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A Markov-Switching Model of GDP Growth in Bangladesh

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Abstract

This paper examines the turning points of business cycle in Bangladesh using a Markov regime-switching approach to annual GDP of Bangladesh spanning 1974-2013. In particular, it applies the univariate Markov-switching model proposed by Hamilton (1989) which models GDP series with stochastic trend and a stationary cyclical component in order to identify turning points in business cycles observed in Bangladesh. Estimation shows that real GDP growth in Bangladesh follows a second order autoregressive process, AR(2) where mean GDP growth switches between high growth and low growth regimes. In addition, switching time coincides with the year 1991 when the financial sector reform program (FSRP) started after privatization and trade liberalization in the previous decade. The study also finds that both high and low growth regimes are significant and persistent implying that the high growth regime that began in 1991 is likely to continue in the subsequent years given the data generating process. Identification of turning points in business cycles may be useful to economic agents and policymakers in decision making process.

Keywords: Markov-switching regression, autoregressive process, Business cycle, Regime changes, Bangladesh.

JEL Classification: C22, E32, O53.

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Introduction:

The real GDP growth of Bangladesh has undergone discernible changes in response to shifts of economic policy regimes since her independence through a liberation war in 1971. Bangladesh economy suffered severe output loss owing to devastation loss of physical and human capital in the aftermath of the war. In addition, high dependence on agriculture, low level of industrialization, nationalization of industries, weak international trade and restrained financial sector inhibited the real GDP to stagnate in the years following independence till economic liberalization that were kicked in the early 80's and culminated in financial sector reforms in the early 1990s. It is interesting to examine how the changes in economic policy regimes have impacted the trajectory of real GDP growth of Bangladesh.

Surprisingly, the author could not find in the existing literatureany instance of modeling regime shifts in the real GDP growth rate of Bangladesh. Undoubtedly, the information on regime shifts will provide valuable information to policy makers as the country aspires to sustain high and stable GDP growth rates to attain the status of highermiddle income countries in the near future.

Therefore, the aim of this paper is to fill in this gap in literature using a Markov-switching model of real GDP growth in Bangladesh. Following the methodology used by Hamilton (1989) and Kim and Nelson (1999)for analyzing US business cycles, the paper examines the dynamics of business cycles in Bangladesh using annual GDP growth rate for the period 1974-2013. Specifically, the goal of the paper is to identify the nature of structural break in Bangladesh real GDP towards more stable growth trajectory in the post liberation war period. Economic agents and policy makers may find it useful to consider information on turning points of business cycles in their decision making process.

The remainder of the paper is organized as follows: the next sections review literature, describes data, model and methods, presents empirical results, respectively. The final section summarizes the findings and concludes the paper.

Literature Review

Regime-switching models have been widely applied in identifying the phases of business cycles in many countries via changes in regimes of real GDP (Hamilton (1989), Goodwin (1992), Chauvet (1998), Kim and Nelson (1999), Clemens and Krolzig (2003) and Billio, Ferrera, Gueegan and Mazzi (2013), to mention a few) and other important macroeconomic variables such as consumption, industrial production, inflation, stock returns and so on. This brief literature review will mostly cover existing literature regarding real GDP.

Goldfeld and Quandt (1973), and Hamilton (1989) were among the pioneers in econometric applications of Markov-switching models. However, the first prominent study on business cycles is due to Hamilton (1989), who examined the post-war US real GNP to identify turning points in the US business cycles using a two-state Markov-switching model and found that typical recession in the US were associated with a 3% permanent fall in the level of real GNP in the US.

Filardo, (1994) sought to investigate if expansionary and contractionary phases of the business cycle differ by applying Markov-switching model to monthly series of industrial production. Unlike Hamilton (1989) who used time-invariant transition probabilities in estimating a two-state Markov-switching model, Filardo (1989) used time-varying transitionprobabilities between the regimes. Results of the latter study showed that there was a high correlation between estimated probabilities from the model and traditional reference cycles.

