https://doi.org/10.52131/joe.2021.0302.0027

*i*RASD Journal of Economics

Volume 3, Number 2, 2021, Pages 80 – 92

Journal Home Page:
https://journals.internationalrasd.org/index.php/joe

A Revisit of the Unemployment Rate, Interest Rate, GDP Growth, and Inflation Rate of Pakistan: Whether Structural Break or Unit Root?

Sara Muhammadullah[1], Amena Urooj[2], Faridoon Khan[3]

[1] Department of Economics and Econometrics, Pakistan Institute of Development Economics, Islamabad, Pakistan, Email: saramuhammadullah@gmail.com

[2] Department of Economics and Econometrics, Pakistan Institute of Development Economics, Islamabad, Pakistan, Email: amna@pide.org.pk

[3] Department of Economics and Econometrics, Pakistan Institute of Development Economics, Islamabad, Pakistan, Email: faridoon.marwat@gmail.com

ARTICLE INFO

Article History:
Received: August 30, 2021
Revised: September 19, 2021
Accepted: September 20, 2021
Available Online: September 23, 2021

Keywords:
Step Indicator Saturation
Autometrics
Dummy Saturation model
Macroeconomic Variables

JEL Classification Codes:
L16, O13, Q15, Q43

ABSTRACT

The study investigates the query of structural break or unit root considering four macroeconomic indicators; unemployment rate, interest rate, GDP growth, and inflation rate of Pakistan. The previous studies create ambiguity regarding the stationarity and non-stationarity of these variables. We employ Zivot & Andrews (1992) unit root test and Step Indicator Saturation (SIS) method for multiple break detection in mean. GDP growth and inflation rate are stationary at level whereas unit root tests fail to reject the null hypothesis of the unemployment rate and interest rate at level. However, Zivot and Andrew unit root test with a single endogenous break indicates that the unemployment rate and interest rate are stationary at level with a single endogenous break. On the other hand, the SIS method reveals that the series are stationary with multiple structural breaks. It is inferred that it is inappropriate to take the first difference of the unemployment rate and interest rate to attain stationarity. The results of this study confirmed that there exist multiple breaks in the macroeconomic variables considered in the context of Pakistan.

Corresponding Author's Email: saramuhammadullah@gmail.com

1. Introduction

Since Perron (1989), it is now widely accepted that perceived persistence in macroeconomic indicators can be explained by unmodeled structural breaks in the underlying data process. As a result, even though data appears to be an I(1) process, it could be stationary due to one or more than one structural break. Perron (1989) considered standardized unit-root tests with an alternative trend-stationary hypothesis with a break in the trend, using Nelson–Plosser macroeconomic dataset, a postwar quarterly GDP variable with a break in the trend during the Great Depression of 1929 and Oil-Price Shock. The test indicates that the null hypothesis of the unit root test is rejected for the utmost of the series. However, the actual Data Generating Process (DGP) is stationary variations near a trend function with one structural break. Similarly, a variant of Perron (1989) test was investigated by Zivot & Andrews (1992) in which the break date is estimated rather than fixed (Jouini & Boutahar, 2005).

In econometrics literature, structural break detection in unit root test or model selection techniques has long been a center of attraction since primal. Technological advancement,

political instabilities, socioeconomic issues can alter the economic variables spontaneously or gradually due to the possible correlations between variables. In the late 1970s, the structural break is detected in parameter variability or parameter deviations in a final pre specified model. Chow (1960) preliminary work addressed structural break tests for a single known break. It tests equivalence in the coefficients of the regression model and a break detection mechanism. Quandt (1960) has also carried out an analysis of an unknown structural break detection. He conferred the constant-coefficient option, as well as an alternative with variations in error variance.

Several studies concentrated on the empirical and theoretical specifications of structural break test, beginning with Quandt (1960), Farley & Hinich (1970), Ploberger et al (1989), Ploberger & Krämer (1990), Perron (1989), Perron & Vogelsang (1992), Andrews (1993), (Hansen, 1992, 2012) and Jansen & Teräsvirta (1996). The Implication of these tests required that the model has to be previously specified. It is undoubtedly astute to test if significant structural breaks lead to parameter non-constancy. The obligation of the pre specified model discloses that the models might be defective and how to 'repair' them is unclear (Castle & Hendry, 2019). Usually, macroeconomic time-series variables are subject to multiple unidentified structural breaks. The Chow test is more effective for a single and known structural break. Usually, knowledge of the break timing, kind, or shift magnitude is unknown. Bai & Perron (1998) investigate various structural changes in a least-squares linear model. They suggest specific structural break tests without trending regressors and a selection technique established on a series of tests to consistently estimate the number of breaks. Bai & Perron (2006) test for multiple breaks is subject to certain restrictions: the technique is not valid for trending series and limited to a pre-defined fixed number of breaks. However, Indicator Saturation (IS) methods for structural break detection in the mean do not specify a particular restriction of a pre-defined fixed number of breaks.

