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Unemployment Hysteresis in the English-Speaking Caribbean: Evidence from Non-Linear Models

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Abstract

In the Caribbean Basin, as in many other parts of the world, unemployment, with rates between 15 and 30 percent, has become one of the major problems affecting these societies. This article highlights the specific characteristics of Caribbean unemployment, contrasting them with those observed in the industrialized and developed nations. Secondly, it summarizes the main ideas that have been proposed to explain the problem of unemployment hysteresis and discusses their appropriateness in the case of the countries under consideration. Finally, it uses the framework of threshold models and processes with nonlinearities in the mean to empirically examine the hypothesis of hysteresis. The results supported these non-linear specifications: for Barbados, an LSTAR model is preferred while in the case of Trinidad and Tobago, an ESTAR specification is selected.

Keywords: Unemployment persistence, Unit root tests, Non-linear models

1. Introduction

Mass unemployment has become a phenomenon characteristic of the majority of countries in the Caribbean. In the 1970s, the average unemployment rate of Guadeloupe, Martinique, Barbados, Jamaica and Trinidad and Tobago was 14.2 percent, 18.2 percent, 15 percent, 22.4 percent and 14 percent respectively. These rates stabilized in the 1980s as there was sustained economic growth in these islands. Despite this steady growth, unemployment rates remained at high levels and even expanded in some countries like Jamaica whose average rate was 23.8 percent. During the 1990s to early 2000s, unemployment rates were on the rise again, recording increases of up to 10 points in certain islands, for example, unemployment rates ranged from 20 percent (Barbados) to 30 percent (Guadeloupe, Martinique). These high levels of unemployment, occasioned by little or no growth due to episodes of world recessions and high international prices, reached up to about twice the levels reported in the INSEE (2011) webpage for the industrialized countries.

Given the persistently high unemployment rates mentioned above, a search for explanations by macroeconomists has led to rich theoretical, methodological as well as economic policy debates (see for example Elmeçkov and MacFarlan (1993) and the Policy Board for Employment (2007) for a relatively complete synthesis of these arguments). At the center of these widely shared ideas is the hypothesis of hysteresis which according to the seminal paper of Blanchard and Summers (1986), reflects a kind of memory of events leading to the immutability of unemployment even in the presence of changing circumstances in the labor market. By focusing on the situation in Trinidad and Tobago and Barbados, Downes (1998) and Craigwell and Warner (1999) respectively are probably the first studies to have undertaken an investigation on persistence and hysteresis in unemployment in the Caribbean. They demonstrated the existence of 'persistence' whereby the unemployment rate affects the 'natural rate of unemployment'. Borda (2000) also showed that this theory is verified in the case of Guadeloupe. More recently, Ball and Hofstetter (2009) have examined 20 countries in Latin America and the Caribbean (excluding Barbados and Trinidad and Tobago) and provided evidence that suggest that hysteresis is reflected in the unemployment situation in the countries examined. Also, by conducting a theoretical and numerical analysis of a rational expectations model which include the role of insiders in the labor market, Borda and Mamingi (2009) have demonstrated that the hysteresis phenomenon must be considered as an explanation of labor market fluctuations in Barbados, Jamaica and Trinidad and Tobago.

This paper, like previous authors, explores the hypothesis of hysteresis in two English-speaking Caribbean - Barbados and Trinidad and Tobago - to see if it is consistent with the observed facts. However, there are two notable differences between this work and the earlier research. The first concerns the wealth of the database. The series used for Barbados and Trinidad and Tobago are quarterly covering a fairly long period (1975 to 2010 and 1971 to 2010 respectively). Previous studies employed annual data sets. Note also that the use of more countries was contemplated but quarterly data was unavailable. The second difference relates to the methodology. The empirical tests implemented here are based on time series methods recently employed for the econometric analysis of the labor market, that is, threshold models and processes with nonlinearities in the mean.

2. Unemployment in the Caribbean: A Comparison

2.1. The Data and Their Characteristics

Quarterly unemployment time series data for Barbados and Trinidad and Tobago that spans nearly four decades are used in the empirical investigations below. For Trinidad and Tobago, the data set was available over the sample period 1971Q1 to 2010Q4 and was procured from various issues of the Annual Labour Force Report published by the Central Statistical Office of Trinidad and Tobago. In the case of Barbados, the data covered the period 1975Q1 to 2010Q4 and was sourced from the Continuous Household Labour Force Survey undertaken by the Barbados Statistical Service.

Table 1: Descriptive Statistics for the Unemployment Rate of Barbados and Trinidad and Tobago

Variables	Mean	Medium	Maximum	Minimum	Std. Dev	Skewness	Kurtosis	Jargue-Bera
UNEMP_BDOS	14.15	14.19	26.67	6.88	4.47	0.56	2.64	8.13**
UNEMP_TT	13.62	13.48	23.04	4.44	4.77	-0.001	2.30	3.29

Note: ** means significant at the 5 percent level.

Table 1 above displays the descriptive statistics for the unemployment series. It is observed that the rate of unemployment in Barbados and Trinidad and Tobago are characterized by marked fluctuations; the maximum value reported for Barbados and Trinidad and Tobago respectively is 26.67 percent and 23.04 percent, the minimum values are 6.88 percent and 4.44 percent and the standard deviations are 4.47 percent and 4.77 percent. These results suggest that the unemployment rate is on average higher for Barbados than for Trinidad and Tobago but fluctuates less. Movements in both series can also be assessed by the skewness coefficient which is positive for Barbados (0.56) and negative (almost zero) for Trinidad and Tobago (-0.0015). These findings imply that for Trinidad and Tobago, the unemployment rate appears to exhibit a symmetric behavior as it takes values above or below its average level. In contrast, the rate for Barbados is often higher than average, evidence of asymmetric fluctuations. Additionally, the Jargue - Bera statistics suggest that the unemployment rate in Barbados has a non-normal distribution while that of Trinidad and Tobago approximates the normal distribution.

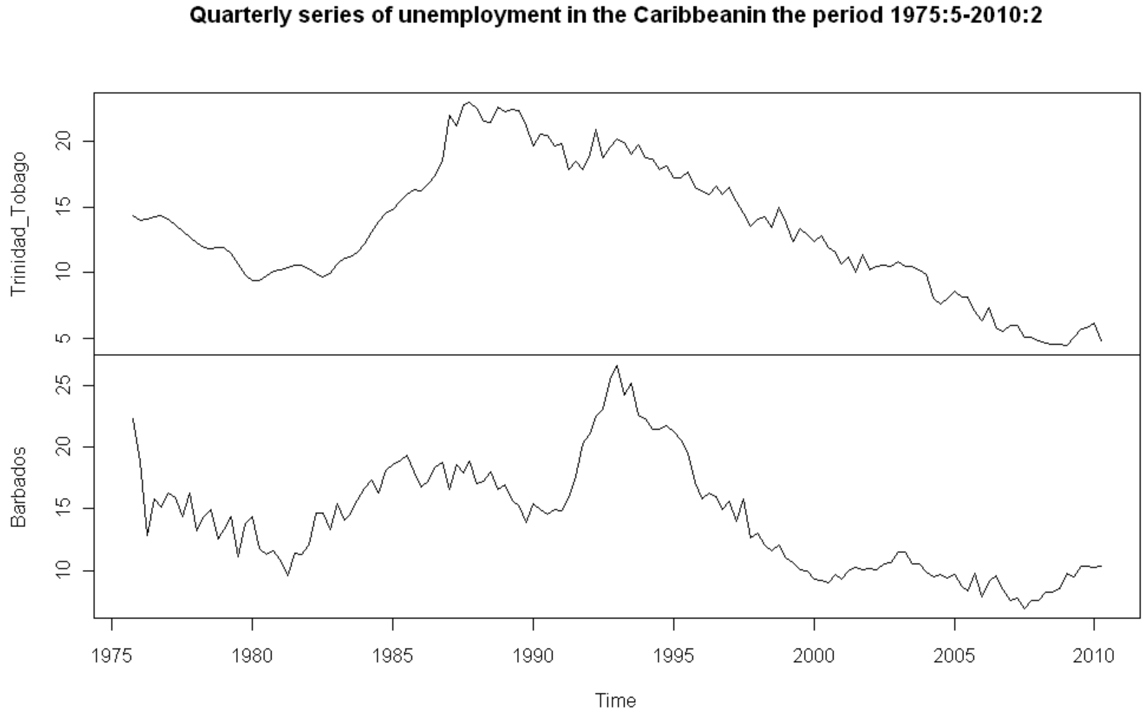
2.2. The Stylized Facts

Figure 1 shows that in the case of Trinidad and Tobago the trend in unemployment is characterised by significant fluctuations, particularly after 1989. Between 1970 and 1972, unemployment increased by 43.5 percent, but later declined in 1973 and 1975 from 69,800 in Q1 of 1973 to 51,600 in Q4 of that year, and from 60,800 in Q1 of 1975 to 57,600 in Q4. Conversely, 1974 and 1976 represented periods of recovery due mainly to the revenue effects of rising oil prices.

During the period from 1977 to 1983, unemployment followed a general downward trend despite rebounding slightly from time to time. From 1983 to 1989, the reverse was true, as unemployment recorded extremely high growth rates. For example, in 1984, 1985 and 1987 the growth rates were 27.6 percent, 16.3 percent and 31.5 percent, respectively. These large increases continued into 1988, when unemployment reached approximately 100,000. In 1990 and 1991 employment rebounded somewhat, but this improvement was short-lived, as unemployment began to rise once again in 1991 and 1992 when the world economy slipped further into recession. After the recession unemployment in Trinidad and Tobago continued on a declining path as that economy benefitted from high oil revenues as a result of increasing oil prices.

With respect to Barbados, the unemployment rate appears to be a relatively unstable variable, whose path seems to be a combination of three curves. The first curve spans the period 1975 to 1981. In 1975, Barbados' unemployment rate reached an alarming 22.5 percent. It then declined gradually, following a linear trend, until 1981, when it registered its third-lowest level for the period.

Figure 1: Quarterly Series of Unemployment in the Caribbean: 1975-2010



The second curve refers to the years 1982 to 1991, during which unemployment experienced significant changes, first increasing from 11.4 percent in 1982Q1 to 19.8 percent in 1985Q3, then fluctuating around a relatively high figure of over 15 percent until 1989Q3, after which it contracted marginally until 1990Q4.

