime threshold model. Omay and Kan (2010) employ a newly constructed model (PSTR model[8]) by using data for six industrialised countries[9]. Their empirical analysis asserts the non-

[8] Gonzalez et al., (2005) develop the Panel Smooth Transition Regression approach. This model is considered to be an extension of the PTR model and, hence, it permits the coefficients to change smoothly from one regime to another.
[9] Six industrialised countries are: Canada, France, Japan, Italy, UK and USA.

linearity evidence among the inflation-growth nexus. They find that, for six industrialised countries, the threshold level of inflation is around 2.52%. However, they focus only on industrialised countries and they neglect the indirect channels through which inflation may affect economic growth. Furthermore, they do not consider the level of financial development, population growth and government expenditure which may affect the relationship between inflation and economic growth.

Lopez-Villavicencio and Mignon (2011) study the impact of inflation on economic growth by categorising countries in their sample into developed and developing countries. This categorisation allows them to investigate different threshold levels for each category of countries. Furthermore, they employ a GMM dynamic panel model in order to obtain more robust results. Their empirical analysis shows that various levels of inflation affect the rate of GDP growth differently. Moreover, they realise that the growth effect of inflation is non-linear and the threshold level differs between the two groups of countries (i.e. 1.2% for developed countries and 14.5% for developing countries). Along the same lines, Seleteng et al. (2013) estimate precisely the threshold level of inflation in the Southern African Development Community (SADC) region. Their results advocate the rejection of the null hypothesis of a linear relationship between inflation and economic growth in the SADC region. Furthermore, the speed of transition from a low to a high inflation regime is smooth but rapid. Therefore, they suggest that SADC central banks should act immediately when the rate of inflation is near the estimated 18.9% threshold level.

2.2.2.4 Causality Issue

When we study the relationship between inflation and economic growth, we must address the causality problem. The debate depends mainly on the direction of the causation; no problems are encountered if the impact runs from inflation to economic growth. However, if it is the other way round, there is an expectation of a strong bias, (Khan and Senhadji, 2001). Fischer (1993) states causality runs mainly from inflation to growth. He introduces the terms of trade as a regressor because he believes that, in developing countries, it is the main source of supply shocks. On the other hand, Bittencourt (2012) asserts the existence of a reverse causality (high growth can lead to high inflation) and, thereby, he employs a fixed effect with instrumental variable (two stage least square). Similarly, Guerrero (2006) employs previous hyperinflationary experience as an instrumental variable. He asserts that inflation has a robust detrimental impact on economic growth and the causation runs from inflation to economic growth.

Unlike previous cross-section studies, by employing a co-integration technique and using time seies data for Mexico, Risso and Carrera (2009) carried out a granger causality test in order to detect the direction of the causation. According to their findings, the real GDP does not lead to granger cause inflation. They also provide evidence that if inflation exceeds 9%, it has a dampening effect on economic growth. On the other hand**,** Ericsson et al. (2001) employ a granger non-causality test for G-7 countries. They notice, for all countries, the existence of co-integration between inflation and output growth. Moreover, they argue that, in the long run, inflation has a negative effect on economic growth.

In contrast with the foregoing studies, Hwang (2007) provides interesting evidence of bidirectional causality. He uses monthly data of the rates of US growth rate and inflation for the period from 1974 to 2005 and applies VARMA-ML-Asymmetric-VGARCH. He shows that cross volatility, which runs from inflation to economic growth, is much greater than from real growth to inflation. This means that a period of high volatility in inflation is followed by a rise in volatility in the real rate of growth. However, the opposite direction is valid but it does not have a strong impact due to the effect of inflation on the real rate of growth.

Previous studies suggest that the first lag of inflation should be employed as an instrumental variable (e.g. Vaona and Schiavo, 2007 and Espinoza et al., 2012). However, other studies argue that the IV effect is fragile because it is difficult to find an exogenous instrumental variable for inflation, (Bruno and Easterly, 1998). In the same context, other studies are concerned with the endogeneity, which may rise from control variables (e.g. Kremer et al., 2013). On the contrary, some studies do not deal with this and control the bias results from endogeneity of control variables (e.g. Khan and Senhadji, 2001; Bick, 2010 and Burdekin et al. 2004). At the end, they admit that accounting for endogeneity, which may arise from control variables, does not have a significant effect on the estimated thresholds. This is because their results are consistent with previous studies whose models did not control endogeneity (Kremer et al., 2013; Ibarra and Trupkin, 2016).

Lastly, the estimation method employed in this chapter, has not been extended to deal with such problems. Consequently, in order to circumvent the endogeneity problem that arises from inflation, we employ the predicted value of inflation. Moreover, the Hausman test shows no evidence of endogeneity, which might arise between inflation and economic growth. In the same vein, most previous studies average their dataset over 4 or 5 years in order to avoid the variations in rates of annual growth. We favour the employment of annual observations because it enables us to capture the maximum variations in the employed dataset. Furthermore, if rates of inflation depend on the current levels of growth, inflation cannot be endogenous because we cannot promptly observe inflation's impact on economic growth.

2.2.2.5 Inflation and Finance, Growth Nexus

There is another scenario suggest that inflation affect economic growth through the channel of financial activity. Thereby, Rousseau and Wachtel (2002) examines whether the relationship between the size of a country's financial sector and its rate of economic growth varies concurrently with the changes in the rate of inflation. Additionally, they employ a rolling regression technique in order to shed light on the relationship between financial development and the rate of inflation, which affects economic growth. Due to the difficulties in determining an exact threshold level, there is no consensus regarding the relationship between inflation and growth. Nevertheless, their findings confirm that there is a significantly strong and robust relationship between finance and growth. Furthermore, they suggest that financial depth has a positive effect on growth only when inflation falls below the threshold, which varies between 13% and 25%, and that the threshold level depends on the measure of financial depth.

Along the same vein, Huang et al., (2010) re-investigate whether the finance-growth nexus varies according to the changes in the rate of inflation. Particularly, they attempt to discover the existence of any threshold level of inflation between finance and economic growth. The novelty of their model is concerned mainly with controlling the endogeneity problem between the finance and growth nexus. Therefore, they employ a threshold regression with instrumental variable to detect whether, through financial development, inflation can enhance or dampen economic growth. Their analysis provides evidence that below the 8% threshold level of inflation, financial development has a positive effect on economic growth while, beyond that level, it has an insignificant impact. Additionally, Yilmazkuday (2013) employ a rolling-regression window 2sls regression to conduct a continuous analysis of the threshold level of inflation. His empirical analysis shows that inflation removes financial development positive impact on economic growth beyond the

8% threshold level. However, he takes no account of the heterogeneity across both country and time levels in his analysis. Therefore, we attempt to employ a new international database about financial fragility in order to detect the impact of the threshold level of inflation on the finance-growth nexus.

2.3 Methodology

In the context of the inflation-growth nexus, we employ the PSTR model, which is an extension of the PTR[10] model developed by Hansen (1999). Gonzalez et al. (2005) state that the PSTR model has the same characteristics as the PTR model. However, the PSTR model allows the coefficients to be changed smoothly from one regime to another. In other words, the PSTR model suggests that the discontinuity function to be replaced by a smooth transition one whereby a continuum of regimes is permitted and is distinguished by a distinct value of the transition function, (Colletaz and Hurlin, 2006). This is because sometimes it is counter-intuitive to assume that the behaviour of the variables changed suddenly. Gonzalez et al. (2005) define the PSTR model as a fixed effect model with exogenous regressors. Alternatively, it can be defined as a non-dynamic panel with coefficients, which can vary over individuals and over time. This model allows us to determine endogenously the threshold level of inflation.

2.3.1 Panel Smooth Transition Regression Model

2.3.1.1 Model Description

According to Gonzalez et.al, (2005) we can think of the PSTR model as a linear heterogenous panel model[11]. Heterogeneity exists in the regression coefficient because they suppose that these coefficients are a continuous function of an observable variable through a bounded function of this variable called transition function. This oscillates between the two extreme regimes. The transition variable is time varying and individual specific; however, the coefficients for each individual change over time. It can be

[10] PTR model refers to Panel Threshold Regression Model; it suggests that the transition from one regime to another depends on a threshold variable. In the case of the two regime model, if the threshold variable (defined by inflation in our case) is beneath the threshold parameter, inflation is determined by one equation $Z_{it} < c$. On the other hand, it is determined by a different one if the threshold variable is located above the estimated threshold parameter $Z_{it} > c$ (i.e. indicate the discontinuity structure of the threshold model), (Colletaz and Hurlin, 2006).

[11] Or it can be defined as a non-linear homogenous panel model. However this definition is common in the case of a univariate smooth transition regression model (STR), (Gonzalez et al., 2005).

considered to be among the regime switching models. The simplest case for the PSTR model with two extreme regimes and single transition function is defined as follows:

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it}\ g\ (q_{it}; \gamma, c) + u_{it} \qquad (2.3)$$

For i = 1,….,N, and t = 1,….,T, where N and T refer to the cross section and time dimension of the panel respectively. The dependant variable y_{it} is the annual growth rate of GDP; μ_i represents the fixed individual effect; x_{it} is a dimensional vector of time varying exogenous variables; and u_{it} represents the error term.

Gonzalez et al., (2005) define g (q_{it}; γ, c) as the transition function, where q_{it} is the threshold variable. According to Dijk et al. (2002), q_{it} can be either an exogenous variable or a lagged endogenous variable; γ determines the smoothness of the transition from one regime to another; and c denotes the threshold parameter. This transition function is a continuous function of the observable variable q_{it} , which is bounded between 0 and 1; this gives the extremes of the regression coefficients as β_0 and $\beta_0 + \beta_1$. Teräsvirta (1998), Dijk et al., (2002) and Gonzalez et al., (2005) propose that the transition function is defined in the following general form of logistic transition function.

$$G\ (q_{it}; \gamma, c) = \left(1 + exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - c_j)\right)\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq \ldots \leq m \qquad (2.4)$$

According to Teräsvirta (1998), the model in equation (2.4) is called the Logistic Smooth Transition Regression model (hereinafter referred to as LSTR) and the transition function is increased monotonically. Where γ > 0 and $c_1 \leq c_2 \leq \ldots \leq$ m display the identifying restriction and c $= (c_1, \ldots \ldots, c_m)'$ is the m-dimensional vector of the location of the parameters.

In the case of m=1, the model displays two extreme regimes which are correlated with low and high values of q_{it}. If γ → ∞, the logistic transition function becomes an indicator function I[A].This takes a value of 1 when A occurs or 0 otherwise (i.e. g (q_{it}; γ, c) =0 if $q_{it} \leq c$ and g (q_{it}; γ, c) =1 if $q_{it} > c$), (Lee and Chiu, 2011). For m=2, the transition function g (q_{it}; γ, c) has a value of 1 at both low and high values of q_{it} and attains its minimum value at $\frac{(c_1+c_2)}{2}$. In this state, if γ → ∞, the model is a three-regime threshold model. Lastly, for any value of m if γ → 0, the transition functions reduce to a linear panel regression model with fixed effects. Therefore, the PSTR model can be generalised in the following form:

$$y_{it} = \mu_i + \beta_0' x_{it} + \sum_{j=1}^{r} \beta_1' x_{it}\, g_j(q_{it}^{(j)};\, \gamma_j, c_j) + u_{it} \qquad (2.5)$$

In this context, the PSTR model has several advantages. Firstly, inflation-growth coefficients are allowed to change with reference to countries and time. This is because the coefficients will have various values, which rely on the value of the other observable variable. In other words, according to the alteration in the threshold variable, this model permits individuals to shift between groups and over time. Hence, it captures both cross-country heterogeneity and time variability, (Eggoh and Khan, 2014). More specifically, the parameters of the inflation-growth nexus alter smoothly as a function of the threshold variable. If the threshold variable (q_{it}) varies from the inflation rate (inf_{it}), the partial elasticity of growth with respect to the country's rate of inflation (i) at time (t) is defined as follows:

$$\frac{\partial y_{it}}{\partial inf_{it}} = \beta_0 + \beta_1 g(q_{it};\, \gamma, c) \qquad (2.6)$$

While, if the transition variable is similar to the exogenous variables (i.e. $q_{it} = inf_{it}$), the partial elasticity is defined as follows:

$$\frac{\partial y_{it}}{\partial inf_{it}} = \beta_0 + \beta_1 g(inf_{it};\, \gamma, c) + \beta_1 \frac{\partial g(inf_{it}; \gamma, c)}{inf_{it}}\, inf_{it} \quad \forall_i, \quad \forall_t \qquad (2.7)$$

According to (Colletaz and Hurlin, 2006; Eggoh and khan, 2014), it is worth mentioning that the estimated parameters of the extreme regimes are different from the elasticity of growth to inflation. The parameter in both equations (2.6 and 2.7) does not represent the direct effect of inflation on economic growth. The parameter β_0 displays the direct effect of inflation on economic growth when the transition function goes toward zero. However, the sum of the parameters $\beta_0 + \beta_1$ represents the elasticity of the inflation rate on economic growth when the transition function goes toward 1. On the other hand, the elasticity of the parameters between theses extreme regimes is determined by the weighted average of both β_0 and β_1. Thereby, it is more desirable to explain the sign of the parameters, which shows either an increase or a decline in the elasticity with respect to the threshold variable.

According to Gonzalez et al. (2005), the PSTR model is built upon three stages: namely, the specification; estimation; and evaluation stages. The specification stage consists of testing the homogeneity; selecting the transition variable; and selecting the suitable value of m. In the second stage, a non-linear least square technique is employed to estimate the parameters. However, at the evaluation stage, they provide misspecification tests in order to verify the adequacy of the data. These tests encompass testing for no-remaining heterogeneity, parameter constancy and no autocorrelation in the errors.

2.3.1.2 Testing For Linearity (homogeneity)

Teräsvirta (1998) and Gonzalez et al. (2005) mention that, in order to avoid the estimation of unidentified models; we should test firstly the linearity hypothesis against the PSTR. The null hypothesis of the linearity test (i.e. H_0: γ =0 or H_0': β_1=0)[12] is nonstandard because it encompasses unidentified nuisance parameters, for instance, the location parameter (c) are unidentified under both hypotheses. Similarly, both β_1 and γ are unidentified under H_0 and H_0' respectively. Therefore, Gonzalez et al. (2005)[13] employ a solution developed by Luukkonen et al. (1988) in which they replace the continuous function in equation (2.3) with first order Taylor expansion around γ = 0. This leads to the following auxiliary regression

$$y_{it} = \mu_i + \beta_0'^{*} x_{it} + \beta_1'^{*} x_{it} q_{it} + \ldots\ldots\ldots + \beta_m'^{*} x_{it} q_{it}^{m} + u_{it}^{*} \qquad (2.8)$$

Where $\beta_1'^{*}$,….,$\beta_m'^{*}$ represent the parameter vectors which are multiples of γ. Dijk et al.,(2002) confirm that, after using the Taylor series approximation, this identification problem no longer exists. Moreover, they mention that the linearity test can be carried out now by using the Lagrange Multiplier (LM) with a standard asymptotic x^2 distributions. Thus, we find that testing H_0: β_1= 0 in equation (2.3) is equivalent to testing H_0^*: β_1^* =…..= β_m^*= 0 in equation (2.8). It is worth mentioning that under the null hypothesis $u_{it}^* = u_{it}$. Following Colletaz and Hurlin (2006) and Seleteng et al., (2013), the tests can be carried out using the Wald, Fischer and likelihood ratio tests where these tests are distributed $x^2(k)$ under the null hypothesis.

The Wald LM test is as follows: $$LM_w = \frac{NT(SSR_0 - SSR_1)}{SSR_0} \qquad (2.9)$$

[12] Under these null hypothesis, the PSTR model of equation 2.3 and 2.4 reduce to a homogenous model (i.e. y_{it}= μ_i + $\beta_0' x_{it}$ + u_{it})

[13] Alternatively Hansen (1999) proposes another solution for such a problem. He employs a bootstrap method to construct the asymptotic distribution of the likelihood ratio test. Since this is due to the presence of unidentified nuisance parameters under the null hypothesis, the test suffers from a non-standard asymptotic distribution. For more details about how to employ the bootstrap method in the context of a panel, see Hansen; 1999.

The Fischer LM test is as follows: $LM_f = \frac{(SSR_0 - SSR_1)/mk}{SSR_0/(TN-N-mk)}$ (2.10)

The likelihood ratio test as follows: LR = -2[log (SSR_1) - log(SSR_0)] (2.11)

Where SSR_0 represents the sum of squared residuals under H_0, i.e. linear panel model with individual effects. However, (SSR_1 denotes the sum of squared residuals under H_1(PSTR model with two regimes). The LM_w and LR tests have $\mathcal{X}^2$ distribution with mk degrees of freedom where LM_f has an approximate distribution F (mk, TN-N-mk) and k, N, T denotes for the number of explanatory variables, the number of countries and the number of years, (Lee and Chiu, 2011).

2.3.1.3 Model Estimation

In order to estimate the parameters in equation (2.3), we remove the individual effect μ_i by erasing individual means and by employing nonlinear least square. Therefore, equation (2.3) can be rewritten as follows:

$$y_{it} = \mu_i + \beta' x_{it} (\gamma, c) + u_{it} \quad (2.12)$$

Where $\beta = (\beta_0', \beta_1')'$ and x_{it} (γ, c) = $(x_{it}', x_{it}' g(q_{it}; \gamma, c))'$; afterwards we subtract individual means from equation (2.12)

$$y_{it}^* = \beta' x_{it}^* (\gamma, c) + u_{it}^* \quad (2.13)$$

Where $y_{it}^* = y_{it} - \bar{y}_i$, x_{it}^* (γ, c) = $(x_{it}' - \bar{x}_i', x_{it}' g(q_{it}; \gamma, c) - \overline{\omega}_i'(\gamma, c))'$ and $u_{it}^* = u_{it} - \bar{u}_i$. $\bar{y}_i, \bar{x}_i', \overline{w}_i$ and $\bar{u}_i$ represent individual means while $\overline{\omega}_i'(\gamma, c) = \frac{1}{T} \Sigma_{t=1}^{T} x_{it} g(q_{it}; \gamma, c)$. It can be seen clearly from equation (2.13) that the PSTR model is conditional upon both γ and c . Therefore, we employ NLS to estimate the values of the parameters which minimise the concentrated sum of squared errors:

$$Q^c(\gamma, c) = \Sigma_{i=1}^{N} \Sigma_{t=1}^{T} (y_{it}^* - \hat{\beta}(\gamma, c') x_{it}^* (\gamma, c))^2 \quad (2.14)$$

While $\hat{\beta}(\gamma, c)$ is attained from equation (2.13) by ordinary least square at each iteration during the non-linear optimization.

2.3.1.4 Determine the Number of Transition Functions

According to Gonzalez et al. (2005), the linearity test is also useful in identifying the appropriate order of (m). Therefore, the test of no remaining heterogeneity can be used as a misspecification test to identify the appropriate number of transitions. Subsequently, they take into consideration equation (2.3) with three regimes as follows:

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} g_1\ (q_{it}^1;\ \gamma_1, c_1) + \beta_2' x_{it} g_2\ (q_{it}^2;\ \gamma_2, c_2) + u_{it} \qquad (2.15)$$

In this case a three-regime PSTR model can be carried out under the null hypothesis of H_0: γ_2 =0. However, as we stated previously, we cannot perform the test under this null hypothesis due to the existence of the unidentified nuisance parameters. Therefore, in order to overcome this problem, they replace the transition function $g_2\ (q_{it}^2;\ \gamma_2, c_2)$ by Taylor expansion around γ_2 = 0. Subsequently, it results in the following auxiliary regression:

$$y_{it} = \mu_i + \beta_0^{*\prime} x_{it} + \beta_1^{*\prime} x_{it} g_1\ (q_{it}^1;\ \gamma_1, c_1) + \beta_2^{*\prime} x_{it} q_{it}^{(2)} + \ldots + \beta_{2m}^{*\prime} x_{it} q_{it}^{(2)m} + u_{it} \qquad (2.16)$$

In this stage, we use the auxiliary regression in equation (2.16) and we examine the hypothesis of no-remaining heterogeneity under the following null hypothesis H_0^*: β_{21}^*=…..=β_{2m}^*=0. Generally, for any given PSTR model, if we reject the homogeneity test, we should examine a two-regime PSTR model. Furthermore, we should test the non-remaining heterogeneity for this model and, if it is rejected, we should estimate by using a PSTR model with r = 2. This process should continue until the first acceptance of no remaining heterogeneity. Since the transition variable and the appropriate number of the transition function are both selected, the PSTR model is estimated by non-linear least square, (Gonzalez et al., 2005).

2.4 Data

Following Gonzalez et al., (2005) and Hansen (1999), we employ a balanced panel data set. Hansen (1999) mentions that the results are unknown if the sample is prolonged to an unbalanced panel dataset. Since the Middle East and Sub Sahara Africa countries suffer from a lot of missing observations, our data is limited thereby to only 35 countries[14] and

[14] Botswana, Burkina Faso, Burundi, Cameroon, Central Africa, Chad, Cote d'voire, Equatorial, Gabon, Gambia, Ghana, Kenya, Madagascar, Malawi, Mauritania, Mauritius, Niger, Nigeria, Rwanda, Senegal,

restricted to cover the period from 1986 to 2011. We obtained all the items of data from the World Bank's Development Indicators (WDI) or, otherwise, we define the sources. In this model, the dependant variable is the rate of annual growth of GDP (y_{it}) and our variable of interest is inflation, which is measured by the rate of annual growth of the consumer price index[15].

In addition to using inflation as an explanatory variable (x_{it}) and according to the endogenous growth theory, we include other variables, for example:

1. We employ General government final consumption expenditure as a percentage of GDP ($gfce_{it}$). Moral-Benito (2012) mentions that government expenditures can be used to measure macroeconomic stability. He builds his argument upon stating that government expenditures have a distortive effect gained from taxation or government expenditure programs. However, although this does not have a direct effect on the private productivity, it reduces savings and growth.
2. Investment (Inv_{it}), which is defined as gross fixed capital formation as a percentage of GDP, is used as a proxy for capital accumulation and, as illustrated by the growth models, we expect to obtain a positive impact on growth.
3. Population (POP_{it}) is the annual rate of growth of the population. Two opposing points of views explain the impact of population on economic growth. Firstly, population growth is expected to affect economic growth negatively. This is because higher levels of population generate burden on the finite amount of resources and establish several restrictions. Secondly, there is a point of view suggesting that high growth rates of population enlarge labour force and further lead to a large domestic market. Additionally it will induce the demand for technological change and, thus, foster rates of economic growth, (Khan, 2014).
4. $Trade_{it}$, According to the endogenous growth theory, trade should promote economic growth because economies are expected to grow faster if they are more open to trade.

Furthermore, we employ a new panel database on financial fragility. Andrianova et al. (2015) introduce new measures of financial fragility created by aggregating the level of the bank. This data set has an advantage over the bank scope database since it tries to

Seychelles, Sierra Leona, South Africa, Sudan, Swaziland, Togo, Uganda, Algeria, Egypt, Morocco, Tunisia, Bahrain, Iran, Jordan, Saudi Arabia.

[15] It is worth mentioning that the employed method has not been developed in the IV approach. However, we employ the fitted values of inflation to avoid the endogeneity problem.

avoid the bias selection problem arising from the free entrance and exit of banks. However, this data set is only available from 1998 to 2012. They created the newly constructed dataset by aggregating various bank selection entrance rules. Consequently, we can choose the selection rule, which proposes the maximum number of observations. On the other hand, while it suffers from more missing variables, the stricter the rule, the more reliable is the data because most authoritative banks report more frequently. Therefore, there is a trade-off between maximising the number of observations included in the sample and the reliability of the data. In this context, we examine whether the finance-growth nexus varies according to the threshold level of inflation. Thus, according to Andrianova et al. (2015), we employ five financial fragility variables. They are defined as follows[16]:

a) Bank capitalisation is defined as equity divided by total assets; it is related inversely with financial fragility.
b) Managerial efficiency is the costs to income ratio ($\frac{costs}{Income}$). The higher the ratio the lower is the efficiency level.
c) Return on average assets is defined as net income divided by average total assets. It is employed as a measure of institutions earning capacity where higher levels of returns indicate a robust banking system.
d) Net loans, divided by total assets, are used to measure liquidity, while there is a positive relationship with financial fragility. Hence, the higher the ratio, the more the banks are bound into loans.
e) Lastly, Z-score is employed as an indicator of financial fragility; the higher the ratio of Z-score, the less fragile is the banking system. According to Andrianova et al. (2015), the Z-score is defined as follows:

$$Z - score = \frac{ROAA_{jt} + \frac{equity_{jt}}{assets_{jt}}}{\sigma_{ROAA_j}} \qquad (2.17)$$

Where $ROAA_{jt}$ represents the weighted average of banks annual returns, $equity_{jt}$ displays the total value of bank equity, while $assets_{jt}$ represent the total value of bank assets and σ_j shows the standard deviation of returns (i, t).

[16] Other indicators of financial fragility are available (e.g. risk exposure and asset quality); however, we employ only the above-defined indicators due to missing observations in the rest of the indicators.

Lastly, recent growth literature states the importance of institutional quality to improving economic growth (e.g. Knack and Keefer, 1995; Moral-Benito, 2012). Therefore, we employ five different indicators of institutional quality obtained from ICRG dataset. According to the ICRG methodology, the employed data are defined as below:

a) Government Stability: comprise the following components: government unity; legislative strength; and popular support. It takes the value from zero to twelve, the higher the value, the lower is the risk; this refers to a high institutional quality.
b) Law and Order: assess the equality and rigorous consideration of the legal system and that the population pays attention to the law. It ranges between 0 and 6; six indicates high rating of law and order.
c) Ethnic Tension: determines the levels of tension among countries suffering from nationality, racial and language fragmentation. Points range from 0 to 6, with 6 representing countries where the degree of tension is at its lowest levels.
d) Democratic Accountability: shows government reaction to its people needs, with points between 0 and 6. Zero represents a less responsive government and, thereby, it is expected to fall without disturbance in democratic countries but it is more likely to manifest violence in the non-democratic countries.
e) Bureaucratic Quality: represents the institutional strength and quality of bureaucracy. Points ranges from 0 to 4, where 4 relate to less risky countries where bureaucracy is inclined to be independent of political pressure.

We collected further measures of institutional quality variables (i.e. level of democracy (fh_ipolity) and political right (fh_pr) from the Freedom House and the Quality of Government Institute, version Jan 2016, University of Gothenburg.[17] Political rights (fh_pr) allow individuals to be engaged in the political process and to vote in the legitimate elections. Countries take the values between 1 and 7, where 1 represents most free countries while 7 represents the least free ones. However, the levels of Democracy scales are from 0 (least democratic) to 10 (most democratic). Accordingly, we estimate

[17] It is convenient to use the ICRG index, Freedom House and the Quality of Government Institute index because the data is available annually for the whole period under study. However, other institutional quality indexes are available only every two successive years between 1996 and 2000, for instance, the World Bank Governance Index.

and highlight the threshold level of inflation within both democratic and non-democratic countries.

2.5 Empirical Results

Table 2.1 display the summary statistics for the 35 countries employed in our sample. In this respect, we find that the average inflation rates and annual growth rates of GDP for the chosen countries under study are 10.41693% and 4.258369% respectively. Inflation rates ranges from 200% for Uganda to -35.83668% for Equatorial Guinea. Table 2.2 presents the correlation matrix for all variables employed in our baseline model. As expected, both inflation and government expenditure have a negative correlation with economic growth whereas trade, investment and population are positively correlated with economic growth.

Table 2.1: Summary Statistics for 35 Countries.

	Growth rate of GDP y_{it}	INF_{it}	$gfce_{it}$	Inv_{it}	POP_{it}	$Trade_{it}$
Mean	4.258369	10.41693	15.44996	21.80729	2.540762	75.26664
Median	4.002281	6.059096	14.40450	19.66358	2.622549	61.08854
Maximum	149.9730	200.0260	47.19156	219.0694	11.18066	531.7374
Minimum	-50.24807	-35.83668	2.650552	-2.424358	-6.342817	11.08746
Std. Dev.	7.894250	19.01278	6.254432	17.39346	1.218686	51.45898
Observations	910	910	910	910	910	910

Table 2.2: Correlation Matrix for 35 countries.

	Growth rate of GDP y_{it}	INF_{it}	$gfce_{it}$	Inv_{it}	POP_{it}	$Trade_{it}$
GDP	1.000000					
INF	-0.021507	1.000000				
GFCE	-0.056334^{*}	-0.232072^{**}	1.000000			
INV	0.488487^{***}	-0.109984^{**}	0.098765^{***}	1.000000		
POP	0.126236^{***}	0.024117	-0.088283^{***}	0.058504^{*}	1.000000	
TRADE	0.406545^{***}	-0.158423^{**}	0.209151^{***}	0.740908^{***}	0.023326	1.000000

Notes: *, **, *** display the significance levels at 10%, 5% and 1% respectively.

2.5.1 Linearity and Non-Linearity Test:

We employed a linearity test to examine the non-linearity hypothesis. Table 2.3 provide evidence of the non-linear relationship between inflation and economic growth for the countries under study. Hence, we reject the null hypothesis of linearity for all three tests, Lagrange multiplier (Wald and Fisher tests) and Likelihood ratio test at 1% significance level. This indicates that the relationship between inflation and economic growth within the Middle East and the African continent is indeed non-linear. Table 2.4 presents the results of the no-remaining non-linearity test. The null hypothesis suggests that we have a PSTR model with only one threshold variable while the alternative hypothesis claims that we have a PSTR model with at least 2 threshold levels. According to our results, we fail to reject the null hypothesis at 1% significance level; this means that they have only one threshold level of inflation, which splits our sample into two regimes (i.e. low and high inflation regimes).

Table 2.3: Linearity test result for the whole sample.

Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	156.276	0.000
Lagrange Multiplier- Fischer (LM_F)	46.176	0.000
Likelihood Ratio (LR)	173.849	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1)

Table 2.4: Test results for the number of thresholds and no remaining non-linearity for the whole sample.

Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	11.609	0.021
Lagrange Multiplier- Fischer (LM_F)	2.772	0.026
Likelihood Ratio (LR)	11.694	0.021

H_0: PSTR with r =1. H_1: PSTR with at least r =2.

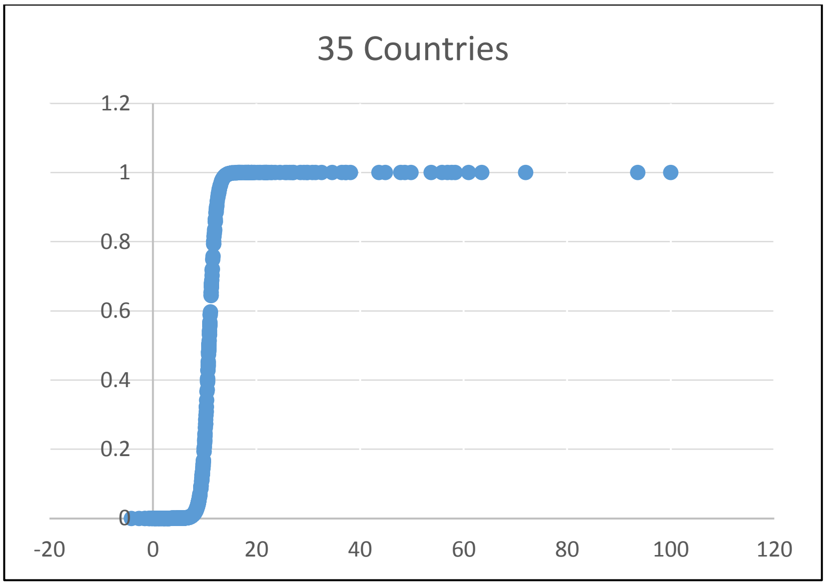
2.5.2 Model Estimation Results

2.5.2.1 Baseline Model

The preceding tests provide clear evidence of the non-linearity hypothesis between inflation and the economic growth nexus. Table 2.5 presents the estimated parameters for our model. According to our results, the estimated threshold level of inflation is 10.8370%. Our threshold levels are consistent with some earlier studies (i.e. Espinoza et al., 2012; Khan and Senhadji, 2001; and Lopez-Villavicencio and Mignon, 2011) whose findings are that the threshold levels for different groups of developing countries are 10%, 11% and 10.27% respectively. On the other hand, Lopez-Villavicencio and Mignon (2011) record a higher 15% threshold level of inflation for a heterogeneous group of advanced and emerging economies. Similarly, Seleteng et al. (2013) find an 18.9% threshold level of inflation for a group of developing countries from the SADC[18] region. In contrast, Vaona (2012) cannot find a precise threshold inflation level for 167 countries.

The results show that the parameter estimates are different for each regime. We recognise that our variable of interest (Inflation) has a significantly positive impact on economic growth below the threshold level while, beyond that level, it has a significantly detrimental impact on economic growth. Thereby, the relationship between inflation and economic growth relies indeed on the level of inflation. However, the slope of transition between regimes is considered to be smooth where γ= 1.4920, Figure 2.1 shows the gradual transition from low to high regimes for the full sample.

[18] SADC refers to Southern African Development Community, according to Seleteng et al., 2013. They are considered to be low-income countries.



*x− axis represent the transition variable,while y−axis display the transition function g (q_{it}; γ,c)

Fig. 2.1. The Estimated Transition function for the whole sample.

With the exception of population, all the coefficients of our explanatory variables are statistically significant during a regime of high inflation. As expected, the sign of the coefficients are consistent with the empirical growth literature. We realise that government expenditure (gfce) has an insignificant negative impact during a regime of low inflation while it has a deleterious significant effect during a regime of high inflation. This result is consistent with Seleteng et al., (2013) who argue that higher government spending does not lead necessarily to increased economic growth. This is because they mention that government spending has little positive impact on economic growth if directed to pay salaries or to unproductive sectors. Similarly, Bittencourt (2012) confirms that higher government spending has a dampening effect on economic growth. As predicted by the Solow model, the investment variable should enhance economic growth in a regime of low inflation. However, we find that, investment has a significant impact on economic growth, not only in the regime of low inflation but also in the regime of high inflation. Lastly, we find that the rate of annual growth of population enhances the rate of economic growth below the estimated threshold level. However, it loses its significant impact beyond the threshold level of inflation. It is worth mentioning that our results are robust once the outliers (Uganda) and the high-income countries within the Middle East region (i.e. Saudi Arabia and Bahrain) are excluded. Tables A.1, A.2, A.3 in Appendix (A) confirm the same results provided by our baseline model.

Table 2.5: Estimate of the threshold level of inflation for the whole sample.