The indicator saturation method simultaneously detects the breaks and estimates the model (Castle et al., 2015; Hendry et al., 2006). Among indicator saturation techniques Step Indicator Saturation (SIS) does not need earlier information of the locations of breaks, nor does it enforce a minimum break length (Castle et al., 2015b). SIS takes over the Chow test, as SIS does not implicate earlier information of the breakpoint. Indicator Saturation already dominates Bai & Perron (2006) test for multiple break detection, as shown in (Castle et al., 2012). Although choosing the data, one must ensure that some of the techniques developed by Castle et al (2015a) are for break detection in mean not valid with trending series. The empirical studies indicate that the inflation rate, interest rates, and the unemployment rate of Pakistan are I(1) series (Aqil et al., 2014; Arshad & Ali, 2016; Ayub et al., 2014; Maqbool et al., 2013; Shabbir et al., 2012). However, Alamro & Al-dalaien (2014) clearly stated that the unemployment rate is stationary at level. This study tries to clarify the ambiguity between the stationarity and non-stationarity of concern variables. The traditional unit root test does not reject the null hypothesis of unemployment rate and interest rate series with the 5% and 1% significance levels. History is evident that since independence, Pakistan has been engulfed with political and socioeconomic chaos, taking a toll on its economy. Hence, considered variables may retain breaks other than unit root as the concerned variables are detrend. Under the possible circumstances, we use the Zivot & Andrews (1992) unit root test and SIS techniques to check the possibilities of structural breaks.

It might be useful to review the significant historical events of Pakistan from 1947-2019 before starting the empirical analysis. The political uncertainty and absence of democracy have underprivileged the country for an uneven record of a long-term vision and continuity of economic policies. In 1960, a huge influx of American aid and political permanence enabled Pakistan to endure high growth rates (Khan, 2002; Zaidi, 2005). Following the 1965 Pakistan-India War, diminished foreign economic support forced the large-scale industry to grow at a slower rate of 10% per year from 1965 to 1970 (Hasan et al., 1997). Extremely severe socioeconomic conditions caused by the Pakistan-India war 1971, the East Pakistani territorial issue, and the empowerment of socialism by elected government (Hasan et al., 1997; Husain,

2000; Zaidi, 2005). Due to the oil price shock, there was an upsurge in Pakistan's import bill in October 1973. The diminishing growth rate prevailed until 2001. The growth rate declined to less than 4% per year due to the "the high public debt", an era of macroeconomic crises (Anjum & Sgro, 2017). Despite improvement in the growth rate 2004-05, as the growth rate was 8.6%, the following years were considered by growth slowdown, inflation upsurge, energy crisis, and declination in fiscal and balance of payments positions (Anjum & Sgro, 2017). In the enlightenment of preceding studies and to the best of my acquaintance, no such study applies the SIS Castle et al (2015b) for break detection and relates these significant breaks with historical events. This study aims to look into the empirical evidence of breaks in Pakistan's interest rates, inflation rates, GDP growth, and unemployment rates, based on a recent technique of multiple structural detections in the mean established by Castle et al (2015b).

The rest of the paper is laid out as follows. The second section describes the SIS Castle et al (2015b) method for structural break detection and estimation. The empirical findings and discussions are presented in the third section. Finally, some final remarks are made in part four, focusing on the economic reasons for the break dates detected via a SIS.

2. Methodology and Data

We use annual interest rates, inflation rates, unemployment rates, and GDP growth series for this study. The data was collected from 1960 to 2019. The data obtained from the World Data Indicator (WDI) for all indicators except interest rate, fetched from International Financial Statistics (IFS). We use discount rate as a proxy of interest rate. The Augmented Dickey & Fuller (1979) (ADF), the Phillips-Perron (1989) (PP), and KPSS unit root tests are used to check the stationarity of variables. The Zivot & Andrews (1992) unit root tests with a single endogenous break are used to check the possibility of breaks in the interest rate, unemployment rate, inflation rate, and GDP growth series.

2.1. Unit root test with a single structural break

Perron (1989) suggested three different models of a unit root test: crash model (i.e. a shift in the intercept), shifting growth model (i.e. slope change), and together with intercept and slope. The Perron (1989) test has been widely considered for handling the break time as exogenous (i.e., the time of break is identified prior). The Perron unit root tests treated breakpoint (TB) as exogenous, Zivot & Andrews (1992) assess the breakpoint (TB) as endogenous. Zivot & Andrews (1992) found less evidence contrary to the unit-root hypothesis than Perron (1989) found for several data series but more robust evidence against it. The following regression is used test the null hypothesis versus the alternate of a trend stationary procedure with a structural break in cooperation intercept and slope:

$$y_t = \mu + \theta DU_t + \quad + \beta_t + \gamma DT_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + e_t \qquad (1)$$

DU_t and DT_t are dummy regressors that represent a mean and trend shift, correspondingly; DU_t=1, and 0 otherwise. For t=1,2, ..., T1, the breakpoint is expected using Ordinary Least Squares (OLS), and the breakpoint is found using the least t-statistics of the autoregressive variable (t_α) coefficient.

2.2. Structural Break Detection and Estimation Methods

It is more probable that macroeconomic variables contain more than one structural break. Step Indicator Saturation is a popular method for multiple break detection in the mean. The SIS method possesses dummy indicator regressors equivalent to the number of the observations in series, which is not feasible to estimate by the traditional OLS method. The SIS method is viable because of Autometrics; it can deal with additional *N* candidate variables than *T* observations with a mixture of increasing and contracting multiple block searches as defined in (Doornik, 2009; Doornik & Hendry, 2015).