The third curve, which relates to the period 1991 to 2010, is parabolic in form. The upward-sloping portion of this parabola represents the years 1991 to 1993, a recessionary period for the Barbadian economy. This period was characterised by an eight-percentage salary cut for public workers, massive lay-offs and a rate of unemployment that steadily increased from 17.3 percent in 1990 to 23 percent in 1992, then to 25.1 percent in 1992Q4 and 27.1 percent in 1993Q1. The downward-sloping portion shows a spectacular decline in the unemployment rate from nearly 30 percent in 1993 to 9.3 percent by 2000Q1. This drop was due mainly to the effects of prudent policy actions, a reduction in the labour force resulting from emigration, and adjustments made after the census found that prior population estimates were too low. From 2001 to 2003 the unemployment rate rose again as economic growth slowed after the 2001 terrorist attacks in the United States. Afterwards the rate trended down as the economy picked up. This continued until the start of the current recession in 2008 when there were some job losses and unemployment expanded again.

3. Unemployment Hysteresis in the Caribbean

3.1. Hysteresis: Definition and Explanation

This section focuses on the phenomenon of hysteresis to explain the high and sharp rise of unemployment observed in the two Caribbean countries over the last four decades or so. As a first step, it is useful to recall the distinction between the concepts of hysteresis and persistence of unemployment, given that the first is often defined using words that describe the second.

The literature on labor markets usually states that persistence of unemployment occurs when, after an adverse shock to employment, the unemployment number returns very slowly to its equilibrium level. Various situations are put forward to explain the lack of rebalancing mechanisms including weak demand and the role of finance. For its part, hysteresis is a situation which sees the natural rate of unemployment steadily increasing with the actual unemployment following a shock. It has its sources in the impact of mass unemployment on the functioning of the labor market: the long-term unemployed who gradually lose their employability and union actions in the interests of insiders, conflicting with those of outsiders. Given this, it is necessary to focus on the concept of hysteresis. An appropriate approach to better understand the concept of hysteresis is to answer Blanchard (1986) query “What causes a high rate of unemployment?” by distinguishing between the actual unemployment rate and the natural rate of unemployment. For the latter concept Elmeçkov and MacFarlan (1993) states that "the natural rate can be defined as the rate of equilibrium unemployment in the long term as it is determined by the underlying structural characteristics of the labor market” (p. 73). With this definition, Blanchard (1986) further delineate the central query above by posing two questions: "Is it because unemployment is ‘naturally’ high in the countries concerned, that is to say, because the observed rate is close to the natural rate but it is high? Or is it due to a significant difference between the observed rate and a low natural rate?” (p. 3).

The difficulties in answering these questions are related primarily to the fact that the natural rate of unemployment is not an easy concept to define; it is not a statistically directly observable and its estimated value may vary from one period to another. Given these two features of the natural rate, Blanchard (1986) cites the phenomenon of hysteresis as a third property which makes it hard to estimate ‘the natural rate’ [which] is partially determined by the rate observed. Therefore, the natural rate of a given period may have determinants from the previous juncture. In other words, hysteresis reflects the idea that a temporary negative impact on demand which push up the actual level of unemployment may have a resultant increase in structural unemployment; it may persist even after the recovery in demand.

In theoretical terms, the explanations that are given for hysteresis are varied. The two hypotheses that are often echoed by economists are the Insider-Outsider phenomenon and low employability of long-term unemployed. The idea of "Insider-Outsider”, discussed in Lindbeck and Snower (1988), blames the situation of hysteresis in unemployment on the unions. It is argued that workers who are already employed ("insiders") do not take into account the situation of "outsiders"; their bargaining power is used for the sole purpose of fixing the nominal wage that would be consistent with maintaining existing jobs and when a recession occurs because aggregate demand decreases (and, in general, is not anticipated) it follows that there will be an expansion in the volume of outsiders because of layoffs in companies. Subsequently, in the recovery times of the cycle, previously dismissed workers will not be rehired due to renegotiations of contracts requiring insiders’ increases in wages. Thus, the number of excluded workers would tend to grow over the long term.

The explanation for the low employability of long-term unemployed is to assume that when a person goes through a long period of unemployment, it is likely that its human capital (its working capacity, technical expertise, productivity) will deteriorate. Such an unemployed person would have difficulty in re-entering the work place and if lucky, may take a temporary job. In all cases, the consequence is an increase in unemployment in the long term.

3.2. A Review of Unemployment Hysteresis in the Caribbean

With unemployment rates persistently high between 20 per cent and 30 per cent in some countries in the Caribbean, the phenomenon of unemployment hysteresis may offer a viable explanation. On the causes of unemployment in Caribbean countries, Downes (1998) conducted a very interesting analysis of Trinidad and Tobago. He tests a co-integrated econometric model that allows unemployment to depend on input prices, gross domestic product, labor market regulations and technical changes. An important conclusion of his study is the validation of the hypothesis of hysteresis, that is, he found that a one percent change in the unemployment rate in the previous period can lead to a 0.51 percent change in the current unemployment rate. Recall that the hysteresis theory suggests that the natural or equilibrium rate of unemployment depends on the history of the actual unemployment rate.

Craigwell and Warner (1999) determine some of the causes of unemployment in Barbados over the years 1980 to 1996 by using the Autoregressive Distributed Lag methodology. The findings indicate that wages paid by the employer is one of the major determinants of the unemployment rate, and therefore, a reduction in social security taxes may be considered as a possible remedy for reducing this rate. Other factors affecting unemployment were the high levels of hiring and firing costs, indicating that labor market legislation should be re-examined as a policy to combat unemployment. As with Downes (1998) for Trinidad and Tobago this study validated the hypothesis of hysteresis, that is, the authors found that there is significant persistence in employment, as the sum of the lagged values of employment in the distributed lag model is relatively high at 0.80.

4. An Empirical Examination of the Hysteresis Hypothesis

It is useful for the purpose of this study to dissect the path of the unemployment series to identify whether they are linear or nonlinear and stationary or non-stationary. In this context, recall the statistical discussion of Table 1 given in Section 2.1 above. Also note that the unemployment rates in Trinidad and Tobago and Barbados are well above, up to twice the average in certain periods, those of the G20 countries (see INSEE, 2011). In addition, the path of unemployment in Trinidad and Tobago is quite peculiar as it is one of the few nations in the world where there is a period of a long decline, almost two decades since its record high of 22 percent reported in 1987. Finally, the trend in the unemployment rate in Barbados is represented by several changes, consisting of two periods of increases and three episodes of decreases between 1975:4 and 2001:1 followed by a period of smaller fluctuations from 2001: 2 to 2010:3. The configuration of this trajectory also shows that the upward change in the unemployment rate appear quick compared to that of its downward movement.

In line with the empirical studies done on various regions in the world, see for example Phaneuf (1988), Trabelsi (1997), and the Policy Board for Employment (2007), this paper checks for the presence of hysteresis by implementing different techniques from time series econometrics. First, unit root tests that highlight the statistical properties of the economic variables and the interpretation of their non-stationarity in terms of long memory are applied. Then nonlinear regime switching models that aim at verifying the idea that the dynamics of the unemployment rate depends on the speed in which it is located are employed. All the calculations are done with the econometric software programs RATS, EVIEWS and R, the first two for everything dealing with the unit root analysis and the third for the nonlinear modeling.

4.1. Unit Roots Tests

The graphic examination of the unemployment rates given above in section 2 shows that in the case of Barbados, the evolution is not stable over time, as the unemployment series varies around different average values. For Trinidad and Tobago, instability is also apparent but is a reflection of long periods of growth or decay and the existence of average levels that change from one sub-period to another. Given the recent results in the literature on economic time series, it is accepted that this instability may have two major origins. On the one hand, it may be the result of non-stationarity. On the other hand, it may be due to non-linear behaviors such as switching from one unemployment regime to another.

In the tradition of empirical studies that test for hysteresis in unemployment, the following commonly used unit root tests - Dickey-Fuller (ADF), Phillips-Perron and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) - are implemented. The results of these procedures are reported in Table 2 and they validate the hypothesis of a unit root, implying that the hypothesis of hysteresis for the two countries selected is upheld. However, in the event that the data-generating process of the unemployment rate is actually a non-linear but stationary process, it is well recognized that these traditional tests exhibit low power and can lead one to wrongly accept the hypothesis of non-stationarity. It is then necessary to examine the order of integration taking into account possible nonlinear effects. In this regard the extension of the Dickey-Fuller test proposed by Kapetanios et al. (2003) (KSS) is considered. This procedure provides a statistical framework to test the alternative "non-stationarity and stationarity and linearity versus nonlinearity" hypothesis.

The starting point for the KSS method is similar to the DF regression test and incorporates the nonlinearity by means of an autoregressive specification for thresholds with an exponential transition function:

$$\Delta X_t = \gamma X_{t-1}\left[1-\exp\left(-\theta X_{t-1}^2\right)\right]+\varepsilon_t \tag{1}$$

where the series X_t is in deviation form from its trend, the parameter $\varepsilon_t \sim N(0;\sigma_\varepsilon^2)$ and $\theta \geq 0$ is used to modulate the speed of transition. The null hypothesis H_0: $\theta = 0$ must be tested against the alternative hypothesis $H_1: \theta > 0$. However, since the parameter γ is not identified under H_0, Kapetanios et al. (2003) have proposed a re-parameterization based on Taylor series approximation. This gives the following regression equation that allows the test to be easily implemented:

$$\Delta X_t = \delta X_{t-1}^3 + \varepsilon_t \tag{2}$$

By introducing the lagged terms of X_t to correct for autocorrelation in the errors, a regression equation analogous to the ADF test is obtained:

$$\Delta X_t = \delta X_{t-1}^3 + \sum_{k=1}^{p} \gamma_k \Delta X_{t-k} + \varepsilon_t \tag{3}$$

The DF, ADF and KSS tests share the same null hypothesis of non-stationarity H_0: $\delta = 0$ while the alternative hypothesis of the Dickey and Fuller stationary linear KSS test is that of the stationary nonlinear process (H_1: $\delta < 0$).