	35 countries (1986-2011)	
Variable	β_0	β_1
Inf	0.3216 $(2.0342)^{**}$	-0.4022 $(-2.5123)^{**}$
gfce	-0.0939 (-0.9334)	-0.7677 $(-3.4960)^{***}$
Inv	0.1138 $(2.7023)^{***}$	0.7081 $(3.7711)^{***}$
Pop	0.7081 $(2.0584)^{**}$	1.0572 (1.1956)
Threshold (c)	10.8370	
Slope (γ)	1.4920	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively.

2.5.2.2 Other Control Variables:

Omay and Kan (2010) claim that the threshold level of inflation alters significantly if we augment other variables to our baseline model. Moreover, they declare that, when using the fixed effect panel method, investment and trade openness are the most robust variables. Thereby, we employ Trade as a percentage of GDP as an additional explanatory variable and re-estimate the PSTR model. It is defined as the sum of exports and imports of goods and services measured as a share of GDP.

Inconsistent with Omay and Kan's (2010) claim, our results, which include openness to trade support our baseline model estimations. Our results assure the existence of a non-linear relationship between inflation and economic growth for the 35 countries under study. Furthermore, they emphasise the occurrence of only one threshold level and no more non-linearities. Consistent with our baseline estimations (i.e. Table. 2.5), our results presented in Table 2.6 confirm that various levels of inflation behave differently in relation to economic growth. No significant change has been realised for the estimated threshold level and the speed of transition between regimes.

Similarly with our baseline model, we recognize that inflation promotes economic growth during a regime of low inflation while it has a harmful effect beyond the estimated threshold level. Along the same lines, government expenditures have a distortionary impact above the threshold level of inflation. On the other hand, we note that, in regimes of low and high inflation, openness to trade and the rate of annual growth of population enhance significantly the rate of economic growth.

Table 2.6: Estimate of the threshold level of inflation: Control Trade.

	35 countries (1986-2011)	
Variable	β_0	β_1
Inf	0.3016 $(1.8088)^{*}$	-0.3988 $(-2.3535)^{**}$
gfce	-0.0129 (-0.1068)	-1.0243 $(-2.7215)^{***}$
Trade	0.0489 $(2.7507)^{***}$	0.2213 $(2.6434)^{***}$
Pop	0.8343 $(2.1297)^{**}$	1.9603 $(2.2144)^{**}$
Threshold (c)	10.8878	
Slope (γ)	1.1924	
LM_{f1}	0.000	
LM_{f2}	0.076	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively. LM_{f1} Represent the p-value of linearity test. LM_{f2} Display the P-value for no remaining non-linearity.

2.6 Robustness Checks

2.6.1 Control Financial Fragility

Another line of research emphasises the relationship between financial depth and economic growth; this varies according to the level of inflation (e.g. Huang et al., 2010; Rousseau and Wachtel, 2002). They argue that high inflation rates handicap the amalgamation of global and domestic financial markets and, furthermore, they inhibit the efficient allocation of resources. In this vein, we employ a newly published international database about financial fragility in order to investigate the impact of the threshold level of inflation on the finance-growth nexus. However, these pieces of data are available only for a short period of time and, thereby, our estimation is restricted to the period from 1998 to 2012[19]. As defined previously, we employed five financial fragility indicators: these are Bank Capitalisation ($\frac{Equity}{total\ assets}$); Liquidity($\frac{Net\ Loans}{total\ assets}$); Managerial efficiency($\frac{Costs}{Income}$); Z-score; and Return on Assets (hereinafter referred to as ROAA).

Table 2.7 represents the financial fragility variables, which we tested simultaneously in the PSTR model. Consistent with our baseline model, we confirm the nonlinearity hypothesis between inflation and economic growth. Our estimated threshold level of inflation is 8.7% beyond which inflation exhibits a significantly negative impact on economic growth. Furthermore, we realize that with respect to the results of our baseline model the speed of transition between regimes is considerably high (γ = 384.5969). With regard to our financial fragility indicators, by definition Z-score, ROAA and Bank capitalisation, have negative correlations with financial fragility while both liquidity and managerial efficiency have positive correlations with financial fragility. We recognise that Z-score has a respective insignificant negative and positive impact on growth during regimes of high and low inflation. This finding is consistent with Fielding and Rewilak (2015) who record the insignificance of Z-score in predicting bank crises. On the other hand, liquidity, managerial efficiency and ROAA display clearly a significantly negative impact on economic growth during a regime of high inflation while, below the threshold level, they have either an insignificant negative or significantly positive impact. As expected, the higher the value of net loans the higher the financial risk (fragile banking system); in turn, these harm economic growth. Only bank capitalisation exhibits insignificant positive and negative effects on economic growth during regimes of high and low inflation respectively. The overall results suggest that, during regimes of high inflation, a high value of net loans and costs, inefficient allocation of resources will encourage banks to make fewer loans. This in turn will lead to an inefficient banking system and, indeed, have a distortionary effect on economic growth (i.e. decline in the return on equity and capital investment). Similarly, Huang et al., (2010) suggest that high and variable inflation rate suppress the positive impact of financial development on economic growth. This is due to the fact that unstable inflation environment impede the amalgamation between domestic and international financial markets. However, during

[19] Due to limited availability of a balanced panel dataset, the number of countries reduced to 20 countries namely: Botswana, Burkina Faso, Cameroon, Cote d'voire, Gambia, Ghana, Kenya, Madagascar, Malawi, Mauritania, Mauritius, South Africa, Sudan, Swaziland, Uganda, Algeria, Egypt, Morocco, Tunisia, Jordan.

low inflation environment, it is possible to observe the advantages of financial development on economic growth.

Table 2.7: Estimate of the threshold level of inflation control financial fragility.

Variable	20 countries (1998-2012)	
	β_0	β_1
Inf	-0.1295 (-0.7026)	-0.4440 $(-1.8838)^{*}$
gfce	-0.0828 (-0.9291)	0.3437 (1.4481)
Inv	0.1389 $(3.2617)^{***}$	-0.3515 $(-2.6453)^{***}$
pop	1.3221 $(1.6846)^{*}$	9.7862 $(3.8400)^{***}$
ROAA	0.9547 $(2.7140)^{***}$	-2.2058 $(-3.3907)^{***}$
Bank capitalisation	-0.0803 (-0.5297)	0.4860 (1.5872)
liquidity	-0.0126 (-0.5650)	-0.1238 (-1.6115)
Managerial efficiency	0.0309 $(2.0515)^{**}$	-0.2273 $(-2.8184)^{***}$
Z-score	0.0009 (0.0092)	-0.0038 (-0.0488)
Threshold (c) Slope (γ) LM_{f1} LM_{f2}	8.7095 384.5969 0.077 0.075	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively. LM_{f1} Represent the p-value of linearity test. LM_{f2} Display the P-value for no remaining non-linearity.

2.6.2 Institutional Quality and inflation-growth nexus:

In this section, we aim to highlight the importance of institutional quality on the relationship between inflation and economic growth. In particular, we employ institutional quality variables in two different ways. Firstly, we employ it as control variables in our estimations. Secondly, we use them as alternative threshold variables in order to detect whether the inflation-growth nexus varies according to the level of institutional quality, which is new in the literature. Previous studies either investigate the relationship between institutions and inflation (e.g. Aisen and Veiga, 2006; Narayan et al., 2011); split the sample according to their institutional quality level (e.g. Ibarra and

Trupkin, 2016); or explore the institutions-growth nexus (e.g. Knack and Keefer, 1995; Glaeser et al., 2004).

In this context, we examine the non-linear relationship between inflation and economic growth whilst controlling various measures of institutional quality. Table 2.8 illustrates the estimated threshold level of inflation by controlling various indicators of institutional quality. It is clear that in all specifications, except for government stability (see Model A, table 2.8), inflation displays a negative and significant impact on economic growth beyond the threshold level. On the other hand, it has an insignificant positive impact during a regime of low inflation. The estimated threshold levels of inflation are consistent with our benchmark model and range from 8.4% to 10.8%. However, with the exception of ipolity and political rights (P.rights) there is a very high speed of transition between regimes. With regard to our institutional control variables, we recognise that government stability, iploity and Democratic accountability enhance the rate of economic growth during a regime of low inflation whereas they have either insignificant or significant negative effect during a regime of high inflation. Similarly, Bureaucratic quality and political rights have a detrimental and significant impact on economic growth beyond the estimated threshold level of inflation. Although Ethnic Tension and Law and Order exhibit different behaviours during both regimes, neither was significant. All other explanatory variables coefficients are consistent with our baseline results.

Table 2.8: Estimate of the threshold level of inflation: control Institutional quality.

Variable	Model A		Model B		Model C		Model D		Model E		Model F		Model G	
	β_0	β_1	β_0	β_1	β_0	β_1	β_0	β_1	β_0	β_1	β_0	β_1	β_0	β_1
Inf	0.1150 (0.6136)	-0.1892 (-0.995)	0.1788 (1.055)	-0.264 (-1.651)	0.1734 (1.0117)	-0.2631 (-1.524)	0.2181 (1.3004)	-0.3043 (-1.795)	0.2684 (1.648)	-0.3445 (-2.082)	0.2399 (1.618)	-0.2821 (-1.931)	0.1712 (1.037)	-0.258 (-1.547)
gfce	-0.2213 (-2.135)	-0.0043 (-0.046)	-0.2773 (-2.650)	0.0425 (0.446)	-0.3273 (-3.124)	0.0848 (0.8536)	-0.2672 (-2.617)	0.0271 (0.2961)	-0.1220 (-1.188)	-0.6716 (-3.184)	-0.132 (-1.369)	-0.6374 (-3.064)	-0.267 (-2.728)	0.049 (0.542)
Inv	0.1216 (2.394)	-0.0485 (-0.761)	0.1292 (2.469)	-0.0261 (-0.425)	0.1372 (2.5466)	-0.0336 (-0.540)	0.1354 (2.5995)	-0.0391 (-0.651)	0.1098 (2.637)	0.7012 (3.7805)	0.1110 (2.655)	0.7241 (3.856)	0.0947 (1.826)	-0.013 (-0.20)
Pop	0.0302 (0.1318)	1.4108 (2.274)	-0.1536 (-0.739)	1.6828 (2.486)	-0.1265 (-0.555)	1.5643 (2.4227)	-0.1679 (-0.791)	1.6280 (2.4742)	0.6253 (1.852)	1.1576 (1.2912)	0.5713 (1.929)	1.3660 (1.404)	-0.341 (-1.58)	1.829 (2.76)
Gov.Stab	0.2888 (2.0260)	-0.0268 (-0.172)												
L and Order			0.4720 (1.371)	-0.6231 (-1.483)										
B. Quality					0.3517 (1.0230)	-1.1955 (-2.307)								
E. Tension							0.2942 (0.9837)	-0.3195 (-1.018)						
ipolity									0.4699 (2.9188)	-0.4381 (-1.508)				
P. rights											-0.033 (-0.122)	-0.8180 (-1.662)		
D. Account.													0.905 (3.499)	-0.842 (-2.215)
c = Slope γ=	8.4443 1.1005e+04		8.4467 1.1424e+04		8.4384 1.2976e+04		8.4375 9.0927e+03		10.8056 1.5215		10.8074 1.4985		8.4371 6.512e+03	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors.

Table 2.9 indicates the results achieved through employing various combinations of institutional quality indicators as threshold variables[20]. With respect to the linearity test results (LM_{f1}, see Table 2.9), we reject the null hypothesis of linearity for government stability, Law and order, B. Quality and Ethnic tension at the 1% level of significance. Moreover, we confirm the presence of one threshold level of institutional quality, which splits the sample in two regimes. Our estimated threshold level of government stability, Law and order, B. Quality and Ethnic tension are respectively 5.416, 2.618, 1.775 and 3.7231. According to our data definitions, high values of institutional quality indicate less risk. Therefore, we expect to have weak institutions below the estimated threshold level whereas high quality and strong institutions are achieved beyond the threshold level. With respect to the inflation-growth nexus, we realise that, for all institutional quality variables, inflation has a significantly negative impact on economic growth below the threshold level of institutional quality. On the other hand, it has a lower and insignificant effect beyond the threshold. This indicates that inflation's harmful impact is stronger when accompanied with weak institution. Similarly, previous studies (e.g. Aisen and Veiga, 2006; Narayan et al., 2011) argue that economies with weak institutions suffer from lower levels of central banks transparency and independence. Additionally they might experience ineffective tax system; this in turn will lead to high inflation rates. Furthermore, the speed of transition between regimes is smooth and is considered to be quick when both B.quality and Ethnic Tension are employed as threshold variables.

[20] Linearity test for other institutional quality variables (i.e. ipolity, political rights and Democratic Accountability) reject the evidence of non-linearity.

Table 2.9: Estimate of the PSTR model: Institutional quality Threshold.

Variable	26 countries							
	Gov. Stability		**Law and Order**		**B. Quality**		**Ethnic Tension**	
	β_0	β_1	β_0	β_1	β_0	β_1	β_0	β_1
Inf	-0.1013 $(-2.456)^{**}$	0.0623 (-1.423)	-0.0888 $(-2.463)^{**}$	0.0357 (0.6556)	-0.0763 $(-2.977)^{***}$	0.0052 (0.1248)	-0.0862 $(-3.045)^{***}$	0.0467 (1.1752)
gfce	-0.6780 $(-4.779)^{***}$	0.4822 $(3.4111)^{***}$	-0.7966 $(-4.920)^{***}$	0.5989 $(4.064)^{***}$	-0.4747 $(-3.084)^{***}$	0.2574 $(1.9793)^{**}$	-0.5942 $(-4.807)^{***}$	0.3726 $(3.4666)^{***}$
Inv	0.3498 $(3.6783)^{***}$	-0.2377 $(-2.695)^{**}$	0.3574 $(4.9699)^{***}$	-0.3319 $(-3.833)^{***}$	0.1856 $(2.859)^{***}$	-0.0675 (-0.942)	0.2349 $(4.6824)^{***}$	-0.2001 $(-3.823)^{***}$
Pop	0.8018 $(1.7677)^{*}$	-0.4656 (-0.926)	0.9787 (1.3592)	-0.6758 (-0.871)	1.4022 $(2.3615)^{**}$	-1.4499 $(-2.651)^{***}$	0.9808 $(1.8462)^{*}$	-0.8286 (-1.597)
c = Slope	5.4167		2.6218		1.7753		3.7231	
γ=	9.0019		2.9533		214.7344		2.1506e+03	
LM_{f1}	0.002		0.002		0.002		0.006	
LM_{f2}	0.779		0.636		0.316		0.891	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively. LM_{f1} Represent the p-value of linearity test. LM_{f2} Display the P-value for no remaining non-linearity.

Lastly, we split our sample into two groups of democratic and non-democratic nations according to their average level of democracy. Table 2.10 presents the estimated threshold level of inflation for both democratic and non-democratic countries. Although we expected the threshold level of inflation for the democratic countries to be lower than the non-democratic ones, our reported results indicate that the threshold levels of inflation for both groups of countries are almost the same at around 10%. However, when compared to the non-democratic countries, the speed of transition between regimes is considered to be high for the Democratic countries, see figure 2.2[21]. We may relate this to the fact that all the 26 studied countries are classified as developing countries. Moreover, the average rates of inflation for both democratic and non-democratic nations are 10.37% and 9.15% respectively. This suggests a further research avenue in order to investigate the importance of institutional quality on the inflation-growth nexus for various groups of developed and developing countries. This potential avenue of research is because there is an argument that the threshold level of inflation in developing countries is much higher than in the developed ones. This is due to the fact that most developed countries are democratic ones. Thereby, there is an expectation of significant differences

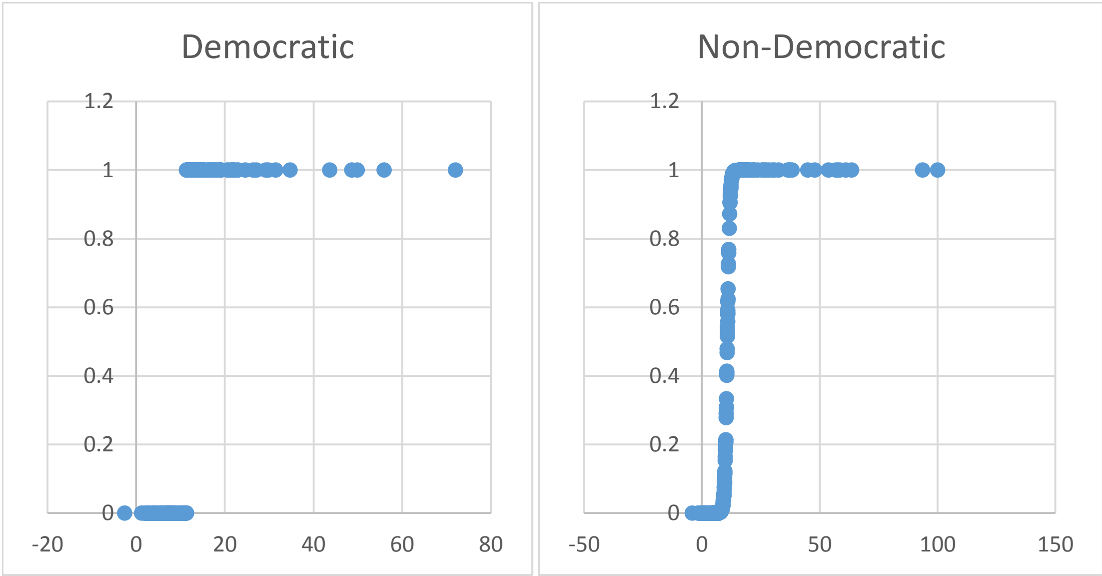
[21] Thus the transition function of the democratic countries seems to be discrete (i.e. step function).

in the threshold levels of inflation of the democratic developed countries when compared to the non-democratic developing countries.

Table 2.10: Estimate of the threshold level of inflation for Democratic and Non-Democratic countries.

	Democratic		Non-Democratic	
Variable	β_0	β_1	β_0	β_1
Inf	0.4357 $(2.0595)^{**}$	-0.5305 $(-2.3190)^{**}$	0.5421 $(2.3228)^{**}$	-0.6282 $(-2.5450)^{**}$
gfce	-0.1314 (-1.2305)	-0.0995 (-0.8618)	-0.0617 (-0.4189)	-0.8995 $(-3.5321)^{***}$
Inv	0.0557 (0.9408)	0.2068 $(2.8238)^{***}$	0.1312 $(2.9390)^{***}$	0.7450 $(4.5648)^{***}$
Pop	1.0249 $(2.3143)^{**}$	0.5823 (0.7050)	0.3199 (1.0302)	2.0414 (1.2426)
Threshold (c)	10.2197		10.7529	
Slope (γ)	650.9182		1.9463	
LM_{f1}	0.054		0.000	
LM_{f2}	0.354		0.120	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively. LM_{f1} Represent the p-value of linearity test. LM_{f2} Display the P-value for no remaining non-linearity.



*x− axis represent the transition variable,while y−axis display the transition function g (q_{it}; γ,c)

Fig. 2.2. The Estimated Transition function for the democratic and the non-democratic countries.

2.6.3 Split sample according to the Geographical Location:

In view of all the preceding findings, we accept the nonlinearity hypothesis between inflation and the growth nexus. In this section, we split our sample into two groups based on their geographical locations (i.e. MENA and SSA countries)[22]. To the best of our knowledge, the non-linear relationship between inflation and economic growth has never been investigated for the MENA countries and for this large group of SSA countries. As shown in Tables 2.11 and 2.12, our results support generally the non-linearity hypothesis for both groups of countries. We reject the null hypothesis of linearity for MENA countries at the 10% level of significance. While, for SSA countries, we reject the null hypothesis of linearity for all three tests at the 1% level of significance. The nonlinearity evidence is stronger in SSA countries when compared with MENA countries. Based on our estimation results, (see Table 2.13), for both groups of countries, we realise that inflation has a significantly deleterious effect on economic growth beyond the threshold level whereas, below the threshold level, it has an insignificantly positive impact on economic growth. The estimated threshold level of inflation for both MENA and SSA

[22] A promising extension for this section would account for the differences between resource-based economies versus non-resource based economies; fragile states versus non-fragile states; land-locked countries versus coastal countries.

countries are 8.4% and 11.35% respectively. However, when compared to SSA countries, the speed of transition between regimes is abrupt for MENA countries (see Figure 2.3). Unlike the smooth transition function for SSA countries, we can observe a discrete function for the MENA countries.

Our estimated threshold value is adequate with regard to the average rates of inflation for the 35 countries in our study. For SSA countries, we observe that Ghana, Madagascar, Malawi, Nigeria, Sierra Leone, Sudan, and Uganda have an average rate of inflation (16.55%, 12.35%, 15.36%, 16.76%, 22.67%, 27.32% and 20.377% respectively) which is higher than the estimated threshold level. Additionally, Kenya has an average rate of inflation (11.067%) almost the same as the threshold level. Similarly, the average rates of inflation of some MENA countries (e.g. Iran; 17.63% and Egypt; 8.95%) are beyond the estimated threshold level. Thereby, they should consider the high inflation rate due to its detrimental impact on economic growth. Meanwhile, the rest of the countries should be cautious about their rates of inflation because of the high speed of transition between regimes. Indeed, this means that, when the rate of inflation is near the threshold level, its impact on the rate of economic growth will change suddenly.

Table 2.11: Linearity test results for the MENA and SSA Countries.

Test	MENA Countries		Sub-Sahara Africa	
	Statistics	P-value	Statistics	P-value
Lagrange Multiplier-Wald (LM_W)	9.177	0.057	142.630	0.000
Lagrange Multiplier- Fischer (LM_F)	2.257	0.065	44.048	0.000
Likelihood Ratio (LR)	9.414	0.000	162.197	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1)

Table 2.12: Test results for the number of thresholds and no remaining non-linearity for MENA and SSA Countries.

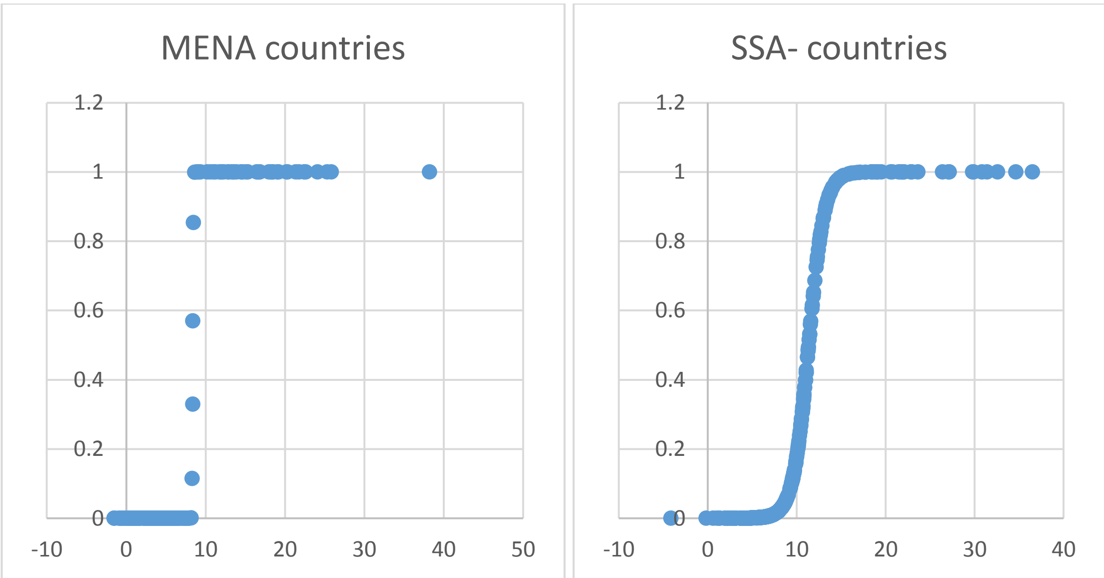
Test	MENA Countries		Sub-Sahara Africa	
	Statistics	P-value	Statistics	P-value
Lagrange Multiplier-Wald (LM_W)	11.415	0.022	8.385	0.078
Lagrange Multiplier- Fischer (LM_F)	2.712	0.032	1.991	0.094
Likelihood Ratio (LR)	11.784	0.022	8.443	0.078

H_0: PSTR with r =1. H_1: PSTR with at least r =2

Table 2.13: Estimate of the threshold level of inflation for MENA and SSA.

Variable	MENA countries (1986-2011)		Sub-Sahara Africa (1986-2011)	
	β_0	β_1	β_0	β_1
Inf	0.0457 (0.2150)	-0.1940 (-0.8504)	0.2298 (1.3574)	-0.2969 $(-1.7766)^{*}$
gfce	-0.2782 $(-2.2191)^{**}$	-0.3232 $(-1.7670)^{*}$	-0.1166 (-1.0489)	-0.6139 $(-3.1117)^{***}$
Inv	0.1450 (1.4794)	-0.0747 (-0.4924)	0.1183 $(2.8299)^{***}$	0.8137 $(4.9974)^{***}$
Pop	-0.6546 $(-2.6782)^{***}$	3.7479 $(3.0913)^{***}$	1.6316 $(2.7095)^{***}$	-0.1375 (-0.1759)
Threshold (c)	8.3684		11.3594	
Slope (γ)	30.6317		1.1382	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively.



*x− axis represent the transition variable,while y−axis display the transition function g (q_{it}; γ,c)

Fig. 2.3. The Estimated Transition function for the MENA and SSA countries.

2.7 Conclusion

Recently, central banks in different developing countries have embraced monetary policies, which target inflation. Therefore, it is useful to determine a precise threshold level of inflation. Based on the approach adopted in this study, we re-examined the relationship between inflation and economic growth for 35 Middle East and Sub-Sahara Africa countries. Particularly, the PSTR model had advantages over the previous models, which were used in the literature to examine the inflation-growth nexus. Hence, it allowed us to estimate the threshold level of inflation endogenously. Moreover, it determines the smoothness of the transition between regimes of low and high inflation. Accordingly, in order to investigate the impact of the inflation threshold on the finance-growth nexus, we employed a new international database about financial fragility. Furthermore, we contributed to the literature by examining whether the inflation-growth nexus varied with respect to threshold of institutional quality.

Our reported results support strongly the existing evidence of a non-linear relationship between inflation and economic growth. The misspecification test results imply the presence of only one threshold level of inflation, which split the sample into two regimes. Our results comply with the existing empirical growth-literature. This indicates that inflation has a detrimental impact on economic growth beyond its threshold level and that it has insignificantly positive (or negative) impact during regimes of low inflation. The estimated threshold level of inflation for the 35 countries was 10.8%. Our estimated threshold level is similar to other threshold levels found in various studies for different groups of developing countries (e.g. Khan and Senhadji, 2001; Vaona, 2012; Espinoza et al., 2012). With respect to financial fragility indicators, we find that net loans, costs and return on assets have a significantly negative impact on economic growth beyond the threshold level of inflation. However, during the regime of low inflation, it turns out to have an insignificantly positive (or negative) impact. In an attempt to introduce institutional quality as threshold variables of the inflation-economic growth nexus, we recognize that inflation has a significantly harmful impact on economic growth below the threshold level of institution quality. Lastly, we split our sample according to their geographical location and found a threshold level of inflation of 8.4% and 11.35% for both MENA and SSA countries respectively. However, when compared to SSA countries, the speed of transition between regimes was abrupt for MENA countries. Additionally the evidence of non-linearity is clearer for the SSA than the MENA countries.

Determining a suitable threshold level of inflation will give policymakers feedback about the role of money supply and will authorise them to handle different policies (i.e. inflation targeting), (Lopez-Villavicencio and Mignon, 2011). This is because the monetary policy objective for some of the 35 countries in our study is to achieve high rates of economic growth and low levels of inflation (price stability), while other countries sought to adopt frameworks of targeting inflation. Thus, it could be useful for these central banks to consider this threshold level of inflation because it provides good guidance for policy makers when selecting the optimal target for inflation.

Chapter 3

Does government size matter for economic growth? A non-linear analysis using state space model.

3.1 Introduction:

The literature has studied extensively the relationship between government size and economic growth. The theoretical literature offers evidence of both the positive and negative impacts of government size on economic growth. Some scholars confirm that the government should intervene in the economy in order to both develop the legal, administrative and economic infrastructures and to avoid market failure, (e.g. Ram, 1986). In contrast, other studies confirm that the government should not be involved in the economy. This is because, in the long run, government intervention has a destructive impact on economic growth due to excessive burdens of taxation, unproductive use of resources and crowding out effects (e.g. Landau, 1983; Cameron, 1982).

Existing empirical studies, which investigate the relationship between government size and economic growth, present inconclusive results. This is a result of most of these studies using linear models and ignoring the possibility of a non-linear relationship between government size and economic growth (e.g. Dar and AmirKhalkhali, 2002; Afonso and Furceri, 2010; Hansson and Henrekson, 1994). Also, very few empirical studies examine the relationship between government size and economic growth from a non-linear perspective (e.g. Christie, 2012; Chen and Lee, 2005). These studies argue that, above a certain threshold level, government size has a deleterious impact on economic growth. However, there is no clear consensus about the optimal size of government expenditures.

This study addresses the non-linearity hypothesis between government size and economic growth in respect of a panel of 5 countries from the Middle East and North Africa region (hereinafter, MENA countries). Our reason for doing so is that most previous studies focused only on estimating the optimal size of government expenditures in developed countries and, more specifically, in OECD countries. Therefore, we endeavour to fill the gap in the literature by studying this group of countries since they suffer from high fiscal imbalances. Thus, it will be helpful for policy makers to understand whether or not government functions are productive. Our study objectives can be summarized as follows: 1) to investigate the optimal size of government expenditures for a selected group of MENA countries; 2) to introduce a new way of estimating the PSTR model by using state space equations; and 3) to estimate simultaneously two different threshold variables (inflation and government size).

This study contributes to the literature by introducing a new insight into estimating the Panel Smooth Transition Regression (PSTR) model in the context of government size and the economic growth nexus. We define the PSTR model in the form of state space system equations in order to determine endogenously a precise and significant threshold level of government size. The PSTR model, developed by Gonzalez et al., (2005), is a non-linear homogenous panel model which we used to help us to avoid pre-selection of the threshold level and to estimate the smoothness of the transition between regimes. In this regard, the state space model gives an explanation of the dynamics system which includes unobserved state variable and it can present the most complex problems in a simple way (Mergner, 2009). In this context, defining the PSTR model in the form of state space equations gives us the opportunity to estimate two different threshold values simultaneously. Hence, we use both inflation and government size as the two different threshold variables. Accordingly, by using different coefficients and the same coefficients respectively, we estimate the threshold levels and smoothness of transition between regimes for both variables.

Our main findings conclude that there is a threshold level (17.245 % of GDP) below that level, government expenditure has a significant negative effect on economic growth while, beyond that level, it has an insignificant impact on economic growth. The rest of this chapter is organized as follows: section 3.2.1 reviews the theoretical background behind the relationship between government size and economic growth and the role of government. Section 3.2.2 discusses the empirical literature from different perspectives and introduces the non-linearity hypothesis. Section 3.3 discusses the methodology used in this study and defines both the PSTR and state space model and illustrates how we define PSTR model in the form of state space equations. Section 3.4 explains the data employed in this study. Section 3.5 analyses our empirical results and the final section, 3.6, presents our conclusions.

3.2 Literature review:

The role of government in stimulating economic growth is one of the oldest debates in Economics. For decades, there has been no consensus regarding the relationship between government size and economic growth. Some economists suggest that the government plays a significant role in the economy. For instance, Fallahi and Shoorkchali (2012) confirm that the government is important in providing the rule of law; setting up property rights; and promoting investment. In contrast, Christie (2012), confirm that growing governments have destructive impacts on long-run economic growth. Hence, a large government may have a detrimental effect because of the crowding-out effect and bureaucracy which consequently may lead to a decline in productivity. Other economists argue that the government should not interfere in the economy and, hence, this will lead to a marginal decline in economic welfare (Weil, 2005). At the same time, there are associated costs which arise from the unproductive use of resources, an increased burden of taxation and the principal agent problem. Vedder and Gallawy (1998) confirm that government is necessary but not sufficient for growth to flourish.

3.2.1 Theoretical background:

3.2.1.1 Which is better for economic growth - large, small or No government?

According to Smith (1776), government has only the following obligations: 1) to establish justice, 2) to provide public works and, finally, to defend the country. Along the same lines, Friedman (1990) reduces the essential functions of government duties to defending the country from outside enemies and adjudicating disputes between citizens. Wagner's law states that government spending is important to economic growth; this happens regardless of the way in which the relationship between government size and economic growth is examined.

Theoretically, there exist two different points of view concerning the role of government in economic growth. The first is the neoclassical growth theory introduced by Solow

(1956) and the second one is the endogenous growth theory developed by Romer (1986) and (Lucas 1988). The former suggests that there is no government; they assume that growth take place due to exogenous technological change. Therefore, in the long run, government policy does not have any impact on economic growth. However, it may have a temporary effect on growth during the transition of the economy to its steady state, (Pevcin, 2004).

On the other hand, the latter theory argues that long-run economic growth is determined endogenously. Consequently, long run growth rates can vary across nations and there is no need for convergence in per capita income to take place. The endogenous growth theory's main conclusion is that government policy affects a country's growth performance in the long run (Dar and AmirKhalkhali, 2002). Hence, an increase in taxation leads to a permanent decline in growth rates and, at the same time, a permanent increase in productive government expenditures causes a permanent boost in rates of economic growth (Bergh and Henrekson, 2010). This negative effect of an increase in taxes may be alleviated partially or completely through productive government spending.

The endogenous growth theory sees, also, the role of government from a different perspective and, hence, it allows for a non-linear relationship between government expenditure and economic growth. Barro (1990) argues that an increase in taxes due to a rise in government spending has a detrimental effect on economic growth. However, a boost in public expenditure accelerates marginal productivity of capital which, in turn, leads to an increase in rates of economic growth. Therefore, he introduces the presence of a non-monotonic relationship between government expenditure and economic growth. This means that, when the government size increases, its positive effect declines over time.

Later, Armey (1995) introduced an inverted U-Shaped curve (Armey Curve)[23] in order to explain the relationship between government size and economic growth. Since, in a world

[23] Forte and Magazzino (2010) emphasize that the idea behind the Armey curve is that there exists an optimal level in the relationship between public expenditure and GDP in order to maximize aggregate growth rate of income. This is because, at low levels of public expenditure, there is no guarantee that the government can protect property rights and can affect positively rates of growth. While, at high levels of public expenditures, there is no incentive to work and invest and, therefore, there is an expectation of low levels of economic growth. Along the same lines, Herath (2012) asserts that no economy can achieve high rates of economic growth without government. On the other hand, too large government leads to a decline in the rates of economic growth.

without government, there will be no rule of law and no protection of property rights. Therefore, moving away from a no government situation would lead to an increase in the growth rate of GDP. However, as government grows, the law of diminishing returns holds; this is because of the increase in taxes to finance expenditures. Therefore, when keeping other variables constant, an enormous increase in government expenditures leads to a decline in rates of economic growth. Generally speaking, *Armey curve does not mean that all government is bad, but like most good things, too much of it is harmful* (Vedder and Gallawy, 1998).