2.2.1.*Step Indicator Saturation*

The SIS method is applicable for multiple breaks detection even if break's location, magnitude, and duration are unknown. SIS works as an extra variable to the model, which is defined for each observation. SIS method is the sum of impulse indicators up to each following observation. Step indicators take whole-sample vectors, the system of $l_1' = (1,0,0,\dots\dots..,0)$, $l_1' = (1,1,0,0,\dots\dots,0)$, and $l_n' = (1,1,1,\dots\dots.,1)$ which is dummy for intercept. Autometrics contain a set of SIS regressors (dummy variables belonging to each observation separately), or additional exogenous variables that could affect the dependent variable can be considered. This study concentrates on the univariate analysis of series by including a set of SIS dummy indicators for the sake of multiple break detection. Attempting to estimate the Generalized Unidentified Model (GUM) in this manner is impractical because a number of dummy indicators are equal to the sample size. Autometrics (based on general-to-specific modeling) is used to detect these breaks and estimate the model simultaneously.

$$Y_t = \alpha + \varepsilon_t \tag{2}$$

$$\varepsilon_t \sim IIN(0, \sigma_t^2), \qquad t = 1,2,\dots\dots\dots.,T$$

Whereas SIS indicator can be represented as

$$I_{it} = \begin{bmatrix} 1 & 1 & 1 & \cdots & 1 \\ 0 & 1 & 1 & \cdots & 1 \\ 0 & 0 & 1 & \ddots & 1 \\ \vdots & \vdots & \vdots & 1 & \vdots \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Here the I_{it} is a matrix of step dummies introduced for observation of y_t equal to ones and zero for all other observations. The last column in the matrix represents the dummy for intercept; hence we do not include intercept dummy while estimating the procedure.

$$y_t = \sum_{m=1}^{T} \gamma_m I_m + \varepsilon_t \tag{3}$$

Where ε_t is independently and identically distributed (IID) with mean zero and variance σ_t^2, m is the change point subscript in the above model. y_t is regressed on a complete set of saturated dummies under the null hypothesis of no shifts with nominal or 1-cut selection (Castle et al., 2012).

2.2.2.Autometrics Selection Algorith

Doornik (2009) proposed Autometrics, a third-generation algorithm created on the similar concepts as PcGets. PcGets is a model selection algorithm proposed by Hendry & Krolzig (1999) and Krolzig & Hendry (2001)**.** Monte Carlo simulation is used to investigate the likelihoods of PcGets, recovering the DGP, and found promising findings. The consistency of the PcGets approach was established by Hendry & Krolzig (2004).

The concept of general to specific (gets) modeling is the cornerstone of this approach. It begins with a fully saturated model that includes the key aspects of the innate data set. Conventional testing methods decrease complexity by expelling statistically irrelevant dummy indicators, with the reliability of the reductions confirmed at each stage to prove the congruence. To find and eliminate statistically insignificant variables, Autometrics use a multi-path search. Such an algorithm does not turn out to be trapped in a single path, where a significant regressor is unintentionally deleted. In contrast, other variables are retained as substitutions (like stepwise-regression).

The fundamental concept is to start with a linear model that includes all possible regressors in GUM. The GUM is calculated using the OLS estimate and subject to diagnostic testing. Modest models are estimated via a tree-path decrease search and endorsed by diagnostic tests if the coefficient estimates are statistically insignificant. If many terminal models are discovered, Autometrics tests their union once more. Combining the 'surviving' terminal models develops a new GUM for one more tree-path search repetition. The whole exploration process is repeated, with the terminal models being evaluated alongside their combination once more. If multiple models pass the encompassing tests, a pre-determined information criterion is used to make the final decision. Autometrics is a partially black box in several ways (Epprecht et al., 2021). However, it allows the user to establish modeling techniques by selecting "nominal significance level" or "1-cut/tight significance level". Multi-path algorithm of Autometrics shuns path dependency via a tree structure and employs a similar stepwise backward examine, a built-in function of gets package in R environment (Pretis et al., 2018).

3. Empirical Results

Table 1 and 2 illustrates the ADF, PP, KPSS, and Zivot & Andrews (1992) test to check the possibility of unit root for the GDP growth, inflation rate, unemployment rate, and interest rate. Table 3-6 shows the estimated result of multiple break detection with AR(1) and without AR(1) series and model selected with 1% and 5% significance levels and diagnostic tests.

Table 1 shows that unemployment and interest rate do not reject the null hypothesis at a 5% significance level. As a result, we can deduce that the series is of order one. Apart from this, all of the considered unit root tests indicate that GDP growth and Inflation series are stationary at level.

Table 1
Unit root test

	ADF Test Level	PP Test Level	KPSS Test Level
GDP growth	-5.551 (0.000)***	-5.655 (0.000)***	0.595 (0.463)
Inflation rate	-3.186 (0.027)**	-3.374 (0.017)**	0.153 (0.463)
Unemployment rate	-2.292 (0.178)	-2.404 (0.146)	0.125 (0.463)
Interest rate	-2.628 (0.094)*	-2.728 (0.076)*	0.178 (0.463)

* denotes the significance level (0 .01*** 0.05 ** 0.1 *)

Table 2
Zivot test for structural break

	t-statistics	Chosen Break point
GDP growth	-6.827 (0.041)**	1977
Inflation rate	-3.881 (0.013)*	2004
Unemployment rate	-6.71 (0.000)***	2006
Interest rate	-3.222 (0.042)**	2000

*denotes the significance level (0.01***,0.05**,0.1*)

We employ Zivot & Andrews (1992) unit root test, for a single endogenous break detection. The test assume that break date is preserved as endogenous; the null hypothesis is a=1, i.e., a unit root, alongside the alternate that the series is a stationary process with a structural break. The assessed regression yield the smallest t_a statistic with the optimal number

of k regressors, presented in Table 2. There is a strong confirmation that unemployment and interest rates are stationary with a single endogenous break. The null hypothesis is rejected at 1% and 5 % significance levels for unemployment and interest rates, respectively. The test indicates that the breakpoint happens in 2000 for interest rate and 2006 for unemployment.