Chauvet (1998) proposed a dynamic factor model with a two-state Markov-switching that facilitates drawing inference about unobserved nonlinear factor and latent Markov state. Using an MSAR specification of switching factors coincident index for the quarterly series 1952.04-1993.03 and the monthly series 1952.2-1931, the author was able to optimally date the turning points in the US business cycle which was strongly correlated with NBER dating of business cycles.

Many studies on business cycles also attempted to identify asymmetry in real GNP. Potter (1995) estimated a nonlinear threshold autoregressive model for US GNP which was found to outperform standard linear models. Estimates of Potter (1995) showed that the US economy turned more stable in the post-1945 period than it was in the pre-1945 period which evidenced the existence of asymmetric effects of shocks on US business cycles.

Kim and Nelson (1999) extended Hamilton's (1989) taking a Bayesian approach to Markov-switching model with regime heterogeneity. The authors attempted to identify the existence, timing and nature of business cycles in the US using quarterly real GNP. The study found evidence in favor of a structural break in US business cycle around the first quarter of 1984 towards more stable real GDP growth as reflected in lower difference in real GDP growth between recessions and expansions.

Clemens and Krolzig (2003) examined asymmetries of business cycles and applied two and three state Markov-switching models to detect turning points in US business cycles using real GDP of the US together with models examining consumption and investment growth in the US. The author found that asymmetries in the mean of these series which did not depend on regime-heteroscedasticity if they are incorporated in the Markov-switching model whereas non-parametric tests produced the mean of these series which were subject to regime heteroscedasticity.

Kim et al. (2005) modeled US real GNP using endogenously estimated unobservable Markov-switching regimes in order to see whether US business cycles show asymmetric effects of shocks. The study found that predicted dating of business cycle turning points matched those of NBER. The estimated non-linear Markov-switching model was found statistically significant but permanent effects of recession were small.

Empirical study of business cycles using Markov-switching models extended to cross-country experience as well. For instance, Goodwin (1992) studied business cycles of eight developed market economies using Hamilton's (1989) Markov-switching model and stated that improvements in forecasting were marginal and prediction of turning points were no different than those from traditional methods.

Ocal and Osborn (2000) developed and examined non-linear smooth transition autoregressive (STAR) models to understand the nature of UK business cycle using real consumption expenditure and industrial production. The study found a two regimes (recession and expansion) in consumption but three regimes (recession, normal growth and high growth) in industrial production and transitions from recovery were similar for the two macroeconomic variables.

Billio et al. (2013) attempted to evaluate whether Markov-switching as well as threshold models can identify the turning points in business cycles of the Euro Area. They found that Markov-switching models could generate more robust estimators in detecting turning points of business cycles.

In general, Markov-switching models performed well in modeling non-linearity and discrete nature of regime changes, as well as detecting turning points and asymmetric nature of business cycle turning points compared to linear and threshold models. It appears that application of Markov switching models to real GDP may reveal important information about regime shifts in real GDP of Bangladesh that may be useful in policy decisions about economic growth and stability.

Data, Model and Methodology

The study uses annual GDP growth rate for the period 1974-2013 calculated from the real GDP series collected from the International Financial Statistics (2014) CD-ROM. The sample period starts from 1974 recognizing the fact that real GDP growth in the immediate post-liberation period was highly volatile and constitutes outliers in the sample (Appendix-1).

In this paper, a combination of two-state Markov-switching Autoregressive model (MSAR) of Hamilton (1989) and Kim and Nelson's (1999) regime-heteroscedasticityis used to analyze the nature of business cycles as measured in real GDP growth of the post-1971 Bangladesh. Hamilton (1989) specifies a two-state Markov switching model where the mean growth rate of GNP in the USA switches between two regimes under the assumption that the error terms exhibit a regime-invariant AR(4) process. On the other hand, unlike the regime-invariant error variances in MSAR model of Hamilton (1989), Kim and Nelson (1999) allows regime-specific error variances in their MSAR model. While the paper keeps the two-state nature of regime switching of Hamilton (1989), it incorporates regime-heteroscedasticity in the model it estimates.