Dar and AmirKhalkhali (2002) ensure the efficiency of small governments since it helps to reduce policy distortions and allows resources to be used efficiently. Moreover, it helps to remove the crowding out effect which reduces the motivation to constitute a new capital. In the same vein, they assert that the optimum policy does not necessarily mean reduce government size. While a small government might be effective as a large government in providing the crucial basis for economic growth (i.e. legal and administrative infrastructure).

In the same context, Heitger (2001) introduces the central hypothesis that government expenditures on core goods have a positive impact on economic growth. However, he argues that, if the government keeps increasing its expenditures in the same way, it provides private goods as well. Therefore, this positive impact on economic growth declines or even goes into reverse. Moreover, he confirms that, for different reasons, increasing expenditures may have a negative impact on economic growth and employment. For instance, the necessary taxes to finance expenditures reduce the incentive to work and invest. Similarly, Carboni and Medda (2011) suggest that different kinds of public spending can have various impacts on economic growth; these may lead to a bias.

In the same vein, Yavas (1998), develops a theoretical model in order to investigate the impact of government size on economic growth. Moreover, he investigates how the impact of government size differs according to each country’s level of development. His analysis emphasizes that, in the case of less developed countries, any increase in government size leads to an increase in the steady state level of output. Meanwhile, in the case of developed countries, it leads to a decline in the steady state level of output.

Other factors might affect a government's ability to perform its main function. These are, for instance: degree of corruption; and quality of government. Bergh and Henrekson (2010) suggest that institutions are one of the essential determinants of economic growth since he confirms that both institutional quality and the growth nexus are found to be robust. Hence, they argue that establishing property rights and high institutional quality (non-corrupt governments) are more constructive to most economic activities. It can be seen clearly from the above-mentioned discussion that there is no precise relationship between government size and economic growth. Furthermore, various types of government spending exhibit different impacts. However, we know that the government's primary role is securing property rights; rule of law; and providing health and education at a low level of taxation.

3.2.2 Empirical background:

The above-mentioned theoretical discussion shows us that there is a great controversy concerning the relationship between government size and economic growth and, similarly, we expected to find no consensus in the empirical literature.

3.2.2.1 Early cross-country studies:

Previous cross-country studies exhibit contradictory results and, on the one hand, some of these studies confirm that government has a destructive impact on economic growth whereas others argue the presence of a positive relationship. On the other hand, other studies find no evidence of the existence of a linear relationship but argue for the presence of a non-linear relationship (e.g. Grossman, 1988).

Cameron (1982) carried out one of the earliest studies. He argues for the existence of a negative relationship between the average growth rate of real GDP and average percentage of GDP spent by government. Thereafter, Landau (1983) extends the sample size and adds more control variables for education and geographical dummies. His results are consistent with Cameron (1982) in asserting the presence of a negative relationship between government size and economic growth. Other cross-section studies confirm this relationship (e.g. Marlow, 1986; Afonso and Furceri, 2010). Similarly, Kelly (1997) do not support the non-linear hypothesis since high levels of public investment are related negatively with rates of economic growth. On the other hand, he affirms that, due to the distortions created in the private sector, any additional increase in public capital leads to a decline in economic growth.

On the other hand, Ram (1986) employs two growth models which use a government sector and non-government sector for 115 countries. His results confirm that government size has a positive effect on economic growth. However, Rao (1989) suspects that Ram's results are more subject to bias due to the misspecification problem (omitted variables). Furthermore, the positive impact suffers from limited significance due to the existence of some countries' bidirectional causality.

However, Kormendi and Meguire (1985) find no evidence that government consumption has an adverse effect on economic growth. Likewise, Doppelhofer et al., (2004) examine the most robust variables in determining economic growth through applying Bayesian averaging of classical estimates (BACE) on 88 countries. However, they could not prove that there is a robust relationship between government size and economic growth.

Hansson and Henrekson (1994) examine how government expenditures affect the non-government sector. They detect the impact of various types of government expenditure on productivity growth in the private sectors of 14 OECD countries. Their results reveal that government transfers, consumption and total outlays have a deleterious impact on productivity in the private sector whereas educational expenditure has a positive impact. On the other hand, they cannot provide any evidence that government investment has any effect on private productivity.

Other studies (e.g. Saunders, 1986; Yavas, 1998; Bergh and Henrekson, 2011) reveal the existing controversial results are due to various employed methods, different measures of government size, the sample of countries investigated and the chosen period of time. Additionally, Karras (1996) explains that, if two existing economies have the same government size but different regulatory environments, there are different marginal products of labour, capital and government. While, Grossman (1988) confirms that most previous studies investigated the government size-economic growth nexus from a linear perspective. However, he argues that none of the aforegoing studies combine both effects in one model. In the same context, Bergh and Henrekson (2010) and Agell et al., (1997) confirm that the relationship between government size and economic growth is highly sensitive to what variables should be included in the model. Moreover, they argue that changing the control variables or any econometric specifications either abolish the negative impact of government size on economic growth or change this to have a positive effect.

3.2.2.2 Panel data studies:

Folster and Henrekson (2001) confirm that most previous cross section studies, using long time spans, suffer from lots of problems, which may lead to biased results. For instance, they mentioned that the studies might suffer from severe simultaneity problem, endogenous selection of tax policy and inefficiency due to ignoring all within the country information. On the other hand, they clarify that panel data helps to alleviate simultaneity problem in the long run. Likewise, Bergh and Henrekson (2010) argue that omitted variables may be responsible for the existence of previous studies' controversial results. Thereby, they suggest that the employment of the country-fixed effect method removes the cross-sectional information from the data. Along the same lines, Forte and Magazzino (2010) confirm that panel data is useful in controlling heterogeneity among countries. Moreover, he argues that it gives more degrees of freedom, more variability, more efficiency and less collinearity among the variables. Furthermore, it allows the dynamics of adjustments to be identified and measures the effects which cannot be captured from using cross section or time series data.

Both Heitger (2001) and Dar and AmirKhalkhali (2002) investigates the government size-economic growth nexus for OECD countries, using generalised least square estimates and random coefficient model respectively[24]. Their results generally, confirm that the larger the government, the slower the rate of economic growth. Further they emphasize that both government consumption and investment goods have an adverse impact on economic growth.

Along the same lines, Bayraktar and Dodson (2015) suggest that total public expenditures be divided into core, non-core and other expenditures.[25] Furthermore, they divide the sample of developing countries into fast growing countries and another group including countries with various growth patterns. Their analysis confirms that, for fast growing

[24] They employ different measures of government size, (e.g. total government expenditure as the share of GDP, government expenditure on public goods as the percentage of GDP) and divide the expenditures into government consumption and government investment goods.

[25] Core expenditure is presented in the form of general public services, fuel, energy, education, health, housing, transportation and communication. On the other hand, social security, welfare, manufacturing and construction are defined as non-core expenditures. Other expenditures are safety, defence expenditure etc…..

countries, core public expenditure has a positive and significant impact on real GDP per capita while they could not find a robust result for the latter group. Additionally, they show that, when compared to non-core expenditure, core public expenditure has a higher impact on growth. Correspondingly, they shed light on the caveats of pooling the two groups together. Hence, their results show that core expenditure is insignificant in explaining the growth of the pooled sample.

The relationship between government size and economic growth is examined rarely in the case of developing countries. Only Gregoriou and Ghosh (2009) examine the effects of government expenditure on economic growth in a heterogeneous panel of 15 developing countries. They employ the GMM estimator in order to address the endogeneity in the panel and to capture the cross-country heterogeneity. Their empirical analysis provides evidence that current expenditure has a positive effect on economic growth. Correspondingly, Blankenau et al., (2007) analyse the relationship between public education expenditure and economic growth for a panel of 23 countries. Their empirical analysis shows that, in the long-run, public expenditure on education has a positive effect on economic growth but only when they control for government budget constraint. Surprisingly, after controlling government budget constraint in poor countries, the results confirm that public expenditure on education has no impact on economic growth.

On the contrary, Folster and Henrekson (2001) argue that there is no evidence of the presence of a robust negative relationship between government size and economic growth. On the other hand, they suggest that the more econometric problems, which you address, the more robust the relationship becomes between government size and economic growth. However, Agell et al., (2006) suspect their results because they ignore all sources of endogeneity bias arising from reverse causation and the sample selection problem since they care only about the heteroscedasticity problem. Bergh and Henrekson (2010) summarize the debate between the former studies in the sense that correlation is less robust when only OECD countries are included. Furthermore, they explain the difficulty in capturing the causality problem by using an instrumental variable.

The above mentioned studies display the advantages of using panel data analysis instead of cross-section studies. However, we can argue that this pooling assumption may give us, also, imprecise results. Hence, among a group of developed and developing countries, each country has it is own characteristics, different level of economic development and various political situations. Furthermore, the composition of government expenditure varies from one country to another. Along the same lines, Bayraktar and Dodson (2015) argue that including a set of heterogeneous countries in one sample may lead to losing the significance of government expenditure. This might be one of the reasons behind the insignificant statistical relationship between government size and economic growth.

3.2.2.3 Non-linearity in the relation between government size and economic growth.

Although some of the previous studies suggest the existence of a negative and significant relationship between government size and economic growth, others still confirm that this negative impact is expected only after exceeding a certain threshold level. Barro (1990) is the pioneer who investigated the non-linearity hypothesis in the relationship between government size and economic growth. He mentions that different government sizes have various impacts on economic growth[26].

Therefore, Pevcin (2004) examine the government size-economic growth nexus from non-linear perspective for a panel of 12 European countries. His results confirm the presence of the Armey curve in these countries. Hence, they find an optimal threshold range of government size between 36 and 42 percent of GDP. However, De Witte and Moesen's (2010) criticism of the former study is based on the idea that there are some obstacles to the Armey curve. Their criticism is built upon two folds: namely, 1) measuring the optimal government size, using the Armey curve, assumes that all countries have the same starting point, same preferences and same declining marginal returns; and 2) differences in budgetary institutions and political economy factors may lead to different social costs and benefits.

Other studies suppose that optimal government size is provided when its marginal product equates to unity according to the Barro rule (e.g. Karras, 1996 and Pushak et al., 2007). They introduce institutional quality as one of the most important determinants of growth. Their results, using OLS, generalised least squares, fixed and random effect, confirm that

[26] This is due to any increase in taxes will reduce the rates of economic growth because there is no motivation to work and invest. At the same time, any increase in government spending increases the marginal productivity of capital, which, in turn, causes an increase in rates of growth. However, the first effect dominates if government is large while the second impact dominates if government is small (Pevcin, 2004).

above a certain threshold level, public spending has a negative effect on rates of economic growth while, below this level, it has insignificant impact on rates of growth. On average, they suggest the optimal government size is 23% for all countries. Moreover, they provide evidence that there is a negative relationship between government services' marginal productivity and government size. Additionally, they show that institutional quality, which is measured by quality of governance, helps to alleviate the public sector's deleterious impact on economic growth.

In order to assess the Barro non-linear hypothesis, Christie (2012) applies a threshold regression (PTR) model and GMM estimation method for a panel of 136 developing and developed countries during the period from 1971 to 2005. His empirical results show evidence of the presence of a threshold level of government size of 33% of GDP. Accordingly, above this threshold level, government size has a negative effect on economic growth. Furthermore, he provides evidence from additional sources of the rise in non-linearity from levels of economic development and quality of government. On the other hand, we can argue that this pool-ability assumption of both developed and developing countries might be questionable because of the existing differences between both groups in the composition of government expenditures. Therefore, the integration of both developed and developing countries may lead to estimation bias. More details about the discrepancy between both groups are presented in the following section 3.2.2.5.

Interestingly, Davies (2009) investigates the optimal size of government consumption expenditure and its effect on social welfare instead of GDP. He employs dynamic GMM for a panel of 154 countries and uses Human Development Index (HDI) as a measure of social welfare. Hence, he argues that it is better to use HDI since it allows him to differentiate between standard of living and income. According to his empirical analysis, he reveals that optimal government size with respect to HDI is higher than optimal government size with respect to GDP.

By using different approaches, a few studies address the possibility of a non-linear effect in a time series data context. For instance, by using a German time series data set, Mittnik and Neuman (2003) empirical analysis supports the non-linear hypothesis in the case of public consumption but not in the case of public investment. Correspondingly, Chen and Lee (2005) employ a threshold regression model in order to examine the presence of the Armey curve in Taiwan. Their results provide evidence of non-linearity employing various measures of government size: namely, total government expenditure; government investment expenditure; and government consumption expenditure. Along the same lines, Facchini and Melki (2013) investigate the relationship between public spending and GDP in France. Their analysis asserts that government size is efficient when public spending reaches 30% of GDP. In the same context, a few cross-section studies examine the non-linear hypothesis of the relation between government size and economic growth (e.g. Afonso and Furreci, 2010; Kelly, 1997). However, they cannot prove the presence of a non-linear relationship and, hence; their tendency is to employ only a quadratic term[27] of government size, (Christie, 2012).

3.2.2.4 <u>Does the negative relation between government size and economic growth related to reverse causality?</u>

While studying the relationship between government size and economic growth, it is worth mentioning the reverse causality problem, which is considered to be one of the substantial problems in this context. According to Afonso and Furceri (2010), the results in this area are inconclusive. They state that, with respect to Wagner's Law, government spending is more elastic since public spending grows relative to income. This means that public expenditure can be defined as an endogenous variable instead of causing growth; in this case, causality runs from national income to public spending. Accordingly, Abu-Bader and Abu-Qarn (2003), present the following reasons to justify Wagner law: 1) government is important to control monopoly; 2) economic development leads to a growth in cultural and welfare expenditures; and 3) government offers public goods instead of private sector. Furthermore, Hansson and Henrekson (1994) confirm that there exists a tendency for government expenditure to increase as long as income increases and, thus, countries grow rapidly. Therefore, in this case, government expenditure is considered to be an endogenous factor.

In contrast, Keynesians' deal with public spending as an exogenous factor and, consequently, causality runs from public spending to national income. According to Bergh and Henrekson (2011), it is important to understand that a negative correlation

[27] The quadratic term imposes only a specific form of non-linearity, as it implies that government size impact on economic growth increase and decrease monotonically alongside with economic growth. However other studies (e.g. Law and Singh, 2014 and Law et al., 2013), criticise employing the quadratic term, as they claim that a certain level of government size need to be attained before distinguishing its effect on economic growth.

between government size and economic growth does not reveal causality. It is likely to imply reverse causality due to various reasons. These are, for instance, business cyclical fluctuations[28] and social insurance programs which act as automatic stabilizers. Therefore, Bergh and Henrekson (2010) argue that, in order to resolve the former problem, both automatic stabilizers and cyclical fluctuations can be avoided by averaging rates of growth over the whole cycle. In contrast, Bayraktar and Dodson (2015) assert that the use of annual data is better than averaging data in explaining both the short run and the long run relationship between variables[29].

Others demonstrate that when growth increases, both tax revenue and ratio of tax revenue to GDP increases. Furthermore, in boom years, there is an expectation of higher revenue due to an increase in taxation of capital gains and profits. This implies that high taxes correlate positively with rapid growth and, therefore, direction of causality runs from growth to taxes. Subsequently, the negative coefficient of government expenditure does not always mean that government expenditure has a negative effect on economic growth. In contrast, the negative coefficient on taxes implies that high taxes lead to a decline in economic growth since we expect a positive correlation due to reverse causality, (Bergh and Henrekson, 2011).

Along the same lines, Agell et al., (2006) argue that the reverse causality problem can indicate the presence of a negative relationship between government size and economic growth. Hence, they emphasize that both taxes and government spending affect growth through the supply side relationship. However, growth affects tax revenue through the income elasticity of demand. Therefore, the negative relationship between government spending and economic growth can be explained as an increase in demand for spending on unemployment benefits and social assistance. Hansson and Henrekson (1994) suggest that, in order to avoid the endogeneity problem, the impact of government expenditures in the non-government sector at a disaggregated level should be investigated. This is because they believe that the largest part of government expenditures is, also, a part of

[28] In boom years, we expect high economic growth rates and a decline in the unemployment rate. Thus public expenditures will decline. Therefore, in the short run, there is expected to be a negative relationship between public expenditure and economic growth. Accordingly, this negative relationship does not imply that high expenditure causes a decline in rates of economic growth.

[29] They believe that averaging data may lead to information being lost and there is no confirmation that averaging data can remove business cycle fluctuations. In addition, annual data allow the maximum variation in the employed dataset to be captured.

measured GDP. This means that GDP may grow due to the growth in government expenditures.

Consistently, Abu-Bader and Abu-Qarn (2003), argue that military expenditures might be the reason for this negative effect. Therefore, they disaggregate total government expenditure into civilian and military expenditures. Their results reveal that, in all countries under study (Egypt, Syria and Israel); military expenditure has a negative effect on economic growth. While civilian expenditure has a positive impact on economic growth in the case of Israel and Egypt, surprisingly, it has a negative effect on economic growth in Syria. Furthermore, their results confirm, in the cases of Israel and Syria, the presence of negative long-run bidirectional causality between government spending and economic growth. However, in the case of Egypt, they find a negative short-run relationship and unidirectional causality from growth to government expenditures.

Facchini and Melki (2013), employ granger causality tests based on a VAR approach for the case of France. Their results confirm the presence of a bi-directional causality directed from government size to growth. While there is indirect feedback from GDP to government size through taxation, in turn, this alleviates the direction of causality from government size to economic growth. In the same context, Wu et al., (2010) employ the panel granger causality test for 182 countries during the period from 1950 to 2005. Their empirical analysis emphasizes the presence of bidirectional causality between government size and economic growth. However, when they split their sample according to income level or degree of corruption, they find that government spending does not granger cause economic growth.

Other scholars suggest using instrumental variables in order to deal with the reverse causality problem. However we can argue the difficulty of finding an instrumental variable, which is not correlated with any other omitted variable. Therefore, they cannot solve this problem due to the lack of a good instrumental variable and hence, more studies are required to address this problem. In the context of threshold models, there is no existing solution to the problem of estimating the threshold model when both slope and the threshold variable are endogenous. Therefore, in this study, we employ the Hausman test for endogeneity but are unable to detect any evidence of endogeneity. Lastly endogeneity problem within threshold model context has been discussed in details in chapter 4, section 4.3.1.

3.2.2.5 Why the impact of government size is different between developed and developing countries?

According to Facchini and Melki (2013), it is difficult to assign the efficient government size to a group of countries due to their various countrywide characteristics. Additionally, they confirm that inconsistencies, which arise from various political and cultural environments, spending histories and each country's level of economic development, leads to different results. In the same context, we believe that combining both developed and developing countries in one sample causes a measurement error problem which, in turn, leads to biased results. In growth equations, Hansson and Henrekson (1994) argue the importance of including human capital and other control variables when integrating different countries with various levels of development.

Bergh and Henrekson (2011) argue that developing countries' public sectors are small and, thus, there may be a positive relationship between government size and economic growth. However, in rich countries, the public sectors are large and, consequently, the relationship between government size and economic growth is less positive and more likely to be negative. They assert that this contrasting effect is due to several theoretical reasons. They explain that there is a positive relationship between tax revenue and growth since the government is successful in providing infrastructure, health care, education, protecting property rights and rule of law. However, the negative effect of taxes, required to finance public expenditure, may dominate the positive effect of government activities in cases of government expenditures characterized by declining returns.

Correspondingly, Yavas (1998) discuss why government spending has different impacts on steady state employment in developed and developing countries. He argues that, in developing countries, government expenditures are directed towards building infrastructure, airports, highways, etc. Thus, an increase in government expenditure has a positive and direct impact on private output which, in turn, dominates the negative effect through lower real wages. On the other hand, in the case of developed countries, most government expenditures are directed towards social welfare programs. Consequently, the positive effect of spending on welfare programs is not as great as the positive effect of expenditures on infrastructure. Thereafter, the negative effect of increases in government expenditure on employment via lower real wages may take control over the positive effect.

The above-mentioned empirical studies investigate the government size and economic growth nexus through employing a cross-country data set using different regression approaches (e.g. Ram, 1986; Landau, 1983; Marlow, 1986; Dar and Amir khalkhali, 2002; Folster and Henrekson, 2001 and Afonso and Furceri, 2010). They try to include most of the determinants of economic growth which are, for instance: physical and human capital; ratio of government consumption or total government expenditures; measure of macroeconomic stability; institutional quality; and degree of corruption. Meanwhile, other scholars are inclined towards studying this relationship in panel data format by using various econometric ways starting from fixed and random effect, threshold regression model (PTR model), polynomial analysis and quantile regression (e.g. Dar and Amirkhalkhali, 2002; Folster and Henrekson, 2001; Herath, 2012; Chen and Lee, 2005; Wu et al., 2010). However, in this context the results are still inconclusive. Because we believe that previous studies, which built their models on either positive or negative monotonic relationships, suffer from misspecification bias. Although, the impact of a single component of the public budget, for instance infrastructure, may be found to be strongly positive, it is important to examine the impact of other public expenditure on growth before deciding whether or not to expand investment in infrastructure. Hence, this can be considered to be one of the reasons for the existing debate in the literature. Therefore, it is preferable to determine how to allocate public resources, only after all the components of public spending have been checked, (Carboni and Medda, 2011).

3.3 Methodology:

Our main objective is to examine the non-linearity hypothesis between government size and economic growth. Accordingly, we estimate the threshold level of government size and explore its impact on economic growth below and beyond the threshold level. In this context, we define a Panel Smooth Transition Regression (PSTR) approach in the form of a state space system. The state space model allows us to determine endogenously the threshold value of government size. We believe that this model provides a new insight to the threshold effects of the government size and economic growth relationship. This is because the state space model has the advantage of estimating two different threshold variables; for instance, we estimate simultaneously the threshold level of inflation and government size. In other words, the model is flexible which allow for different transition coefficients and, furthermore, we can impose an econometric restriction by restricting all transition coefficients to be the same. In the following sections, we explain the PSTR model briefly; illustrate the state space model; and, finally, we demonstrate how to define the PSTR model in the form of state space equations.

3.3.1 Panel Smooth Transition Regression approach

The PSTR model was developed by Gonzalez et al., (2005); it is considered to be a fixed effect model with exogenous regressors. It is a nonlinear homogenous panel model[30]. Or it can be defined as a linear heterogenous panel model with coefficients differing across individuals and across time. Heterogeneity is allowed by supposing that coefficients are a continuous function of an observable variable through a bounded function of this variable; this is named the transition function, which oscillates between a limited numbers of regimes.

The simple PSTR model with two extreme regimes is defined as:

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} \, f(q_{it}; \gamma, c) + u_{it} \qquad (3.1)$$

For $i = 1, \ldots, N$, and $t = 1, \ldots, T$, where N and T indicate the cross section and time dimensions of panel data respectively. The dependent variable y_{it} is a scalar representation of the annual rate of growth of GDP for five developing countries, μ_i presents the fixed individual effect, x_{it} is a dimensional vector of time varying exogenous variables and, lastly, u_{it} represents the error term. The transition function $f(q_{it}; \gamma, c)$ is defined as a continuous function of an observable variable q_{it}[31]; this is restricted between 0 and 1. These two values are correlated with the regression coefficients β_0 and $\beta_0 + \beta_1$. While γ locates the smoothness of transitions between regimes, c indicates the threshold parameter. According to Gonzalez et al., (2005), Granger and Teräsvirta (1993), the general form of logistic transition function (i.e. LSTAR) is defined as follows:

$$F(q_{it}; \gamma, c) = \left(1 + exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - c_j)\right)\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq \ldots \leq m \qquad (3.2)$$

$c = (c_1, \ldots \ldots, c_m)'$ is an m-dimensional vector of location parameters while $\gamma > 0$ and $c_1 \leq c_2 \leq \ldots \leq m$ represent the imposed restrictions. In the case of m=1, the model displays that two extreme regimes are correlated with low and high values of q_{it}. If $\gamma \rightarrow \infty$, the

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[30] According to Gonzalez et al., (2005) this definition is preferred in the context of univariate transition autoregressive models.

[31] Threshold variable is individual specific and time varying

logistic transition function becomes an indicator function I[A]; this take value 1 when A occurs or 0 otherwise.

For m=2, the transition function f (q_{it}; γ, c) has a value of 1 at both low and high values of q_{it} and attains its minimum value at $\frac{(c_1+c_2)}{2}$. In this state, if γ $\rightarrow \infty$, the model is a three-regime threshold model. Lastly, for any value of m if γ $\rightarrow$ 0, the transition functions reduce to the linear panel regression model with fixed effects. According to Gonzalez et al., (2005), the building of the PSTR model is based on specification, estimation and evaluation stage. [32]

In addition to the logistic function defined above (eq. 3.2), another exponential function can be defined in the context of the STAR model. Thereby, the transition function is defined in the following format:

$$F\ (q_{it};\gamma,c) = \left(1 - exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - c_j)\right)\right)^2 \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq \ldots \leq m \qquad (3.3)$$

In this case, the model is defined as ESTAR. Similarly with LSTAR model, c represents the threshold parameter while γ displays the smoothness of transition among regimes. Figure 3.1 below shows the difference between the logistic and exponential STAR model.

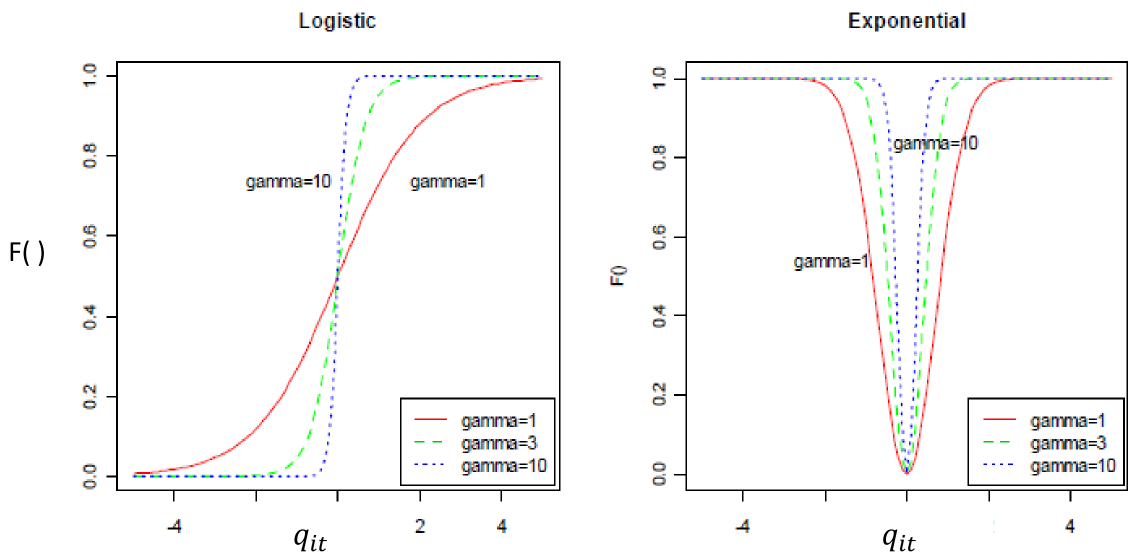


Fig.3.1. Logistic and Exponential Transition function, Zivot and Wang (2007).

[32] These stages have been explained in detail in section 2.4 in the previous chapter.

With respect to Figure 3.1 above, it is seen clearly that both functions are steeper with the quicker speed of transition. Zivot and Wang (2007) illustrate the characteristics of both functions as follows:

i) If $\gamma \rightarrow \infty$, both transition functions tend to a binary indicator function $I(q_{it} > c)$ and $I(q_{it} = c)$for both LSTAR and ESTAR model respectively. However, the LSTAR model gives the PTR model while the ESTAR model does not reduce to a TAR model as a special case.
ii) The logistic transition function is considered to be monotonic; it allows the coefficients to change smoothly between regimes. It relies on how much the transition variable q_{it} is beneath or beyond the threshold. For the LSTAR model, both the sign and distance between q_{it} and c are substantial.
iii) On the other hand, only the distance between q_{it} and c is important for the ESTAR model. This is because the exponential transition function is symmetrical; it depends mainly on the distance between q_{it} and c while the sign does not matter.

3.3.2 State space model:

3.3.2.1 General idea of state space models:

The State Space model is a dynamic system which involves unobserved state variable. A broad range of linear and non-linear models can be addressed: these include regression models with changing coefficients; autoregressive moving average (ARIMA); and unobserved component models (Mergner, 2009). State Space models are based on two sets of equations: measurement equations (signal or observation equation); and transition equations (state equation).

a) The Measurement equation: characterizes the relationship between observed variables (data) and unobserved state variables.

b) Transition equation is an equation which displays the dynamics of the unobserved state variables, (Kim and Nelson, 1999). According to Mergner (2009), Commandeur and Koopman (2007), a state vector may include trend, seasonal, cycle and regression components plus an error term. The state variable and the unknown parameter have to be estimated from the data using maximum likelihood which can be obtained from the Kalman filter.

In the state space models, the unknown parameters comprise of equation parameters and the state variances, which are known as hyperparameters. These hyperparameters are estimated by using an iterative procedure in order to maximize the likelihood value, (Cuthbertson, Keith et al., 1992).

A general state space model can be represented as follows:

Measurement equation: $Y_t = Z_t A_t + d_t + \varepsilon_t$ E $(\varepsilon_t) = 0$, Var $(\varepsilon_t) = H_t$ (3.4)

Transition equation: $A_t = T_t A_{t-1} + x_t + e_t$ E $(e_t) = 0$, Var $(e_t) = Q_t$ (3.5)

Where Y_t is a vector of variables observed at time t with dimensions $(n \times 1)$, A_t represents state vector of unobserved variables with dimensions $(m \times 1)$, Z_t is a matrix which links the observed vector Y_t and the unobserved A_t with dimensions $(n \times m)$, d_T is an $(n \times 1)$, while ε_t is a vector of serially uncorrelated disturbances $\varepsilon_t \sim N(0, H_t)$. According to the transition equation, T_t is an $(m \times m)$ matrix, x_t is an $(m \times 1)$ vector and e_t represents serially uncorrelated disturbances $e_t \sim N(0, Q_t)$.

Other assumptions should be imposed to complete the State Space model specification: 1) A_0 has mean a_0 and covariance matrix P_0; and 2) the disturbance ε_t and e_t are not correlated with each other at any period of time and not correlated with the initial state. Therefore,

$$\forall(s,t) \qquad E(\varepsilon_t . e_s') = 0 \qquad (3.6)$$

$$\forall t \qquad E(\varepsilon_t . A_0') = 0 \qquad (3.7)$$

Harvey (1989) explains the Kalman filter as a recursive algorithm, which calculates the optimal estimator of the unobserved component (state vector) at time t, and depends on accessible information at the same time t.

According to Cuthbertson, Keith et al., (1992), the Kalman filter estimate the unknown state variables based on the following stages:

1) Prediction: we want to provide the best estimate of Y_t based on the available information at time t. Thus it calculates the one step ahead of prediction errors υ_t and their variance covariance matrix provisional on the unknown parameters.

2) Updating: once the new information of Y_t has been obtained, the prediction error decomposition employ the one step ahead prediction error and their variance-covariance matrix. Afterwards, the prediction error decomposition is maximised with respect to the unknown parameters, (it implement an updating plan for the unobservable state variable A_t based upon the available information). In other words, it employ all the available information of the successive data of Y_t in order to update the optimal estimation of A_t.

Simply, the idea behind Kalman filter is that we have an initial value of A_0 and its covariance P_0. We assume that we know the values of (Z_t, H_t, T_t, Q_t) and we observe y_t. Consequently, the Kalman filter employs all this information in order to provide an optimal estimator for the unobserved state A_t. According to Kalman, the optimal estimator is a minimum mean square error. One additional assumption should be imposed is that the error terms are distributed normally; afterwards, it provides the maximum likelihood estimator of A_t. Figure 3.2 shows the framework of the maximum likelihood along with the Kalman filter.

Two types of models can be represented by using the Kalman filter. These are an unobservable components model and a time varying parameter model. Furthermore, the state space model is characterised by two important features; these are, namely, flexibility and transparency[33]. Mergner (2009) argues that the state space model offers a high degree of flexibility and, hence, it permits time varying coefficients. Along the same lines, Basdevant (2003) emphasises the state space model's ability to offer a simple representation of complex problems. Furthermore, it evaluates the relative features of various approaches and, therefore, it can be considered to be an encompassing approach.

State Space models have some caveats since the value of unobserved state at the beginning of time series is unknown. Specifying initial values for both parameters and hyperparametres before the estimation stage is considered to be a potential problem in the State Space model and, hence, prior information about A_0 is rarely available. Therefore, Basdevant (2003) argue that the Kalman filter can be initialized by using the mean and covariance matrix of unconditional distribution A_t when A_t is stationary or time invariant. However, if A_t is non stationary or not time invariant, the unconditional mean and covariance no longer exist. Unless a prior information is available, the initial distribution

[33] It permits visual examination of the single components, Mergner (2009).

of A_0 should be determined by using diffuse prior[34], (Harvey, 1989). Furthermore, Commandeur and Koopman (2007) suggest that researchers can depend either on theoretical considerations or previous research in order to calculate a reasonable initial value.