3.1. GDP growth

The SIS method tests the null hypothesis of no structural break against an unknown number of breaks with a 1 % and 5% significance level for the growth rate. A huge decline in GDP growth can be observed in 1970 and 1971. These breaks are because of the oil crisis in 1970 and the Pakistan-India war in 1971. The graph indicates that Pakistan maintained an average growth rate of more than 5% started 1979 and ended in 1989. The graph also indicates that in 2002-2006 the growth rate was around 8% which declined 3.65% in 2007. This finding is aligned with the historical event as the growth rate was 8.6 % in earlier half of 2000, the following years were considered by growth slowdown (Anjum & Sgro, 2017).

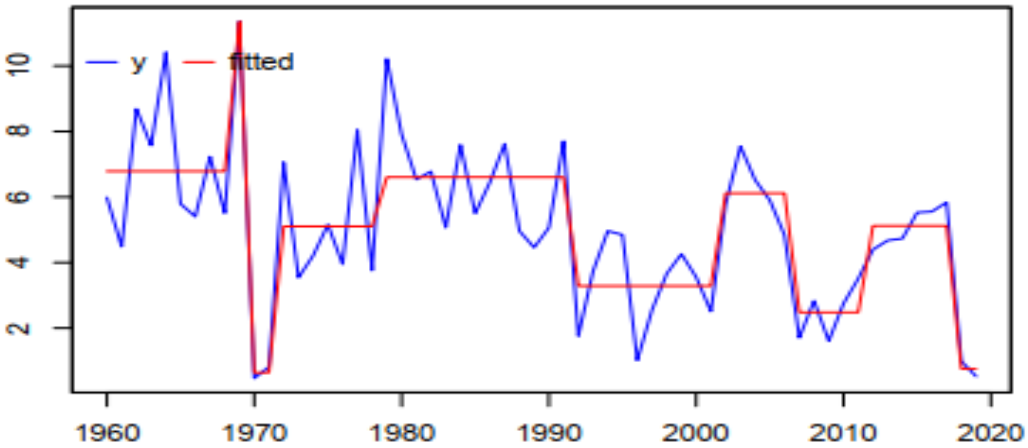

Figure 1. The Estimated Four Breaks in the GDP Growth

Table 3
Empirical Results for the GDP growth (1960-2019)

Break Detection with 0.05 level of significance					
	mconst	**sis1969**	**sis1970**	**sis1972**	**sis1979**
Coef.	6.786	4.567	-10.712	4.462	1.501
P-values	(0.000)***	(0.004)***	(0.000)***	(0.0003)***	(0.029)**
	sis1992	**sis2002**	**sis2007**	**sis2012**	**sis2018**
Coef.	-3.320	2.829	-3.635	2.641	-4.362
P-values	(0.000)***	(0.0007)***	(0.0002)***	(0.003)***	(0.0005)***
Diagnostic tests					
AR(1) Ljung-Box Test 0.556 (0.455)					
ARCH(1) Ljung-Box Test 0.138 (0.710)					
R-squared 0.704					
Break Detection with 0.01 level of significance					
	mconst	**sis1970**	**sis1972**	**sis1992**	
Coef.	7.243	-6.602	5.440	-2.221	
P-values	(0.000)***	(0.000)***	(0.000)***	(0.000)***	
Diagnostic tests					
AR(1) Ljung-Box Test 0.99442 (0.3416)					
ARCH(1) Ljung-Box Test 0.99410 (0.3187)					
R-squared 0.427					

*Denotes the significance level (0.01***,0.05**,0.1*)

The result in table 3 indicates that the Autometrics with a 1% significance level omits a significant dummy indicator primarily that occurred at the end of observation. Autometrics with a 1% significance level possesses R-squared (0.427), which is less than the R-squared of the model selected with a 5% significance level. Consequently, we explain the model with a 5% significance level. The diagnostic tests indicate that the model does not possess an ARCH effect and autocorrelation.

The GDP growth appears to be well modeled with nine mean breaks and R-square (0.704) with a 5% significance level. Detected breaks are credible because the breaks correspond to actual socioeconomic historical events. We explain each break with historical events that occurred in Pakistan. During the 1960s and 1970s, Pakistan's GDP grew at an annual pace of 6.7 % on average; however, in 1970, a sharp decline of 10.71% in growth rate could be observed due to the 1970s oil crisis. An increase of 4.46% average growth detects in 1972 which prevails till 1978. A further upsurge of 1.5 % average growth was detected in 1979 and prolonged to 1991. Pakistan struggled with dwindling worker remittances and growing external deficits in the 1990s. The second-worst inflation in the 1990s decreased GDP growth, with a decline of 3.3 % in 1992. Macroeconomic crises in the 2000s can be considered as persistent consequences of the 1990s debt crisis. In 2008, Pakistan had an economic problem intensified by the global financial crisis, which further declined the growth rate to 3.63% in 2007, whereas it surged to 2.64% in 2012. The growth rate declined 4.36% in 2018 due to political instability.

3.2. Inflation Rate

Figure 2 illustrates the historical inflation rate spike due to the global oil crisis 1970 and 1971 Pakistan-India war. Due to the oil crisis, there was an upsurge in import bill in October 1973. In the 1990s, the second-worst inflation occurred in the wake of decreasing GDP growth rates due to diminishing worker remittances and increasing external deficits (Hasan et al., 1997).