The two-step MSAR(2) model, we estimate in this paper, may be posed as the following

$$y_t - \mu_{s_t} = \emptyset_1(y_{t-1} - \mu_{s_{t-1}}) + \emptyset_2(y_{t-2} - \mu_{s_{t-2}}) + \sigma\varepsilon_t,\ \varepsilon_t \sim N(0,1) \ldots\ldots(1)$$

$$\mu_{s_t} = \alpha_1 + \alpha_2 s_t, \ldots..(2)$$

$$s_{t=1} = 1 \text{if the economy is in high growth state, 0 otherwise}$$

$$P(s_t = 1|s_{t-1} = 1) = p_{11} \ldots\ldots(3)$$

$$P(s_t = 1|s_{t-1} = 2) = p_{12}$$

$$P(s_t = 2|s_{t-1} = 1) = p_{21}$$

$$P(s_t = 2|s_{t-1} = 2) = p_{22}$$

Equation (1) refers to MSAR(2) process while equation (2) defines how the mean growth rate evolves. Equation (3) describes the Markov transition matrix whichcontains the probabilities of making transition from one state to the other. These three equations constitute theMSAR(2) model to be estimated in this paper. There are seven parameters, namely, $\alpha_1, \alpha_2, \sigma, p_{11}, p_{22}, \emptyset_{1,}, \emptyset_2$ that defines this two-stateMSAR(2) model of real GDP.

Empirical Results

Table 1 reports the estimated parameters of Markov-switching regression. It can be seen that except the coefficient on AR(1) term, all coefficients appear significant at either 1%

or 5% level of significance. The estimates of the study satisfy diagnostic tests including inverted AR root, autocorrelation, and normality tests (Appendices). Therefore, the real GDP growth of Bangladesh may be characterized as a second order autoregressive process, MS-AR(2) in which the mean GDP growth switches between high growth and low growth regimes.

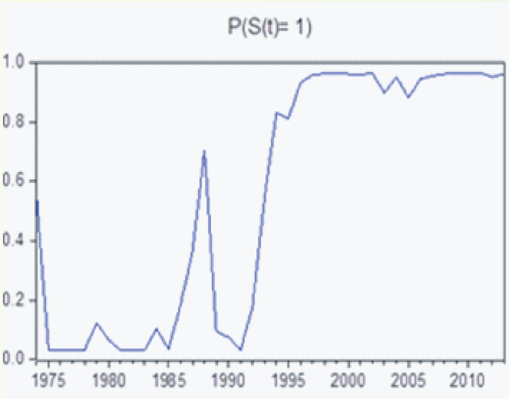
Table 1: Maximum Likelihood Estimates of Hamilton-MSAR(2) Model

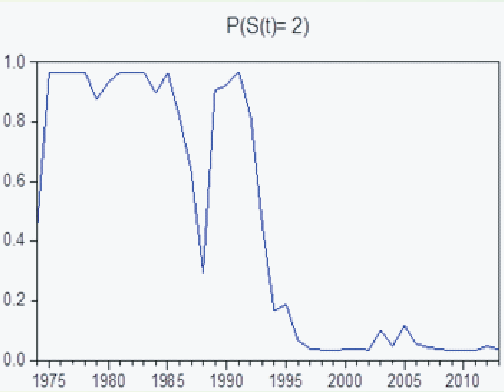
	Regime Means		Regime-Specific Standard Errors		Transition Matrix Parameters		Parameters to AR Terms	
	α_1	α_2	σ_1	σ_2	p_{11}	p_{22}	$\emptyset_{1,}$	$\emptyset_{2,}$
Coefficient	0.058**	0.070**	-5.181**	-3.503**	3.554*	-3.389*	0.212	0.484*
Standard Error	0.005	0.010	0.174	0.205	1.425	1.531	0.1425	0.122

*Significant at 5% level,**Significant at 1% level

Figure 1 exhibits predicted regime probabilities together with the timing of regime switching. It turns out that the change from low growth to high growth state is observed to occur around 1991.