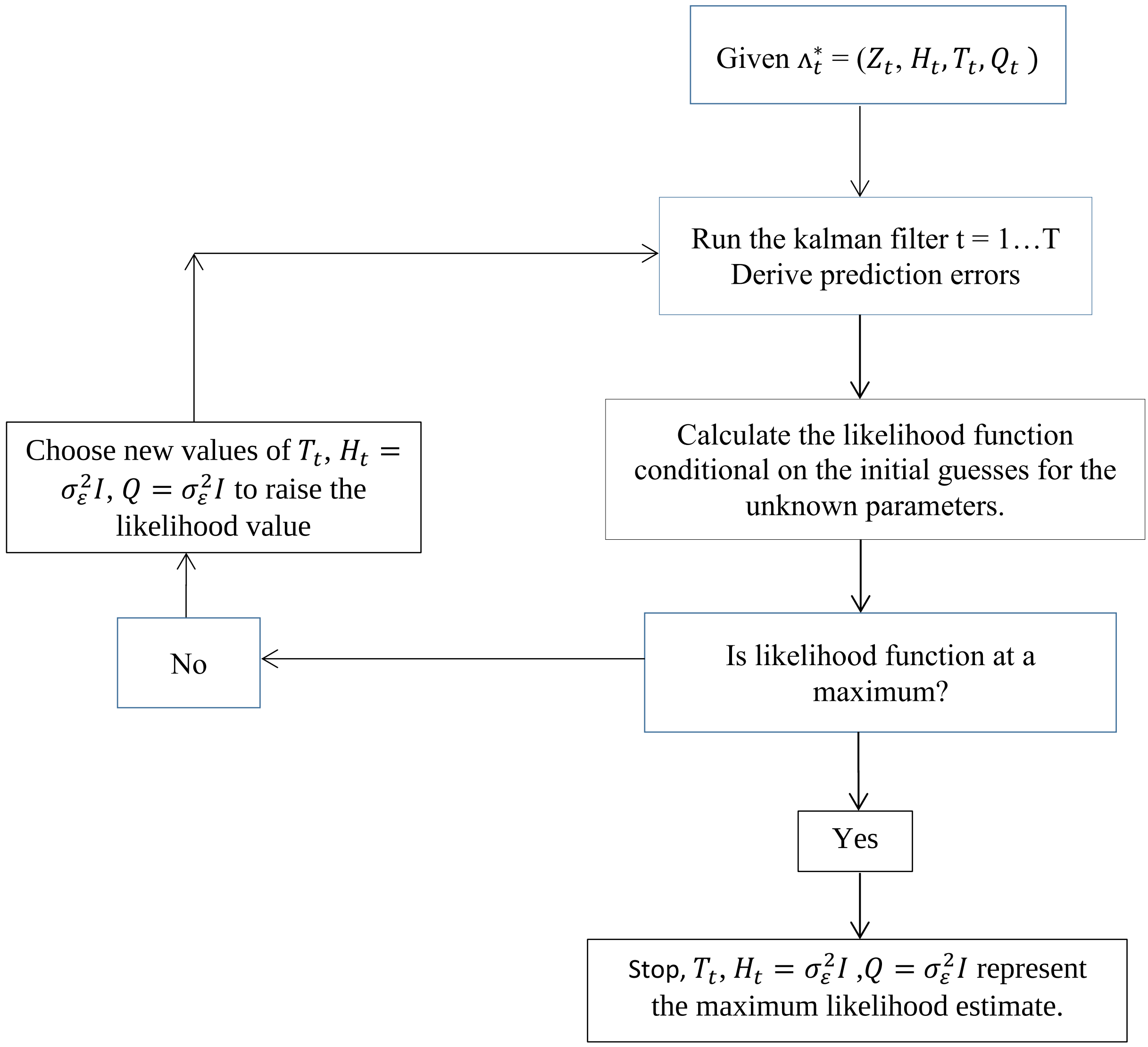


Fig.3.2. The maximum likelihood framework along with Kalman filter, (Cuthbertson, Keith et al., 1992).

[34] According to Harvey (1989), diffuse prior means establishing a suitable prior value from the first (m) sets of observations.

3.3.3 Define PSTR model in state space form:

Although huge academic presentations exist about State Space models and the Kalman filter (e.g. Harvey, 1989; Kim and Nelson, 1999 and Commandeur and Koopman, 2007), very few economic problems have been analysed by using State Space models. Mergner (2009) relates this to the shortage of available software to estimate these models. However, we argue that State Space models can be applied easily by using available software such as Eviews.

The main contribution in this chapter stems from Hall, S.G. et al., (2015) who mention that nonlinear models along with a single framework can be represented within a standard time varying coefficient model. This permits both measurement errors and missing variables. Although Kalman filter and state space system should be linear in state variables, they can deal with other variables nonlinearities. Therefore, we contribute to the literature by estimating a popular threshold model within a panel framework (PSTR) in state space model format. Our main contribution is four fold.

Firstly, we define the PSTR model in state space form so that we can estimate the threshold level of government size and examine its impact on economic growth. The State Space model is defined as follows:

Measurement equation: $y_{it} = \beta_{0t} + \beta_{1t} gfce^{35}{}_{it} + \varepsilon_{it}$ (3.8)

Transition equation: $\beta_{0t} = \pi_0$ (3.9)

$$\beta_{1t} = \pi_1 \mathrm{F}(Z_{it}, \gamma, \mathrm{C}) + \pi_2[1 - \mathrm{F}(Z_{it}, \gamma, \mathrm{C})] \quad (3.10)$$

Where the transition function is defined as:

$$\mathrm{F}(Z_{it}, \gamma, \mathrm{C}) = \frac{1}{(1+\exp(-\gamma(Z_{it}-c)))} \qquad \gamma > 0 \quad (3.11)$$

Where, y_{it} displays the annual growth rate of GDP and β_{0t} shows fixed country effect. Both π_1, π_2 display how government size affects economic growth above and below the threshold level respectively. Whereas, F (Z_{it}, γ, C) represent our transitional function. Hence, Z_{it} displays the threshold variable of government size, γ determines the slope or smoothness of transition between regimes while C displays the threshold value.

[35]Gfce: defined as general government final consumption expenditure as percentage of GDP.

Accordingly, this can be considered to be a special case of the former equation (3.4) e.g. A_{1t} =β_{0t} , A_{2t} =β_{1t} , x_{1t} = π_0 and x_{2t} = π_1F (Z_{it}, γ, C) + π_2[1- F (Z_{it}, γ, C)] where T=0 and Q_t= 0. It can be clearly seen that the time varying parameter model is non standard, therefore least square approach cannot be implemented.

Secondly, this technique outperforms other models and, hence, it allows for the inclusion of more than one threshold variable in a single model. According to the specifications of the State Space model, it facilitates the simultaneous estimation of two or more different threshold variables. Therefore, we estimate two different threshold variables at same time by using different coefficients for each variable. Hence, we have two different transition functions; each function is defined for a certain threshold variable. While each variable has its own threshold level (C) and slope (γ) separately. Previous studies provide clear evidence about the non-linear relationship between inflation and economic growth (i.e. Omay and Kan; 2010, Lopez-Villavicencio and Mignon; 2011; Seleteng et al., 2013). Therefore, we employ inflation as another threshold variable alongside government size to be estimated simultaneously; this is relatively new in the literature. Likewise, this allows us to explore the effects of both government size and inflation beneath and beyond their threshold levels. Consequently, the state space model can be defined as:

Measurement equation:

$$y_{it} = \beta_{0t} + \beta_{1t} inf_{it} + \beta_{2t} gfce_{it} + \varepsilon_{it} \qquad (3.12)$$

Transition equations:

$$\beta_{0t} = \pi_0 \qquad (3.13)$$

$$\beta_{1t} = \pi_1 F_1\ (q_{it}, \gamma_1, C_1) + \pi_2[1- F_1\ (q_{it}, \gamma_1, C_1)] \qquad (3.14)$$

$$F_1\ (q_{it}\ , \gamma_1, C_1) = \frac{1}{(1+\exp(-\gamma_1(q_{it}-C_1)))} \qquad \gamma_1 > 0 \qquad (3.14.a)$$

$$\beta_{2t} = \pi_3 F_2\ (Z_{it}, \gamma_2, C_2) + \pi_4[1- F_2\ (Z_{it}, \gamma_2, C_2)] \qquad (3.15)$$

$$F_2\ (Z_{it}, \gamma_2, C_2) = \frac{1}{(1+\exp(-\gamma_2(Z_{it}-C_2)))} \qquad \gamma_2 > 0 \qquad (3.15.a)$$

In state equation (3.14), q_{it} is defined as the threshold variable of inflation while γ_1 and C_1 determine the smoothness of transition between regimes and the threshold value of inflation respectively. Meanwhile, (π_1 ,π_2) represent how inflation affects economic growth above and below the threshold level respectively. However, in state equation

(3.15), Z_{it} represents the threshold variable of government size and, similarly, γ_2 and C_2 determine the smoothness of transition between regimes and the threshold value of government size respectively. However, (π_3 ,π_4) demonstrate the impact of government size on economic growth above and below the threshold level.

Thirdly, we developed our second contribution to impose an econometric restriction on the transitional function since we restrict the transitional variables coefficients ($\gamma_1, \gamma_2, C_1, C_2$) of the above mentioned threshold variables to be the same (C and γ). In other words, we estimate only one threshold value (c) for two different threshold variables (inflation and government size). Subsequently, the threshold value (c) is analysed as the optimal threshold level for both variables. Thus, the state space equations are defined as follows:

Measurement equation:

$$y_{it} = \beta_{0t} + \beta_{1t} inf_{it} + \beta_{2t} gfce_{it} + \varepsilon_{it} \quad (3.16)$$

Transition equations:

$$\beta_{0t} = \pi_0 \quad (3.17)$$

$$\beta_{1t} = \pi_1 F\ (q_{it}, \gamma, C) + \pi_2[1 - F\ (q_{it}, \gamma, C)] \quad (3.18)$$

$$F\ (q_{it}, \gamma, C) = \frac{1}{(1+\exp(-\gamma(q_{it}-c)))} \qquad \gamma > 0 \quad (3.18.a)$$

$$\beta_{2t} = \pi_3 F\ (Z_{it}, \gamma, C) + \pi_4[1 - F\ (Z_{it}, \gamma, C)] \quad (3.19)$$

$$F\ (Z_{it}, \gamma, C) = \frac{1}{(1+\exp(-\gamma(Z_{it}-c)))} \qquad \gamma > 0 \quad (3.19.a)$$

In contrast to the previous case, (c) is defined as the threshold value for both inflation and government size while (γ) represents the simultaneous smoothness of transition between regimes for both variables.

Fourthly, according to Hall, S.G. et al. (2015), a stochastic STAR model can be represented by introducing a stochastic error term in equation (3.22). Thus, we repeat all the previous steps independently but with a stochastic transition function. The simplest way to estimate the state space model is as follows:

Measurement equation: $y_{it} = \beta_{0t} + \beta_{1t} gfce_{it} + \varepsilon_{it}$ (3.20)

Transition equation: $\beta_{0t} = \pi_0$ (3.21)

$$\beta_{1t} = \pi_1 F(Z_{it}, \gamma, C) + \pi_2[1 - F(Z_{it}, \gamma, C)] + U_{it} \qquad (3.22)$$

$$F(Z_{it}, \gamma, C) = \frac{1}{(1+\exp(-\gamma(Z_{it}-c)))} \qquad \gamma > 0 \qquad (3.22.a)$$

As we can see, the main difference between the stochastic format and the former static format is the inclusion of an error variance expression to our state or transition equation (3.22). The errors in equation (3.22) are assumed to be distributed normally with constant variance. The error term allows capturing any adjustment or part of the adjustment that might happen from the error term itself.

3.4 Data:

This study's data sample comprises 5 developing countries selected from the Middle East and North Africa (MENA) region: these are, namely, Egypt, Iran, Morocco, Tunisia and Turkey. We selected these countries due to the availability of the data for a long period of time. We obtained the balanced panel data from World Bank development indicators (WDI) while the time span is from 1970 to 2014.

Our dependent variable is defined as annual growth rate of GDP (y_{it}). We use general government final consumption expenditures percentage of GDP (gfce % GDP) as a measure of government size[36]. It is defined as government current expenditures to buy all goods and services and, moreover, it consists of most spending on defence and security and eliminates government military expenditures. Additionally, we employ inflation as a source of macroeconomic stability, it is measured by the annual growth rate of the Consumer Price Index (CPI); it is presumed that it will inhibit rates of economic growth. Previous studies confirm the existence of a non-linear relationship between inflation and economic growth. Thereby, we use it as an additional threshold variable and, hence, we introduce a new way to estimate simultaneously two different threshold variables. Moreover, in order to avoid any misspecifications, and according to (Levine and Renelt, 1992; Barro and Sala-i-Martin, 1995) we included a number of control variables, for instance: Investment defined as gross fixed capital formation as a percentage of GDP. This is expected to have a positive effect on economic growth since it represents the

[36] We employ Hausman test and our results shows no evidence of endogeneity. Moreover, a cross –section dependency test has been employed and our results could not reject the null hypothesis of no cross-section dependence between the residuals.

physical accumulation. Similarly, Trade, as a percentage of GDP, is supposed to enhance economic growth and the population's rate of growth.

Pulling data from the Quality of Government Institute, version Jan 2016, University of Gothenburg, we employ the Human Capital Index (HCI) based on years of schooling (Barro and LEE, 2013). Additionally, this new data set provides a more comprehensive indicator of quality of government. For robustness checks, we employ Quality of Government index (Qog), which represents a simple average of the ICRG variables (corruption, rule of law and bureaucracy quality). It is scaled from 0 to 1, the higher the score, the higher the quality of government. In this respect, the data is available only during the period from 1984 to 2014. In this context, previous studies mention that quality of government represents another source of non-linearity (i.e. Christie, 2012; Pushak et al., 2007); however, they employ World Bank government effectiveness indicators (Kaufmann et al., 2009). Furthermore, we use the Executive Corruption Index (Execorr), which is considered to be a measure of executive bribery and embezzlement. Also, we obtain both debt as % of GDP and revenue as % of GDP from data stream as a source of fiscal sustainability. In this respect, the data for the countries being studied is available only for the period from 1990 to 2014.

Lastly, in order to control the convergence effect, as mentioned by Solow-Swan model, consistently with previous studies, we employ annual growth rate of GDP per capita as a dependent variable[37] and control initial GDP. The results are presented in Table B.1 in Appendix B.

3.5 Empirical Results:

We are interested in understanding government size behaviour and how it affects economic growth. Therefore, Table 3.1 reports the statistics of government size for each country. According to this Table, we can see that Egypt records the maximum level of government size (28.22164 % of GDP) while, among all the MENA countries, Turkey reported the minimum level of government size (7.515493% of GDP). We can see that, among all the countries, the average level of government size reaches (15.10147 % of

[37] Similarly, Hearth (2012), suggest employing GDP per capita as another indicator for economic growth. Because he claims that real GDP did not consider the various sizes of nations and hence represent aggregate figures. However, he believes that real GDP per capita is a sign for the average standard of living of the population.

GDP). Table 3.2 presents the correlation matrix for all variables employed in our baseline model. As expected, both inflation and government size are negatively correlated with economic growth and they are not correlated with each other.

3.5.1 State space estimation results:

Along the same line with our methodological framework, the rate of growth of GDP is defined as a function of both government size and inflation. In this case, we assume the presence of a non-linear relationship between government size and economic growth. We assert that the state space model can be considered to be the best way to capture the non-linearities between government size and economic growth.

Mittnik and Neumann (2003) confirm that, due to modifications in government size, fixed effect models cannot be employed to display the variations in the growth effect. Hence, there may exist periods of positive and negative effects which, in turn, cancel each other and may lead to rejection of the endogenous growth hypothesis. Furthermore, they suggest using state dependent or state varying coefficients to represent the relationship between government size and economic growth. This is because they believe that this approach illustrates the non-linear effects to a greater extent. Consequently, in order to address the non-linearities between government size and economic growth, we define the PSTR model in the form of state space equations.

Table 3.1: Summary Statistics for Government Size

	Egypt	Iran	Morocco	Tunisia	Turkey	Full Sample
Mean	15.13299	14.70781	17.71836	16.41565	11.53255	15.10147
Median	12.63167	13.18154	18.12708	16.42856	11.72639	15.16296
Maximum	28.22164	23.84220	21.67107	19.28257	15.34633	28.22164
Minimum	10.28571	9.714636	11.66719	13.22522	7.515493	7.515493
Std. Dev.	5.213710	4.054677	2.347842	1.138179	1.943883	3.867966
Observations	45	45	45	45	45	225

Table 3.2: Correlation Matrix for 5 MENA Countries (1970-2014)

Correlation	GDP	GFCE	INF	INV	POP	TRADE
GDP	1.000000					
GFCE	-0.052194	1.000000				
INF	-0.139898^{**}	-0.429855^{***}	1.000000			
INV	-0.032970	0.293976^{***}	-0.066861	1.000000		
POP	-0.092681	0.149204^{**}	0.051408	0.245704^{***}	1.000000	
TRADE	0.085625	0.394868^{***}	-0.411095^{***}	0.236825^{***}	-0.360216^{***}	1.000000

Notes: *, **, *** display the significance levels at 10%, 5% and 1% respectively.

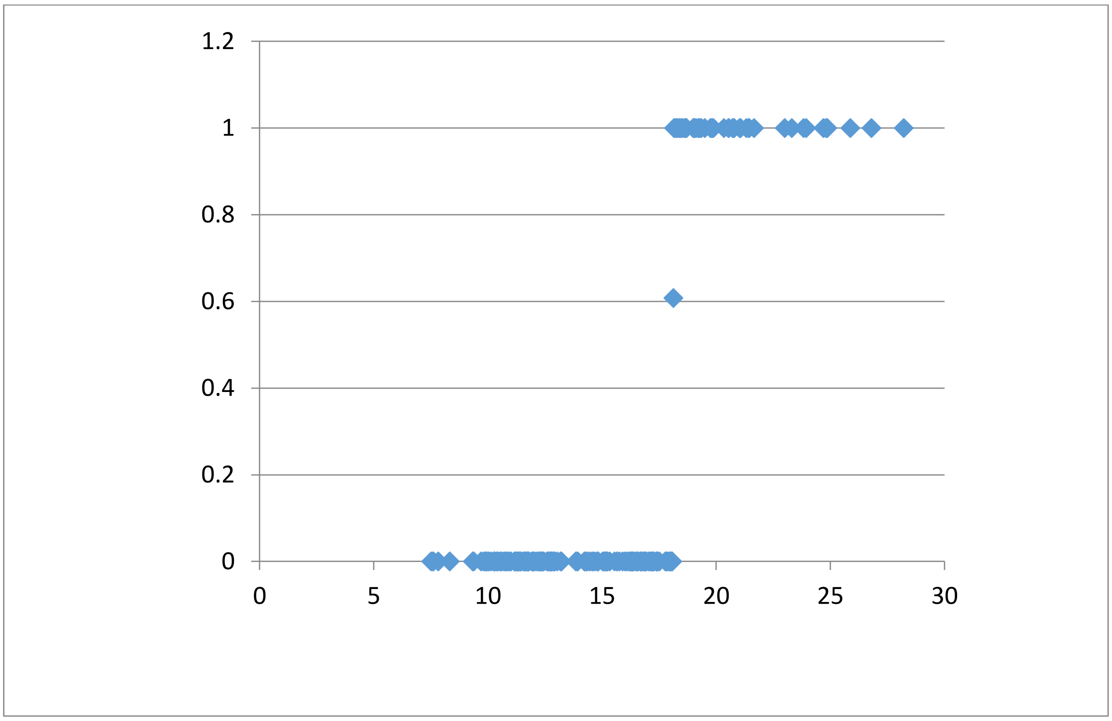
3.5.1.1 STAR model with static transition function:

Our results for the selected MENA countries are consistent with previous studies; which confirm that developing countries are looking for more government expenditures to build their infrastructures (i.e. Yavas; 1998, Bergh and Henrekson; 2011). According to Model A, first row of Table 3.3, we can see that government size has a detrimental effect on economic growth in both cases above (π_1) and below (π_2) the threshold level. However, the growth effect of government size is only statistically significant below the threshold level and loses its significant impact beyond the threshold level[38]. Furthermore, we find that, for the MENA countries, the estimated threshold level of government size at 18.1259 % of GDP is significant at the 1% significance level. However, in this case, we note that the slope (γ) of the transition function is very high; this shows that the impact of government size on economic growth changes quickly when government size is close to the threshold level.

With respect to the significance of the threshold variable, the formulation of PSTAR model in the state space system has an advantage over the model employed in the first chapter. This is because the previously employed codes do not provide the statistics of the threshold variable itself. However, in this chapter we follow Hansen's (1999) approach and employ the likelihood ratio statistics for the test on the threshold variable, (more details about Hansen approach are found in Appendix B). On the other hand, Dijk et al., (2002) illustrate the difficulty in obtaining a precise estimate for the smoothness of

[38] Other studies (e.g. Devarajan et al., 1996 and Josaphat and Morrissey, 2000) suggest that government consumption expenditures affect economic growth positively in developing countries. This is due to the misallocation of government spending toward productive expenditure at the expense of unproductive spending.

transition among regimes (γ). Since, as shown in Table 3.3, the estimated speed of transition between regimes has a large value; this indicates that our transition function appears to be a step function. Furthermore, it can be seen clearly from Figure 3.3 that our estimated threshold variable is half way and has no immediate neighbourhood. They argue that even large changes in the value of (γ) will have a small impact on the shape transition function. Consequently the estimation for (γ) might be insignificant. It is worth mentioning that this is not evidence of week nonlinearity; however, this relates to the identification problem (i.e. γ=0 cannot be tested due to the presence of unidentified nuisance parameters) explained previously in chapter 2, section 2.3.1.2.



*x− axis represent the transition variable,while y−axis display the transition function g (q_{it}; γ,c)

Fig.3.3. The estimated transition function for 5 MENA countries.

Table 3.3: Estimate of the threshold level for both Government Size and Inflation. (Static coefficient).

GDP growth	π_1	π_2	Transition Variables	
			$\exp(\gamma)$	C
Model (A) government size (gfce)	-0.11886 (0.2555)	-0.25028 $(0.0567)^{*}$	5.928677	18.12592 $(0.0001)^{***}$

Model. B) Estimate two different threshold variables using different coefficients.

	π_3	π_4	π_1	π_2	$\exp(\gamma_1)$	$\exp(\gamma_2)$	(c_1)	(c_2)
Inflation	-0.0428 $(0.063)^{*}$	-0.2326 (0.2027)	—	—	8.2171	—	5.9137 $(0.001)^{***}$	—
Government size (gfce)	—	—	-0.12020 (0.3555)	-0.29823 $(0.0912)^{*}$	—	8.4004	—	19.012 $(0.001)^{***}$

Model. C) Estimate two different threshold variables using same transition coefficients.

	π_3	π_4	π_1	π_2	$\exp(\gamma)$	C
Inflation	-0.07053 $(0.0158)^{**}$	-1.2774 (0.1512)	—	—	-1.277425 (0.1512)	14.54799 $(0.0000)^{***}$
Government size (gfce)	—	—	-0.47843 $(0.0142)^{**}$	-1.25453 $(0.0601)^{*}$		

Notes: Values between parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level. π_3 and π_4 represent the impact of inflation above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

Previous studies proved theoretically and empirically the existence of a nonlinear relationship between inflation and economic growth (i.e. there exist a threshold level of inflation beyond which it has a negative effect on economic growth), (e.g. Khan and Senhadji, 2001; Omay and Kan, 2010; Vaona and Schiavo, 2007; Burdekin et al., 2004). Therefore, we contribute to the literature by estimating two different threshold variables (i.e. inflation and government size). Model B in Table 3.3 represents the results of estimating two different threshold variables (inflation and government size). In this case, we have two different transition functions; each function display different threshold variable. Consistent with the first row, we can note that government size has a significant and negative impact on economic growth below the threshold level (π_2) while, beyond this level (π_1), it tends to have an insignificant impact on economic growth. The estimated threshold level for government size is 19.012% of GDP whereas the slope of the transition function (γ_2) is still very high. In the same vein, our results reveal the presence of a threshold level of inflation above which it has a significant destructive impact on economic growth (π_3) while, during a low inflation regime(π_4), it has an insignificant impact on growth. Furthermore, we find that the estimated threshold level of inflation $(c_1 = 5.913\%)$, similarly to the case of government size, the speed of transition between regimes is considered to be very high.

Correspondingly, Model C in Table 3.3 displays how we estimate jointly the threshold level of both inflation and government size as we restrict the transition parameters for both variables to be same. In turn, this means that, for both variables, we have one threshold value (c) and one slope of transition between regimes (γ). The estimated threshold level of both inflation and government size is 14.54% and is significant at the 1% significance level. Nevertheless, under this condition, we cannot capture the non-linear impact of government size on economic growth since it has a significant and negative impact on economic growth during both regimes. However the impact is higher beneath the estimated threshold level. A possible explanation for this finding is that, in this case, the estimated threshold level is lower than the former estimated values (i.e. 18.125%, 19.012% of GDP for both models A and B). On the other hand, the results confirm the nonlinear relationship between inflation and economic growth. Hence, we recognize that, during high inflation regimes, inflation has a significant and negative impact on economic growth; however, it loses its significant impact in low inflation regimes.

3.5.1.2 STAR model with a stochastic transition function:

Along the same lines, we develop the way of defining PSTR model in state space equations. Hence, we write the state space model in stochastic format by adding error variance expression to the state transition equation. In this case, we define the model as a STAR model with stochastic transition function. Consistent with our former results, we can confirm that, during low regimes, government size has a statistically significant negative impact on economic growth. According to the first row of Table 3.4 (i.e. Model A.), we can see that the threshold level of government size ($c = 17.75295\%$ of GDP) is approximately the same as the level which we achieved in the non-stochastic form (Model A, Table 3.3). While the slope of transition between regimes is considered to be smooth, it is, indeed, much lower in this case.

Similarly, we estimate the threshold levels of both government size and inflation using different coefficients. Consistent with Model B in Table 3.3, we find that the estimated threshold level of both inflation and government size are 5.9135% and 19.012% of GDP respectively. With respect to Model C in Table 3.4, we impose an econometric restriction by setting both government size and inflation to the same coefficients. Our results confirm the presence of a nonlinear relationship between inflation, government size and economic growth. Hence, the estimated threshold level for both variables is 12.02159%; this level is considered to be lower than our baseline model. Thereby, in both cases, government expenditure hurts the rate of economic growth rate, as more expenditure are required to enhance economic growth. While the slope of transition between regimes is smooth and slower than the baseline model. Lastly, in order to show the difference between the transitions functions in both cases (i.e. static and stochastic case), both Figures 3.4 and 3.5 represent the estimated state variables for each individual country at each point of time for both cases deterministic and stochastic transition function respectively. As it displays the behaviour of government expenditures during the employed period of time, hence it represents the combination of both coefficients π_1 and π_2 (i.e. above and below the threshold level), which is new in the existing literature.

Table 3.4: Estimate of the threshold level for both Government Size and Inflation. (stochastic coefficient).

GDP growth	π_1	π_2	Transition Variables	
			$\exp(\gamma)$	C
Model **(A)** government size (gfce)	-0.11325 (0.2063)	-0.34677 $(0.0330)^{**}$	0.747548 (0.4667)	17.75297 $(0.0000)^{***}$

Model. **B)** Estimate two different threshold variables using different coefficients.

	π_3	π_4	π_1	π_2	$\exp(\gamma_1)$	$\exp(\gamma_2)$	(c_1)	(c_2)
Inflation	-0.0412 $(0.069)^{*}$	-0.12666 (0.2918)	—	—	8.2171	—	5.9137 $(0.001)^{***}$	—
Government size (gfce)	—	—	-0.08406 (0.3843)	-0.26657 $(0.0310)^{**}$	—	8.4004	—	19.012 $(0.001)^{***}$

Model. **C)** Estimate two different threshold variables using same transition coefficients.

	π_3	π_4	π_1	π_2	$\exp(\gamma)$	C
Inflation	-0.07053 $(0.0299)^{**}$	0.02929 (0.7988)	—	—	-1.37272 $(0.0076)^{***}$	12.02159 $(0.0000)^{***}$
Government size (gfce)	—	—	-0.55736 $(0.0360)^{**}$	-2.12965 $(0.0000)^{***}$		

Notes: Values between parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level. π_3 and π_4 represent the impact of inflation above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

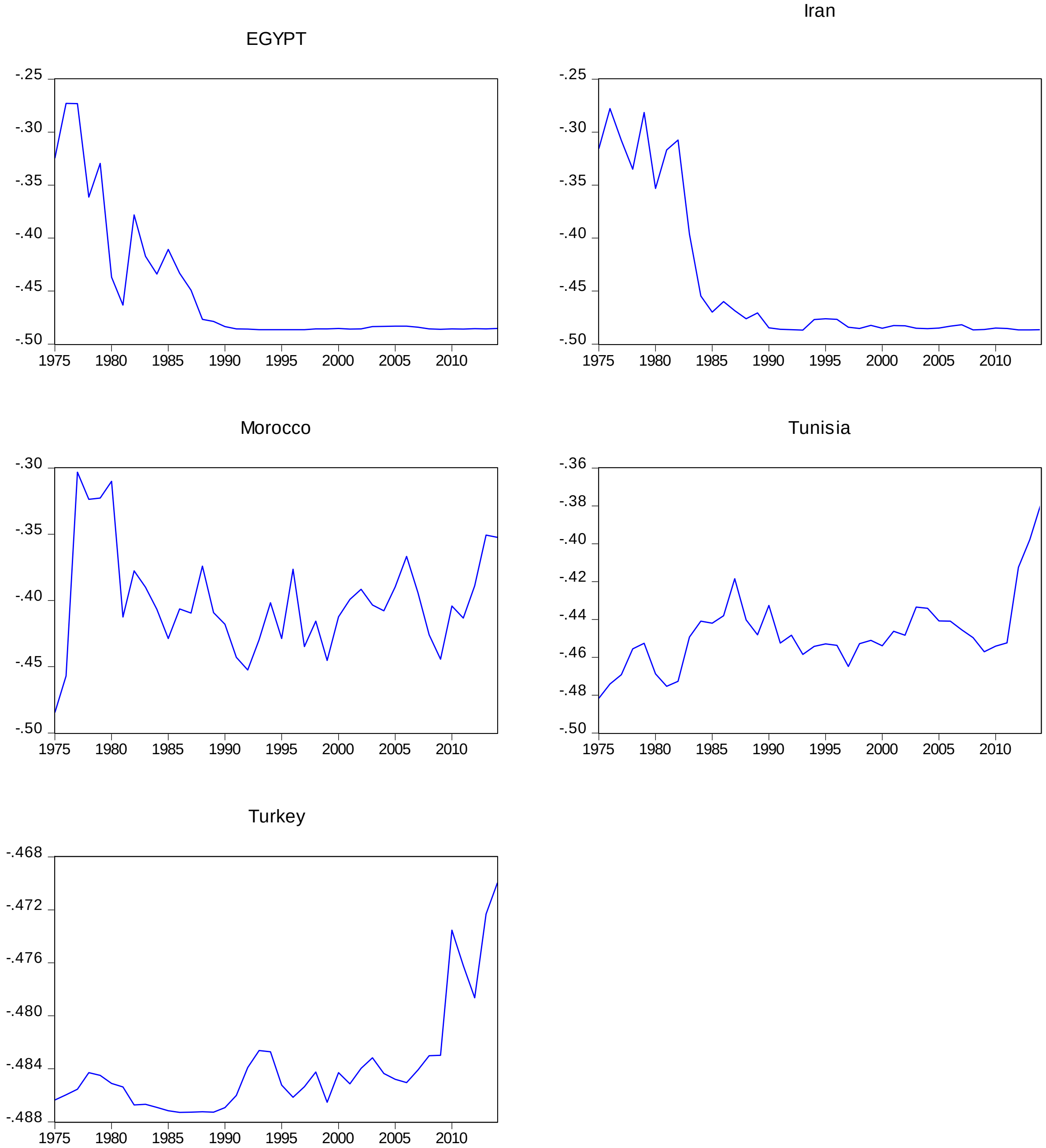


Fig. 3.4 Estimated state variables at each point of time, Model (A), Table (3.3).

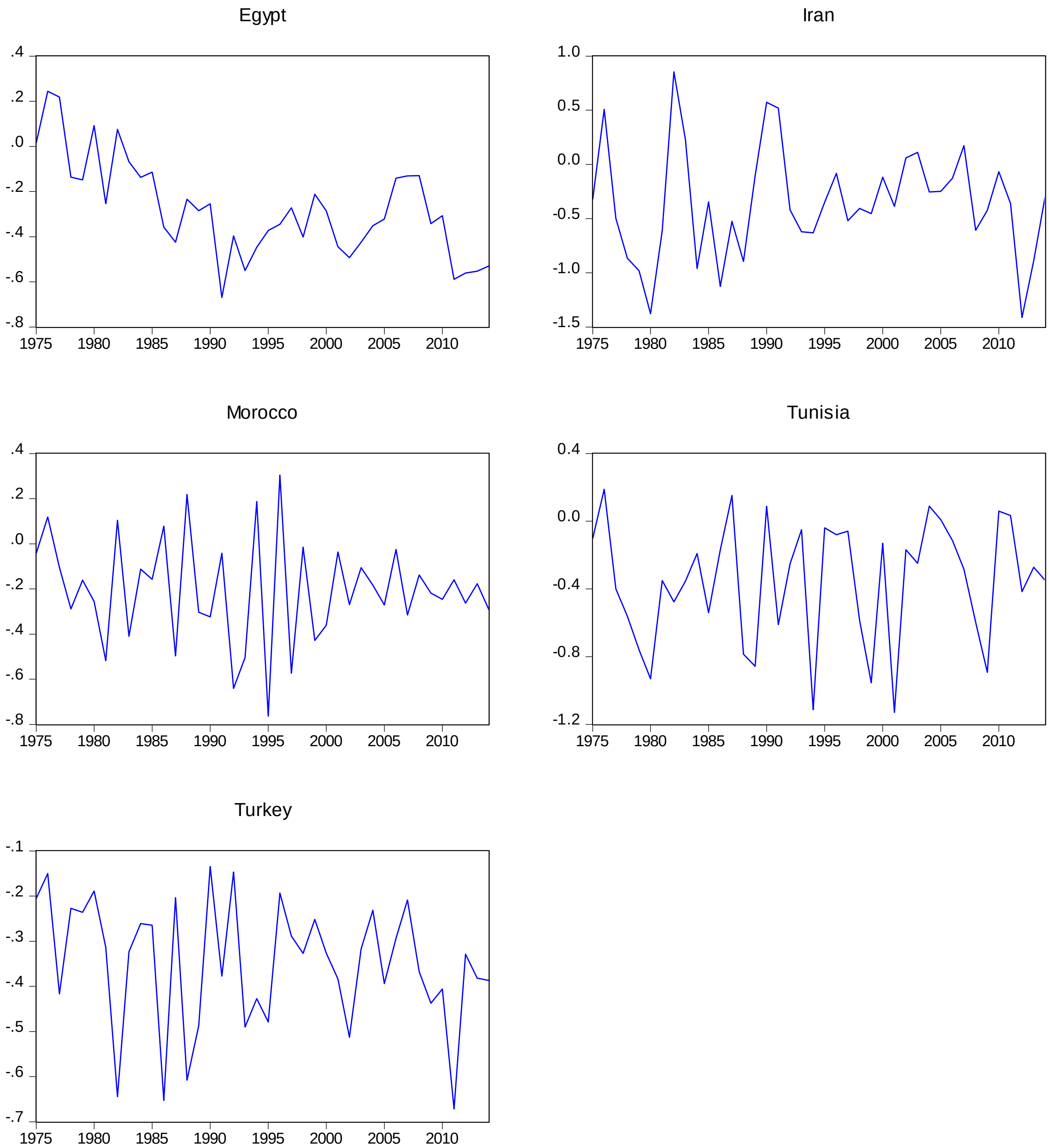


Fig. 3.5 Estimated state variables at each point of time, Model (A), Table (3.4)

3.5.1.3 Avoid Misspecifications and Add control variables:

In order to avoid any misspecifications that might arise from omitted variables and following previous studies, we augment our base line model with control variables. As established in the empirical literature, some variables are considered to be beneficial in growth models. Therefore, as defined in section 3.5, we control inflation, investment as % of GDP, human capital index, trade as % of GDP and population growth. The results in both Tables 3.5 and 3.6 are synchronized with the estimation of our baseline model (i.e. Tables 3.3 and 3.4). Both tables assert the existence of a non-linear relationship between government size and economic growth.