Table 4 illustrates the inflation rates result with 1% and 5% significance levels. The diagnostic tests of the model without AR(1) series rejects the null hypothesis of no autocorrelation and ARCH effect. However, the diagnostic tests of the model with AR(1) series do not reject the null hypothesis of no autocorrelation and no ARCH effect. Autometrics with AR(1) series performed similarly in break detection with 1% and 5% significance levels. In addition, the R-squared of both models is 0.778. The result of structural break detection with AR(1) series estimates four break dates. The break dates are estimated at 1973, 1975, 2008, and 2012. Due to the oil price shock, there was an upsurge in Pakistan's import bills in October 1973, which increased inflation by 14.81% in 1973. Due to the global financial crisis, a further upsurge of 12.73% in 2008, and inflation declined to 13.1% by 2009. There is no evidence in favor of the structural break detected in 1975. Expansions in Pakistan's economy exemplify that inflation rates are pretentious by the national and international economic circumstances and altered intensely over time

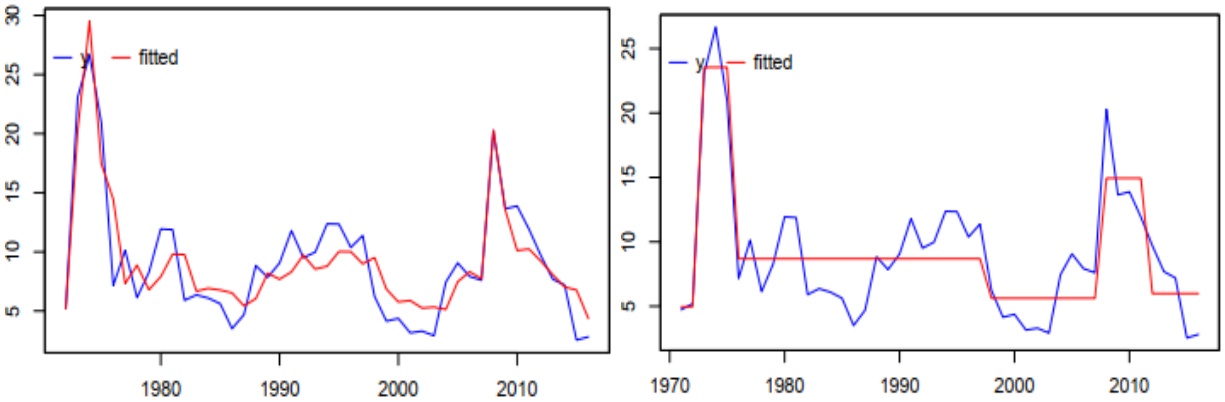

Figure 2. The Estimated Four Breaks in the Inflation Rates

Table 4
Empirical Results for the Inflation Rates (1971-2020)

Break Detection with 0.05 level of significance						
	mconst	**ar1**	**sis1973**	**sis1975**	**sis2008**	**sis2009**
Coef.	2.733	0.517	14.81	-13.931	12.734	-13.302
P-values	(0.3163)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Diagnostics tests						
AR(1) Ljung-Box Test 0.165 (0.684)						
ARCH(1) Ljung-Box Test 0.224 (0.635)						
R-squared 0.778						
Break Detection with 0.05 level of significance						
	mconst	**sis1973**	**sis1976**	**sis1998**	**sis2008**	**sis2012**
Coef.	4.957	18.589	-14.857	-3.076	9.321	-8.949
P-values	(0.014)**	(0.000)***	(0.000)***	(0.005)***	(0.000)***	(0.000)***
Diagnostics tests						
AR(1) Ljung-Box Test 8.322(0.004) **						
ARCH(1) Ljung-Box Test 0.511 (0.474)						
R-squared 0.764						
Break Detection with 0.01 level of significance						
	mconst	**ar1**	**sis1973**	**sis1975**	**sis2008**	**sis2009**
Coef.	2.733	0.518	14.816	-13.931	12.732	-13.302
P-values	0.3163	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Diagnostics tests						
AR(1) Ljung-Box Test 0.165 (0.684)						
ARCH(1) Ljung-Box Test 0.224 (0.635)						
R-squared 0.778						

*Denotes the significance level (0.01***,0.05**,0.1*)

3.3. Unemployment Rate

Table 5 shows the estimation findings of the unemployment rate for structural break detection. Autometrics test the null hypothesis of no structural break in mean against an unknown number of breaks with 1% and 5% significance levels. The model's diagnostic test with AR(1) series doesn't possess an ARCH effect and autocorrelation. However, the diagnostic test of the model without AR(1) series reject the null hypothesis of no autocorrelation and ARCH effect.

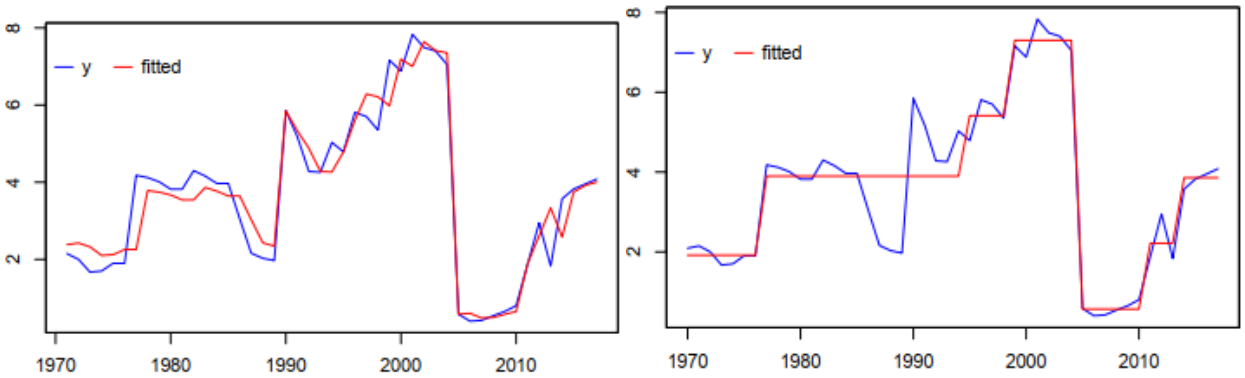

Figure 3. The Estimated Six Breaks in the Unemployment Rates

The result of structural break detection with AR(1) series estimates six break dates with a 5% significance level. However, structural break detection with AR(1) and 1% significance level, the model estimated four breaks and possessed R-squared equals 0.900. Here, we explain