The RATS software is utilized to apply the nonlinear tests associated with Models (2) and (3). In both cases, the unemployment series are centered, that is, they are deviation from a linear trend. To test Equation (3), the Hannan-Quinn (HQ) criterion for selecting the optimal lag is employed. The results of these tests are reported in Table 3 and are similar to those provided by the linear unit root statistics. So, in conclusion, taking into account the non-linearity does not lead to a rejection of the hypothesis of a unit root in the unemployment rates.

Table 2: Classical Unit Root Test for the Unemployment Rates

		ADF		Phillips-Perron		KPSS	
	Time Period	**No trend**	**With trend**	**No trend**	**With trend**	**No trend**	**With trend**
Barbados	1976:Q4 – 2010:Q3	-1.56	-2.04	-2.22	-2.24	0.58	0.23
Trinidad and Tobago	1970:Q2 – 2010:Q2	-0.35	-1.14	-0.53	-1.14	0.45	0.28

Note: ADF, Phillips-Perron and KPSS are the ADF test statistics that include a constant and a time trend in the model, with optimal lag selected automatically with the Hannan-Quinn criterion. For the model without trend, the 5 percent and 1 percent asymptotic critical values for the ADF and Phillips-Perron statistics are −2.88 and −3.48, respectively. For the model without trend, the 5 percent and 1 percent asymptotic critical values for the ADF and Phillips-Perron statistics are −3.44 and −4.02, respectively. For the model without trend, the 5 percent and 1 percent asymptotic critical values for the KPSS statistics are 0.46 and 0.74, respectively. For the model with trend, the 5 percent and 1 percent asymptotic critical values for the KPSS statistics are 0.15 and 0.22, respectively.

Table 3: KSS Test of Non-stationarity against a Non-linear Alternative (ESTAR) For the Unemployment Rates

		KSS		KSS with delay	
	Time Period	**No trend**	**With trend**	**No trend**	**With trend**
Barbados	1976:Q4 – 2010:Q3	-1.81	-1.55	-1.83	-1.91
Trinidad and Tobago	1970:Q2 – 2010:Q2	-0.90	-1.64	-1.06	-1.73

Notes: 1 percent critical values for the KSS test with OLS detrending: -3.48 with constant and -3.93 with constant and trend. 5 percent critical values for the KSS test with OLS detrending: -2.93 with constant and -3.4 with constant and trend.

4.2. An Analysis of the Family of Regime Switching Models

In recent years, the literature on the prolonged persistence of unemployment has applied regime switching models to represent the properties of non-linearity in the unemployment rate and also to provide economic explanations for this behavior. Authors like Trabelsi (1995), Franses (2004) and Uctum (2007) have emphasized the need for econometric analysis to capture economic activity that allows for the phenomenon of asymmetry where an economy goes through different phases of the business cycle involving growth and decline. In his doctoral thesis, Fouquau (2008, p.125) recalls the work of Neftci (1984) and Rothman (1991) and argued that "bad times to employment are less persistent than the good times, indicating that falls are certainly more pronounced but of shorter duration." This observation is in line with Keynes (1936)'s comments on economic fluctuations in the periods of war and boom, when he noted that the unemployment rate is characterized by abrupt jumps and weak declines.

Utilizing OECD data, several authors (see for example Teräsvirta and Skalin (2002)) have conducted empirical studies to test the persistence of unemployment and explained it through modeling of volatility shocks from various sources (such as domestic productivity or domestic monetary policy shocks, as well as external shocks operating, for example, through the foreign interest rate). Research on countries outside the developed world is very scarce. However, Moolman (2003) considered the case of the unemployment rate of South Africa. He used quarterly data for the period 1978 to 2000 to show that total employment and sectoral employment flows are related to the business cycle. In this context, he applied an autoregressive equation incorporating two explanatory factors representative of the state of the economy, using a Markov model with regime changes. Moolman also highlighted that knowledge of the asymmetric behavior of unemployment is of importance for short-term economic stabilization policies.

The data analysis above in section 2 has shown that the unemployment rates for the two Caribbean economies are characterized by asymmetric behavior with ascending and descending phases. Thus applying linear models to these series would be inappropriate for representing the unemployment dynamics. Consequently the next subsection is dedicated to discussing two main classes of regime switching models: the threshold and Markov processes.

4.2.1. An Overview of the Threshold Process

One proposed specification aimed at better understanding the instability in the level of the average economic series that do not have the linear representations of the ARMA are threshold models. These latter models allow switching from one system to another according to a threshold value given by an observable variable. The literature on this class of models is divided into two main categories: models with abrupt transition from one regime to another introduced by Chan and Tong (1986), called the Threshold Autoregressive (TAR) processes, and the smooth transition models in which regime changes are made more gradually (Smooth Threshold Autoregressive (STAR) processes).

To illustrate these processes let X_t, the variable of interest, be governed by a two-regime TAR model of orders p_1 and p_2 if and only if:

$$X_t = \begin{cases} \phi_{0,1} + \phi_{1,1} Z_{t-1} + \ldots + \phi_{p_1,1} Z_{t-p_1} + \varepsilon_{1t} & \text{if } s_t \le \lambda \\ \phi_{0,2} + \phi_{1,2} Z_{t-1} + \ldots + \phi_{p_2,2} Z_{t-p_2} + \varepsilon_{2t} & \text{if } s_t > \lambda \end{cases} \tag{4}$$

where s_t is the observable variable acting as a transition variable, Z_t is a vector of exogenous variables, the parameter λ is the threshold and $\varepsilon_t \sim N(0;\sigma_\varepsilon^2)$. By introducing an indicator variable I (I (A) =1 if it is true and 0 otherwise), the definition in Equation (4) becomes equivalent to the following expression:

$$\begin{aligned} X_t &= \left(\phi_{0,1} + \phi_{1,1} Z_{t-1} + \ldots + \phi_{p_1,1} Z_{t-p_1}\right)\left(1 - I(s_t \le \lambda)\right) \\ &\quad + \left(\phi_{0,2} + \phi_{1,2} Z_{t-1} + \ldots + \phi_{p_2,2} Z_{t-p_2}\right)\left(I(s_t > \lambda)\right) + \varepsilon_t \end{aligned} \tag{5}$$

A major difficulty with this approach is the choice of the indicator variable since an incorrect selection can cause severe consequences in the dynamics of the variable. In practice, the alternatives suggested are an exogenous variable, a lagged endogenous variable or a combination of non-lagged dependent variables. When the selection is an endogenous variable ($s_t = X_{t-d}$), the TAR model becomes a SETAR (Self-Exciting Threshold Autoregressive) model. Thus, in these linear piecewise specifications, the transition from one regime to another is abrupt, as long as s_t is below (above) λ and, the process generating the values of X_t change, even if slightly.

It should be clear from the above that determining the threshold, λ, is very important. The threshold value also provides an initial economic interpretation of the regimes defining the dynamics of the process. In the case where λ =0, the two regimes are well known, that is, they are positive and negative growth.

To allow for a more gradual transition from one regime to another, Teräsvirta and Anderson (1992), Granger and Teräsvirta (1993) and Teräsvirta (1994) proposed a generalization of the TAR model, called the STAR model in which a continuous function, bounded between 0 and 1, is substituted for the indicator function. A STAR specification with two regimes is defined by the following equation:

$$\begin{aligned} X_t &= \left(\phi_{0,1} + \phi_{1,1} X_{t-1} + \ldots + \phi_{p_1,1} X_{t-p_1}\right)\left(1 - F(s_t,\lambda,\gamma)\right) \\ &\quad + \left(\phi_{0,2} + \phi_{1,2} X_{t-1} + \ldots + \phi_{p_2,2} X_{t-p_2}\right)\left(F(s_t,\lambda,\gamma)\right) + \varepsilon_t \end{aligned} \tag{6}$$

F is the transition function associated with s_t and λ is as defined above. F also depends on the smoothing parameter γ that measures the speed of transition: the higher it is the more abrupt the transition.

In reviewing the STAR literature, Uctum (2007) mentioned two distinct specifications, the logistic STAR (LSTAR) and the exponential STAR (ESTAR), so called because the transition functions are based on the logistic function ($F_L(s_t,\lambda,\gamma) = \left(1 + e^{-\gamma(s_t-\lambda)}\right)^{-1}, \gamma > 0$) and the exponential function (($F_E(s_t,\lambda,\gamma) = \left(1 - e^{-\gamma(s_t-\lambda)^2}\right), \gamma > 0$), respectively. These two specifications have different dynamics of the mean reversion process. The logistic function implies an asymmetric adjustment of the series, X_t; accordingly the values are associated with positive or negative deviations of s_t from the threshold λ. It is therefore sensitive to the signs of the deviations (sign effect). Conversely, the exponential function imposes a symmetric adjustment regardless of the sign of (s_t - λ); it is sensitive to the magnitude of the deviations (size effect) rather than the sign. In other words, when the STAR process is specified based on a logistic function, it is assumed that the positive and negative deviations of X_t return to their average levels with different speeds. On the contrary, in the case of the exponential function, the return is made with the same speed as the deviations are positive or negative.

With elements of the structure and characteristics of threshold models discussed, it remains to mention the steps of estimating their parameters. In the case of threshold models of the TAR family, these pitfalls are particularly important because of problems identifying the threshold variable. As Salem and Perraudin (2001) argued, the choice of the transition variable (or the delay parameter), and the threshold in a TAR model is not covered by conventional nonlinear methods, because the likelihood function is not differentiable with respect to these parameters. For the SETAR specification, identification and estimation of the parameters are usually conducted by comparing the log-likelihood function and the information criteria defined over all possible combinations of *d* and λ. Once their values are estimated, fixed parameters of the two regimes can be obtained by applying Ordinary Least Squares to the observations belonging to each regime. Regarding STAR models, many methods have been proposed in the literature to achieve phases of identification, estimation and statistical validation. Today, it seems to be a consensus around a three-step procedure as described by Téräsvirta and Anderson (1992), Teräsvirta (1994, 1998) and Van Dijk, Teräsvirta and Franses(2000).