With respect to Table 3.5, there is a very slight change in the estimated threshold values for both government size and inflation. Since the observations lie in the low regime, any further increase in government spending leads to a decline in economic growth by 0.48%. On the other hand during high regime, government size shows a less distortionary impact on economic growth. Although the coefficient is still negative, it is considered to be small and insignificant. All our control variables have the expected signs according to the literature but only inflation in Model A and the human capital index in Model B have a significant impact on economic growth. Similarly, Table 3.6 displays results for the STAR model with a stochastic transition function; our results are consistent with Table 3.4. With respect to Model A in Table 3.6, a higher and significant threshold level of government size was realised. While the non-linear impact is consistent with our baseline findings, we recognise, also, in all three models that investment enhances the rate of economic growth. Similarly, the estimated threshold levels of inflation in both Models B and C are consistent with our earlier findings; only a very slight change in the magnitude of the coefficients was realised.

Table 3.5: Estimate of the threshold level for both Government Size and Inflation. (Static coefficient with control variables).

GDP growth	π_1	π_2	Transition Variables	
			C	Exp (γ)
Model (A) gfce	-0.267168 (0.1154)	-0.487458 (0.0595)*		
Inf	-0.066458 (0.0071)***			
Inv	0.15229 (0.3006)		19.04174 (0.0000)***	-0.47658 (0.7038)
hci	-2.83895 (0.1523)			
trade	0.051139 (0.28939)			

Model. B) Estimate two different threshold variables using different coefficients.

	π_3	π_4	π_1	π_2	Transition Variables			
					$\exp(\gamma_1)$	$\exp(\gamma_2)$	(c_1)	(c_2)
Inf	-0.0668 (0.012)***	-0.1971 (0.266)			8.217		5.913 (0.05)**	
gfce			-0.26248 (0.1786)	-0.43120 (0.0654)*		9.152		19.015 (0.05)**
Inv	0.11442 (0.3729)							
hci	-2.92150 (0.0680)*							
trade	0.04384 (0.3425)							

Model. C) Estimate two different threshold variables using same transition coefficients.

	π_3	π_4	π_1	π_2	Transition Variables	
					C	Exp (γ)
Inf	-0.07053 (0.0158)**	-0.057905 (0.7491)				
gfce			-0.4784 (0.0142)**	-1.25453 (0.0601)*	14.54799 (0.0000)***	-1.277425 (0.1512)
Inv	0.125019 (0.4388)					
hci	-2.727506 (0.1649)					
trade	0.032979 (0.5124)					

Notes: Values between parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level. π_3 and π_4 represent the impact of inflation above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

Table 3.6: Estimate of the threshold level for both Government Size and Inflation. (Stochastic coefficient with control variables).

GDP growth	π_1	π_2	Transition Variables	
			C	Exp (γ)
Model (A) gfce	-0.036515 (0.7401)	-0.29396 $(0.0398)^{**}$	23.5824 $(0.051)^{**}$	5.40776
Inf	-0.06904 $(0.0037)^{***}$			
Inv	0.22477 $(0.0129)^{**}$			
pop	0.0517 (0.9456)			
trade	0.04758 (0.8453)			

Model. **B)** Estimate two different threshold variables using different coefficients.

	π_3	π_4	π_1	π_2	Transition Variables			
					$\exp(\gamma_1)$	$\exp(\gamma_2)$	(c_1)	(c_2)
Inf	-0.0567 $(0.079)^{*}$	-0.0671 (0.626)			8.217		5.913 $(0.000)^{***}$	
gfce			-0.1709 (0.291)	-0.3757 $(0.056)^{*}$		9.152		19.015 $(0.000)^{***}$
Inv	0.185805 $(0.0872)^{*}$							
pop	-0.32547 (0.7448)							
trade	-0.015015 (0.6280)							

Model. C) Estimate two different threshold variables using same transition coefficients.

	π_3	π_4	π_1	π_2	Transition Variables	
					C	Exp (γ)
Inf	-0.062363 $(0.0575)^{*}$	0.06479 (0.6510)			12.4362 $(0.0000)^{***}$	-1.495059 $(0.0478)^{**}$
gfce			-0.52764 $(0.059)^{*}$	-2.13859 $(0.0914)^{*}$		
Inv	0.197235 $(0.0612)^{*}$					
pop	-0.87402 (0.4251)					
trade	-0.03968 (0.2259)					

Notes: Values between parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level. π_3 and π_4 represent the impact of inflation above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

3.5.2 Robustness Checks:

For sensitivity analysis, we carried out other robustness tests by using additional control variables. Table 3.7 displays the robustness checks results. Generally, the results are consistent with our findings in Tables 3.3 to 3.6. The estimated threshold variable and its qualitative impact are synchronized with our main results. Although, when we augment our model with additional control variables, the results change since, as a measure of fiscal sustainability, we attempted to control debt as the % of GDP. As shown in Model A Table 3.7, it does not support the presence of a threshold level of government expenditure. Since we cannot provide evidence of a significant threshold level, correspondingly, during both regimes, government size loses its significant impact on economic growth. Indeed, this means probably that debt may be responsible for the distortionary impact of government expenditure on economic growth. Along the same lines, taxes can be another channel through which government spending can have a negative effect on economic growth but, due to the unavailability of the data for the MENA countries being studied, we cannot detect its impact. On the other hand in Model B, we control government net revenue as % of GDP and realize a significant threshold level of government expenditure (17.6325% of GDP) below which government spending has a deleterious impact on economic growth.

In the same context, other studies are concerned about the importance of good governance that can help to mitigate the distortionary impact of government size on economic growth. They argue that government effectiveness or quality of government can be another source of nonlinearity. For instance, Christie (2012) split his sample between high and low effective governments. He observes the predominance of the nonlinear effect of government size on economic growth among the less efficient government. On the other hand, in a highly effective government, there is no evidence of non-linearity. In our analysis, we employ quality of government (Qog) and executive corruption (Execorr) as indicators of government effectiveness. We classified the MENA countries as having medium class effective governments and, on average, the quality of government = 0.52465. As reported in Models C and D Table 3.7, our results display clear evidence of nonlinearity while the coefficients of both Qog and Execorr have a non-significant impact on economic growth. Lastly, we re-estimate our baseline model using annual growth rate of GDP per capita, our results (See table B.1 in appendix B) confirm that non-linear relation between government size and economic growth. We found a threshold level (i.e. 23%) beyond which it has positive insignificant impact on economic growth, while below that level it affects economic growth negatively.

On average we can see that the estimated threshold level of government size (18.1259%) is beyond the average level for all the MENA region countries. Nevertheless, for most of the MENA region countries, the average level of government size is very close to the estimated threshold level. Our results suggest that policy makers should expand government expenditures since we find a threshold level of government size below which it has a distortionary effect on economic growth. Also, we observe that the speed of transition between two regimes is very high.

We expect that the results, obtained in the context of our selected sample of MENA region countries, can be of relevance to other developing countries. Accordingly, these results can be used as guidelines for other countries that share similar levels of development, economic structure and cultural environments. Moreover, this study provides evidence for policy makers since it can help them to identify which countries actually can increase their government expenditures and promote economic growth over the long term. However, the optimal composition of government expenditures for each country really matters. Therefore, further research needs to be done in order to provide policy makers with clear and precise guidelines. Another suggested avenue of research is to compare the existing results with oil exporter countries within the MENA region such as Gulf countries, which are characterised by higher levels of government expenditures.

Table 3.7: Estimate of the threshold level for Government Size (Additional Control variables).

GDP growth	Model (A)		Model (B)		Model (C)		Model (D)	
	π_1	π_2	π_1	π_2	π_1	π_2	π_1	π_2
gfce	-0.3523 (0.4964)	-0.6422 (0.1675)	-0.6422 (0.1675)	-0.99480 $(0.0375)^{**}$	-0.2458 (0.1772)	-0.47435 $(0.0724)^{*}$	-0.1993 (0.7714)	-0.86866 $(0.0546)^{*}$
Inf	-0.077114 $(0.0178)^{**}$		-0.076402 $(0.0080)^{***}$		-0.066920 $(0.0074)^{***}$		-0.064237 $(0.08610)^{*}$	
Inv	0.02628 (0.8577)		0.276034 (0.3571)		0.15457 (0.3340)		0.245968 (0.2001)	
hci	-6.447072 $(0.0353)^{**}$		1.449421 (0.4203)		-2.95076 (0.1572)		1.700672 (0.4665)	
trade	0.09662 $(0.0154)^{**}$				0.050813 (0.3218)		0.016248 (0.7385)	
Debt %GDP	**-0.048770** $(\mathbf{0.0073})^{***}$							
Revenue % of GDP			**-0.073115 (0.4811)**					
Execorr					**1.806857 (0.6444)**			
Qog							**-0.010060 (0.9985)**	
Transition Variables: C	17.409519		**17.63225** $(\mathbf{0.0000})^{***}$		**18.91809** $(\mathbf{0.0000})^{***}$		**17.91914** $(\mathbf{0.0000})^{***}$	
Exp (γ)	103.73467		0.914071		-0.484366		0.544144	

Notes: Values between Parentheses represent P-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level.

3.6 Conclusion

So far, no consensus has been reached regarding the relationship between government size and economic growth. This is because some scholars argue that a large government has a dampening effect on economic growth while others confirm that the reverse is true. In this study, we reviewed theoretically and empirically all the possible effects of government size on economic growth. We provide evidence for the debate in the empirical literature regarding the government size-economic growth nexus. One of the possible explanations for these different results is the sample selection, causality problem and chosen methodological framework. In other words, some of these studies include countries with various growth patterns and ignore the variations in the levels of economic development and the different composition of government expenditures. Along the same lines, other studies examine the non-linear hypothesis using inappropriate methodological frameworks to capture the existing non-linearity between government size and economic growth. In turn, these may lead to estimation bias.

This chapter analysed the non-linear relationship between government size and economic growth. We employed panel data for 5 countries within the Middle East region for the period from 1970 to 2014. The MENA region countries have been largely ignored in the context of government size and economic growth. However, it is important to study these countries since they suffer from high political instability and inefficient government expenditures. Consequently, it is important for policy makers to determine the more productive government functions. In this study, we contribute to the literature by introducing a new approach to estimating one of the threshold models, namely, the Panel Smooth Transition Regression (PSTR) approach developed by Gonzalez et al., (2005). We defined the PSTR model in the form of state space system equations.

Based on the PSTR specifications, we captured both cross-country heterogeneity and time variability in the context of government size and economic growth. Moreover, we estimated the threshold level of government size endogenously and the speed of transition between regimes. We developed the state space model to estimate two different threshold variables simultaneously (i.e. to estimate their threshold values and the speed of transition between regimes using different transition coefficients $(c_1, c_2, \gamma_1, \gamma_2)$. We improved the model further in order to restrict the transition function coefficients to be similar for both threshold variables. In other words, we had only one threshold value (c and γ) for two different threshold variables. Lastly, we developed the model further to allow for a stochastic transition function.

Generally, our findings are consistent with the recent empirical literature which confirms the non-linear hypothesis in government size and economic growth nexus (e.g. Pevcin, 2004; Davies, 2009 and Christie, 2012). Our reported results confirmed that the threshold level of government size in the selected MENA region countries was 17.245%. We recognized that government size had a significant negative impact on economic growth below the estimated threshold level while, beyond that level, it had an insignificant negative impact on economic growth. The smoothness of transition between regimes was very high; this indicated that government size changed its impact on economic growth suddenly when it was close to the estimated threshold level. With respect to estimating two various threshold variables employing different coefficients, our results provide evidence of non-linearity between government size, inflation and economic growth. We observed the estimated threshold level of inflation and government size to be (c_1= 5.913% and c_2= 19.0127%) respectively. Therefore, during a high inflation regime, inflation had a dampening effect on economic growth while, during a low inflation regime, it had an insignificant positive impact on economic growth. Our results for the government size threshold level were consistent with our baseline findings.

In order to draw a good policy recommendation, it is important to understand that each country has it is own characteristics and the composition of government expenditures varies from one country to another. Therefore, finding a threshold level of government size does not necessarily mean that expanding government expenditure leads to an increase in economic growth. However, the efficient composition of public expenditures and the presence of a threshold level should be considered. Accordingly, it might be useful for further research to study the optimal composition of public expenditure for each country in order to provide policy makers with precise guidelines.

Chapter 4

Does Foreign Aid Fit All? A Non-Linear Analysis.

4.1 Introduction:

In 2010, official development assistance hits its peak of 134.77 USD billion; this is the highest amount of foreign aid since the 1970s. However, the Development Assistance Committee (DAC) reports the falling amount of foreign aid directed to poor countries. Nowadays, high aid inflows are investigated carefully since foreign aid is considered to be a crucial source of economic growth, (OECD, 2015)[39]. Furthermore, it accounts for more than two thirds of external finance directed to the Least Developed Countries (hereinafter referred to as LDCs).

Many concerns are raised around the effectiveness of high aid inflows. Some researchers find that aid flows always promotes economic growth while others cannot differentiate the impact from zero. On the other hand, research, carried out by the World Bank, asserts that aid is only effective in a good policy environment, (Burnside and Dollar, 2000). A third group of researchers argue that aid has a detrimental impact on economic growth because it may encourage rent seeking activities; lead to the Dutch disease problem; and may be used for non-productive expenditures. Other evidence supports the idea that high aid inflows raise the levels of corruption (e.g. Alesina and Dollar, 2000; Alesina and Weder, 1999).

Although we can conclude that in some circumstances scaling up foreign aid is important to enhance economic growth rates, donors should be sensible with regard

[39] OECD newsroom, (8/4/2015), development aid stable in 2014 but flows to poorest countries still falling. Accessed 1/8/2015. http://www.oecd.org/newsroom/development-aid-stable-in-2014-but-flows-to-poorest-countries-still-falling.htm

to the amount of aid directed to LDCs since they should consider their limited absorptive capacity. In this context, two viewpoints are raised: the big push concept; and absorptive capacity constraints. The big push adopts the idea of scaling up foreign aid in order to half the poverty rate. In this respect, there exists a suspicion as to whether or not the full amount of aid will be absorbed effectively. Therefore, recent studies start to take into account the non-linearity hypothesis between foreign aid and economic growth. However, these studies employ only a quadratic or interaction term to capture the diminishing returns to aid. On the contrary, we argue that this approach imposes only a specific form of non-linearity (inverted U-shape), and may be unable to capture the possibility of multiple threshold levels.

This study aims to examine the relationship between foreign aid and economic growth from a non-linear perspective. We estimate the threshold level of foreign aid for 25 developing countries through the period from 1984 to 2008. Additionally, we estimate the threshold level of foreign aid for three groups of countries according to their income level (upper middle, lower middle and LDCs countries). In this respect, we believe that pooling all countries together may have its own caveats since they have various characteristics and different stages of development. Because of the existing discrepancy among countries, some countries might be in need for more or less amount of foreign aid, (Hansen and Trap, 2000)[40].

In the same context, some of the former studies assert that foreign aid works effectively only in a good policy environment and does not consider corruption as one of its determinants. Consequently, this study will contribute to the literature by employing the interaction term between the level of corruption and foreign aid as one of our explanatory variables in order to capture whether or not the levels of corruption matter in aiding recipient countries effectively.

In order to assess the threshold level of foreign aid, we will contribute to the literature by employing a suitable threshold model. Accordingly, we define the Panel Smooth Transition Regression (hereinafter, referred to as PSTR) model in the form of state space system so as to identify an appropriate threshold level of foreign aid endogenously. This model allows us to avoid the arbitrary determination of

[40] Other studies (e.g. Gyimah-Brempong et al., 2012; Moriera, 2005) suggest that the effect may vary between countries due to the different conditions they might face.

exogenous threshold levels. In addition, we improve our model in such a way that we allow our explanatory variables to vary according to the estimated threshold level of foreign aid (i.e. time varying effects of the explanatory variables). Moreover, we examine the multiple threshold levels of foreign aid[41] for all three groups of countries.

This chapter aims to answer the following questions:

1) Should foreign aid be open-ended?

2) Does foreign aid follow the big push or absorptive capacity concept?

3) Is the threshold level of foreign aid similar across all developing countries?

4) How does aid recipient countries' level of corruption affect the aid allocation process?

The remainder of the chapter is organised as follows: section 4.2.1 review the theoretical literature concerning the relationship between foreign aid and economic growth. Section 4.2.2 focuses on the development of the foreign aid- economic growth nexus in the empirical literature. Section 4.3 highlight the employed methodology, while section 4.4 defines the data employed in this study. Section 4.5 introduces the analysis of our empirical results and the final section, 4.6, presents our conclusion.

4.2 Literature Review:

4.2.1 Theoretical background:

4.2.1.1 Aid and economic growth theories:

In classical economics, physical capital is identified as a major contributing factor to economic growth and development. Therefore, there is a consensus among early growth theories that capital formation has an outstanding role in the growth process. Due to the evolution in economic growth theories, they realise that the growth process depends on a complex set of correlated factors. Accordingly, both the basic Harrod-Domar model and the two-gap model are considered to be very simple, (Moreira, 2005).

[41] Some of the previous studies (e.g.Wagner, 2014; Guillaumont. P. And Guillaumont. J., 2007) suggest the existence of two threshold levels of foreign aid, one support the big push concept while the other advocate the absorptive capacity concept.

Chenery and Strout (1966) are the pioneers who propose the two-gap model in order to frame the relationship between foreign aid and economic growth. The model consists of saving gap and foreign exchange gap. The first gap (saving gap) shows the difference between domestic savings and the amount of investment required to attain a certain economic growth rate. The second gap is defined (foreign exchange gap) as the discrepancy among the foreign exchange prerequisites in attaining a certain level of investment and domestic foreign exchange earnings, (Easterly, 2003). Lastly they propose the capital absorptive capacity due to skill limitation.

4.2.1.1.1 Saving Gap approach

The Chenery-Strout model is based on the Harrod-Domar model and the Cobb-Douglas production function. Their basic model can be represented as follows:

$$g = (\frac{I}{Y})/\mu \qquad (4.1)$$

$$\frac{I}{Y} = \frac{A}{Y} + \frac{S}{Y} \qquad (4.2)$$

The economic growth rate target (g) depends on investment as a percentage of GDP (I/Y) regulated by factors (μ); these detect the quality of investments. Where (I) represents the desired level of investment, (A) is aid, (S) displays domestic saving and (μ) shows the Incremental Capital-Output Ratio (hereinafter referred to as ICOR[42]). According to the above model, Easterly (2003) point out that a high ICOR ratio is considered to be a poor measure for quality of investment.

This approach is based mainly on the following assumptions:

1) Capital is the key factor of the growth process.

2) They employ the Keynesian saving hypothesis which is based on the assumption that the marginal propensity to save is higher than the average propensity to save.

3) Developing countries suffer from low capital formations, which, in turn, hinder the achievement of high economic growth rates.

[42] It identifies the additional units of capital desired for additional units of output.

4.2.1.1.2 Foreign exchange gap approach

The shortage of foreign exchange is another possible constraint for growth in developing countries. Chenery and Strout (1966) propose the presence of a foreign exchange gap since they claim that developing countries do not have enough export earnings in order to import capital goods for investment. This is because developing countries' foreign exchange reserves are insufficient to import goods and services which cannot be produced domestically. Thus, foreign aid is suggested to fill this gap.

The foreign exchange gap approach or trade gap is based mainly on the assumption that, at an early stage of development, many goods and services, required for investment, are not produced domestically. Furthermore, the optimum level of production is influenced by the shortage of these goods and services which, in turn, leads to inefficient use of domestic resources, (Pankaj, 2005).

4.2.1.1.3 Capital absorptive capacity approach

Most developing and LDCs are characterised by a low level of capital absorptive capacity; in turn, this influences their efficient use of resources. As in the early stage of development, these countries suffer from lack of skilled labour and, that consequently mitigates the effort to achieve high level of investments. Therefore, foreign aid must be directed towards skill development programmes, the formation of human capital and investing in educational and technical institutions, so that these countries' growth rates will be improved in the long run. In this context, Chenery and Strout (1966) define the capital absorptive capacity as a skill limitation which restrains the growing levels of investments, (Pankaj, 2005).

Along the same lines, Bacha (1990) introduces a fiscal gap between government revenues and expenditures. The fiscal gap highlights the fact that some developing countries do not have enough revenue to attain the required levels of investments. Subsequently, foreign aid can be directed to these governments as complementary to its revenues in order to fill the gap and to enhance high economic growth rates, (Mercieca, 2010). Collectively, these gap models ensure that foreign aid can help to relax the constraints of savings, foreign exchange, capital absorptive capacity and government revenues. In turn, this may lead to high levels of saving, investments and promote economic growth rates.

4.2.1.1.4 Critique directed toward aid-growth theories

On a theoretical basis, the Chenery-Strout two-gap foreign aid model has been widely criticized. Easterly (2003) doubt the existence of a linear relationship from investment to growth (a constant ICOR). Considering the neoclassical growth model, he highlights that, a temporary increase in growth is expected during the transition from one steady state to another, due to a boost in investment. Whilst, there will be no perpetual causal relationship between investment and growth.

In the same vein, the endogenous growth theory models a number of key determinants of growth alongside physical capital. For instance, these are technological progress, human capital and the economy's social and cultural characteristics. However, these factors are largely ignored by the saving gap's production function. Along the same lines, there exist doubts regarding the effectiveness of foreign aid-growth models which are based on the assumption that the marginal propensity to save is higher than the average propensity to save. Many economists reject this assumption because they believe that saving is a function of institutional arrangements, saving habits and government policy. Hence it is inaccurate to build such a simple relationship between saving and income, (Pankaj, 2005).

Additionally, other critiques have been directed towards the foreign exchange gap approach. Burton (1981) denotes that the domestic economy's productive sector should depend on exports produced by the agricultural or manufacturing sector. Otherwise, it will fail if it relies on foreign exchange earnings either coming from remittances or petroleum exports. Furthermore, a number of economic and political problems will be raised.

Generally, there exists a controversy regarding foreign aid as a key factor for self-sustained growth in developing countries. For instance, Pankaj (2005) define people's beliefs, behaviours, social and political values as determinants of development which are not influenced by the inflow of foreign aid. Furthermore, he provides evidence that some countries e.g. Japan and Hong Kong achieve self-sustaining growth without receiving a substantial amount of foreign aid. On the other hand, other countries e.g. India and Pakistan receive a significant amount of foreign aid but fail to reach self-sustaining growth.

4.2.2 Empirical Background

A large and growing body of literature investigates the relationship between foreign aid and economic growth. The literature on the aid-growth nexus comprises three main generations. Theoretically, the first generation spans the period from 1970 to 1972 and relates to studies of the causal string which starts from savings to investment to growth. The second generation estimates a link between aid and growth through investment; however, they continued to concentrate on the capital accumulation channel.

As better data became available, a third generation of studies arises from Boone (1996) and continues to the present day. This generation works with panel data and covers a large number of developing countries. Furthermore, they address the aid endogeneity problem and employ an aid-policy interaction term to new growth theory regressions, (Hansen and Trap, 2000)[43].

4.2.2.1 Does foreign aid stimulate or hurt growth?

The early studies that employ the two-gap model is based mainly on the Harrod-Domar growth model. They find a positive relationship between foreign capital flows and savings through accumulation of physical capital, (Hansen and Trap 2000). Afterwards, many empirical studies doubt this finding.

During the 1960s, 1970s and 1980s there is ambiguous literatures on aid[44] and economic growth due to data limitations. Mosley et al. (1987) reveal the presence of a micro-macro paradox within the aid-economic growth nexus. They point out that there is a clear positive impact at the micro level while the macroeconomic impact is still vague. In the 1990s, studies start to concentrate on the relationship between aid, policies and growth; however, the results are still unclear. Recently, many studies, employing various samples and methodologies, assert that foreign aid has a positive influence on growth (e.g. Hansen

[43] Aurangzeb and Stengos (2010) demonstrate that this generation experienced an institutional or policy gap while previous generations suffer from a financing gap.

[44] For example: Griffin and Enos (1970) claim that part of foreign aid has been directed towards consumption instead of saving; in turn, this is responsible for the negative impact of foreign aid on growth. On the other hand, Papanek (1973) dissociate foreign capital flows to foreign investments, foreign aid and other flows in order to identify the impact of foreign aid on domestic savings. His results provide evidence of the presence of a strong positive relationship between foreign aid and high growth rate in aid receipt countries.

and Trap, 2000; Gomanee et al., 2003; Hansen and Trap, 2001; Karras, 2006 and Clemens et al., 2012).

According to the recent empirical literature, Moreira (2005) and Hansen and Trap (2001) confirms that foreign aid promotes economic growth rates through investment. They argue that foreign aid enhance economic growth while the impact varies between countries due to different conditions. Similarly, Karras (2006) employ panel data which spanned from 1960 to 1997 for 71 developing countries. The results show that per capita growth rate will increase by 0.14 to 0.26 percent if foreign aid raises by 1 percent of GDP. On the other hand, we claim that combining 71 developing countries with various income levels and different stages of development is inconsistent and may lead to biased results[45]. Likewise Gyimah-Brempong et al., (2012), report a number of ways in which foreign aid may help to promote economic growth. Hence, they claim that aid may be used to finance institutional reforms and to raise productivity since it may be used to import required inputs so as to expand their existing absorptive capacities.

In order to analyse the effectiveness of foreign aid on economic growth, Neanidis and Varvarigos (2007) address the importance of splitting foreign aid into productive and unproductive categories. This is because they suggested that different categories of aid may have various impacts on economic growth[46]. Their findings confirm that productive aid has a positive effect on economic growth while unproductive aid has a significant negative impact on economic growth. Moreover, they discover that volatility of productive aid inhibits economic growth. In the same context, Clemens et al., (2012) re-examine the data for most prominent studies in the context of aid and economic growth (e.g. Boone, 1996; Burnside and Dollar, 2000; and Rajan and Subramanian, 2008). Despite the regression specifications, they argue that aid promoted economic growth. On the other hand, they assert that high levels of foreign aid lead to diminishing returns and, furthermore, the magnitude of the impact varies between aid-recipient countries.

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[45] Due to the existing heterogeneity among countries, there might be some countries that are less in need for foreign aid, (Hansen and Trap 2000, 2001). Similarly, other studies (e.g. Lopez-Villavicencio and Mignon, 2011) suggest splitting the sample according to their income level (i.e. upper middle, lower middle and Low developed countries). As they expect a notable difference in the threshold levels among all groups of countries.

[46]They suggest that foreign aid effectiveness will be realised in the short run if it is directed toward industry, trade or infrastructure. On the other hand, if it is specified for the purpose of health and education, its effectiveness will be recognized in the long-run.

In contrast, other group of researchers argue that aid has a detrimental effect on economic growth (e.g. Svensson, 2000; Economides et al., 2008; Djankov et al., 2008 and Feeny and De Silva, 2012). They relate the poor macroeconomic impact of foreign aid on economic growth to the prevalence of corruption and various types of rent seeking activities. Hence, it motivates self-interested people toward extracting resources for their personal gain and stops productive work. In the same vein, Moyo (2009) and Remmer (2004) provide evidence that countries, which were highly dependent on foreign aid, are more likely to expand their government size compared to other countries. Furthermore, the rent-seeking impact will rise if the size of aid recipient country's public sector is large and accompanied by a considerable amount of aid.

Moreover, Feeny and De Silva (2012) point out that foreign aid may not be used effectively in developing countries due to the problem of limited absorptive capacity[47]. This is because a high amount of aid inflows may exceed the recipient country's management capability. For instance, Lavy and Sheffer (1991) argue that the amount of aid inflows directed to Egypt, Jordan and Syria, exceeds the investment projects in which it is to be employed and, thus, the rest must be consumed.

In view of all that has been mentioned so far, foreign aid could not achieve its development objectives effectively for the following reasons:

1) Aid recipient countries may rely on external supply, which in turn, creates an aid dependency problem since it kills the process of learning.

2) Part of foreign aid may be consumed or wasted by aid recipient countries.

3) Foreign aid may be assigned to developing countries for a strategic or political consideration and not to meet their needs (Guillaumont. P. and Guillaumont. J., 2007).

[47] Feeny and De Silva (2012), argue that most developing countries have many obstacles for growth; for instance, these are human and physical constraints, macroeconomic constraints and institutional constraints.

4.2.2.2 Aid conditionality

In 1998, the World Bank released a report stating that aid may promote economic growth only in countries with a good policy environment. They claim that foreign aid ought to be designated according to the recipient country's policy environment. However, Gyimah-Brempong et al., (2012) raise an important question about the determinants for good policy environments and whether they are the same for all countries.

Burnside and Dollar (2000) create a policy index which involve budget surplus to GDP, inflation rate and trade openness. Furthermore, they employ an interaction term between aid and policy index for a group of developing countries over the period from 1970 to 1993. They argue that foreign aid enhances real GDP per capita only when it interacts with the policy variable. In addition, Collier and Dollar (2002) claim that Brunside and Dollar (2000) ignore many factors that are likely to affect growth rates. Therefore, in order to identify poverty-efficient allocation of aid, they create a more comprehensive index including macroeconomic issues, structural policies and social inclusion. Consistently they conclude that poverty would decline only if aid was allocated to poor countries characterised by a good policy environment. However, this contradict with the fact that the poorer the countries, the more corrupt they are.

On the other hand, there exists a debate about the effectiveness of foreign aid conditioned on a good policy environment. Further studies claim that Burnside and Dollar's 2000 results are fragile and are restricted only to the chosen sample and time period (e.g., Hansen and Trap, 2000, 2001; Lensink and White, 2001; Easterly, 2003 and Karras, 2006). Covering the period from 1970 to 1997, Easterly et al., (2003) employ an extended dataset and use the same regression specifications, 4-years average and controlling same variables as Burnside and Dollar's (2000) study. Their analysis shows that the interaction term between aid and policy index is insignificant. Moreover, they use ODA[48] as a measure of foreign aid, include financial depth to their policy index and consider various

[48] Burnside and Dollar (2000) used effective development assistance (hereinafter referred to as, EDA) introduced by Chang et al., (2002) as a measure of foreign aid. According to the World Bank (1998), there is no significant difference in estimation if we use either EDA or Official Development Assistance (ODA) as a measure for foreign aid.

periods of eight, 12, 24 years[49]. Nonetheless, he fails to prove the conditionality of the effectiveness of aid on a good policy environment.

In the same vein, Karras (2006) conclude that foreign aid has a positive effect on real GDP per capita and he does not limit its effectiveness to a good policy environment. He explains that the positive impact of aid can be realised even without controlling for the recipient countries policies. Additionally, Hansen and Trap (2000, 2001) confirm that foreign aid enhanced economic growth without conditioning on a good policy environment. While they ensure that, due to heterogeneity between countries, it may be the case that some countries are less in need of foreign aid, at the same time, the effectiveness of aid can be clearly realised. On the other hand, although other countries may have bad policies, providing them with foreign aid may improve their situation and bring them back on the track. Similarly, Guillaumont. P. and Guillaumont. J. (2007b) provides examples of low-income countries which are able to emerge with the help of aid inflows.

The present argument raises an important question. If foreign aid has only a positive effect on economic growth in a good policy environment, why do donors keep offering significant amount of aid to countries with bad policy environment?

4.2.2.3 Evidence of Non-Linearity

Another line of research confirms the positive impact of foreign aid on economic growth but with diminishing returns. Foreign aid improves economic growth up to a certain point; however, once they pass the threshold level its impact starts to decline (e.g. Hadjimichael et al., 1995; Durbarry et al., 1998; Hansen and Trap, 2000, 2001; Lensink and White, 2001; Clemens et al., 2012 and Wagner, 2014). They highlight the presence of a robust non-linear relationship through employing an aid-squared term, which eliminates the aid-policy interaction term when both are included.

The literature suggests another point of view for which support-doubling amount of aid is given to developing countries. Big push and absorptive capacity concepts are the two opposing point of views which dominate the current debate in the aid-growth nexus. Guillaumont. P. and Guillaumont. J. (2007b) argues that both concepts are based on the

[49] He believes that a smaller period of time will capture business cycle fluctuations; however, it will not be enough to capture the beneficial impact of aid on growth.

idea that low incomes countries suffered structural obstacles, which hinder growth, and, therefore, significant amounts of investment are required. Due to the fears of wasting more aid and the fact that there is a significant increase in the amount of aid, absorptive capacity can be considered to be a warning sign of the risk of waste.

4.2.2.3.1 Absorptive capacity constraint

Countries' limited absorptive capacities do not mean that we should stop sending more aid to developing countries. However, it implies that foreign aid should be directed to these countries according to their economy's capacity to absorb aid effectively. Simultaneously we should work on how to raise their capacities. Feeny and De Silva (2012) propose that absorptive capacity should be included in the models in order to maximize the effectiveness of aid and to allocate a proper amount of aid between countries. They provide evidence that some developing countries receive significant amounts of aid which are more than they can manage.

Along similar lines, Guillaumont. P. and Guillaumont. J. (2007a, 2007b) highlight that the absorptive capacity concept is correlated with various factors. Firstly, there are: disbursement constraints; this means the existence of a large gap between commitments and disbursements. Furthermore, there is the underutilization of aid due to infrastructure constraints and low administrative capacity. Secondly, there are macroeconomic drawbacks (Dutch disease) which may occur since they argue that a high amount of aid may lead to appreciation of the real exchange rate and will have a counteractive effect on the export competitiveness of aid recipient developing countries, (Feeny and McGillivray, 2010). Lastly, there are social and cultural constraints, institutional constraints and deficiencies in donors' communities. On the other hand, Yang et al., (2006) argue that the existence of Dutch disease effects depends on how much aid is spent and how much is absorbed. Moreover, aid volatility is recognised as a source of macroeconomic instability.

Indeed most of previous studies' estimates depend upon employing an aid-squared term in order to capture the nonlinear effect (e.g. Hansen and Trap 2000, 2001; Lensink and white, 2001; Feeny and McGillivray, 2011; Kourtellos et al., 2007 and Wagner, 2014). Feeny and McGillivray (2010, 2011) suggest that foreign aid maximises its impact on economic growth when it reaches 20% of the recipient country's GDP. They observe that 16 developing countries received a significant amount of aid, which exceeded the optimum level. They conclude that the amount of aid, required to maximise per capita income, is twice the amount required for growth. Correspondingly, Lensink and White (2001) assume the presence of an aid Laffer curve for 138 countries; this confirms the beneficial impact of foreign aid on economic growth while, after a certain point, its positive impact starts to decline.