the estimation result of the model with a 5% significance level, as the model possesses a higher R-squared (0.92). The unemployment rate declined to 3.54% in 1990 and sharply increased to 3.11% in 1991. In 2000 unemployment rate increased by 7.2% can be observed, which is the consequence of financial debt preceding the 1990s (Anjum & Sgro, 2017). The unemployment rate dropped to 6.53 % in 2005 as the GDP growth increased at highest since last two decades, See Figure 1 or Table 3. In 2006 employment rate upsurges by 4.3% as a consequence of the economic slowdown. We conclude that there is strong evidence favoring the structural breaks in the unemployment rate in the context of economic events.

3.4. Interest Rate

The ADF and PP test for unit root fail to reject the null hypothesis at a 5% significance level for the interest rate. Table 6 shows the estimation findings of the interest rate for break detection at a 1% and 5% significance level. The diagnostic test of no autocorrelation and ARCH effect test rejects the null hypothesis of interest rate without AR (1) series. The diagnostic test of structural break detection with AR (1) series indicates no autocorrelation and no ARCH effect with R-squared equals 0.92.

Table 5
Empirical Results for the Unemployment Rates (1970-2017)

Break Detection with 0.05 level of significance						
	mconst	**ar1**	**sis1990**	**sis1991**	**sis1996**	**sis2005**
Coef.	0.984	0.669	-3.545	3.117	0.981	-6.536
P-values	(0.004)***	(0.000)***	(0.000)***	(0.0001)***	(0.013)**	(0.000)***
	sis2006	**sis2011**				
Coef.	4.355	1.141				
P-values	(0.000)***	(0.009)***				
Diagnostics tests						
AR(1) Ljung-Box Test 0.162 (0.687)						
ARCH(1) Ljung-Box Test 0.068 (0.793)						
R-squared 0.923						
Break Detection with 0.05 level of significance						
	mconst	**sis1977**	**sis1995**	**sis1999**	**sis2005**	**sis2011**
Coef.	1.915	1.982	1.514	1.889	-6.736	1.653
P-values	(0.000)***	(0.000)***	(0.0004)***	(0.0002)***	(0.000)***	(0.002)***
	sis2014					
Coef.	1.638					
P-values	(0.004)***					
Diagnostics tests						
AR(1) Ljung-Box Test 5.697 (0.017) *						
ARCH(1) Ljung-Box Test 34.88 (3.504e-09) ***						
R-squared 0.895						
Break Detection with 0.01 level of significance						
	mconst	**ar1**	**sis1990**	**sis1991**	**sis2005**	**sis2006**
Coef.	0.393	0.866	3.749	-3.267	-6.406	6.060
P-values	0.208	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Diagnostics tests						
AR(1) Ljung-Box Test 0.314 (0.579)						
ARCH(1) Ljung-Box Test 0.039 (0.844)						
R-squared 0.900						

*denotes the significance level (0.01***,0.05**,0.1*)

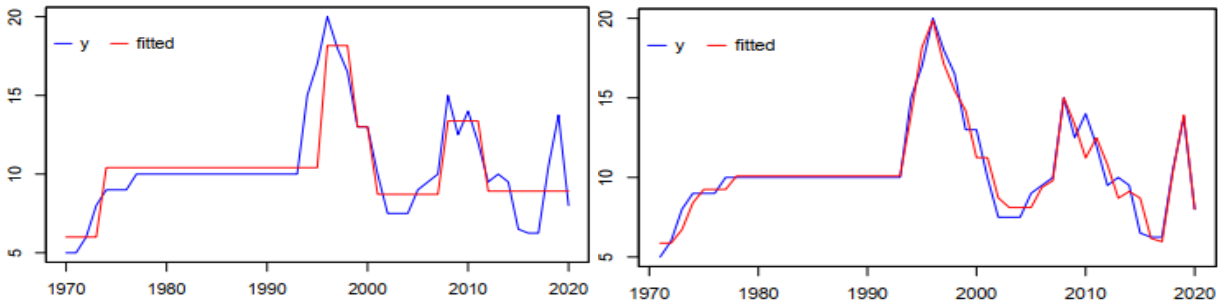

Figure 4. The Estimated Seven Breaks in the Interest Rates

Table 6. Empirical Results for the Interest Rates (1970-2020)

Break Detection with 0.05 level of significance					
	mconst	**ar1**	**sis1994**	**sis1997**	**sis2003**
Coef.	1.657	0.843	3.873	-5.246	1.502
P-values	(0.006)**	(0.000)**	(0.000)**	(0.000)**	(0.034)**
	sis2008	**sis2009**	**sis2018**	**sis2020**	
Coef.	4.782	-5.880	4.375	-8.656	
P-values	(0.000)**	(0.000)**	(0.000)**	(0.000)**	
Diagnostics tests					
AR(1) Ljung-Box Test 3.195 (0.073) .					
ARCH(1) Ljung-Box Test 0.174 (0.67)					
R-squared 0.926					
Break Detection with 0.05 level of significance					
	mconst	**sis1974**	**sis1996**	**sis1999**	**sis2001**
Coef.	6.00	4.409	7.757	-5.166	-4.285
P-values	(0.000)***	(0.000)***	(0.000)***	(0.003)***	(0.005)***
	sis2008	**sis2012**			
Coef.	4.661	-4.458			
P-values	(0.002)***	(0.000)***			
Diagnostics tests					
AR(1) Ljung-Box Test 8.561 (0.003)**					
ARCH(1) Ljung-Box Test 5.584 (0.018) *					
R-squared 0.70					
Break Detection with 0.01 level of significance					
	mconst	**ar1**	**sis1994**	**sis1997**	**sis2008**
Coef.	2.357	0.767	4.242	-4.719	5.453
P-values	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
	sis2009	**sis2018**	**sis2020**		
Coef.	-5.836	4.207	-8.246		
P-values	(0.000)***	(0.000)***	(0.000)***		
Diagnostics tests					
AR(1) Ljung-Box Test 0.287162 (0.5920)					
ARCH(1) Ljung-Box Test 0.052904 (0.8181)					
R-squared 0.91805					