4.2.1.1. First Step: Identification

This step is dedicated to selecting the optimal value of the delay parameter *d* which is based on the review of the information criteria (Teräsvirta, 1994). In addition, since the over and under-parameterization create significant problems (autocorrelation of errors in the case of under-parameterization and loss of model performance in the case of over-parameterization) it can be very useful to apply the criterion of significance (Kmax) in the estimated autoregression and tests of residual autocorrelation.

4.2.1.2. Second Step: Test for Linearity

The second step involves the evaluation of the hypothesis of linearity against the alternative of a STAR model. The literature now offers a wide range of tests that deliver evidence sufficient to conclude whether the study variable is linear or not. Most authors advocate testing the equality of coefficients between the two regimes $(\phi_{i,1} = \phi_{i,2}, \forall i)$ while determining the delay parameter, d, and the threshold, λ. For this, the least squares adjustments for linear and nonlinear relationships are built from the specification (6), and tests of equality of their variances are then made.

The presence of unidentified parameters under the null hypothesis makes inappropriate the standard laws of common statistical tests. The solutions developed by several authors have been to replace the transition function by a Taylor expansion to obtain regression equations for which the asymptotic theory becomes applicable. Lardic and Mignon (2002) and Van Dijk et al. (2002) outline the most popularly used tests, including, among other approaches, Tsay (1987), Luukkonen, Saikkonen and Teräsvirta (1988), Téräsvirta and Anderson (1992) and Escribano and Jorda (1999).

Currently, the procedure generally adopted to test the non-linearity is based on calculating Lagrange multiplier statistics derived from the following auxiliary regression:

$$X_t = \phi_0 + \sum_{i=1}^{p}\phi_{1,i}X_{t-i} + \sum_{i=1}^{p}\phi_{2,i}X_{t-i}X_{t-d} + \sum_{i=1}^{p}\phi_{3,i}X_{t-i}X_{t-d}^2 + \sum_{i=1}^{p}\phi_{4,i}X_{t-i}X_{t-d}^3 + \eta_t \quad (7)$$

The null hypothesis is linearity and can be written as $H_{01}: \phi_{2,i} = \phi_{3,i} = \phi_{4,i} = 0 \ \forall i = 1,...,p$. More precisely, the estimation of Equation (7) is implemented for different values of d, $1 \le d \le D$, and the LM (d) statistics obtained. The value of d for which linearity is rejected most strongly is retained. In fact, it should be noted that one has to consider variants of the regression model (7) and determine the values of various expressions of the LM(d) statistics. Indeed, by introducing the Taylor expansions of different orders of the transition function the statistics $\mathrm{LM_i(d)} = \frac{\mathrm{T}(\mathrm{SCR}_0 - SCR_i)}{SCR_0}; i = 1,2,3,4$ or SCR_0 which is the sum of squares of the estimated residuals for the AR model and SCR_i the sum of squares of estimated residuals from Equation (7) or its variants can be derived. Thus, using the logistic function to test linearity against the alternative LSTAR model, the LM_1 and LM_3 corresponding to respectively the Taylor expansion of order 1 and order 3 is obtained. In this case, SCR_1 is associated with all regressors in linear form $\{1, X_{t-i}, X_{t-i}X_{t-d}\}$ and SCR_3 is related to the entire set of linear and nonlinear explanatory variables $\{1, X_{t-i}, X_{t-i}X_{t-d}, X_{t-i}X_{t-d}^2, X_{t-i}X_{t-d}^3\}$ (Luukkonen et al., 1988)). Concerning the exponential function to test linearity against the alternative of an ESTAR model, the statistic LM_2 which comes from the Taylor expansion of order 1 is obtained (Saikkonen and Luukkonen, 1988)). Similarly, LM_2 is calculated in the same way as the quantities $LM_1$and LM_3. By introducing a Taylor expansion of order 2 Escribano and Jorda (1999) proposed a more robust test statistic - LM_4 - which is estimated like the preceding statistics.

It is also important to remember that the LM (d) statistics admit an asymptotic distribution under the null hypothesis of linearity and for small sample sizes it is preferable to use versions of the Fischer test which have good power properties. Fischer statistics $\mathrm{LM_i(d)} = \frac{(\mathrm{SCR}_0 - SCR_1)/v_1}{SCR_0 / v_2}; i = 1,2,3,4$ are calculated with v_1 and v_2 as the appropriate numbers of degrees of freedom.

The final step in testing for linearity comes after the rejection of linearity. It is dedicated to the choice between the ESTAR and LSTAR models and is conducted on the basis of a series of nested hypotheses:

$H_{04}: \phi_{4,i} = 0 \ i = 1,...,p$

$H_{03}: \phi_{3,i} = 0 / \phi_{4,i} = 0 \ i = 1,...,p$

$H_{02}: \phi_{2,i} = 0 / \phi_{3,i} = \phi_{4,i} = 0 \ i = 1,...,p$.

The decision rule is as follows:

- The rejection of $H_{04}: \phi_{4,i} = 0$ allows one to accept the selection of LSTAR specification.
- When H_{04} is accepted, proceed to test the hypothesis $H_{03}: \phi_{3,i} = 0; \phi_{4,i} = 0$. If rejected the conclusion is the validation of the ESTAR specification.
- If $H_{03}: \phi_{3,i} = 0; \phi_{4,i} = 0$ is accepted, go and test $H_{02}: \phi_{2,i} = 0; \phi_{3,i} = \phi_{4,i} = 0$. The rejection of this hypothesis allows one then to conclude in favor of a LSTAR specification.

As an alternative approach to decide on the appropriate form of the transition function, Escribano and Jorda (1999) have opted for a solution based on the application of two separate tests instead of a single hypothesis test. For this, they evaluate the assumptions $H_{0E}: \phi_{2,i} = \phi_{4,i} = 0 \ i = 1,...,p$ and $H_{0L}: \phi_{1,i} = \phi_{3,i} = 0 \ i = 1,...,p$ and accept the

LSTAR model (ESTAR) if the highest value of the Fischer statistic is obtained for H_{0E} (H_{0L}).

4.2.1.3. Step Three: Estimation

In contrast to the previous step of identification, a more systematic approach can be used to estimate the selected model. Of course, once the transition function and the transition variable have been determined, nonlinear least squares estimators can be computed by applying an iterative numerical optimization algorithm. Several estimation strategies can be employed (see Teräsvirta (1994), van Dijk, Terasvirta and Franses (2002) and Uctum (2007)). However, it is difficult to validate their content. Indeed, in practice the complexity of estimating parameters of the STAR model are linked to the inherent difficulty of properly selecting the threshold variable (see Uctum (2007, p. 454). For example, regarding the estimation of the transition parameters γ and λ, Tsay (2005, p. 163) notes that "experience shows that the transition parameters γ and λ of a STAR model are hard to estimate. In particular, most empirical studies show that standard errors of the estimates of γ and λ are often quite large, resulting in t-ratios of about 1.0 ".

It is also important to add that the nature of the data that these models depend on has an impact on the quality of the results of the econometric adjustment operations. For instance, whether good or bad results of estimating specification (6) are obtained depend on if the series of interest are in levels, differences or deviation from trend. The empirical literature on the unemployment rate suggests that all of these prior transformations are used from time to time. For example, Rothman (1998) considered several nonlinear models on level data, deviation from a linear trend and filtered by applying the Hildeth and Prescod method. Skalin and Teräsvirta (2002) conducted their modeling effort directly on the raw quarterly data of 11 OECD countries, not seasonally adjusted. Similarly, Akram (2005) has identified these types of data adjustments when estimating LSTAR models. In more recent articles such as that of Franchi and Ordóñez (2009), the authors apply LSTAR models for Spain directly on raw data prior to retaining the assumption of stationarity of the unemployment rate around multiple structural changes.

4.2.2. Empirical Results

To implement the nonlinear time series models within the R platform, tsDyn, TSA and BayStar software packages are the most utilized in the literature (see Antonio et al. (2008)). In this paper, the tsDyn package developed by Antonio et al. (2008) and the less known but very powerful RSTAR library propounded by Balcılar Mehmet (2009) are used.

4.2.2.1 Identification

In the tradition of modeling linear stochastic processes AR models that best represent the unemployment rate series are selected and estimated in first differences using the software programme EVIEWS. The model selection criteria employed are the Akaike (AIC) and Baysian (BIC) methods along with several statistical validation tests, especially those related to the behavior of non-autocorrelation, homoscedasticity and Gaussian noise. The AR models that gave the best performances are respectively AR (3) for Barbados and AR (4) for Trinidad and Tobago (see Table 4).

Table 4: Estimation Results for the AR Models for Barbados and Trinidad and Tobago

	Barbados		Trinidad and Tobago	
Variables	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
C	0.016278	0.152671	-0.048691	-0.7229
AR(1)	-0.225629	-2.687759*		
AR(2)	0.094518	1.202867	0.175040	2.180046**
AR(3)	0.209730	2.859198**		
AR(4)			-0.143233	-1.79338*
Adjusted R^2	0.097504		0.030840	
Durbin-Watson	2.004771		1.872716	

Note : Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

4.2.2.1. Tests of Linearity

The unit root tests discussed in section 4.1 provided information on the stationary properties of the unemployment rates but not on their linearity. These series should therefore be placed in the general LM testing framework explained above. To this end, the package RSTAR (Balcilar Mehmet (2009)) which has the advantage of being able to implement many of the methods proposed by Van Dijk, Teräsvirta and Franses (2002) is used. Thus, LM1, LM2, LM3, and $LM3^e$ and LM4 calculated by RSTAR correspond in sequence to the statistics LM_1, LM_2, LM_3, LM_3^e (economy version of LM3) and LM_4. Similarly, other statistics (such as LM.S2, LM.S3, LM.S4, LM.H1, etc...) are available to allow verification of various assumptions) of the STAR model such as the presence of residual autocorrelation and invariance of parameters. These LM statistics are obtained for each value of the delay parameter d over the interval $1 \leq d \leq 5$. The results are shown in Tables 5 to 8 which contain only the p-value, the probability of wrongly rejecting the null hypothesis of linearity. Based on these p-values, particularly those related to LM3 and LM4, it can be deduce that the: (i) LSTAR representation is preferred for Barbados, with the transition variable corresponding to the delay d=2 (ΔU_BDOS_{t-2}); (ii) ESTAR specification best suit the unemployment rate of Trinidad and Tobago, with the transition variable also associated with d=2 (ΔU_TT_{t-2}); (iii) conclusions of the LM.1 to LM.4 tests are corroborated by the Escribano and Jorda (1999) statistics: for Barbados, the hypothesis H_{0L} has smaller p-values compared to H_{0E} for almost all values of d while the reverse is true for Trinidad and Tobago and (iv) specification choices are consistent with the stylized facts found for the unemployment rates presented in Section 2. Specifically the asymmetric dynamics of the unemployment rate for Barbados is consistent with a logistic transition function while Trinidad and Tobago rate can be identified with an exponential transition framework.