Likewise, Kourtellos et al., (2007) employ a sample splitting method and threshold regression. Unlike previous studies, weak evidence of non-linearity has been detected. They introduce the interaction between aid and ethnolinguistic fractionalization and, thus, they recognise that aid has a negative effect on economic growth when, for some countries, ethnolinguistic fractionalization exceeded the threshold level. Whereas, there is no growth effect for those countries with ethnolinguistic fractionalization levels below the threshold level.

However, we claim that their approach is very naïve since the inclusion of aid squared to detect the nonlinearity hypothesis might be biased. Law and Singh (2014) and Law et al., (2013) suggest that this specific form of non-linearity is proposed to be an inverted u-shape for the relationship between aid and economic growth. In other words, the inclusion of aid-squared term means that a priori restriction about the impact of foreign aid on economic growth has been imposed, i.e. the effect of foreign aid on economic growth has monotonically increase and decrease alongside with the level of foreign aid. On the other hand a specific level of foreign aid should be achieved before foreign aid has any effect on economic growth. Furthermore, a multiple number of thresholds may exist while this form supposes only one threshold level, (Gomanee et al., 2003).

4.2.2.3.2 Big Push concept

The United Nations aims to reduce poverty by half[50]; therefore they intend to raise the amount of aid directed to developing countries. In contrast, there is a doubt if foreign aid will be absorbed efficiently, (Wagner, 2014). Moreover, donors should distinguish between the necessary amount of aid, required to reduce poverty, and levels of aid required to promote growth.

The big push theory is based mainly on the poverty trap concept (Guillaumont. P. and Guillaumont. J., 2007b). It implies that aid should be directed towards investment which, in turn, will enhance economic growth. Nonetheless, this concept considers the nonlinearity hypothesis between the aid and economic growth relationship since aid will boost economic growth only if it is above a minimum threshold level.

Some recent empirical studies support the big push concept and supported increasing aid to developing countries (e.g. Gomanee et al., 2003; Aurangzeb and Stengos, 2010; Gyimah-Brempong et al., 2012 and Wagner, 2014). In order to capture non-linearities between the aid-growth nexus, Aurangzeb and Stengos (2010) employ the threshold approach, developed by Hansen (2000), for 42 developing countries through the period from 1970 to 2000. They used EDA as a measure of foreign aid. They confirm the presence of a minimum threshold level above which aid promotes economic growth rates. Likewise, Gomanee et al., (2003) find no evidence for diminishing returns of aid while they show that, beyond a threshold level (2 percent of GDP), aid exhibits positive returns to economic growth. Similarly, Kalyvitis et al., (2012) observe that EDA ought to be higher than 3.4 percent of GDP in order to foster economic growth[51].

In an attempt to accommodate both the big push theory and absorptive capacity concepts, Guillaumont. P. and Guillaumont. J. (2007b) suggests the existence of two threshold levels. One match with the big push theory and the other relates to the absorptive capacity constraint idea. In this context, Wagner (2014), identify economic vulnerability as a key factor in assessing the impact of aid on economic growth. Among 89 developing

[50] According to the Millennium development goal report (2015), extreme poverty has declined by more than half since it reduced from 1.9 billion in 1990 to 836 million in 2015. In the 1990s, almost half of the population in the developing countries lived under $1.25 per day; it dropped to 14% in 2015.

[51] These studies has been criticised due to estimating same threshold level of foreign aid (i.e. 2% and 3.4%) for all countries. Accordingly, Guillaumont. P. and Guillaumont. J. (2007b) argues that aid threshold level effectiveness will differ among aid recipient countries due to the various circumstances they might face.

countries, he realises the presence of two thresholds levels for vulnerable countries. The first threshold level (2 percent) supports the big push concept while the second threshold level (12 percent) relates to the absorptive capacity constraint concept above which marginal returns of aid declines.

Notwithstanding, if the big push hypothesis calls for doubling amount of aid directed to LDCs, an important question should be raised, namely:

> Why do poor countries remain poor if they receive significant amount of foreign aid and are characterised by a good policy environment?

Guillaumont. P. and Guillaumont. J. (2007b), point out that the low level of human capital and high vulnerability to external shocks are considered to be two main handicaps to economic growth. Also, it may be the case that governments of aid recipient countries misused foreign aid.

4.2.2.4 Does foreign aid worsen institutions and raise the level of corruption?

We anticipate that foreign aid may promote investment; enhance economic growth rates; and, thereby, raise the standard of living. While, if foreign aid does not affect economic growth directly through investments, it may have an indirect impact via institutions or policies. Acemoglu (2003) highlights both institutions and geography as main causes for different degrees of prosperity between countries. Current literature provides a great debate about whether aid distorts political institutions or promotes democracy. From the theoretical point of view, foreign aid should supply developing countries with the assistance required to construct effective institutions and democratic governments, (Busse and Groning, 2009). In contrast, some scholars consider foreign aid to be a curse for developing countries (e.g. Djankov et al., 2008; Knack, 2004; Svensson, 2000; Economides et al., 2008 and Feeny and McGillivary, 2010). They believe that aid weakens democratic institutions; furthermore, it may stimulate coups and political instability. Moreover, it may encourage governments to rely on foreign aid instead of tax revenues (aid dependency problem). Additionally, it can raise the power in hand of politicians; in turn, this induces rent-seeking activities and increases corruption levels, (Djankov et al., 2008).

Therefore, the existing studies about the nexus between aid and growth also raise a pertinent question of whether aid could actually worsen institutional quality or not.

Additionally, in relation to this, should the aid be directed towards less or more corrupt countries? In an attempt to investigate the above questions, Coviello and Islam (2006) employ pooled data for 113 countries over a 5-year period. They conclude that foreign aid has neither a positive nor a negative impact on economic institutions. However, they show that, through the rent seeking problem, foreign aid negatively affects both institutions and corruption. Simultaneously, they claim that foreign aid provides incentives to conduct reforms and supplies of the required resources to setup institutions. Overall the impact may be zero since the positive and negative effects will offset each other.

Along the same lines, high amount of aid inflows has a detrimental impact on institutions via its impact on private savings and state revenue. Since aid recipient countries may direct aid toward low development projects or may reduce taxes. Accordingly, the private sector will benefit from lowering tax rates and will depend on foreign aid as a source of revenue, (Feeny and McGilllivary, 2010). Guillaumont. J. and Guillaumont. P. (2007b) argue that, if aid leads successfully to reducing high amounts of taxes, it will reduce the drawbacks for growth and, in future, will consequently lead to higher amounts of public revenue.

Since the 1990s, donors start to allocate aid to countries; that is characterised by qualified institutions, good governance and good policy environment. However, they do not consider corruption to be one of the determinants, which may affect both institutions and the policy environment. Theoretically, a rise in institutional quality leads to lower levels of corruption; in turn, this stimulates high levels of aid inflows. Therefore, there is an expectation of a negative correlation between aid and levels of corruption, (De la Croix and Delavallade, 2013).

On the other hand, both Alesina and Dollar (2000) and Alesina and Weder (2002) claim that foreign aid programmes are misdirected; however, they cannot provide any evidence that less corrupt governments receive higher amount of aid. They demonstrate that foreign aid, directed to developing countries, is determined mostly by a political and strategic consideration. Accordingly, they assert that high amounts of foreign aid are directed to inefficient and non-democratic past colonies when compared with other countries which have the same characteristics but are not former colonies.

Similarly, De La Croix and Delavallade (2013) realise that changes in productivity levels are responsible for a positive correlation between aid and levels of corruption. This is more robust than the negative relationship arising from changes in the quality of institutions. Furthermore, they explain that the positive relationship between corruption and aid is due to the fact that more corrupt countries are the poorer ones. However, if it is the truth that the poorer the countries, the more corrupt they are, at the same time, donors are willing to give more aid to the poorer countries. Indeed, it is implausible to provide more aid to poorer countries.

In contrast, both Tavares, 2003; Okada and Samreth, 2012 provides evidence that foreign aid leads to a decline in the aid recipient countries' levels of corruption. A decline in the levels of corruption is justified by assuming that foreign aid should be associated with rules which, in turn, limit the discretion of the recipient country's officials. Furthermore, they claims that foreign aid may reduce the shortage in public revenues and may raise employees' salaries and, thereby, there will be less misappropriation of public funds.

The foregoing discussion implies that the impact of directing foreign aid to developing and highly corrupt countries is still an unanswered question. Since we will analyse the impact of foreign aid on economic growth from a non-linear perspective, we will introduce the interaction term between aid and the level of corruption in order to investigate, for a group of developing countries corruption's indirect impact on economic growth through aid.

4.3 Methodology:

Due to the existing controversy about the impact of foreign aid on economic growth, this chapter aims to reinvestigate the relationship from a non-linear perspective. This study will introduce an econometric technique, which will vary from the existing ones. Accordingly, we will define a Panel Smooth Transition Regression model (PSTR) in the form of state space system[52] equations. Opposed to other threshold methods, our model will determine the threshold level of foreign aid endogenously and examine its impact on economic growth above and below the threshold level. Additionally, it will set the speed of transition between regimes. Our model will be developed in such a way that it will allow the parameters of our explanatory variables to react to the changes in the foreign aid threshold level. Consequently, we will assign two coefficients for each explanatory

[52] Both the PSTR model and the state space model have been defined in detail in the previous chapter.

variable (i.e. time varying effects of the explanatory variables) in order to capture their impact above and below the threshold level. Lastly, this model will give us the opportunity to examine the presence of multiple threshold levels of foreign aid.

A simple representation of the PSTR model in the form of state space system is as follows:

Measurement equation:

$$y_{it}= \beta_{0t}+\beta_{1t}aid_{it}+\beta_{2t}inf_{it}+\beta_{3t}inv_{it}+\beta_{4t}gfce_{it}+\beta_{5t}aid*corr_{it} + \beta_{6t}corr_{it}+\beta_{7t}M2_{it}+ \varepsilon_{it} \qquad (4.3)$$

Transition equation:

$$\beta_{0t}=\pi_0 \qquad (4.4)$$

$$\beta_{1t} = \pi_1 \mathrm{G}(Z_{it}, \gamma, \mathrm{C}) + \pi_2[1- \mathrm{G}(Z_{it}, \gamma, \mathrm{C})] \qquad (4.5)$$

$$\mathrm{G}(Z_{it}, \gamma, \mathrm{C}) = \frac{1}{(1+\exp(-\gamma(Z_{it}-c)))}\ \gamma > 0 \qquad (4.6)$$

$$\beta_{2t}= \pi_3,\quad \beta_{3t}= \pi_4,\quad \beta_{4t}= \pi_5,\quad \beta_{5t}= \pi_6,\ \beta_{6t}= \pi_7\ ,\ \beta_{7t}= \pi_8 \qquad (4.7)$$

Where y_{it} represents the annual growth rate of GDP per capita, β_{0t} displays the fixed country effect. While both π_1, π_2 show the impact of foreign aid on economic growth above and below the threshold level respectively. Whilst G (Z_{it}, γ, C) represents the transitional function since Z_{it} displays the threshold level of foreign aid, γ determines the smoothness of transition between regimes. Meanwhile, C expresses the threshold value. Whereas the transition function will take the value of zero if $z_{it} < c$ and one if $z_{it} \geq c$. Furthermore, $\beta_{2t}, \beta_{3t}, \beta_{4t}, \beta_{5t},\ \beta_{6t}$ and β_{7t} display repectively the impact of inflation, investment, government expenditure, the interaction term between aid and corruption, corruption and M2 on economic growth.

The state space model is flexible since it allows us to estimate a threshold level of foreign aid with time varying effects of exogenous variables. Thereby, we can recognize the explanatory variables impact on economic growth with respect to the estimated threshold level of foreign aid. Therefore, the state space model can be defined as follows:

Measurement equation:

$$y_{it} = \beta_{0t} + \beta_{1t}aid_{it}+\beta_{2t}inf_{it}+\beta_{3t}inv_{it}+\beta_{4t}gfce_{it}+\beta_{5t}M2_{it}+ \varepsilon_{it} \qquad (4.8)$$

Transition equation:

$\beta_{0t} = \pi_0$ (4.9)

$\beta_{1t} = \pi_1 G(Z_{it}, \gamma, C) + \pi_2[1- G(Z_{it}, \gamma, C)]$ (4.10)

$\beta_{2t} = \pi_3 G(Z_{it}, \gamma, C) + \pi_4[1- G(Z_{it}, \gamma, C)]$ (4.11)

$\beta_{3t} = \pi_5 G(Z_{it}, \gamma, C) + \pi_6[1- G(Z_{it}, \gamma, C)]$ (4.12)

$\beta_{4t} = \pi_7 G(Z_{it}, \gamma, C) + \pi_8[1- G(Z_{it}, \gamma, C)]$ (4.13)

$\beta_{5t} = \pi_9 G(Z_{it}, \gamma, C) + \pi_{10}[1- G(Z_{it}, \gamma, C)]$ (4.14)

$G(Z_{it}, \gamma, C) = \frac{1}{(1+\exp(-\gamma(Z_{it}-c)))} \quad \gamma > 0$ (4.15)

In this case, π_3, π_5, π_7, π_9 display respectively the impact of inflation, investment, government expenditure and M2 on economic growth beyond the threshold level of foreign aid. Whereas, π_4, π_6, π_8 and π_{10}represent respectively how inflation, investment, government expenditure and M2 affect the rate of economic growth beneath the threshold level of foreign aid. On the other hand the transition function will be similar across all state equations.

Lastly, in order to examine the existence of multiple threshold levels of foreign aid and since we have only one threshold variable; we expect to have three regime threshold models. Therefore, a multiple (3-regime) threshold model is defined as below:

Measurement Equation:

$y_{it} = \beta_{0t} + \beta_{1t}aid_{it} + \beta_{2t}inf_{it} + \beta_{3t}inv_{it} + \beta_{4t}gfce_{it} + \beta_{5t}M2_{it} + \varepsilon_{it}$ (4.16)

State Equation:

$\beta_{0t} = \pi_0$ (4.17)

$\beta_{1t} = [\pi_2[1- G_1(Z_{it}, \gamma_1, C_1)] + \pi_1 G_1(Z_{it}, \gamma_1, C_1)]\ (1-G_2(Z_{it}, \gamma_2, C_2)) + \pi_3 G_1(Z_{it}, \gamma_1, C_1)\ G_2(Z_{it}, \gamma_2, C_2)$ (4.18)[53]

$G_1(Z_{it}, \gamma_1, C_1) = \frac{1}{(1+\exp(-\gamma_1(Z_{it}-c_1)))} \quad \gamma_1 > 0$ (4.18.a)

[53] However, a four regime threshold models is anticipated if we have two different threshold variables (C_1, C_2). In this case, state equation (4.18) will be represented as follows:
$\beta_{1t} = [\ \pi_2(1- G_1(Z_{it}, \gamma_1, C_1)) + \pi_1 G_1(Z_{it}, \gamma_1, C_1)]\ (1-G_2(Z_{it}, \gamma_2, C_2)) + [\pi_3(1 - G_1(Z_{it}, \gamma_1, C_1)) + \pi_4 G_1(Z_{it}, \gamma_1, C_1)] G_2(Z_{it}, \gamma_2, C_2)$.
Thus, we can realise a 4-regime model change smoothly from π_2 to π_1 to π_3 to π_4.

$$G_2\ (Z_{it}, \gamma_2, C_2) = \frac{1}{(1+\exp(-\gamma_2(Z_{it}-c_2)))} \qquad \gamma_2 > 0 \tag{4.18.b}$$

$$\beta_{2t}= \pi_4,\ \beta_{3t}= \pi_5,\ \beta_{4t}= \pi_6,\ \beta_{5t}= \pi_7 \tag{4.19}$$

Where both G_1 (Z_{it}, γ_1, C_1) and G_2 (Z_{it}, γ_2,C_2) represent the first and second transitional functions respectively. Accordingly, C_1 and C_2 are defined as the first and the second threshold values of foreign aid whereas $c_1 \leq c_2 \leq \ldots \leq$ m and $\gamma > 0$ display the imposed restrictions. The coefficients will change smoothly from π_2 to π_1 to π_3, where π_2 displays the impact of foreign aid on economic growth, when $Z_{it} < C_1$, π_1 shows the effect wherever $C_2 > Z_{it} \geq C_1$ and π_3 occur when $Z_{it} \geq C_2$.

		G_2	
		1	0
G_1	1	π_3	π_1
	0	0	π_2

Figure 4.1: A simple diagram displays the movements between regimes.

4.3.1 Endogeneity Problem

Recent empirical literature argues the presence of a spurious correlation between aid and the economic growth nexus. Since foreign aid is not allocated arbitrarily to countries, it is likely to be specified to countries, which used its past inflows efficiently or suffer from natural disasters (Kalyvitis et al., 2012). The aid endogeneity problem is likely to occur. Hence, a bias in estimations is expected if aid is directed towards developing countries is a result of reverse causality and unobserved heterogeneity (Kourtellos et al., 2007). Additionally, Clemens et al., (2012) point out that donors may anticipate the future growth levels of aid recipient countries. They suggest the presence of a correlation between the current levels of foreign aid and future growth rates. This is because poor growth levels at time t will be followed with high levels of aid at time t and, hence, a better growth rates at t+1 will be accomplished. On the other hand, growth levels are highly unpredictable and, thus, in the short run, there are expected to be errors in forecasting growth. In contrast, Feeny and McGillivray (2010) argue that aid levels are specified based upon rates of growth for at least one period prior to the current period since donors do not have any information about current rates of growth. Therefore, current aid and growth are indeed not correlated endogenously.

The common solution to the endogeneity problem is to employ instruments and to apply 2sls estimation just as in linear regression. For instance, Aurangzeb and Stengos (2010) and Kalyvitis et al., (2012) propose to use an instrumental variable as a measure for aid. They suggest choosing an instrumental variable directly at the level of donors instead of the recipient countries (e.g. size of the donor and the recipient countries and the interaction between country size and the colonial link). They claim that choosing instrumental variables should be based on the following conditions. Firstly, aid is more likely to be allocated to countries, which have colonial links with the donors or share its language. Secondly, donors are willing to give aid because they assume that they will have power over aid recipient countries.

In contrast, Kourtellos et al., (2007) believe that instrumental variables are ineffective between the aid-growth nexus. This is because it is difficult to find an instrumental variable, which is not associated with any other omitted variable. Along the same lines, Fenny and McGillivray (2010) suggest that instrumenting foreign aid is not essential; they state that, even if foreign aid has been allocated according to current level of growth, aid cannot be endogenous because the impact of aid on economic growth will not be recognised immediately. They demonstrate that most previous studies average their data over four or five years in order to avoid the annual variations in rates of economic growth; however this will make foreign aid partially endogenous.

One weakness, which applies to all threshold models, is dealing with the endogeneity problem. Hansen (1999) is the pioneer who introduces the PTR model, which determines the threshold level endogenously; however, the threshold variable is assumed to be exogenous. Caner and Hansen (2004) develop a model with endogenous variables but with exogenous threshold variable. They employ a 2sls estimator for the threshold parameter and a GMM estimator of the slope parameter. Afterwards, Gonzalez et al., (2005) introduce a panel smooth transition regression approach, which is a generalization of Hansen's PTR model; they introduce only the smooth transition between regimes in a panel format. Kourtellos et al., (2007) argue that a solution for estimating a threshold model where both slope and threshold variable are endogenous does not exist currently. However, Fouquau et al., (2008), lee and Chiu (2011, 2013) employ the PSTR model with

IV estimation. They assume that the estimators are convergent; on the other hand, there is no formal proof of this.

However, Yu (2013) provide evidence that 2sls is inconsistent in dealing with the endogeniety problem in threshold regression. Along the same line, due to the non-stationary discontinuity structure of the threshold regression, Yu and Phillips (2014) argue that the threshold effect can be examined even in the presence of endogeneity and the absence of instrumentation. However, if the instrumental variable is available, they will improve only the efficiency and raise the convergence rate for the threshold parameter and related coefficients.

According to the foregoing discussion, we can conclude that it is difficult to control endogeneity in the aid-economic growth relationship. Although some recent studies use sample splitting models or other threshold models, they are incapable of tackling endogeneity (e.g. Kourtellos et al., 2007). Lastly, Yu and Phillips (2014) introduce the Integrated Difference Kernel Estimator (IDKE), which may be useful for future research in producing a consistent estimator even if the threshold variable is endogenous.

4.4 Data

The empirical analysis is based on panel data for 25 developing countries; this covers the period from 1984 to 2008[54]. The countries are selected according to the availability of a balanced panel data set; Table (c.1) in appendix C displays a list of all the countries included in the sample. Data are obtained from the World development indicators (World Bank), otherwise it is specified. The dependant variable is defined as annual growth rate of GDP per capita (y_{it}). My sample includes a set of various explanatory variables which reflect economic policies. For instance, we employ the general government final consumption expenditure (percentage of GDP), inflation measured by annual growth rate of consumer price index and M2 percentage of GDP employed as a measure of financial development. Furthermore, we include gross fixed capital formation (percentage of GDP) as a measure for investment. Our main threshold variable is foreign aid measured by Net

[54] Most of previous studies average their dataset over 4 or 5 years so as to avoid the variations in annual growth rates. I am in favour to employ annual observations, thus it enable us to capture the maximum variations in the employed dataset. Furthermore, if foreign aid depends on current level of growth, foreign aid cannot be endogenous because we cannot promptly observe its impact on economic growth.

Official Development Assistance (net ODA percentage of GDP)[55]. This is defined as net official development assistance and official aid received; this lists all transfers of financial resources, goods and services by official donors valued at the cost to the donor minus any repayment of loan.

Lastly, since some of the economic literature argues that aid can work only in a good policy environment. For example, Burnside and Dollar (2000) create a policy index comprising inflation, budget surplus and trade openness; Kalyvitis et al., (2012) and Gyimah-Brempong at al., (2012) employs institutional quality; and Lensink and White (2001) include index of civil liberities and political rights. However, corruption is not included as one of the policy variables. It is considered as a potential hazard to foreign investment from different aspects. Hence, it could ruin the financial and business environment. Additionally it may lead to prohibition or termination of investments. Corruption may appear in several forms for instance: make a special payments or bribes for tax ratings. Therefore, we will employ both the corruption index and its interaction term with foreign aid as one of the explanatory variables[56]. We obtain data about corruption from the International Country Risk Guide (ICRG) data[57]. However, the data is limited only to the period from 1984 to 2008; thereby, our data set is restricted to this period of time. According to the ICRG data, corruption index scales from 0 to 6. A score of 6 display very low levels of corruption while a score of 0 indicates high levels of corruption. For robustness checks, another variable of institutional quality is considered (i.e. level of democracy)[58] which is obtained from the Quality of Government basic dataset, version Jan 2016, University of Gothenburg. Its scale starts from 0 to 10, 0 point out to least democratic while 10 represent highly democratic.

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[55] Another question might be raised in this context, which type of aid, grants or loans? There exists an argument that aid recipient countries consider grants as free resources of revenue, while loans will raise the burden of repayments in the future. Therefore a natural extension to this paper is to evaluate the nonlinear relations ship between loans, grant and economic growth as a further research avenue.

[56] Some of the previous studies (e.g. De la Croix and Delavallade, 2013), employ control of corruption index created by the World Bank to determine the relationship between foreign aid and corruption.

[57] The ICRG index, Freedom House and the Quality of Government Institute index is more convenient to use in this case, because the data is available annually for the whole period under study. However, other institutional quality indexes are available only every two successive years between 1996 and 2000, for instance, the World Bank Governance Index.

[58] Consistently with previous studies (e.g. Svensson, 1999) we employ level of democracy as another source of institutional quality.

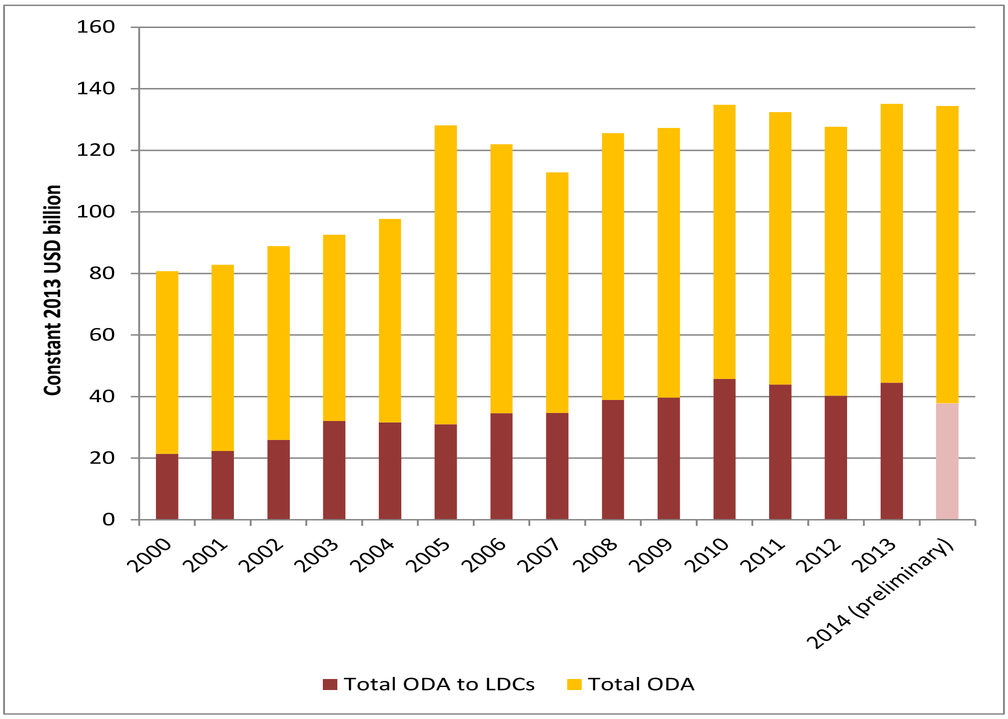
4.5 Empirical Results.

4.5.1 Estimate of the threshold level for all developing countries.

OECD declares that ODA increased significantly during 2013, 6.1% in real terms[59]. Although ODA is considered to be a crucial source of finance for LDCs, they highlight that aid flows to poor countries declined during 2014. Hence ODA recorded a decline from 135.05 USD billion in 2013 to 134.38 USD billion in 2014. Figure (4.2) displays the amount of ODA assigned to LDCs; we can see that the share of ODA, directed to LDCs, increases steadily until it reaches its maximum in 2010 while it starts to fall again during 2011, 2012 and 2014.

In this section, we examine the presence of a threshold level of foreign aid and capture its impact on economic growth. Furthermore, we investigate whether aid flows follow absorptive capacity or the big push concept for developing countries using a new estimation technique. Additionally, we employ the interaction term between aid and corruption in order to determine whether the effectiveness of foreign aid is conditional upon the recipient country's level of corruption. Table (4.1) illustrates respectively the main statistics of net ODA as a percentage of GDP for all developing countries, upper middle, lower middle and LDCs countries. The mean of ODA as a percentage of GDP is 6.155% and ranges from 39.78162% for Malawi (LDC country) to -0.17457% for Gabon (upper middle country). It is plain that, compared to other groups of countries, LDCs receive a significant amount of foreign aid.

[59] OECD news room (8/4/2014), Aid to developing countries rebounds in 2013 to reach an all-time high. Accessed 1/8/2015. http://www.oecd.org/newsroom/aid-to-developing-countries-rebounds-in-2013-to-reach-an-all-time-high.htm



Source: OECD, 8 April 2015[60].

Figure 4.2: Share of total ODA directed to least developed countries.

Table 4.1: Summary statistics for net ODA as % of GDP.

	All developing countries	Upper middle	Lower middle	Low and least
Mean	6.155802	1.232633	3.407554	13.89889
Median	2.770677	0.555437	2.003853	13.69470
Maximum	39.78162	8.577450	19.16267	39.78162
Minimum	-0.174570	-0.174570	0.051344	1.700356
Std. Dev.	7.238783	1.614403	3.436669	7.496185
Observations	625	175	250	200

[60] OECD newsroom, (8/4/2015), development aid stable in 2014 but flows to poorest countries still falling. Accessed 1/8/2015. http://www.oecd.org/newsroom/development-aid-stable-in-2014-but-flows-to-poorest-countries-still-falling.htm

According to the methodological framework, the growth rate of GDP per capita is considered to be a function of ODA percentage of GDP, inflation, investment, government expenditure, interaction term and M2 percentage of GDP. We define the PSTR model in the form of state space equations in order to examine the presence of a nonlinear relationship between foreign aid and economic growth. Firstly, we examine the non-linearity hypothesis between foreign aid and economic growth for all developing countries included in my sample. Table (4.2) reveals that the threshold level of foreign aid is 12.24% of GDP and significant at 10% significance level; furthermore, the smoothness of transition between regimes is high. Consistently with Gomanee et al., 2003; Aurangzeb and Stengos, 2010; Kalyvitis et al., 2012 and Gyimah-Brempong et al., 2012, our results confirm that foreign aid exhibits a significant positive impact on economic growth above the threshold level (π_1) while the impact is negative and insignificant below this level (π_2). All our control variables have the expected sign, while only investment and government expenditure have a significant impact on economic growth at 5% significance level.

Table 4.2: Estimate of the threshold of foreign aid for all developing countries.

Variable	π_2	π_1	Transition Variables	
			C	Exp (γ)
Aid	-0.020324 (0.8632)	0.838861 (0.0322)**	12.2439* (0.071)	10.8157
Inflation	-0.027097 (0.4144)			
Investment	0.200503 (0.0495)**			
Government expenditure	-0.325594 (0.0422)**			
M2	-0.049650 (0.4683)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-value. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

The literature provides ambiguous evidence regarding the non-linear relationship between aid flows and economic growth. Furthermore, there exist mixed results about the threshold level of foreign aid. This may relate to the heterogeneity of aid; various characteristics for each developing country; and different income and financial development levels. Consistently, our estimated threshold level for all developing countries (12.24% of GDP) is considered to be high when compared with the average levels of foreign aid received by both upper middle and lower middle countries. Additionally some of the previous studies (e.g. Guillaumont. P. and Guillaumont. J.; 2007b; Hansen and Trap, 2000, 2001) Suggest that the effectiveness of foreign aid threshold levels will vary among aid recipient countries. Thus in order to examine a more homogenous set of aid inflows, we classify our sample in to 3 groups of (upper middle, lower middle and low and least) developed countries according to the World Bank classification. According to Table (4.3), some countries[61], included in our sample, are considered to be in the top 10 of aid receipt countries in 2013. Furthermore, it encompasses all the largest aid receipt countries since the 1970's (see Figure (C.1) in Appendix C).

Table 4.3 Top ODA Receipts by recipient USD million.

Net disbursements in 2013	
1) Egypt	5506
2) Afghanistan	5266
3) Viet Nam	4085
4) Myanmar	3935
5) Ethiopia	3826
6) Syrian Arab Republic	3627
7) Tanzania	3430
8) Kenya	3236
9) Turkey	2741
10) Bangladesh	2669
Other recipients	111766
Total	150086

Source: OECD-DAC Statistics, Development Aid at a Glance, Statistics by Region, 2015 edition.

[61] These countries are Egypt, Bangladesh and Ethiopia.

4.5.2 Estimate of the threshold level for various income level countries.

In this context, we estimate the threshold level of foreign aid for three different groups of countries according to their income levels. Our explanatory variables involve both corruption index and the interaction term between foreign aid and corruption. According to the reported results in Table (4.4), we realise the insignificant impact of the interaction term for all three groups of countries. In turn, this means that corruption does not play a significant role in allocating foreign aid to developing countries. Furthermore, there is no clear nonlinear impact for lower middle countries as foreign aid display insignificant impact during both regimes. On the other hand, for LDCs, it is obvious that aid flows follow the big push concept. This is because we can realise the presence of a threshold level of foreign aid (11.38% of GDP) above which it exhibits a significant positive impact on economic growth level (π_1). While, its behaviour changes to insignificant negative impact below the threshold level. Due to the insignificant impact of both corruption index and the interaction term (aid*corr), we omit both variables from our analysis. It might be responsible for the vague impact of foreign aid on economic growth. Our results are in line with some previous studies (e.g. Easterly et al., 2003; Rajan and Subramanian, 2008; Wagner, 2014), which provide little evidence about the effectiveness of institutional quality among foreign aid and economic growth nexus.

Therefore, Table (4.5) represents the estimated results for all three groups of countries excluding the interaction term. For the upper middle countries, we find a threshold level of foreign aid (1.22% of GDP); this is consistent with our data while the smoothness of transition between regimes is considerably high. Additionally, our results confirm that foreign aid is only effective below the threshold level (π_2). However, it turns to have non-significant impact above this level (π_1). This means simply that, after a certain threshold level, foreign aid loses its significant impact (displaying a diminishing marginal return) and, thus, high level of foreign aid cannot be employed effectively. Although foreign aid display different behaviour during both regimes, our estimated threshold level is not suitable, because it is not significant at all levels. Additionally, all our economic policy variables, namely, inflation, investment and government expenditures have the expected sign and are, also, significant except M2 has insignificant negative impact on economic growth.

On the other hand, both lower middle[62] and LDCs countries' results support the big push concept. We find that threshold levels for both groups of countries are 4.3% and 11.385% of GDP respectively and significant at 1% significance level. Also we realise that foreign aid enhance economic growth rates beyond the threshold level (π_1) while, below this level, it turns to having a negative insignificant impact. Furthermore, both investment and government expenditures have the expected signs and display significant impact at various significance levels. While both inflation and M2 have their anticipated sign but no longer significant. Additionally, the smoothness of transition between regimes is smooth but considerably high for lower middle countries when compared with LDCs countries. Indeed, various groups of countries have different threshold levels and might follow diverse concepts. Consequently, our results confirm the idea that pooling different group of countries with various income levels leads to biased results[63].

Table 4.4: Estimate of the threshold level of foreign aid for various income level countries.

Variable	π_2	π_1	Transition Variables	
			C	Exp (γ)
A) Upper Middle Income countries				
Aid	2.221649 (0.0716)*	2.498169 (0.3389)	1.19975	17.34482
Inflation	-0.10726 (0.0238)**			
Investment	0.49185 (0.0002)***			
Government expenditure	-0.46549 (0.0001)***			
Aid*corr	-0.4179 (0.1416)			
Corruption	-0.5949 (0.2226)			
M2	-0.06103 (0.1482)			

62 For lower middle countries, Egypt is considered to be an outlier in our sample. Among all the countries, it records the highest score in the top 10 ODA recipients by 2013 and is considered to be one of the largest recipients of aid since 1970's. Therefore, we omit it from our sample because, whenever it is included, we fail to recognize foreign aid impact on economic growth.