*denotes the significance level (0.01***,0.05**,0.1*)

The below table indicates that Autometrics without AR (1) series omits the break that appears at the end of observations even with a 5% level of significance. However, Autometrics

with AR(1) series and a 5% significance level estimates the breaks efficiently. Autometrics, with AR(1) performs similarly with 1% and 5% significance levels. The estimated break dates are 1994, 1997, 2003, 2008, 2009, 2018, and 2020. The estimated breaks are plausible because the State Bank has operational autonomy and uses the interest rate as a policy instrument to control the inflation rate. The result indicates that in 1998 inflation decreased to 3.07%, which is a consequence of the interest rate fell to 5.24% in 1997. In 2008 the inflation increased to 12.73%; meanwhile, inflation rose to 4.78%. The same phenomena can be observed for 2009 as the inflation rate and interest rate simultaneously decrease.

4. Conclusion

The Zivot & Andrews (1992) unit root test and SIS method specify that unemployment and interest rates are stationary with breaks. AR(1) series have less than unity coefficient with multiple breaks in the SIS method for unemployment and interest rates. It indicates that series depends on its past values and shifts but doesn't possess a unit root. Autometrics uses multi-path search algorithms for break detection with a 5% or 1% significance level. The result indicates that Autometrics without AR(1) series and 1% significance level omits the relevant break at the end of observations. However, with AR(1) series it estimates such breaks easily. The study indicates multiple structural breaks in unemployment, GDP growth, interest, and inflation rate. The result demonstrates that the unemployment rate and interest are not subject to I(1) process, rather than the series is subjected to multiple shifts that are related to significant economic events.

It is obvious that macroeconomic variables are correlated; the break detected in this study provides empirical evidence that a break in one variable impacts other economic variables simultaneously or over time. Eventually, GDP growth, inflation, and unemployment rates possess common breaks, especially in 1970, 1971, and 2008. The break detected from the considered series is equitable; subsequently, the breaks correspond to significant economic events Oil crisis 1970, the Pakistan-India war 1971, and the global financial crises. With empirical evidence, it can be inferred that international uncertainty like the Oil crises in 1970 and the global financial crises spontaneously decreases GDP growth, rising inflation, and simultaneously increasing interest rate. On the other hand, the unemployment increment in 2006 is due to the economic slowdown after 2005. However, instability in GDP growth is because of international and national political uncertainties, which consequently impact the unemployment rate, inflation rate, and interest rate. The results suggest political solidity to endorse a strong investment climate for national and international investors; extraordinary levels of human capital investment are needed to achieve sustainable development. Reducing dependency on crude oil can reduce import bills, as other events like the oil crisis would not impact the economy in the future. The break detected via the SIS method indicates that the rigid fiscal and monetary policy and significant structural changes were chosen as the principal policy instruments to attain these goals. Researchers and data analysts can adopt the SIS approach to arrive at valid results, leading to better policymaking and forecasting results.

References

Alamro, D. H., & Al-dalaien, Q. F. (2014). Modeling the Relationship between GDP and Unemployment for Okun's Law Specific to Jordan. *SSRN Electronic Journal*, *October*. https://doi.org/10.2139/ssrn.2440674

Andrews, D. W. K. (1993). Tests for Parameter Instability and Structural Change With Unknown Change Point. *Econometrica*, *61*(4), 821. https://doi.org/10.2307/2951764

Anjum, M. I., & Sgro, P. M. (n.d.). *A brief history of Pakistan's economic development*. Retrieved August 25, 2021, from https://rwer.wordpress.com/comments-on-rwer-issue-no-80/

Anjum, M. I., & Sgro, P. M. (2017). A brief history of Pakistan's economic development. *Real-World Economics Review*, *80*, 171–178.

Aqil, M., Qureshi, M. A., Ahmed, R. R., & Qadeer, S. (2014). Determinants of unemployment in Pakistan. *International Journal of Physical and Social Sciences*, *4*(4), 676–682.

Arshad, S., & Ali, A. (2016). *Trade-off between inflation, interest and unemployment rate of*