Figure 1: One-step Ahead Predicted Regime Probabilities





The year 1991 is characterized by a number of events that might have shaped the real GDP growth trajectory of Bangladesh. First, this is a year when the financial sector reform program (FSRP) began in a sequel to liberalization, particularly, the deregulation and privatization of nationalized industries initiated in the preceding decade. Second, 1991 marks the end of authoritarian regime and the beginning of a democratic regime. Third, internal resource mobilization through introduction of value added tax kicked in since 1991 and dependence on external aid started to diminish as well. Therefore, we may surmise that the influence of all these positive changes set real GDP growth on a higher trajectory since 1991.

Table 2: Estimated Transition Probabilities and Expected Duration of Regimes

	State 1	State 2
State 1	$p_{11} = 0.972$	$p_{12} = 0.029$
State 2	$p_{21} = 0.033$	$p_{22} = 0.967$
Expected Duration	35.95	30.64

The predicted regime probabilities (Table 2) reveal high persistence of both regimes. The probability of the low growth regime (1974-1990) to persist is 0.972 with an expected duration of 35.95 periods while the probability of the high regime (1991-2013) to persist in 0.967 with an expected duration of 30.64 periods.

Summary and Conclusion

Given their non-linear nature, business cycles modelling by traditional linear models often fails to identify turning points in business cycles which are often subject to unobserved regime shifts. Therefore, the study attempts to examine business cycle dynamics using annual real GDP growth of Bangladesh using Markov-switching auto-regression (MSAR) that assumes that real GDP growth rate switches between two states with regime specific standard errors. Estimation reveals that real GDP growth of Bangladesh may be characterized as a second order autoregressive process, MS-AR(2) in which the mean GDP growth switches between high growth and low growth regimes. In addition, it may be noted that real GDP of Bangladesh switches from low growth to high growth regime around the year 1991 when implementation of financial sector reform program (FSRP) began together with internal resource mobilization through valued-added tax and diminishing dependence on external aid.

Evidently, the turning points identified by the Markov-switching model indicates that there has been a structural break in Bangladesh real GDP growth toward more stabilization since 1991. Particularly, post-1991 period is marked by lower volatility in GDP growth rate and a stable growth trajectory that made Bangladesh's transition to lower middle income status in 2014. If the notably stable economic growth that Bangladesh attained in recent two decades can be sustained and accelerated, it appears that Bangladesh has the potential to makethe transition to higher middle-income country status with right set of institutions and economic policy regimes.

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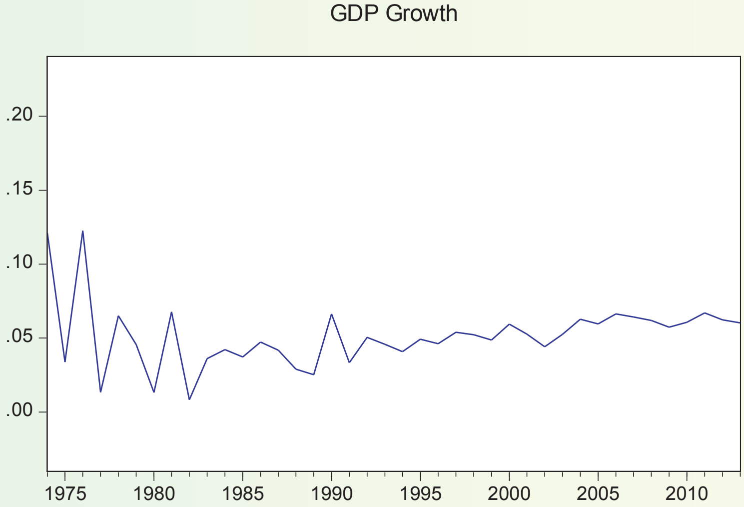
Appendices

Appendix 1: Plot of Real GDP Growth over the Sample Period 1974-2013



Appendix 2: ARMA Structure

Inverse Roots of AR/MA Polynomial(s)
Specification: GDP_GROWTH C AR(1) AR(2)
Date: 08/31/15 Time: 09:58
Sample: 1974 -2013
Included observations: 38

AR Root(s)	Modulus	Cycle
0.809809	0.809809	
-0.598220	0.598220	

No root lies outside the unit circle.
ARMA model is stationary.