Table 5: Results of the LM-STR Test for Linearity for Barbados

Tests Standards				
Transition Variable	**LM.1**	**LM.3**	**LM.3e**	**LM.4**
$d = 1$	0.016068	0.055052	0.030404	0.119204
$d = 2$	0.359984	0.046613	0.305071	0.096848
$d = 3$	0.056985	0.076594	0.046375	0.060014
$d = 4$	0.015960	0.162872	0.049053	0.132826
$d = 5$	0.726523	0.782919	0.752094	0.721534

Table 6: Results of the LM-STR Test for STAR Model Selection for Barbados

Tests of Escribano and Jordà		
Transition Variable	**LM.HL**	**LM.HE**
d = 1	0.061916	0.887528
d = 2	0.096524	0.312406
d = 3	0.334238	0.338654
d = 4	0.400247	0.627077
d = 5	0.996924	0.398938

Table7: Results of the LM-STR Test for Linearity for Trinidad and Tobago

Tests Standards				
Transition Variable	**LM.1**	**LM.3**	**LM.3e**	**LM.4**
d = 1	0.023392	0.003665	0.041605	0.000938
d = 2	0.004605	0.000276	0.008514	0.000031
d = 3	0.060372	0.004876	0.107742	0.007081
d = 4	0.001121	0.000445	0.002759	0.001604
d = 5	0.007468	0.001756	0.009154	0.004452

Table 8: Results of the LM-STR Test for STAR Model Selection for Trinidad and Tobago

Tests of Escribano and Jordà		
Transition Variable	**LM.HL**	**LM.HE**
d = 1	0.006362	0.003799
d = 2	0.028857	0.000166
d = 3	0.008213	0.108603
d = 4	0.021996	0.421693
d = 5	0.001875	0.133126

4.2.2.3. Estimation of the STAR Models

The STAR models that best represent the nonlinear behavior of the unemployment variables were chosen based on the information criteria AIC, BIC and HQ but especially on the significant values of the two parameters γ and λ (see Tables 9 to 11 and Figures 2 and 3). At first reading, note that the AR coefficients are statistically significant in the vast majority of cases. It is also clear that the STAR models are an improvement over the AR models previously considered. In particular: (i) the parameters γ and λ directly associated with non-linearity are greatly significant, confirming the nonlinear dynamics of the variables ΔU_BDOS_t and ΔU_TT_t (ii) the two selected models show lower values for the information criteria AIC and HQ; (iii) the threshold parameter λ with estimated values of -0.1216 and -0.0162 respectively for Barbados and Trinidad and Tobago match the actual values of the series (they are in effect between the minimum and maximum values of ΔU_BDOS_t and ΔU_TT_t)); (iv) the calculated values of γ (66.95 to 36.91 for Barbados and Trinidad and Tobago) are high relative to Franchi and Ordonez (2009) study on Spain and Skalin and Teräsvirta (2002) research on Austria, Denmark, Finland, Germany, Italy, Norway and Sweden, who found values of 2.23, 13.37, 2.87, 4.29, 11.56, 93.98 and 1.95, respectively. The Caribbean results suggest that switching from one regime to another is abrupt and rapid. It should be noted however that the LSTAR specifications used are not always the same neither are the explanatory variables.

In the case of Barbados, a detailed examination of the statistical validation of the estimated parameters (Tables 9 and 11) led to the conclusion that the LSTAR model is an adequate characterization of the data generation process. On the basis of methodological concepts established by several authors and well summarized by van Dijk, Terasvirta and Frances (2002), a thorough evaluation of the results of estimating the model using various misspecification tests of STAR model was also conducted. These tests relate to those for non residual autocorrelation, nonlinearity and stability of the parameters. The results reproduced in Appendix 2-A are satisfactory insofar as they support the absence of residual autocorrelation and linearity as well as the constancy of parameters.

As regards the empirical results for Trinidad and Tobago, they confirm that the ESTAR specification is appropriate to reproduce the regime changes that characterize the variations in the unemployment rate. To corroborate this specification, it should be noted that numerous attempts were made to estimate a logistic STAR model. For all latter specifications tested, the estimators calculated were statistically insignificant. The results of Appendix 2-B which describes the misspecification tests for the ESTAR model conclude that the model is well specified and has overall good residual statistical properties. The threshold value close to zero suggests that the dynamics of the series ΔU_TT_t assumes a regime of positive growth and a regime of negative growth.

The estimated transition function for Barbados is described by the two curves in Figure 2. The first is plotted against time and the second based on the transition variable. It is observed that variations in the unemployment rates adjust quickly between low speed (for which $F_L(s_t, \lambda, \gamma) = 0$) and the high regime ($F_L(s_t, \lambda, \gamma) = 1$). Figure 2-A shows clearly that the series ΔU_BDOS_t is mostly in the scheme above, with 53.24 percent of the observations of ΔU_BDOS_t satisfying $\Delta U\_BDOS_t > -0.1216$. Figures 3 which reproduce the transition function of Trinidad and Tobago show different profiles. However, they indicate that variations in unemployment are more often located on the lower end when compared to those of Barbados and change their values more frequently. Figure 3-B revealed the expected finding of an exponential transition function: the majority of observations is distributed symmetrically around the equilibrium value of -0.0162. Indeed 51.55 percent of observations of ΔU_TT_t satisfy $\Delta U\_TT_t < -0.0162$. Also note that like Barbados, this transition function reaches unity, indicating a relatively abrupt transition between regimes.

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Table 9: LSTAR Model for Barbados (Dependent Variable : ΔU_BDOS_t)

	Coefficient	S.D.	t-value	p-value
		Linear part		
constant	0.041859	0.026449	1.583	0.113507
AR_1(1)	0.072184	0.077493	0.931	0.351596
AR_1(2)	0.186576	0.111948	1.667	0.095589 .
AR_1(3)	0.265770	0.090055	2.951	0.003166 **
		Non linear part (transition variable : ΔU_BDOS_{t-2})		
Gamma	66.956334	91.566360	0.731	0.464637
Treshold	-0.121676	0.002794	-43.546	< 2e-16 ***
constant	-0.048961	0.027893	-1.755	0.079211 .
AR_2(1)	-0.418137	0.120176	-3.479	0.000503 ***

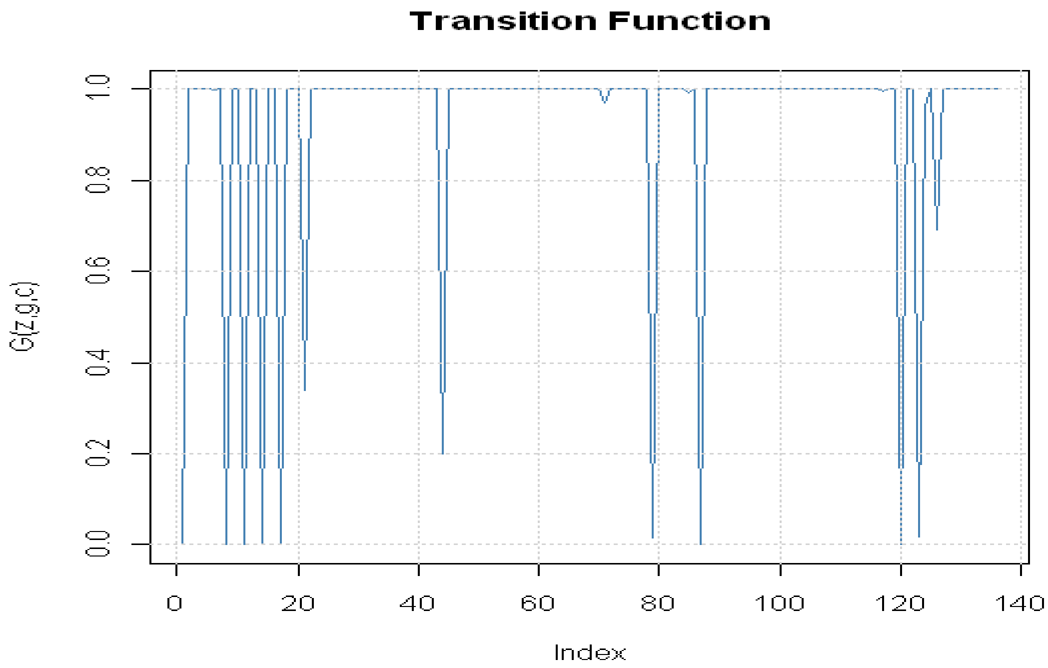
Note : Significant Codes are 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Table 10: LSTAR Model for Trinidad and Tobago (Dependent Variable : ΔU_TT_t)

	Coefficient	**S.D.**	**t-value**	**p-value**
		Linear part		
constant	-0.001421	0.008079	-0.176	0.860434
AR_1(1)	0.363297	0.136784	2.656	0.007908 **
AR_1(2)	0.498707	0.234787	2.124	0.033663 *
AR_1(3)	-0.358307	0.163672	-2.189	0.028584 *
AR_1(4)	-0.443545	0.163532	-0.081	0.006682 **
		Non linear part (transition variable : ΔU_TT_{t-2})		
γ	36.912784	19.325991	1.910	0.056132.
λ	-0.016269	0.006664	-2.441	0.014639 *
constant	-0.001433	0.017752	-0.081	0.935653
AR_2(1)	-0.841824	0.285963	-2.944	0.003242 **
AR_2(2)	-0.518668	0.283175	-1.832	0.067008 .
AR_2(3)	0.995471	0.264563	3.763	0.000168 ***
AR_2(4)	0.762111	0.325129	2.344	0.019077 *

Note : Significant Codes are 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Figure 2: Graphs for Barbados