63 This is in line with Hansen and Trap (2000, 2001) and Guillaumont. P. and Guillaumont. J. (2007.b) who confirms the effectiveness of foreign aid, however they indicate that some countries are less in need of foreign aid. Furthermore, they criticise the estimation of a threshold level of foreign aid for a large group of various income level countries.

B) Lower Middle Income countries				
Aid	-0.1907 (0.6238)	0.8388 (0.2618)	4.5595** (0.05)	0.983060
Inflation	-0.01902 (0.7080)			
Investment	0.09055 (0.3168)			
Government expenditure	-0.10743 (0.2675)			
Aid*Corr	0.04905 (0.7025)			
Corruption	-0.8890 (0.3174)			
M2	-0.0227 (0.7052)			
c) Low and Least developed countries				
Aid	0.22866 (0.1929)	1.17336 (0.0000)***	11.38522*** (0.0000)	6.710653
Inflation	-0.0048 (0.7412)			
Investment	0.3203 (0.0221)**			
Government expenditure	-0.41585 (0.0939)*			
Aid*corr	-0.0657 (0.3386)			
Corruption	0.8705 (0.1604)			
M2	0.02542 (0.4745)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

Table 4.5: Estimate of the threshold level of foreign aid, omitting the interaction term.

Variable	π_2	π_1	Transition Variables C	Transition Variables Exp (γ)
A) Upper Middle Income countries				
Aid	0.4913 (0.0947)*	0.4134 (0.8333)	1.221345	18.87879
Inflation	-0.1151 (0.0049)***			
Investment	0.4169 (0.0003)***			
Government expenditure	-0.4037 (0.0003)***			
M2	-0.0355 (0.2472)			
B) Lower Middle Income countries				
Aid	-0.105155 (0.2525)	0.83563 (0.0382)**	4.3337*** (0.000)	13.21608
Inflation	-0.03001 (0.3103)			
Investment	0.1216 (0.0614)*			
Government expenditure	-0.17113 (0.0479)**			
M2	-0.02789 (0.5403)			
c) Low and Least developed countries				
Aid	0.09507 (0.5668)	1.14157 (0.0000)***	11.38522*** (0.000)	6.710653
Inflation	-0.0049 (0.6825)			
Investment	0.3697 (0.0074)***			
Government expenditure	-0.48357 (0.0404)**			
M2	0.02548 (0.5021)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

4.5.3 Time varying effects of explanatory variables.

We developed our model in such a way that we let the parameters on our explanatory variables vary with respect to the changes in the estimated threshold level. Therefore, we provide each explanatory variable with two coefficients in order to distinguish their impact during both regimes. Table (4.6) display the results of the estimated equations (4.8 - 4.15), it provides the changes in the parameters of each explanatory variable according to the threshold level of foreign aid. Similarly with our baseline results, foreign aid in upper middle countries exhibits a significant positive impact on economic growth below the threshold level; however the estimated threshold level is insignificant. We recognise consistently that investment enhances the economic growth rate below the threshold level; however, beyond that level the impact is insignificant. Similarly, both government expenditure and inflation exhibit a detrimental effect on economic growth below threshold level while, above the threshold level, there is an insignificant impact.

In contrast, for lower middle countries, all our explanatory variables are insignificant during both regimes. Perhaps, they are not sensitive to the changes in foreign aid. For LDCs, we observe that only investment and government expenditure have a significant impact below the threshold level of foreign aid. We can say that the amounts of aid below this threshold level are not enough to ameliorate economic growth rates, however investment can promote economic growth. While due to the lack of experienced labour and staff, foreign aid is not employed efficiently. And thereby, a significant amount of investment is required to raise the human capital constraint which, in turn in the long run, will foster economic growth. Consistent with Feeny and De Silva (2012), additional flows of foreign aid will be handicapped due to the shortage of skilled staff; thereby more foreign aid should be directed to skill development programmes.

Table 4.6: Estimate of the threshold level of foreign aid with time varying exogenous variables

Variable	π_2	π_1	Transition Variables	
			C	Exp (γ)
A) Upper Middle Income countries				
Aid	0.4906 (0.0968)*	0.6009 (0.9859)	1.221346	18.878791
Inflation	-0.1062 (0.068)*	-0.3087 (0.7682)		
Investment	0.3951 (0.0212)**	0.3452 (0.9269)		
Government expenditure	-0.3829 (0.0015)***	-1.3986 (0.7406)		
M2	-0.03137 (0.5547)	-0.2330 (0.9653)		
B) Lower Middle Income countries				
Aid	-0.1022 (0.3353)	0.7838 (0.0956)*	3.8542*** (0.000)	8.7268
Inflation	-0.02959 (0.5949)	-0.0854 (0.5823)		
Investment	0.1032 (0.2663)	0.29004 (0.438)		
Government expenditure	-0.1606 (0.1258)	-0.5550 (0.4771)		
M2	-0.02167 (0.7158)	-0.06613 (0.8765)		
c) Low and Least developed countries				
Aid	0.02118 (0.9232)	1.18932 (0.6398)	9.78821** (0.05)	-0.29451
Inflation	-0.01457 (0.4244)	-0.1016 (0.8702)		
Investment	0.3671 (0.0186)**	-2.9006 (0.6009)		
Government expenditure	-0.56285 (0.0967)*	1.7185 (0.8012)		
M2	0.0117 (0.8100)	3.6268 (0.5701)		

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

4.5.4 Multiple threshold level of foreign aid.

Lastly, we want to examine the multiple regime threshold models and, thus, we developed our model to explore the possibility of another threshold level of aid for all groups of countries[64]. For upper middle countries, we are looking for a lower threshold level below which it exhibits a detrimental impact on economic growth. In contrast, for lower middle and LDCs, we examine the presence of a higher threshold level of foreign aid above which it may harm rates of economic growth.

In an attempt to estimate another threshold level of foreign aid for upper middle countries, it is apparent from Table (4.7) that we fail to provide any suitable threshold level. Further foreign aid coefficients display insignificant impact during all regimes. Similarly, our results provide little evidence for the existence of a higher threshold level of foreign aid for both lower middle and LDCs countries, because only one threshold level of foreign aid, (i.e. 4.33% and 11.33% of GDP for lower middle and LDCs countries respectively) proved to be significant at 1% significance level. Although foreign aid of LDCs countries displays different behaviour during all regimes, we could not find a higher suitable threshold level. Hence our estimated level (27.737% of GDP) is no longer significant at all levels. Moreover, we recognise that the transition between all regimes (first π_2 to second π_1 to third π_3) is smooth. However, the speed of transition from second π_1 to third regime π_3 is slow when compared to the speed of transition from the first π_2 to second regime π_1 which seems to be relatively high.

Together, the results provide important insights that pooling a heterogenous group of countries may lead to misleading results. This is because we observe that the threshold level varies between various groups of income level countries. Interestingly, we argue that both lower middle and LDCs countries are in need of more aid inflows; nevertheless, donors should be cautious in providing high aid inflows specifically to LDCs countries. Consistent with our data, we can see that in 1994 Malawi hits the peak (39.78% of GDP) while, its growth rate of GDP per capita was -10.49%. Also, the foreign assistance received by Sierra Leona accounted 30.017% of GDP whereas the growth rate of GDP

[64] Similarly, some of the previous studies (e.g. Guillaumont. P. and Guillaumont. J.; 2007b) suggest the presence of two threshold levels of foreign aid (i.e. there exist a minimum threshold level of foreign aid that follow the big push concept and a higher threshold level which support the absorptive capacity concept).

per capita was -1.049%. In addition, we observe that most of the LDCs, included in our sample, are located in Africa. However, in Appendix C, Figure (C.2) shows that the highest aid inflows are directed towards African countries. Consequently, we may conclude that policy makers should examine and regulate the rules, which control the allocation of aid inflows to recipient countries.

Table 4.7: Estimate of a multiple threshold levels of foreign aid.

Variable	π_2	π_1	π_3	Transition Variables: C	Transition Variables: Exp (γ)
A) Upper Middle Income countries					
Aid	0.08575 (0.9781)	-0.41259 (0.9894)	0.3659 (0.9904)	C_1 =1.3948 C_2=0.3887	γ_1 =-0.0617 γ_2 =-0.0609
Inflation	-0.1254 (0.0151)**				
Investment	0.39053 (0.0281)**				
Government expenditure	-0.4641 (0.0005)***				
M2	-0.03943 (0.4607)				
B) Lower Middle Income countries					
Aid	-0.14206 (0.1277)	0.6892 (0.1982)	0.09714 (0.7286)	C_1=4.3334*** (0.000) C_2=9.5115	γ_1 =13.2161 γ_2 =-15.1875
Inflation	-0.02824 (0.3347)				
Investment	0.12131 (0.0964)*				
Government expenditure	-0.17745 (0.0419)**				
M2	-0.02868 (0.5650)				
c) Low and Least developed countries					
Aid	0.10996 (0.2864)	0.51096 (0.0007)***	-0.20933 (0.3485)	c_1 = 11.337*** (0.000) c_2 = 27.737	γ_1 = 8.1384 γ_2 = 0.6824
Inflation	-0.00494 (0.5559)				
Investment	0.36852 (0.0027)***				
Government expenditure	-0.4721 (0.0247)**				
M2	0.01595 (0.6494)				

Notes: Dependent Variable is real GDP per capita growth Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_2 represent the impact of foreign aid below C_1, π_1 shows the effect wherever $C_2 > Z_{it} \geq C_1$ and π_3 occur when $Z_{it} \geq C_2$. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

4.6 Robustness analysis.

In this section we will present the robustness checks of the main results displayed in section 4.5.2. Section 4.6.1 illustrates results with another institutional quality variable (democracy). In section 4.6.2 we employ the institutional quality variables (corruption and democracy) as an alternative threshold variable and furthermore we will split our sample with respect to their corruption and democracy level respectively. Finally in section 4.6.3 we address the issue of endogeneity.

4.6.1 Another measure of institutional quality:

In order to detect whether institutional quality matter for aid effectiveness in developing countries, another measure of institutional quality (democracy) is considered. Correspondingly with our main results presented in table (4.4), our results presented in table (4.8) shows no evidence that institutional quality might promote aid effectiveness for all three groups of countries. Alike with our baseline results both democracy and the interaction term has no significant impact on economic growth. In addition, our estimated threshold levels and aid coefficients are comparable to those given in table (4.4), only inconsiderable change in the magnitude.

Table 4.8: Threshold Variable: Foreign Aid, (control democracy).

Variable	π_2	π_1	Transition Variables	
			C	Exp (γ)
A) Upper Middle Income countries				
Aid	1.3207 (0.2693)	1.25575 (0.3223)	1.168022	12.86232
Inflation	-0.12966 (0.0009)***			
Investment	0.38713 (0.0003)***			
Government expenditure	-0.44911 (0.0009)***			
Aid*democ	-0.1274 (0.3519)			
Democracy	0.33378 (0.5316)			
M2	-0.03771 (0.2403)			

B) Lower Middle Income countries

Aid	-0.02484 (0.9248)	0.8738 (0.0489)**	4.0969*** (0.000)	25.28143
Inflation	-0.03357 (0.2958)			
Investment	0.16695 (0.1048)			
Government expenditure	-0.17733 (0.1383)			
Aid*democ	-0.0207 (0.6106)			
Democracy	0.05348 (0.8570)			
M2	-0.2115 (0.7258)			
c) Low and Least developed countries				
Aid	0.00753 (0.9716)	1.05687 (0.0002)***	11.635*** (0.000)	5.98785
Inflation	-0.005729 (0.7057)			
Investment	0.37028 (0.0070)***			
Government expenditure	-0.42967 (0.0678)*			
Aid*democ	0.00929 (0.6379)			
Democracy	-0.0807 (0.6805)			
M2	0.01607 (0.6770)			

Notes: Dependent Variable is real GDP per capita growth Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

4.6.2 Alternative Threshold Variables: Corruption and Democracy.

Other studies criticise the strategy of employing the interaction term (e.g. Law and Singh, 2014; Law et al., 2013). They suggest that the interaction term for instance; between foreign aid and institutional quality variables (corruption or democracy) propose a priori constraint in which, the effect of foreign aid on economic growth will increase monotonically with respect to the institutional quality level. While they claim that a specific level of institutional quality needs to be attained prior to distinguish the impact of foreign aid on economic growth. Thereby in this section we employ both corruption and democracy as threshold variables to detect whether there exist a threshold level beyond or below which, foreign aid have any significant impact on economic growth. Tables 4.9 and 4.10 illustrate the results accomplished with using both corruption and democracy as threshold variables respectively. Both tables show no evidence of a suitable threshold level for both corruption and democracy. Additionally and consistently with our previous results, foreign aid lose its significant impact on economic growth during both regimes and with respect to the changes of both institutional quality variables.

Finally we split our sample in to two groups with respect to the average level of both corruption and democracy. Results reported in table 4.11 shows evidence of non-linearity between foreign aid and economic growth for both high and low corrupted countries. However the estimated threshold level of foreign aid for high corrupted countries is 9.5% of GDP beyond which, it enhance economic growth rate. The estimated threshold level is close to our baseline finding hence most of high corrupted countries are belong to LDCs group. A lower threshold level of foreign aid (3.44% of GDP) is realized for low corrupted countries. Similarly, Alesina and Dollar (2000), Alesina and Weder (2002) could not provide any evidence that low corrupted countries receive high amount of aid. In the same vein, table 4.12 display the impact of foreign aid on economic growth for most and least democratic countries. According to our estimated results, we find a threshold level of foreign aid (7.97% of GDP) for the most democratic countries, below which it has insignificant negative impact on economic growth, while above that level it fosters economic growth. On the other hand, with respect to the least democratic countries, we could not recognise a suitable threshold level of foreign aid. Similarly foreign aid is no longer significant during both regimes. This result is consistent with previous studies (i.e. Isham et al, 1997; Svensson, 1999) who suggest that foreign aid display higher impact in the most democratic countries measured by civil liberties and political rights.

Table 4.9: Threshold Variable: Corruption.

Variable	π_2	π_1	Transition Variables C	Transition Variables Exp (γ)
A) Upper Middle Income countries				
Aid	0.45395 (0.1134)	10.4643 (0.3863)	1.46302	11.103889
Inflation	-0.13218 (0.0011)***			
Investment	0.38397 (0.0007)***			
Government expenditure	-0.481565 (0.0000)***			
M2	-0.03276 (0.2360)			
B) Lower Middle Income countries				
Aid	-0.122448 (0.2193)	0.101978 (0.5115)	0.51372	14.49295
Inflation	-0.033046 (0.2255)			
Investment	0.14212 (0.0289)**			
Government expenditure	-0.166233 (0.1779)			
M2	-0.02759 (0.4989)			
c) Low and Least developed countries				
Aid	0.01535 (0.9403)	32.78 (0.9985)	2.63218	1.297057
Inflation	-0.002589 (0.8496)			
Investment	0.366231 (0.0170)**			
Government expenditure	-0.2503 0.384			
M2	0.00223 (0.9556)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach. C is the threshold level of corruption.

Table 4.10: Threshold Variable: Democracy.

Variable	π_2	π_1	Transition Variables C	Transition Variables Exp (γ)
A) Upper Middle Income countries				
Aid	0.1598 (0.15987)	7.33769 (0.6303)	1.08472	1.71225
Inflation	-0.14399 (0.0012)***			
Investment	0.37650 (0.0014)***			
Government expenditure	-0.4965 (0.0000)***			
M2	-0.04324 (0.2055)			
c) Low and Least developed countries				
Aid	-0.0676 (0.6235)	0.605685 (0.3038)	1.430074	0.257422
Inflation	-0.0089 (0.4873)			
Investment	0.39104 (0.0020)***			
Government expenditure	-0.4516 (0.0814)*			
M2	0.00996 (0.7962)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach. C is the threshold level of democracy.

Table 4.11: Estimate of the threshold level of foreign aid: Split the sample according to corruption level.

Variable	High corrupted countries		Low corrupted countries	
	π_2	π_1	π_2	π_1
Aid	0.055304 (0.7588)	0.664944 (0.0043)***	-0.148832 (0.3408)	0.568228 (0.0226)**
Inflation	-0.01183 (0.3849)		-0.03469 (0.2490)	
Investment	0.30919 (0.1841)		0.13446 (0.0966)*	
Government expenditures	-0.23114 (0.4747)		-0.37983 (0.0089)***	
M2	0.01379 (0.8466)		-0.009265 (0.8014)	
Threshold (c)	9.52435 (0.0405)**		3.4411 (0.000)***	
Slope {exp (γ)}	5.02162		0.9337	
LM_f	0.022		0.021	

Dependent variable: is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. C is the threshold level of foreign aid.

Table 4.12: Estimate of the threshold level of foreign aid: Split the sample according to democracy level.

Variable	Most Democratic		Least Democratic	
	π_2	π_1	π_2	π_1
Aid	-0.1728 (0.1674)	1.8823 (0.0906)*	-0.0671 (0.7371)	0.13137 (0.8183)
Inflation	-0.017396 (0.6370)		-0.025116 (0.7545)	
Investment	0.1534 (0.2157)		0.34186 (0.5420)	
Government expenditures	-0.33208 (0.0129)**		-0.48571 (0.1803)	
M2	0.02257 (0.5186)		-0.0314 (0.4792)	
Threshold (c)	7.9721 (0.0107)**		5.53102	
Slope: Exp(γ)	-0.0976		16.74105	
LM_f	0.004		0.000	

Dependent variable: is real GDP per capita growth. Values in parentheses represent p-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. C is the threshold level of foreign aid.

4.6.3 Foreign Aid Endogeneity:

In an attempt to control the endogeneity problem, we will perform the following steps:

1) Net official development assistance is regressed on higher lags plus all exogenous regressors; then, we will predict the values for net ODA.
2) We will follow the benchmark estimation procedure (equations 4.3-4.7); however, we will employ the fitted values of net ODA as % of GDP as a threshold variable and, also, as a slope parameter.

Table (4.13) shows the estimated threshold level of foreign aid for all groups of developing countries as corrected for endogeneity. Consistent with our benchmark results, we underline the nonlinearity hypothesis between foreign aid and economic growth. Furthermore, we emphasize that various income level countries are in need of different levels of foreign aid. For instance, both lower middle and LDCs follow the big push idea, while we could not observe a suitable threshold level of foreign aid for the upper middle countries. Accordingly foreign aid has insignificant impact on economic growth during low and high regimes. Comparing these results with the benchmark model, we see only a negligible change in the coefficients. Additionally, the estimated threshold levels of foreign aid are almost same. Lastly, we employ Hausman (1978)[65] test (see table 4.14) and our results show no evidence of endogeneity in our estimation method. As the coefficients on the residuals are not statistically significant from zero, thereby the hypothesis that fitted official development assistance (hereinafter, FODA) being endogenous is rejected[66]. Figure (4.3) shows the estimated transition function for our baseline model and the corrected for endogeneity one, it provide interpretation about the characteristics of the model. Similarly with Omay and Khan (2010) and Gonzalez et al, (2005), the regime change in our model looks to be discontinuous however it is not a problem with smooth transition regression model as its main aim is to place a slow transition between regimes. Both studies recognize a high speed of transition 69.05 and

[65] The main idea behind the Hausman test is to estimate the reduced form of FODA by regressing it on all exogenous variables and lagged values of ODA as instruments then obtain the residuals. Afterwards, we add the residuals to the structural equation and test for the significance of the residuals. For more details about testing for endogeneity see Wooldridge (2009), p527.

[66] 2sls is more convenient in this case because it is difficult to split the instrumented foreign aid within the construction of GMM. Therefore our estimation is limited to a less efficient but consistent estimator, (Baum et al., 2013).

118.77 respectively, while our parameter estimate for the corrected endogeneity model[67] are (exp {4.571 and 7.657}) respectively for lower middle and LDCs countries.

Table 4.13: Estimate of the threshold level of foreign aid corrected for endogeneity.

Variable	π_2	π_1	Transition Variables C	Transition Variables Exp (γ)
A) Upper Middle Income countries:				
Foda	0.306551 (0.5047)	0.45175 (0.7893)	1.04778	7.1415
Inflation	-0.124482 (0.0169)**			
Investment	0.47922 (0.0002)***			
Government expenditure	-0.41993 (0.0001)***			
M2	-0.03792 (0.2261)			
B) Lower Middle Income countries:				
Foda	-0.0585 (0.7061)	0.90604 (0.0128)**	4.031562** (0.05)	4.50355
Inflation	-0.033257 (0.1542)			
Investment	0.13907 (0.1025)			
Government expenditure	-0.1575 (0.1365)			
M2	-0.03727 (0.5052)			
c) Low and Least developed countries:				
Foda	0.00494 (0.5352)	0.71155 (0.0478)**	6.016707** (0.038)	7.657241
Inflation	0.00836 (0.7598)			
Investment	0.30785 (0.1565)			
Government expenditure	-0.24742 (0.4097)			
M2	0.01756 (0.7575)			

Notes: Dependent Variable is real GDP per capita growth. Values in parentheses represent p-value. *, **, *** display the significance levels at 10%, 5% and 1% respectively. Foda refers to the fitted values of Net Official Development Assistance. Meanwhile, π_1 and π_2 represent the impact of foreign aid above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

[67] Similarly the speed of transition between regimes (γ) for the baseline model is high.

Table 4.14: Hausman test Results.

A) Upper middle-income countries: dependent variable is the growth rate of GDP-per capita.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.747733	1.692916	-1.032380	0.3039
ODAF	0.362486	0.427958	0.847014	0.3986
INF	0.007348	0.034832	0.210949	0.8333
INV	0.011356	0.077174	0.147152	0.8833
M2	0.074993	0.013428	5.584903	0.0000
GFCE	0.026205	0.069819	0.375334	0.7081
RESID01	0.059427	1.008885	0.058904	0.9531

R-squared	0.435721	Mean dependent var	3.056714
Adjusted R-squared	0.407970	S.D. dependent var	3.986806
S.E. of regression	3.067589	Akaike info criterion	5.132397
Sum squared resid	1148.033	Schwarz criterion	5.287580
Log likelihood	-324.0396	Hannan-Quinn criter.	5.195451
F-statistic	15.70085	Durbin-Watson stat	1.389001
Prob(F-statistic)	0.000000		

B) Lower middle-income countries: dependent variable is the growth rate of GDP-per capita.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.565525	1.312864	1.192450	0.2347
ODAF	-0.308583	0.163201	-1.890813	0.0603
INF	-6.59E-05	0.015213	-0.004331	0.9965
INV	0.234134	0.065451	3.577260	0.0005
GFCE	-0.157132	0.114618	-1.370912	0.1722
M2	-0.027999	0.030285	-0.924519	0.3565
RESID02	0.412101	0.421322	0.978115	0.3294

R-squared	0.123743	Mean dependent var	2.054752
Adjusted R-squared	0.093353	S.D. dependent var	4.312046
S.E. of regression	4.105844	Akaike info criterion	5.700812
Sum squared resid	2916.427	Schwarz criterion	5.824983
Log likelihood	-506.0731	Hannan-Quinn criter.	5.751158
F-statistic	4.071796	Durbin-Watson stat	1.749134
Prob(F-statistic)	0.000760		

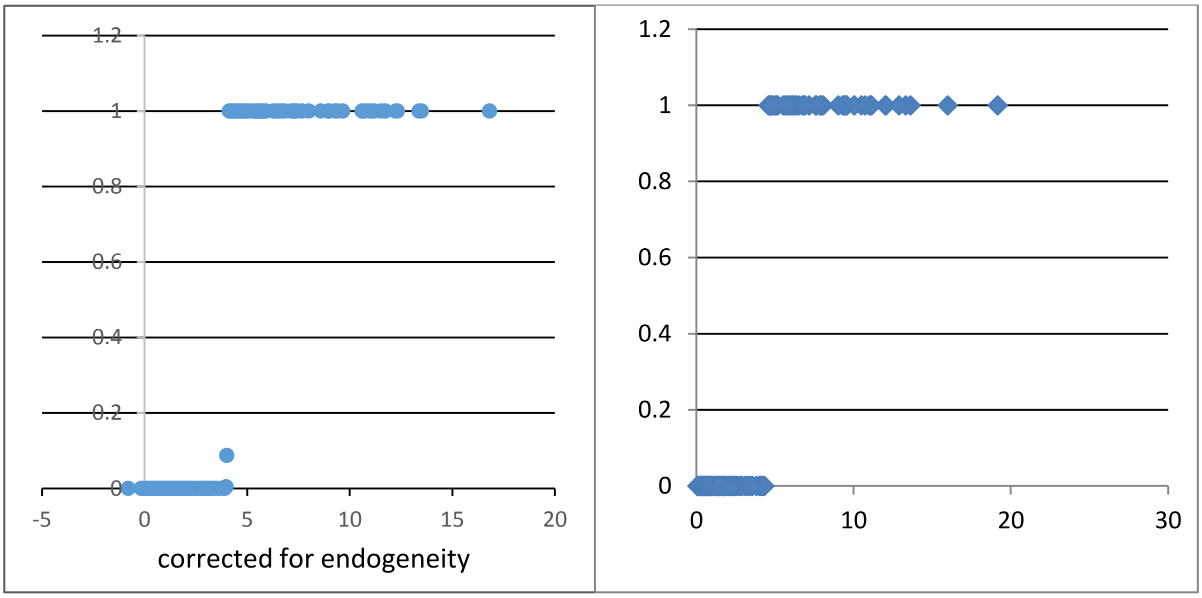
C) Low and Least developed countries: dependent variable is the growth rate of GDP-per capita.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.479276	2.326392	-1.065717	0.2882
ODAF	0.275531	0.147097	1.873126	0.0630
GFCE1	-0.462424	0.164930	-2.803761	0.0057
INF1	0.005578	0.023033	0.242190	0.8090
INV1	0.318033	0.080687	3.941561	0.0001
M2	-0.011033	0.064711	-0.170499	0.8648
RESID03	0.016534	0.243669	0.067856	0.9460

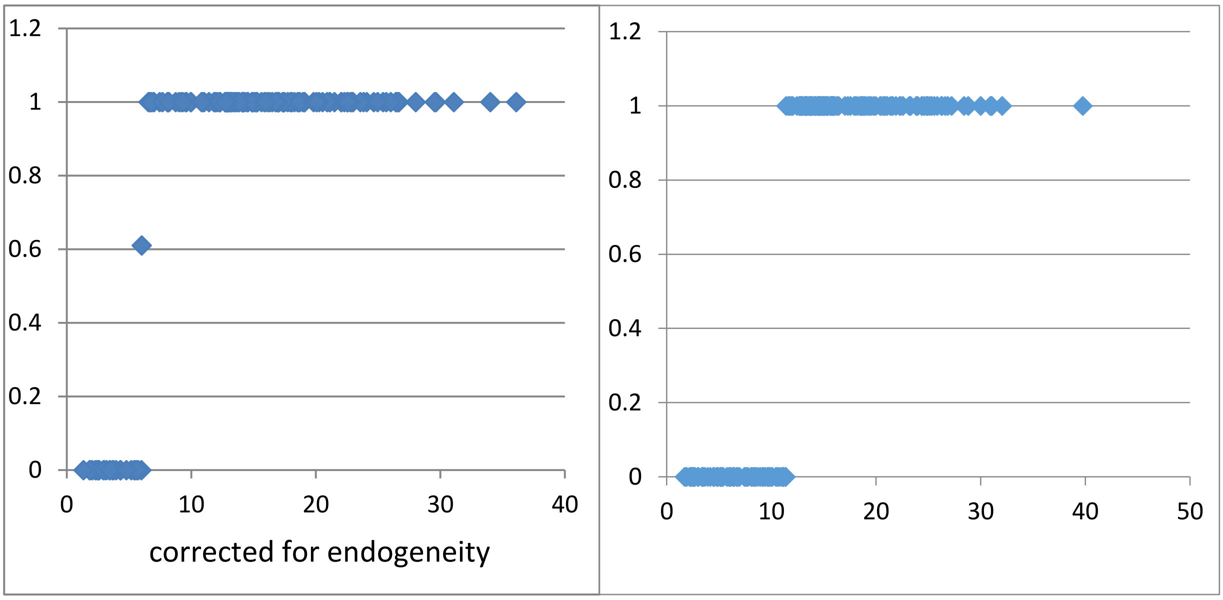
R-squared	0.153047	Mean dependent var	1.248390
Adjusted R-squared	0.119615	S.D. dependent var	5.300264
S.E. of regression	4.973176	Akaike info criterion	6.089021
Sum squared resid	3759.337	Schwarz criterion	6.224130
Log likelihood	-477.0772	Hannan-Quinn criter.	6.143887
F-statistic	4.577817	Durbin-Watson stat	2.341614
Prob(F-statistic)	0.000267		

Notes: Dependent variable is the real GDP per capita growth. ODAF: represent the fitted values of foreign aid.

Lower Middle Income countries.



Low and Least Developed Countries



*x− axis represent the transition variable,while y−axis display the transition function g (z_{it}; γ,c)

Fig. 4.3. The Estimated Transition functions for various income level countries.

4.7 Conclusion:

One of the most persistent issues in development economics is the debate about the relationship between foreign aid and economic growth. For instance the World Bank points out that foreign aid works effectively only in a good policy environment while others argue that foreign aid will hamper the rates of economic growth (e.g. Lensink and white, 2001; Feeny and McGillivray, 2011; Kourtellos et al., 2007, Wagner, 2014). We may relate this discrepancy to heterogeneity of aid and various characteristics for each recipient country. Also, the limited absorptive capacity for developing countries has been largely ignored. Moreover, previous empirical studies fail to provide a clear and precise estimate for the threshold level of aid due to employing inappropriate methods.

Therefore, this chapter aims to reinvestigate the nonlinear hypothesis between foreign aid and economic growth for 25 developing countries during the period from 1984 to 2008. We propose a new estimation method for the PSTR model, developed by Gonzalez et al., (2005), since we define PSTR model in the form of state space equations. This method allows us to estimate the threshold level of aid endogenously. Also, it has been developed in two ways: firstly, we introduce time varying effects of the explanatory variables; and secondly, the model has been extended to detect the possibility of multiple threshold levels of foreign aid.

In this study we examine the role of income level in assessing the non-linear relationship between foreign aid and economic growth. Hence we split our sample into three groups based on their income level according to the World Bank classifications. This is because we believe that, since countries vary from different perspectives, pooling various groups of countries may lead to insignificant or biased results. Additionally we employ the interaction term between aid and corruption level in order to detect whether or not the effectiveness of aid is conditional upon the recipient country's level of corruption.

In this context, our analysis confirms the presence of one threshold level of foreign aid 4.3% and 11.38% of GDP respectively for both lower middle and LDCs countries. Whereas, beyond that level foreign aid affect economic growth positively. However, we could not find a precise threshold level of foreign aid for upper middle countries. Therefore we can observe that it is misleading to estimate a threshold level for all developing countries collectively. In the same vein, we recognise the insignificant impact of aid conditional upon the level of corruption. On the other hand, we recognize that the threshold level of foreign aid for high-corrupted countries (9.5% of GDP) exceeds the low corrupted countries (3.44% of GDP). Additionally we could not provide any evidence for a further threshold level of foreign aid for all three groups of countries. While donors and international organizations should implement some precautionary policies towards assigning high aid flows to LDCs because we observe that foreign aid is no longer effective during the third regime.

In addition, policy makers should regulate the allocation process of foreign aid, they should work on how to raise the capacity for these countries and they should differentiate between the amount of aid required to reduce poverty and the levels of aid needed to accomplish high rates of economic growth. Furthermore, they should consider that each country has its own specific characteristics and its own environment. Thereby time series studies are required in order to consider variations between countries. Likewise, since various kinds of aid are expected to have different threshold levels, it might be useful for future research to investigate various types of aid and to examine their impact on economic growth.

Chapter 5

Conclusions

This chapter aims to highlight the respective findings and the policy implications for each of the empirical chapters. The first section of this chapter outlines a general summary encompassing both conclusion and policy recommendation for each chapter. The second section pinpoints the main limitations of the thesis and introduces further research avenues.

5.1 Main finding and Policy Implications.

The main theme of this thesis is to analyse the non-linearity hypothesis among three distinct macroeconomic variables (i.e. inflation, government size and foreign aid) and economic growth.

The second chapter provided a new insight concerning the relationship between inflation and economic growth from non-linearity perspective, for a panel of 35 countries in the Middle East and Sub-Sahara Africa countries. The primary objective was to determine a precise and endogenous threshold level of inflation; thereby we employed the panel smooth transition regression approach. Our baseline results suggests a threshold level of inflation 10.8% which split the sample into two regimes, beyond which inflation exhibit a significant detrimental impact on economic growth, while it has either positive (or negative) insignificant impact during low inflation regime. Additionally we employed a new database about financial fragility to investigate whether inflation levels matter for finance-growth nexus. Consistently with previous studies we observe that net loans, costs and return on assets as measures for financial fragility display a significant negative impact on economic growth during high inflation regime. Unlike previous studies, we employed institutional quality as threshold variables among inflation-growth nexus, our results advocate the harmful impact of inflation accompanied with low levels of institutional quality. Our results are robust to alternative indicators of institutional quality: government stability, Law and Order, Bureaucratic Quality, Ethnic tension, Political Rights, Democratic Accountability and level of democracy.

On average, we realise that some of the countries in our study have inflation rates beyond the estimated threshold level of inflation. And hence High inflation has many adverse effects (e.g. hinders financial development, prohibits the efficient allocation of resources). The harmful impact of high inflation rate affects the poor people in a much greater magnitude than the rich because they do not have the financial assets to keep them safe from it. Moreover, it leads to a rise in export prices and drives a decline in competitiveness with international countries and, thereby, it diminishes long run economic growth, (Frimpong and Oteng-Abayie, 2010). Therefore, it is vital for policy makers to consider inflation threshold levels and further action should be implemented to reduce inflation rate in order to promote economic growth.

The Third chapter examined the non-linear relationship between government size and economic growth for 5 countries among the MENA region. In this chapter we introduced a new way of estimating the PSTR model employed in the second chapter using state space model. The most important feature of this approach is that it allows determining the significance of the threshold variable, further it can estimate two different threshold variables simultaneously and jointly. Moreover we can display the behaviour of the threshold variable of interest at each point of time and for each individual country. Lastly, we developed the model further to a STAR model with a static and stochastic transition function. Generally and consistently with previous studies, our findings confirm the non-linear relation between government size and economic growth. More particularly for the chosen countries under study, we find a significant threshold level of government size (17.245%) below which it has a significant negative effect on economic growth. The speed of transition between regimes is high which point out to the sudden change of government size impact when it is close to the estimated threshold level.

In order to draw an adequate policy implication, it is vital to acknowledge that detecting a threshold level of government size does not always mean that increasing government spending will enhance economic growth. Since each individual country has its own characteristics, it is important to consider the discrepancy among the composition of government expenditures between countries. Furthermore an efficient structure of government spending that is synchronized with the evidence of a threshold level of government expenditures will provide policy makers with a precise guideline.