Pakistan: Revisited.
Ayub, G., Rehman, N., Iqbal, M., Zaman, Q., & Atif, M. (2014). Relationship between inflation and interest rate: evidence from Pakistan. *Research Journal of Recent Sciences ISSN*, *2277*, 2502.
Bai, J., & Perron, P. (1998). Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, *66*(1), 47. https://doi.org/10.2307/2998540
Bai, J., & Perron, P. (2006). Multiple structural change models: a simulation analysis. *Econometric Theory and Practice: Frontiers of Analysis and Applied Research*, *1*, 212–237.
Castle, J. L., Doornik, J. A., & Hendry, D. F. (2012). Model selection when there are multiple breaks. *Journal of Econometrics*, *169*(2), 239–246. https://doi.org/10.1016/j.jeconom.2012.01.026
Castle, J. L., Doornik, J. A., Hendry, D. F., & Pretis, F. (2015a). Detecting location shifts during model selection by step-indicator saturation. *Econometrics*, *3*(2), 240–264. https://doi.org/10.3390/econometrics3020240
Castle, J. L., Doornik, J. A., Hendry, D. F., & Pretis, F. (2015b). Detecting location shifts during model selection by step-indicator saturation. *Econometrics*, *3*(2), 240–264. https://doi.org/10.3390/econometrics3020240
Castle, J. L., & Hendry, D. F. (2019). Key Concepts: A Series of Primers. *Modelling Our Changing World*, 5–36. https://doi.org/10.1007/978-3-030-21432-6_2
Chow, G. C. (1960). Tests of Equality Between Sets of Coefficients in Two Linear Regressions. *Econometrica*, *28*(3), 591. https://doi.org/10.2307/1910133
Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427–431.
Doornik, J. A. (2009). *Econometric model selection with more variables than observations*. Citeseer.
Doornik, J. A., & Hendry, D. F. (2015). Statistical model selection with "Big Data." *Cogent Economics & Finance*, *3*(1), 1045216.
Epprecht, C., Guegan, D., Veiga, Á., & Correa da Rosa, J. (2021). Variable selection and forecasting via automated methods for linear models: LASSO/adaLASSO and Autometrics. *Communications in Statistics-Simulation and Computation*, *50*(1), 103–122.
Farley, J. U., & Hinich, M. J. (1970). A test for a shifting slope coefficient in a linear model. *Journal of the American Statistical Association*, *65*(331), 1320–1329.
Hansen, B. E. (1992). Testing for parameter instability in linear models. *Journal of Policy Modeling*, *14*(4), 517–533. https://doi.org/10.1016/0161-8938(92)90019-9
Hansen, B. E. (2012). Tests for Parameter Instability in Regressions with 1(1) Processes. *Http://Dx.Doi.Org/10.1080/07350015.1992.10509908*, *10*(3), 321–335. https://doi.org/10.1080/07350015.1992.10509908
Hasan, P., Kemal, A. R., & Naseem, S. M. (1997). Learning from the past: A fifty-year perspective on Pakistan's development [with comments]. *The Pakistan Development Review*, *36*(4), 355–402.
Hendry, D. F., Johansen, S., & Santos, C. (2006). *Selecting a Regression Saturated by Indicators*.
Hendry, D. F., & Krolzig, H. (1999). Improving on 'Data mining reconsidered' by K.D. Hoover and S.J. Perez. *The Econometrics Journal*, *2*(2), 202–219. https://doi.org/10.1111/1368-423X.00027
Hendry, D. F., & Krolzig, H. M. (2004). We ran one regression. In *Oxford Bulletin of Economics and Statistics* (Vol. 66, Issue 5, pp. 799–810). John Wiley & Sons, Ltd. https://doi.org/10.1111/j.1468-0084.2004.102_1.x
Husain, I. (2000). Pakistan: The economy of an elitist state. *OUP Catalogue*.
Jansen, E. S., & Teräsvirta, T. (1996). TESTING PARAMETER CONSTANCY AND SUPER EXOGENEITY IN ECONOMETRIC EQUATIONS. *Oxford Bulletin of Economics and Statistics*, *58*(4), 735–763. https://doi.org/10.1111/J.1468-0084.1996.MP58004008.X
Jouini, J., & Boutahar, M. (2005). Evidence on structural changes in U.S. time series. *Economic Modelling*, *22*(3), 391–422. https://doi.org/10.1016/j.econmod.2004.06.003
Khan, M. H. (2002). *When is Economic Growth Pro-poor?: Experiences in Malaysia and Pakistan* (Vol. 2). International monetary fund.

Krolzig, H. M., & Hendry, D. F. (2001). Computer automation of general-to-specific model selection procedures. *Journal of Economic Dynamics and Control*, *25*(6–7), 831–866. https://doi.org/10.1016/S0165-1889(00)00058-0

Maqbool, M. S., Mahmood, T., Sattar, A., & Bhalli, M. N. (2013). Determinants of unemployment: Empirical evidences from Pakistan. *Pakistan Economic and Social Review*, 191–208.

Perron, P. (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Econometrica*, *57*(6), 1361. https://doi.org/10.2307/1913712

Perron, P., & Vogelsang, T. J. (1992). Testing for a unit root in a time series with a changing mean: corrections and extensions. *Journal of Business & Economic Statistics*, *10*(4), 467–470.

Ploberger, W., & Krämer, W. (1990). The local power of the CUSUM and CUSUM of squares tests. *Econometric Theory*, *6*(3), 335–347.

Ploberger, W., Krämer, W., & Kontrus, K. (1989). A new test for structural stability in the linear regression model. *Journal of Econometrics*, *40*(2), 307–318.

Pretis, F., Reade, J. J., & Sucarrat, G. (2018). Automated general-to-specific (GETS) regression modeling and indicator saturation for outliers and structural breaks. *Journal of Statistical Software*, *86*. https://doi.org/10.18637/jss.v086.i03

Quandt, R. E. (1960). Tests of the Hypothesis That a Linear Regression System Obeys Two Separate Regimes. *Journal of the American Statistical Association*, *55*(290), 324–330. https://doi.org/10.1080/01621459.1960.10482067

Shabbir, G., Anwar, S., Hussain, Z., & Imran, M. (2012). Contribution of financial sector development in reducing unemployment in Pakistan. *International Journal of Economics and Finance*, *4*(1), 260–268.

Zaidi, S. A. (2005). Issues in Pakistan's economy. *OUP Catalogue*.

Zivot, E., & Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics*, *10*(3), 251. https://doi.org/10.2307/1391541