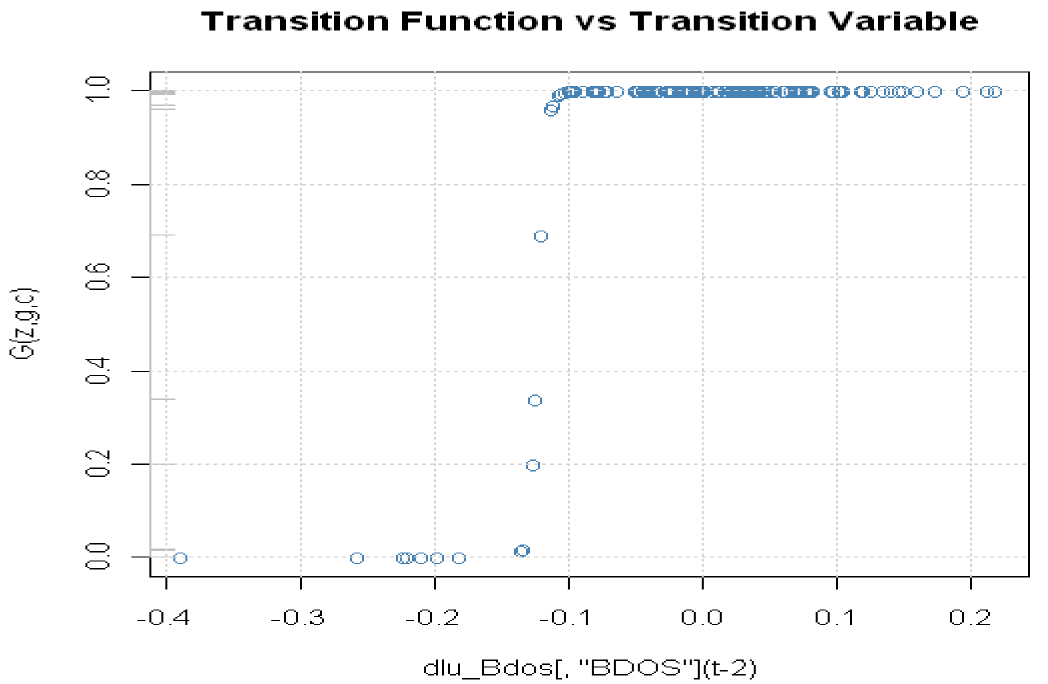
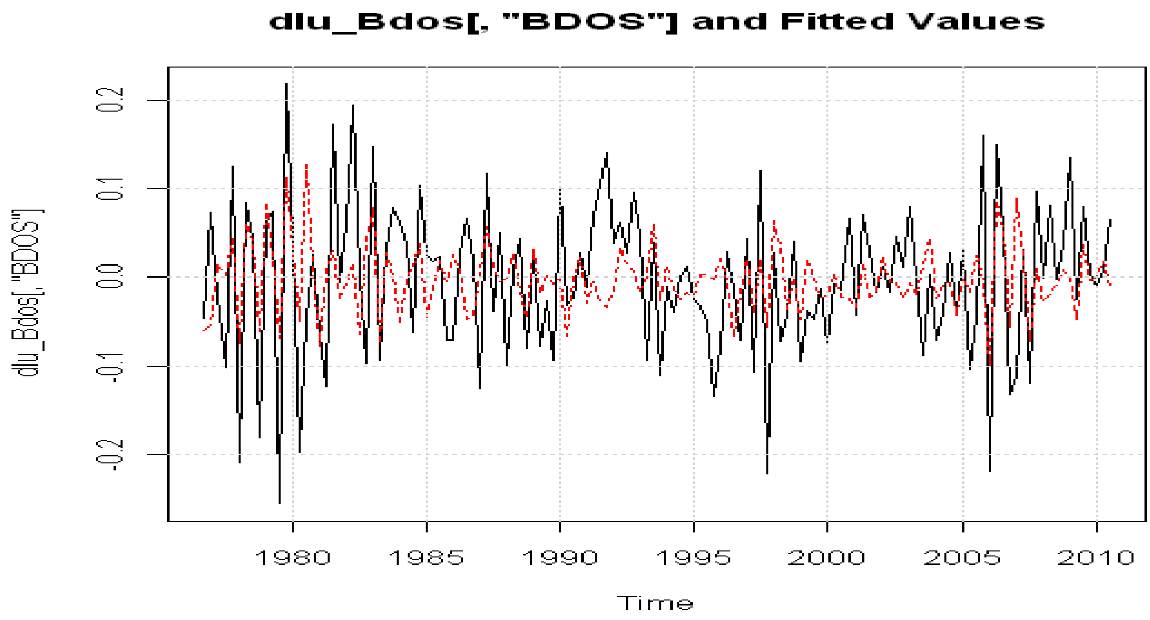
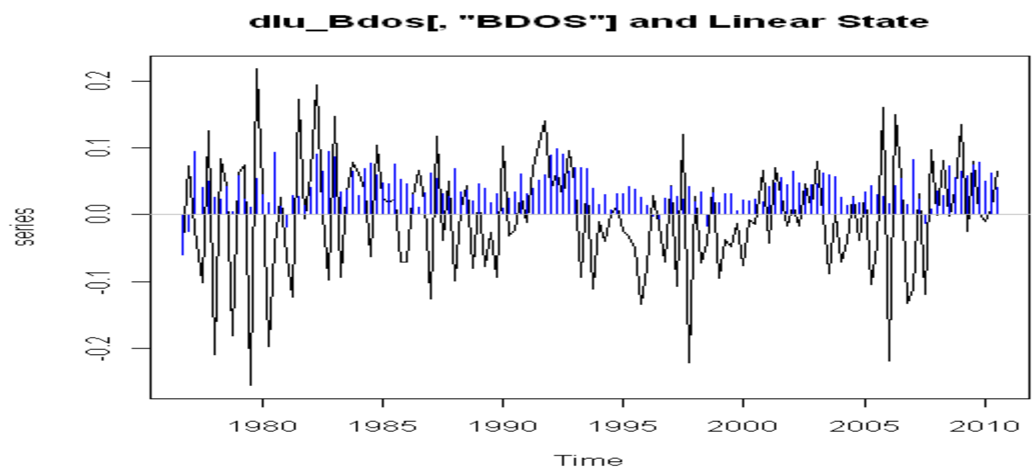


Figure 2: Graphs for Barbados (Cont'd)





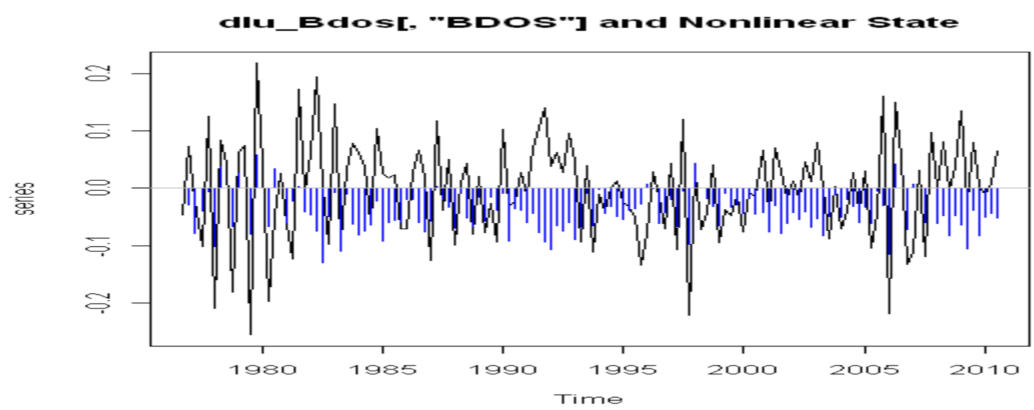
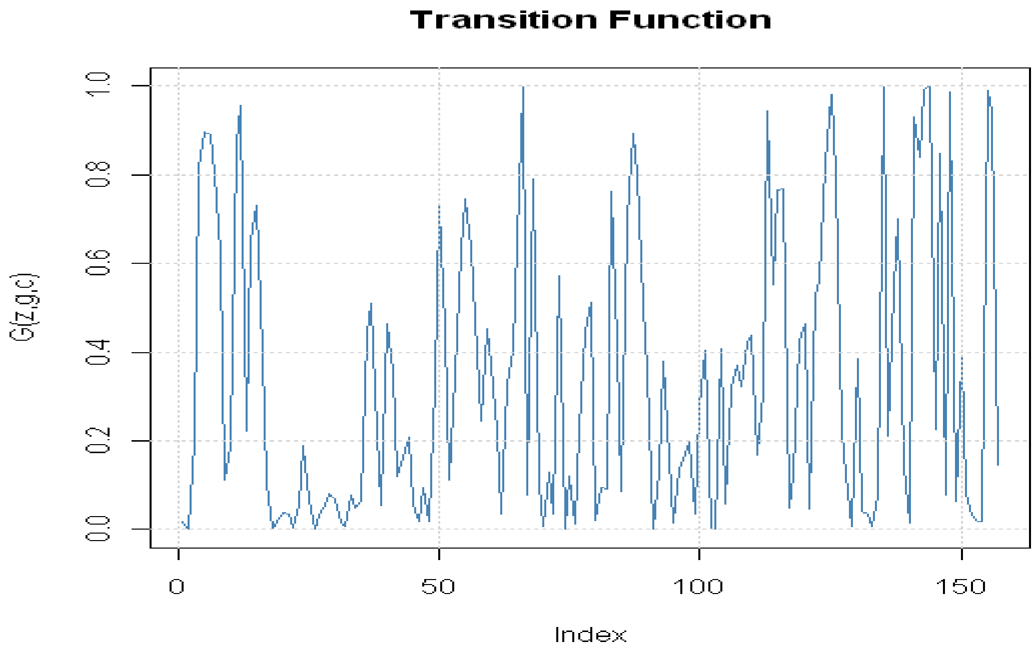