Using a panel of 25 developing countries through the period from 1984 to 2008, the fourth chapter estimate the threshold level of foreign aid for three groups of developing countries based on their income level. We extended the employed model in the third chapter to allow for a time varying effects of explanatory variables and estimate a multiple regime threshold model. Further we investigate whether corruption levels influence the amount of aid specified to the developing countries. Our results assert the pooling various groups of countries with diverse stages of developments and income levels has its own caveats and may lead to bias results. As we find distinct threshold levels of foreign aid for both lower middle and LDCs countries (4.3% and 11.38%), beyond which foreign aid promote economic growth significantly. Meanwhile a precise threshold level for upper middle countries could not be detected. Along the same line, we conclude that foreign aid effectiveness does not depend on the corruption level of the recipient country. However, we found that the threshold level for more corrupted countries (9.5% of GDP) is higher than less corrupted countries (3.44% of GDP). Additionally, no evidence was detected for a higher threshold level of foreign aid for all groups of countries. We recognize that our baseline results are robust to the endogeneity problem.

The main policy implication that can be derived from the results of this study is that policy makers should notice the heterogeneity among countries when assigning aid flow to developing countries. International organizations should apply more precautionary policies with respect to specifying high amount of aid to LDCs, as we recognised the insignificant impact of aid during the third regime. Because some countries might suffer from a limited absorptive capacity and they should work on how to raise it.

5.2 Limitations and Further Research.

The main limitation concerning this thesis relates to the employed methodology to estimate the empirical models. Although the Panel Smooth Transition regression approach has various advantages over the opponent's ones, it has some limitations. For instance, it considers the rest of the control variables exogenous, which may bring endogeneity and thus expected bias results. As one weakness applied to all threshold models is dealing with endogeneity problem, thus further studies and specifications tests are required to consider the case whereby both slope and threshold variable are endogenous. The analysis in each empirical chapter is limited to accomplish its aim; a likely future extension can be listed as below:

1. For the second chapter, we should acknowledge that inflation threshold level would vary from one country to another due to various incomes, financial development levels and subject to certain macroeconomic conditions. Consequently, time series studies could be a further research avenue. Additionally we could either investigate institutional quality impact on inflation-growth nexus for a large group of developed and developing countries, or split the sample according to the estimated threshold level of institutional quality. This will allows us to distinguish inflation threshold levels among countries which characterized by a high or low levels of institutional quality.
2. The third chapter determined the threshold level of government size for a group of countries within the MENA regions. Future studies could carry out a comparison between MENA and Gulf countries that are characterised by higher levels of government spending. Alternative measures of government spending can be employed as indicators of government expenditures. For instance, we can disaggregate government spending into productive and non-productive government spending and thereby we can determine an efficient composition of government spending.
3. The employed model in both third and fourth chapters is restricted only to a non-dynamic panel PSTR model, however the model can be extended to a dynamic panel smooth transition regression model, which will be a relatively new contribution in the literature.
4. Although our results in the fourth chapter suggest the donors to increase the amount of foreign aid directed to lower middle and LDCs countries, another question has been raised, which type of aid, grants or loans? Therefore there exists an argument that aid recipient countries consider grants as free resources of revenue, while loans will raise the burden of repayments in the future. This in turn will induce policy makers to employ funds sagely. This motivates us to evaluate the nonlinear relations ship between loans, grant and economic growth as a further research avenue. However, foreign aid fungability is another issue that should be addressed in this context. Lastly, it will be useful to create a more comprehensive index of the absorptive capacity for each individual country, which will help to assign an appropriate amount of foreign aid for aid recipient countries.

Appendix A:

Table A.1: Linearity test result: Exclude Outlier and High Income countries.

Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	144.525	0.000
Lagrange Multiplier- Fischer (LM_F)	42.806	0.000
Likelihood Ratio (LR)	161.001	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1)

Table A.2 Test results for the number of thresholds and no remaining non-linearity: Exclude Outlier and High Income countries.

Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	12.986	0.011
Lagrange Multiplier- Fischer (LM_F)	3.106	0.025
Likelihood Ratio (LR)	13.102	0.011

H_0: PSTR with r =1. H_1: PSTR with at least r =2

Table A.3: Estimate of the threshold level of inflation: Exclude Outlier and High Income countries.

	35 countries (1986-2011)	
Variable	β_0	β_1
Inflation	0.3218 $(1.9315)^{**}$	-0.4226 $(-2.5374)^{**}$
Government expenditures	-0.1470 (-1.3268)	-0.7186 $(-3.2377)^{***}$
Investment	0.1190 $(2.7729)^{***}$	0.7099 $(3.7806)^{***}$
Population	0.9237 $(2.1923)^{**}$	0.8894 (1.0177)
Threshold (c)	10.8527	
Slope (γ)	1.4833	

Dependent variable: annual growth rate of GDP. Values in the parenthesis are t-statistics based on corrected standard errors. *, **, *** display the significance levels at 10%, 5% and 1% respectively.

Appendix B:

Table B.1: Estimate of the threshold level for both Government Size and Inflation. (Static coefficient with control variables).

GDP per capita growth	π_1	π_2	Transition Variables	
			C	Exp (γ)
Model (A) gfce	0.023991 (0.6930)	-0.192875 (0.0203)**	23.68425** (0.051)	5.21887
Initial GDP	-0.538405 (0.1231)			
Inf	-0.031731 (0.0685)*			
Inv	0.236845 (0.0063)***			
Pop	0.118195 (0.8894)			
Trade	0.026925 (0.1934)			

Notes: Values between Parentheses represent P-values. *, **, *** display the significance levels at 10%, 5% and 1% respectively. π_1 and π_2 represent the impact of government size above and below the estimated threshold level. The significance of the threshold calculated by the likelihood ratio test of Hansen (1999) approach.

Table B.2: Linearity test result of Government Size for 5 MENA countries.

Test	Statistic	P-value
Lagrange Multiplier-Wald(LM_W)	9.567	0.080
Lagrange Multiplier- Fischer (LM_F)	1.910	0.085
Likelihood Ratio (LR)	9.777	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1)

Test the significance of the threshold estimate, Hansen (1999):

To examine the hypothesis H_0: C=C_0, the likelihood ratio test will be rejected for large values of $LR_1(C_0)$ where $LR_1(c)$= ($S_1(c)$-$S_1(\hat{c})$)/$\hat{\sigma}^2$ (S_1 represent sum of squared errors). If the likelihood ratio test $LR_1(C_0)$ exceed 10.59, 7.35 or 6.35 critical values, the null hypothesis will be rejected at the asymptotic level 1%, 5% and 10% respectively. It is worth mentioning that this test is different from testing the hypothesis H_0: β_1=β_2 (i.e. no threshold effect).

Sample of State space model codes reported in section 3.3.3:

A) Estimate threshold level of government size:

```
@signal gdp2 = sv5 + sv6*gfce2+ [var = exp (c(10))]
@state sv5 = c(11)
@state sv6 = c(4)*(1/(1+exp(-(exp(c(5)))*(gfce2-((c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(gfce2-((c(6))))))))


@signal gdp3 = sv7 + sv8*gfce3+ [var = exp (c(12))]
@state sv7 = c(13)
@state sv8 = c(4)*(1/(1+exp(-(exp(c(5)))*(gfce3-((c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(gfce3-((c(6))))))))


@signal gdp5= sv11 + sv12*gfce5+ [var = exp (c(16))]
@state sv11= c(17)
@state sv12= c(4)*(1/(1+exp(-(exp(c(5)))*(gfce5-((c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(gfce5-((c(6))))))))


@signal gdp7 = sv15+ sv16*gfce7+ [var = exp (c(20))]
@state sv15 = c(21)
@state sv16= c(4)*(1/(1+exp(-(exp(c(5)))*(gfce7-((c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(gfce7-((c(6))))))))


@signal gdp8= sv17 + sv18*gfce8+ [var = exp (c(22))]
@state sv17 = c(23)
@state sv18 = c(4)*(1/(1+exp(-(exp(c(5)))*(gfce8-((c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(gfce8-((c(6))))))))
```

B) <u>Estimate threshold level of both government size and inflation using different coefficients:</u>

```
@signal gdp2 = sv1 + sv2*inf2+ sv3*gfce2+ [var = exp (c(12))]
@state sv1 = c(13)
@state sv2 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf2-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf2-(exp(c(6))))))))
@state sv3 = c(8)*(1/(1+exp(-(exp(c(9)))*(gfce2-(exp(c(10))))))) +c(11)*(1-(1/(1+exp(-(exp(c(9)))*(gfce2-(exp(c(10))))))))


@signal gdp3 = sv4 + sv5*inf3+ sv6*gfce3+ [var = exp (c(14))]
@state sv4 = c(15)
@state sv5 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf3-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf3-(exp(c(6))))))))
@state sv6 = c(8)*(1/(1+exp(-(exp(c(9)))*(gfce3-(exp(c(10))))))) +c(11)*(1-(1/(1+exp(-(exp(c(9)))*(gfce3-(exp(c(10))))))))


@signal gdp5 = sv10 + sv11*inf5+ sv12*gfce5+ [var = exp (c(18))]
@state sv10 = c(19)
@state sv11 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf5-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf5-(exp(c(6))))))))
@state sv12 = c(8)*(1/(1+exp(-(exp(c(9)))*(gfce5-(exp(c(10))))))) +c(11)*(1-(1/(1+exp(-(exp(c(9)))*(gfce5-(exp(c(10))))))))


@signal gdp7 = sv22 + sv23*inf7+ sv24*gfce7+ [var = exp (c(26))]
@state sv22 = c(27)
@state sv23 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf7-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf7-(exp(c(6))))))))
@state sv24 = c(8)*(1/(1+exp(-(exp(c(9)))*(gfce7-(exp(c(10))))))) +c(11)*(1-(1/(1+exp(-(exp(c(9)))*(gfce7-(exp(c(10))))))))


@signal gdp8 = sv16 + sv17*inf8+ sv18*gfce8+ [var = exp (c(22))]
@state sv16 = c(23)
@state sv17 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf8-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf8-(exp(c(6))))))))
@state sv18 = c(8)*(1/(1+exp(-(exp(c(9)))*(gfce8-(exp(c(10))))))) +c(11)*(1-(1/(1+exp(-(exp(c(9)))*(gfce8-(exp(c(10))))))))
```

C) <u>Estimate threshold level of both government size and inflation using same coefficients:</u>

```
@signal gdp2 = sv1 + sv2*inf2+ sv3*gfce2+ [var = exp (c(12))]
@state sv1 = c(13)
@state sv2 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf2-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf2-(exp(c(6))))))))
@state sv3 = c(8)*(1/(1+exp(-(exp(c(5)))*(gfce2-(exp(c(6))))))) +c(11)*(1-(1/(1+exp(-(exp(c(5)))*(gfce2-(exp(c(6))))))))


@signal gdp3 = sv4 + sv5*inf3+ sv6*gfce3+ [var = exp (c(14))]
@state sv4 = c(15)
@state sv5 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf3-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf3-(exp(c(6))))))))
@state sv6 = c(8)*(1/(1+exp(-(exp(c(5)))*(gfce3-(exp(c(6))))))) +c(11)*(1-(1/(1+exp(-(exp(c(5)))*(gfce3-(exp(c(6))))))))


@signal gdp5 = sv10 + sv11*inf5+ sv12*gfce5+ [var = exp (c(18))]
@state sv10 = c(19)
@state sv11 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf5-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf5-(exp(c(6))))))))
@state sv12 = c(8)*(1/(1+exp(-(exp(c(5)))*(gfce5-(exp(c(6))))))) +c(11)*(1-(1/(1+exp(-(exp(c(5)))*(gfce5-(exp(c(6))))))))


@signal gdp7= sv22 + sv23*inf7+ sv24*gfce7+ [var = exp (c(26))]
@state sv22 = c(27)
@state sv23 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf7-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf7-(exp(c(6))))))))
@state sv24 = c(8)*(1/(1+exp(-(exp(c(5)))*(gfce7-(exp(c(6))))))) +c(11)*(1-(1/(1+exp(-(exp(c(5)))*(gfce7-(exp(c(6))))))))


@signal gdp8 = sv16 + sv17*inf8+ sv18*gfce8+ [var = exp (c(22))]
@state sv16 = c(23)
@state sv17 = c(4)*(1/(1+exp(-(exp(c(5)))*(inf8-(exp(c(6))))))) +c(7)*(1-(1/(1+exp(-(exp(c(5)))*(inf8-(exp(c(6))))))))
@state sv18 = c(8)*(1/(1+exp(-(exp(c(5)))*(gfce8-(exp(c(6))))))) +c(11)*(1-(1/(1+exp(-(exp(c(5)))*(gfce8-(exp(c(6))))))))
```

Appendix C:

Table C.1: List of 25 countries.

A) According to World Bank Classification.		
Low and least countries	Lower Middle countries	Upper Middle countries
Bangladesh	Cameroon	Algeria
Ethiopia	Cote d'lvoire	Botswana
Malawi	Egypt	China
Mali	Ghana	Colombia
Niger	India	Costa Rica
Sierra Leona	Indonesia	Gabon
Togo	Morocco	Tunisia
Uganda	Nigeria	
	Pakistan	
	Sudan	

B) According to Corruption level.	
Highly corrupt countries	Least corrupt countries
Bangladesh	Algeria
Ethiopia	Botswana
Gabon	Cameroon
Indonesia	China
Mali	Colombia
Niger	Costa Rica
Nigeria	Cote d'lvoire
Pakistan	Ghana
Sieera Leona	India
Sudan	Malawi
Togo	Morocco
Ughanda	Tunisia

C) According to Democracy Level.	
Most Democratic	Least Democratic
Botswana	Algeria
Colombia	China
Costa Rica	Gabon
Ghana	Tunisia
India	Cameroon
Bangladesh	Cote d'lvoire
Malawi	Indonesia
Mali	Morocco
Niger	Nigeria
	Pakistan
	Sudan
	Sieera Leona
	Togo
	Ughanda

Table C.2: Correlation Matrix for 25 countries.

Correlation	GDP per capita growth	AID	INF	INV	GFCE	M2	CORR	IPOLITY
GDP per capita growth	1.000000							
AID	-0.112753^{***}	1.000000						
INF	-0.078938^{**}	0.081068^{**}	1.000000					
INV	0.311971^{***}	-0.322297^{*}	-0.284039^{***}	1.000000				
GFCE	-0.007960	0.016362	-0.194576^{***}	0.383218^{***}	1.000000			
M2	0.279487^{***}	-0.403458^{*}	-0.200708^{***}	0.611129^{***}	0.202863^{***}	1.000000		
CORR	0.021429	-0.003508	0.017838	0.098350^{**}	0.374438^{***}	0.117764^{***}	1.000000	
IPOLITY	0.107938^{***}	-0.029644	-0.075776^{*}	0.055738	0.102402^{**}	-0.065117	0.190844^{***}	1.000000

Notes: *, **, *** display the significance levels at 10%, 5% and 1% respectively.

Table C.3: Linearity test result of Foreign Aid.

All developing countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	22.190	0.000
Lagrange Multiplier- Fischer (LM_F)	4.440	0.001
Likelihood Ratio (LR)	20.790	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1). **Dependent variable: annual growth rate of GDP per capita.**

Table C.4 Linearity test results of Corruption.

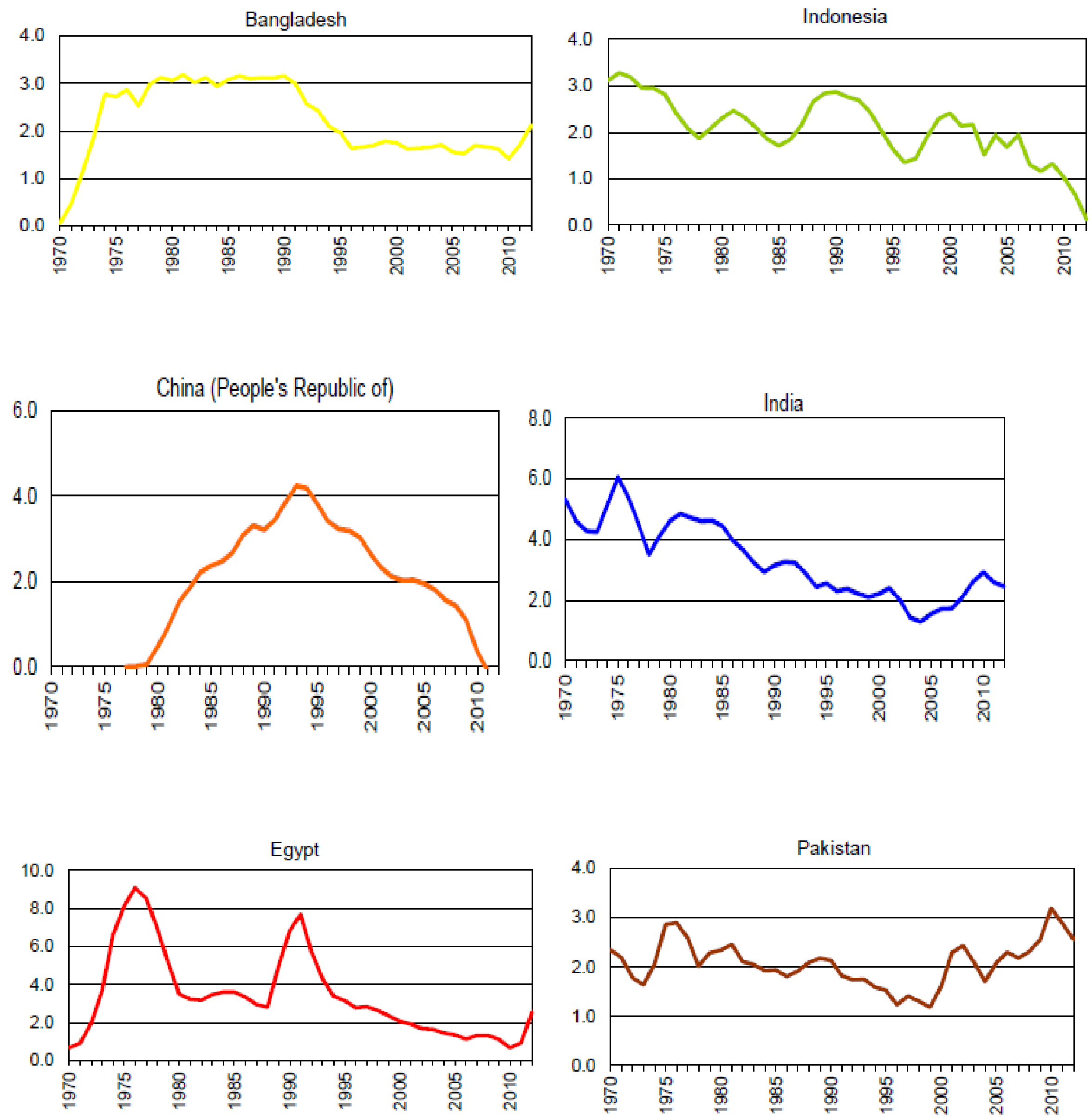
Test	Statistic	P-value
Upper Middle countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	12.592	0.028
Lagrange Multiplier- Fischer (LM_F)	2.528	0.031
Likelihood Ratio (LR)	13.086	0.000
Lower Middle countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	13.574	0.035
Lagrange Multiplier- Fischer (LM_F)	2.247	0.040
Likelihood Ratio (LR)	14.001	0.000
Low and Least Developed countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	13.362	0.038
Lagrange Multiplier- Fischer (LM_F)	2.219	0.043
Likelihood Ratio (LR)	13.829	0.000

H_0: Linear model. H_1: PSTR with at least one threshold(r =1). **Dependent variable: annual growth rate of GDP per capita.**

Table C.5 Linearity test results of Democracy.

Test	Statistic	P-value
Upper Middle countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	16.447	0.006
Lagrange Multiplier- Fischer (LM_F)	3.385	0.006
Likelihood Ratio (LR)	17.303	0.000
Lower Middle countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	6.326	0.388
Lagrange Multiplier- Fischer (LM_F)	1.013	0.418
Likelihood Ratio (LR)	6.417	0.000
Low and Least Developed countries		
Test	Statistic	P-value
Lagrange Multiplier-Wald (LM_W)	11.705	0.069
Lagrange Multiplier- Fischer (LM_F)	1.927	0.079
Likelihood Ratio (LR)	12.061	0.000

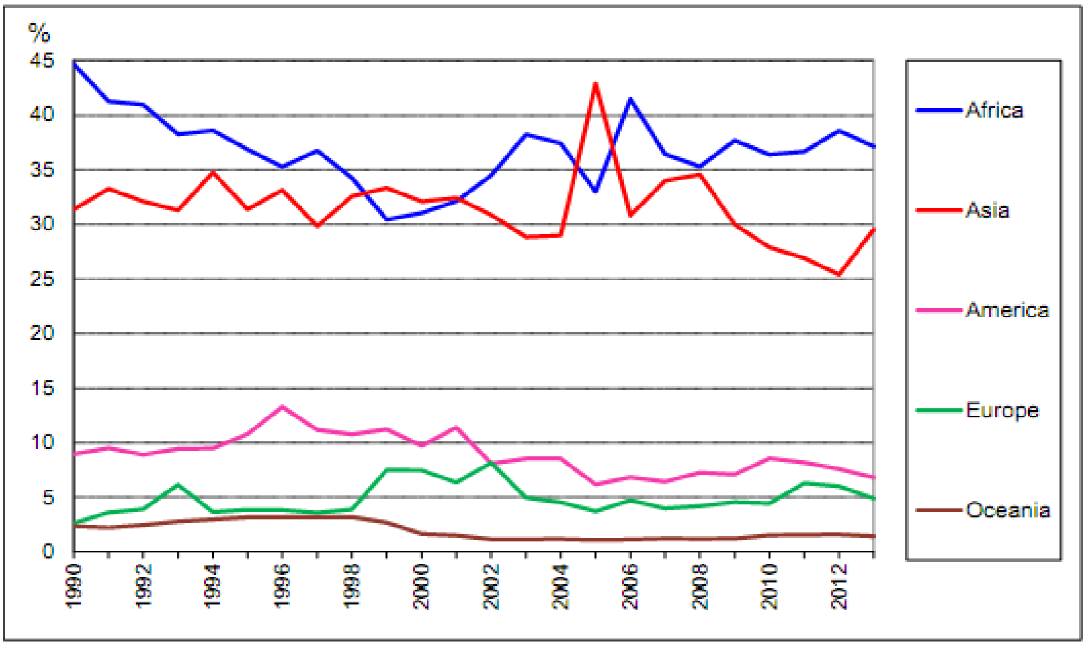
H_0: Linear model. H_1: PSTR with at least one threshold(r =1). **Dependent variable: annual growth rate of GDP per capita.**



Source: OECD-DAC Statistics, Development Aid at a Glance, Statistics by Region, 2015 edition.

Figure C.1. Trends in aid to largest recipients since 1970

USD billion, 2012 prices and exchange rates, 3-year average net ODA receipts.



Source: OECD-DAC Statistics, Development Aid at a Glance, Statistics by Region, 2015 edition.

Figure C.2. Regional shares of total net ODA. (as percentage of total ODA).

EVIEWS code for the reported model in section (4.3):

1) Estimate a threshold level of foreign aid.

```
@signal gdpp1-mgdpp1 = sv1*(curoda1-mcuroda1) + sv2*(inf1-minf1)+sv3*(inv1-minv1)+sv4*(gfce1-mgfce1)+sv5*(m21-mm21)+sv6*(coroda1-mcoroda1)+sv7*(corr1-mcorr1)+[var = exp (c(1))]

@state sv1 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6))))))))

@state sv2 = c(7)          @state sv3= c(8)
@state sv4 = c(9)          @state sv5 = c(10)
@state sv6 = c(11)         @state sv7 = c(12)


@signal gdpp2-mgdpp2 = sv8*(curoda2-mcuroda2) + sv9*(inf2-minf2)+ sv10*(inv2-minv2)+sv11*(gfce2-mgfce2)+sv12*(m22-mm22)+sv13*(coroda2-mcoroda2)+sv14*(corr2-mcorr2)+[var = exp (c(2))]

@state sv8 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6))))))))

@state sv9 = c(7)          @state sv10= c(8)
@state sv11 = c(9)         @state sv12 = c(10)
@state sv13 = c(11)        @state sv14 = c(12)


@signal gdpp4-mgdpp4 = sv15*(curoda4-mcuroda4) + sv16*(inf4-minf4)+ sv17*(inv4-minv4)+sv18*(gfce4-mgfce4)+sv19*(m24-mm24)+sv20*(coroda4-mcoroda4)+ sv21*(corr4-mcorr4)+ [var = exp (c(13))]

@state sv15 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))))

@state sv16 = c(7)         @state sv17= c(8)
@state sv18 = c(9)         @state sv19 = c(10)
@state sv20 = c(11)        @state sv21 = c(12)


@signal gdpp5-mgdpp5 = sv22*(curoda5-mcuroda5) + sv23*(inf5-minf5)+ sv24*(inv5-minv5)+sv25*(gfce5-mgfce5)+sv26*(m25-mm25)+sv26*(coroda5-mcoroda5)+ sv27*(corr5-mcorr5)+ [var = exp (c(14))]

@state sv22 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@state sv23 = c(7)         @state sv24= c(8)
```

@state sv25 = c(9) @state sv26 = c(10)

@state sv27 = c(11) @state sv28 = c(12)

@signal gdpp6-mgdpp6 = sv29*(curoda6-mcuroda6) + sv30*(inf6-minf6)+ sv31*(inv6-minv6)+sv32*(gfce6-mgfce6)+sv33*(m26-mm26)+sv34*(coroda6-mcoroda6)+ sv35*(corr6-mcorr6)+ [var = exp (c(15))]

@state sv29 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6)))))))

@state sv30 = c(7) @state sv31= c(8)

@state sv32 = c(9) @state sv33 = c(10)

@state sv34 = c(11) @state sv35 = c(12)

@signal gdpp7-mgdpp7 = sv36*(curoda7-mcuroda7) + sv37*(inf7-minf7)+ sv38*(inv7-minv7)+sv39*(gfce7-mgfce7)+sv40*(m27-mm27)+sv41*(coroda7-mcoroda7)+ sv42*(corr7-mcorr7)+ [var = exp (c(16))]

@state sv36 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6)))))))

@state sv37 = c(7) @state sv38= c(8)

@state sv39 = c(9) @state sv40 = c(10)

@state sv41 = c(11) @state sv42 = c(12)

@signal gdpp10-mgdpp10 = sv43*(curoda10-mcuroda10) + sv44*(inf10-minf10)+ sv45*(inv10-minv10)+sv46*(gfce10-mgfce10)+sv47*(m210-mm210)+sv48*(coroda10-mcoroda10)+ sv49*(corr10-mcorr10)+ [var = exp (c(17))]

@state sv43 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6)))))))

@state sv44 = c(7) @state sv45= c(8)

@state sv46 = c(9) @state sv47 = c(10)

@state sv48 = c(11) @state sv49 = c(12)

2) Time varying effects of the explanatory variables.

@signal gdpp1-mgdpp1 = sv1*(curoda1-mcuroda1) + sv2*(inf1-minf1)+sv3*(inv1-minv1)+sv4*(gfce1-mgfce1)+sv5*(m21-mm21)+[var = exp (c(1))]

@state sv1 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))))

@state sv2= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))))

@state sv3= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))))

@state sv4= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))))

@state sv5= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda1-mcuroda1)-(exp(c(6)))))))

@signal gdpp2-mgdpp2 = sv6*(curoda2-mcuroda2) +sv7*(inf2-minf2)+sv8*(inv2-minv2)+sv9*(gfce2-mgfce2)+sv10*(m22-mm22)+ [var = exp (c(2))]

@state sv6 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))))

@state sv7= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))))

@state sv8= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))))

@state sv9= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))))

@state sv10= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda2-mcuroda2)-(exp(c(6)))))))

@signal gdpp4-mgdpp4 = sv11*(curoda4-mcuroda4) + sv12*(inf4-minf4)+sv13*(inv4-minv4)+sv14*(gfce4-mgfce4)+sv15*(m24-mm24)+ [var = exp (c(15))]

@state sv11 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6)))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6)))))))

@state sv12= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6)))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6)))))))

@state sv13= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))))

@state sv14= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))))

@state sv15= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda4-mcuroda4)-(exp(c(6))))))))

@signal gdpp5-mgdpp5 = sv16*(curoda5-mcuroda5) + sv17*(inf5-minf5)+sv18*(inv5-minv5)+sv19*(gfce5-mgfce5)+sv20*(m25-mm25)+ [var = exp (c(16))]

@state sv16 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@state sv17= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@state sv18= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@state sv19= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@state sv20= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda5-mcuroda5)-(exp(c(6))))))))

@signal gdpp6-mgdpp6 = sv21*(curoda6-mcuroda6) + sv22*(inf6-minf6)+sv23*(inv6-minv6)+sv24*(gfce6-mgfce6)+sv25*(m26-mm26)+ [var = exp (c(17))]

@state sv21 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))))

@state sv22= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))))

@state sv23= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))))

@state sv24= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))))

@state sv25= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda6-mcuroda6)-(exp(c(6))))))))

@signal gdpp7-mgdpp7 = sv26*(curoda7-mcuroda7) + sv27*(inf7-minf7)+sv28*(inv7-minv7)+sv29*(gfce7-mgfce7)+sv30*(m27-mm27)+[var = exp (c(18))]

@state sv26 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))))

@state sv27= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))))

@state sv28= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))))

@state sv29= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))))

@state sv30= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda7-mcuroda7)-(exp(c(6))))))))

@signal gdpp10-mgdpp10 = sv31*(curoda10-mcuroda10) + sv32*(inf10-minf10)+sv33*(inv10-minv10)+sv34*(gfce10-mgfce10)+sv35*(m210-mm210)+ [var = exp (c(19))]

@state sv31 = c(3)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))) +c(4)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))))

@state sv32= c(7)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))) +c(8)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))))

@state sv33= c(9)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))) +c(10)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))))

@state sv34= c(11)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))) +c(12)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))))

@state sv35= c(13)*(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))) +c(14)*(1-(1/(1+exp(-(exp(c(5)))*((curoda10-mcuroda10)-(exp(c(6))))))))

3) <u>Multiple threshold level of foreign aid.</u>

@signal gdpp1-mgdpp1 = sv1*(curoda1-mcuroda1) + sv2*(inf1-minf1)+sv3*(inv1-minv1)+sv4*(gfce1-mgfce1)+sv5*(m21-mm21) +[var = exp (c(30))]

@state sv1 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda1-mcuroda1)-(exp(c(16))))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda1-mcuroda1)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda1-mcuroda1)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda1-mcuroda1)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda1-mcuroda1)-(exp(c(6)))))))

@state sv2 = c(17) @state sv3= c(18)

@state sv4 = c(19) @state sv5 = c(20)

@signal gdpp2-mgdpp2 = sv6*(curoda2-mcuroda2) + sv7*(inf2-minf2)+ sv8*(inv2-minv2)+sv9*(gfce2-mgfce2)+sv10*(m22-mm22)+sv13*(coroda2-mcoroda2)+sv14*(corr2-mcorr2)+[var = exp (c(31))]

@state sv6 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda2-mcuroda2)-(exp(c(16))))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda2-mcuroda2)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda2-mcuroda2)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda2-mcuroda2)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda2-mcuroda2)-(exp(c(6)))))))

@state sv7= c(17) @state sv8= c(18)

@state sv9 = c(19) @state sv10= c(20)

@signal gdpp4-mgdpp4 = sv11*(curoda4-mcuroda4) + sv12*(inf4-minf4)+ sv13*(inv4-minv4)+sv14*(gfce4-mgfce4)+sv15*(m24-mm24)+ [var = exp (c(33))]

@state sv11 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda4-mcuroda4)-(exp(c(16))))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda4-mcuroda4)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda4-mcuroda4)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda4-mcuroda4)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda4-mcuroda4)-(exp(c(6)))))))

@state sv12 = c(17) @state sv13= c(18)

@state sv14 = c(19) @state sv15 = c(20)

@signal gdpp5-mgdpp5 = sv16*(curoda5-mcuroda5) + sv17*(inf5-minf5)+ sv18*(inv5-minv5)+sv19*(gfce5-mgfce5)+sv20*(m25-mm25)+ [var = exp (c(34))]

@state sv16 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda5-mcuroda5)-(exp(c(16))))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda5-mcuroda5)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda5-mcuroda5)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda5-mcuroda5)-((c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda5-mcuroda5)-(exp(c(6)))))))

@state sv17 = c(17) @state sv18= c(18)

@state sv19 = c(19) @state sv20 = c(20)

@signal gdpp6-mgdpp6 = sv21*(curoda6-mcuroda6) + sv22*(inf6-minf6) + sv23*(inv6-minv6) +sv24*(gfce6-mgfce6) +sv25*(m26-mm26) + [var = exp (c (35))]

@state sv21 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda6-mcuroda6)-(exp(c(16)))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda6-mcuroda6)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda6-mcuroda6)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda6-mcuroda6)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda6-mcuroda6)-(exp(c(6)))))))

@state sv22 = c(17) @state sv23= c(18)

@state sv24 = c(19) @state sv25 = c(20)

@signal gdpp7-mgdpp7 = sv26*(curoda7-mcuroda7) + sv27*(inf7-minf7) + sv28*(inv7-minv7) +sv29*(gfce7-mgfce7) +sv30*(m27-mm27) + [var = exp (c (36))]

@state sv26 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda7-mcuroda7)-(exp(c(16)))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda7-mcuroda7)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda7-mcuroda7)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda7-mcuroda7)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda7-mcuroda7)-(exp(c(6)))))))

@state sv27 = c (17) @state sv28= c (18)

@state sv29 = c (19) @state sv30 = c (20)

@signal gdpp10-mgdpp10 = sv31*(curoda10-mcuroda10) + sv32*(inf10-minf10) + sv33*(inv10-minv10) +sv34*(gfce10-mgfce10) +sv35*(m210-mm210) + [var = exp (c (37))]

@state sv31 = (c(3)*(1/(1+exp(-(exp(c(15)))*((curoda10-mcuroda10)-(exp(c(16)))))) +c(4)*(1-(1/(1+exp(-(exp(c(15)))*((curoda10-mcuroda10)-(exp(c(16)))))))))*(1-(1/(1+exp(-(exp(c(5))))*((curoda10-mcuroda10)-(exp(c(6)))))))+((c(12)*((1/(1+exp(-(exp(c(15)))*(curoda10-mcuroda10)-(exp(c(16))))))))*(1/(1+exp(-(exp(c(5)))*(curoda10-mcuroda10)-(exp(c(6)))))))

@state sv32 = c (17) @state sv33= c (18) @state sv34 = c (19) @state sv35= c (20)

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