Figure 3: Graphs for Trinidad and Tobago



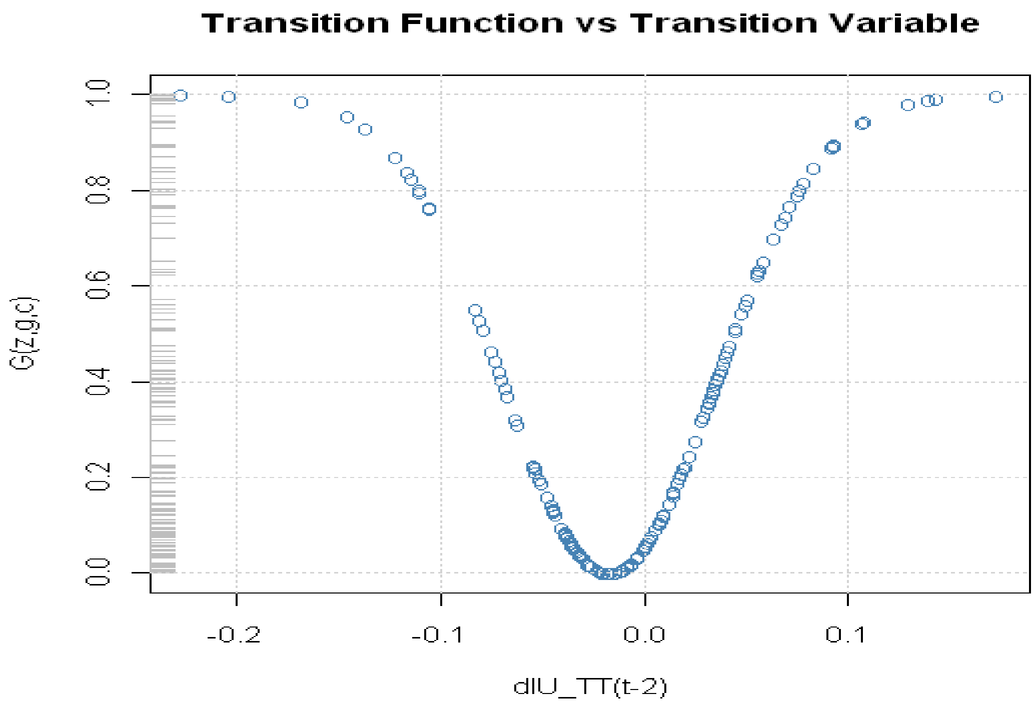
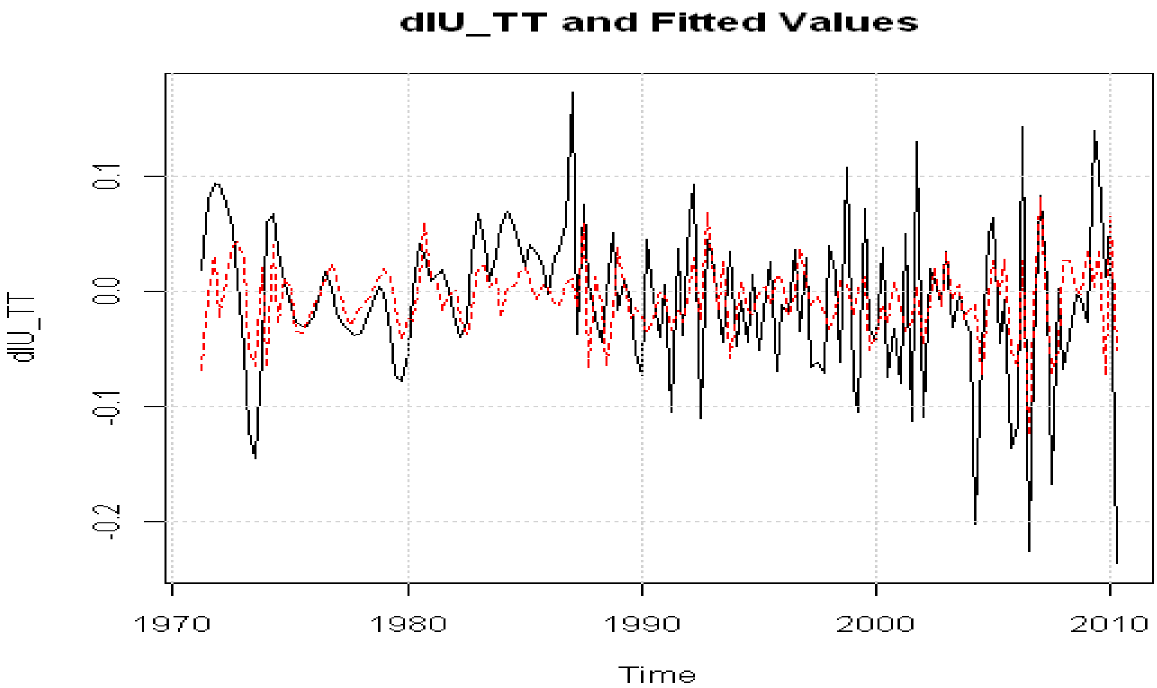
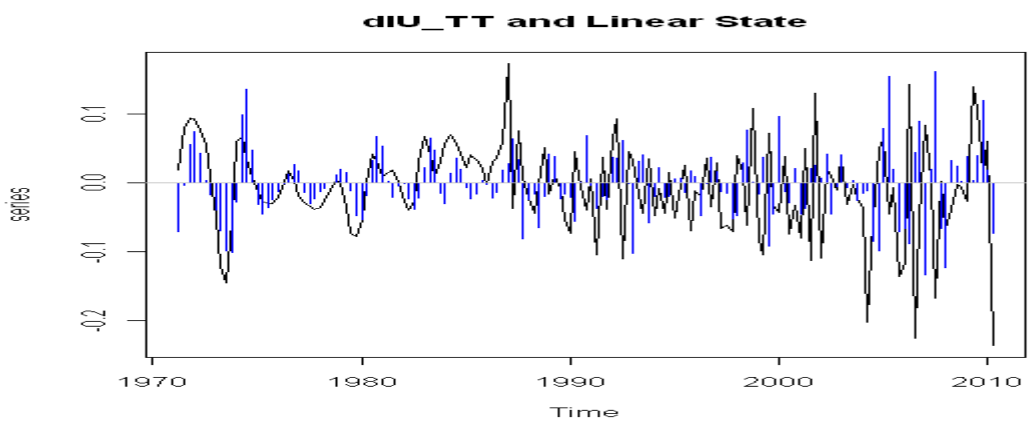
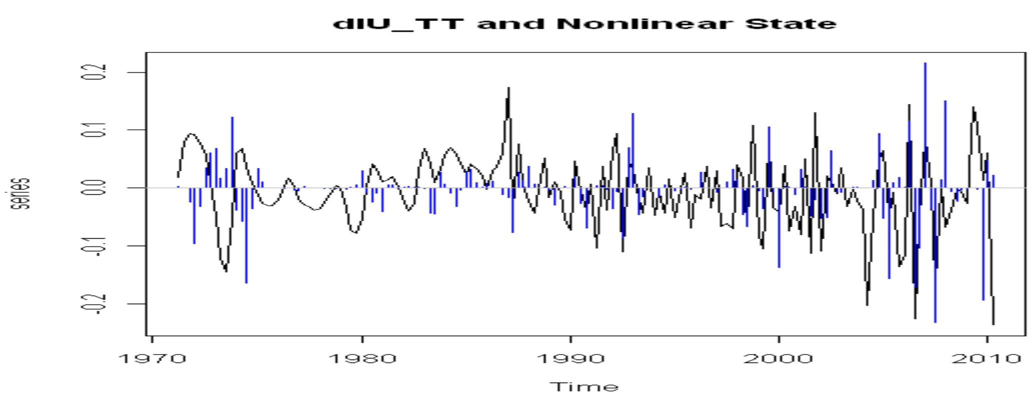


Figure 3: Graphs for Trinidad and Tobago (Cont'd)







The concepts presented and discussed in the preceding paragraphs provide some insight into the dynamic behavior of deviations of the unemployment rates in Barbados and Trinidad and Tobago. To understand more fully the dynamic properties of these series and the associated STAR models, it is useful to study the response functions that estimate the impacts and future behavior of a variable following a shock. Stressing that the analysis of shocks in terms of permanent or transitory effect lose their meaning in the non-linear case, several authors have developed the notion of a generalized impulse response function (GIRF) (see Pesaran and Shin (1999), Teräsvirta and Skalin (2002) and Van Dijk et al. (2007)). Here, as in most applications made in the literature, the GIRFs are simulated by considering the observations of the time series as "historic" and then shock the residuals of the STAR model. When GIRF converges to a point in time, the stability of the model is accepted.

The GIRF estimated for the unemployment series ΔU_BDOS_t and ΔU_TT_t are reproduced in Appendix 1. The profile graphs of 1-A indicate that the GIRF validate the stability of the LSTAR model for Barbados. Stability is also confirmed for the ESTAR model in the case of Trinidad and Tobago, although it is much weaker for the latter (see Figures 1-B). Specifically, in absolute values, the levels attained by the GIRF lead to the conclusion that deviations of unemployment tend to adjust more quickly in Barbados than for Trinidad and Tobago. Also note that the impact of a positive shock is characterized by positive responses in the first quarters of ΔU_BDOS_t, meaning that unemployment increases after the shock. In the case of ΔU_TT_t the responses are alternated. For both series, the responses are broadly balanced by the positive or negative shocks.

5. Conclusion

For several decades, unemployment has emerged as one of the important concerns of policy makers in many countries of the Caribbean Basin. With values that can represent up to twice the levels in the OECD and other European countries, the identification and implementation arrangements for employment is of an even higher priority in these small open countries as the performance of their labor markets is often considered to be very poor. Faced with this situation, it is surprising to note the inadequate number of comprehensive studies on the characteristics and modeling of unemployment in the Caribbean.

To contribute to the literature on this topic, this article undertakes an econometric analysis of the phenomenon of hysteresis in unemployment using relatively high frequency time series data. On this basis quarterly unemployment rates for Barbados and Trinidad and Tobago are the indicators selected over the post 1970 period. The existence of a unit root in these series are checked and the results confirmed the hypothesis of hysteresis demonstrated in previous studies, with shocks to the level of unemployment rates that have a lasting effect in their developments. Next, it is shown that non-linear processes like the STAR model are more appropriate than the linear AR models to reproduce the asymmetry and persistence characterizing unemployment data in the two Caribbean countries examined. More specifically, the rejection of the assumption of linearity in favor of the alternative non-linear STAR is highlighted and the superiority of the latter relative to linear models. Also the paper demonstrates the existence of two equilibria in the dynamic series of differentiated rates of unemployment and the relatively rapid transition from one regime to another.

For Barbados, an LSTAR model which allows for asymmetric deviations of unemployment from its equilibrium level is preferred while in the case of Trinidad and Tobago, an ESTAR specification which reproduces a dynamic series of differential unemployment rate around a system of positive growth and a regime of negative growth is selected.

It is indisputable that the results of this paper provide information of great interest for policy makers in the fight against unemployment. Indeed, the findings made on the characteristics and behavior of asymmetric time series of unemployment rates can be used for the implementation of control measures for employment. In many leading countries, such information is used in the preparation of action plans to maintain and increase structural and cyclical employment especially when there is a need to amplify the process of job creation during the phases of economic growth or, conversely, when it is important to limit job losses during periods of economic recession.

References

[1] Ball L. and M. Hofstetter, 2009. "Unemployment in Latin America and the Caribbean", *Working Paper,* Universidad de los Andes, October.

[2] Borda P. (2000), "De L'effet D'hystérèse sur le Taux De Chômage en Guadeloupe", in Maurin A. and J.G. Montauban, 2000, *Exclusion, Croissance et Développement. La Guadeloupe Entre Défis, Incertitudes et Espoirs*, Economica.

[3] Borda P. and N. Mamingi, 2009. "Structural Shocks and Labor Market Dynamics in a Small Open-Economy: Theory and Some Evidence", Caribbean Centre for Money and Finance, 41st Annual Monetary Studies Conference, November 10-13, Georgetown Guyana.

[4] Blanchard O.J. and L.H.Summers, 1986. "Hystérésis and the European Unemployment Problem", *NBER Macroeconomics Annual,* Cambridge: MIT Press.

[5] Blanchard, O., 2005. "European Unemployment: The Evolution of Facts and Ideas", *NBER Working Paper Series,* No.11750.

[6] Cuestas J. and L.A. Gil-Alana, 2011. "Unemployment Hysteresis, Structural Changes, Non-Linearities and Fractional Integration in European Transition Economies", Sheffield Economic Research Paper Series, University of Sheffield, United Kingdom.

[7] Cheng-Feng Lee, 2010. "Testing For Unemployment Hysteresis in Nonlinear Heterogeneous Panels: International Evidence", *Economic Modeling,* 27, pp. 1097-1102.

[8] van Dijk, D. Terasvirta, T. and P.H. Franses, 2002. "Smooth Transition Autoregressive Models: A Survey of Recent Developments", *Econometric Reviews*, 21, pp. 1-47.

[9] Elmeçkov J. and M. MacFarlan, 1993. "Persistance du Chômage, Revue Economique De L'OCDE". No. 21. Hiver.

[10] Fouquau J., 2008. "Modèles a Changements de Régimes et Données de Panel : De la Non-linéarité a L'hétérogénéité", Thèse de Doctorat, Université D'Orléans.

[11] Franses P.H., 2004. *Time Series Models for Business and Economic Forecasting*, Cambridge.

[12] Franchi M and J., Ordóñez, 2009. "Multiple Equilibria in Spanish Unemployment", *Working paper*, Università di Roma, La Sapienza.

[13] Granger, C. W. J. and T. Teräsvirta, 1993. *Modeling Nonlinear Economic Relationships*, Oxford University Press, Oxford.

[14] INSEE, 2011. http://www.oecd.org/document/34/0,3746, en_2649_37457_40917154_1_1_1_37457,00.html.

[15] Keynes J.M., 1936. "Théorie Générale de L'emploi, de L'intérêt et de la Monnaie", *Editions Payot*, 384.

[16] Kaetanios, G., A. Snell and Y. Shin, 2003. "Testing For Unit Root in the Nonlinear STAR Framework" *Journal of Econometrics,* 112, pp. 359-379.

[17] MacKinnon, James G., 1996. "Numerical Distribution Functions for Unit Root and Co-integration Tests," *Journal of Applied Econometrics*, 11, pp. 601-618.

[18] Moolman, Elna, 2003. "Asymmetric in the Cyclical Behavior of the South African Labor Market", *South African Journal of Labor Relations,* Autumn.

[19] Maddala, G. S., 1991. "Disequilibrium Modeling, Switching Regressions, and their Relationship to Structural Change", in P. Hackl and A. H. Westlund (éds), *Economic Structural Change : Analysis and Forecasting*, Springer, New York, Berlin, London andTokyo, pp. 159-168.

[20] Neftçi, S., 1984. "Are Economic Time Series Asymmetric Over the Business Cycle? ", *Journal of Political Economy*, 92, pp. 307–328.

[21] Louis, Phaneuf 1988. "Hystérésis du Chômage: Faits, Théories et Politiques", *L'Actualité économique*, 64, pp. 509-531.

[22] Rothman, P., 1991. "Further Evidence on the Asymmetric Behavior of Unemployment Rates Over the Business Cycle", *Journal of Macroeconometrics* 13, pp. 291–298.

[23] Sidiropoulos, S. and J. Trabelsi, 2001. "Les Chocs Monétaires et la Persistance du Taux De Chômage", *Économie et Prévision,* No. 148.

[24] Teräsvirta, T., 1994. "Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models", *Journal of the American Statistical Association*, 89, pp. 208-218.

[25] Teräsvirta, T. and H. M. Anderson, 1992. "Characterizing Nonlinearities in Business Cycles Using Smooth Transition Autoregressive Models", *Journal of Applied Econometrics*, 7, S119-S136.

[26] Teräsvirta T. and J. Skalin, 2002. "Modeling Asymmetries and Moving Equilibria in Unemployment Rates", *Macroeconomic Dynamics,* 6, pp. 202-241.

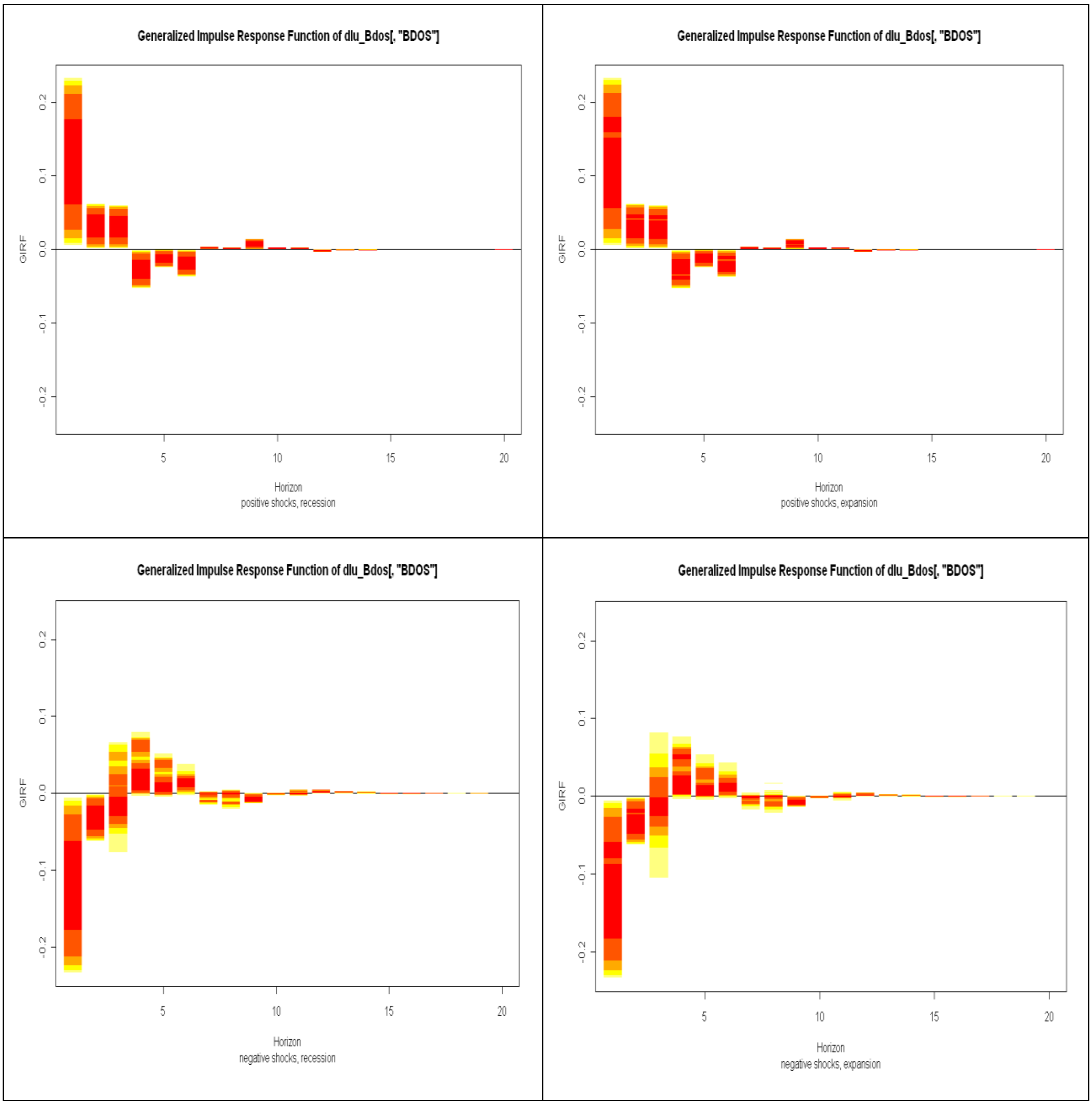
[27] Trabelsi J., 1997. "Les Tests de Racine Unitaire et les Modèles ARCH: Application au Taux de Chômage", *Economie et Prévision,* No.131.

[28] Tsay R., 2005. *Analysis of Financial Time Series,* John Wiley & Sons, Inc.

[29] Uctum R., 2007. "Econométrie des Modèles a Changement de Régimes: Un Essai de Synthèse", *L'actualité économique*.

Appendix 1

A. Generalized Impulse Response Function for Barbados



B. Generalized Impulse Response Function for Trinidad and Tobago