Appendix 3: Residual Diagnostics

3.1: Correlogram of Standard Residuals

Sample: 1974-2013
Included observations: 40
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.*| . |	.*| . |	1	-0.182	-0.182	1.4205	
. | . |	. | . |	2	0.038	0.005	1.4836	
. | . |	. | . |	3	-0.030	-0.023	1.5236	0.217
.*| . |	.*| . |	4	-0.148	-0.163	2.5422	0.281
. |*. |	. | . |	5	0.122	0.072	3.2572	0.354
.*| . |	. | . |	6	-0.081	-0.045	3.5778	0.466
. |*. |	. |*. |	7	0.122	0.092	4.3378	0.502
. | . |	. | . |	8	0.003	0.028	4.3384	0.631
.*| . |	.*| . |	9	-0.119	-0.101	5.1051	0.647
. | . |	. | . |	10	0.025	-0.029	5.1413	0.742
. |*. |	. |*. |	11	0.102	0.159	5.7466	0.765
.*| . |	.*| . |	12	-0.086	-0.079	6.1852	0.799
. | . |	.*| . |	13	-0.032	-0.095	6.2481	0.856
. | . |	. | . |	14	0.002	0.010	6.2482	0.903
.*| . |	.*| . |	15	-0.128	-0.123	7.3512	0.883
. | . |	. | . |	16	0.061	-0.004	7.6146	0.908
. | . |	. | . |	17	-0.035	-0.002	7.7035	0.935
.*| . |	**| . |	18	-0.123	-0.215	8.8495	0.919
. | . |	. | . |	19	0.070	0.006	9.2380	0.932
.*| . |	. | . |	20	-0.117	-0.024	10.395	0.918

*Probabilities may not be valid for this equation specification.

3.2: Correlogram of Standard Residuals Squared

Sample: 1974-2013
Included observations: 40

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob*</th></tr>
<tr><td>. | . |</td><td>. | . |</td><td>1</td><td>0.026</td><td>0.026</td><td>0.0280</td><td>0.867</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>2</td><td>0.024</td><td>0.023</td><td>0.0537</td><td>0.974</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>3</td><td>0.038</td><td>0.037</td><td>0.1205</td><td>0.989</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>4</td><td>-0.026</td><td>-0.028</td><td>0.1511</td><td>0.997</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>5</td><td>-0.027</td><td>-0.028</td><td>0.1872</td><td>0.999</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>6</td><td>0.058</td><td>0.060</td><td>0.3550</td><td>0.999</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>7</td><td>-0.019</td><td>-0.019</td><td>0.3737</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>8</td><td>0.006</td><td>0.005</td><td>0.3755</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>9</td><td>-0.031</td><td>-0.036</td><td>0.4259</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>10</td><td>-0.028</td><td>-0.022</td><td>0.4686</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>11</td><td>-0.029</td><td>-0.024</td><td>0.5159</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>-0.026</td><td>-0.025</td><td>0.5563</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>13</td><td>-0.030</td><td>-0.025</td><td>0.6109</td><td>1.000</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>14</td><td>0.149</td><td>0.151</td><td>2.0419</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.019</td><td>-0.024</td><td>2.0669</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>16</td><td>0.007</td><td>0.002</td><td>2.0702</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>17</td><td>-0.032</td><td>-0.044</td><td>2.1431</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>18</td><td>-0.039</td><td>-0.029</td><td>2.2612</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>19</td><td>-0.041</td><td>-0.030</td><td>2.3954</td><td>1.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>20</td><td>0.019</td><td>0.005</td><td>2.4268</td><td>1.000</td></tr>
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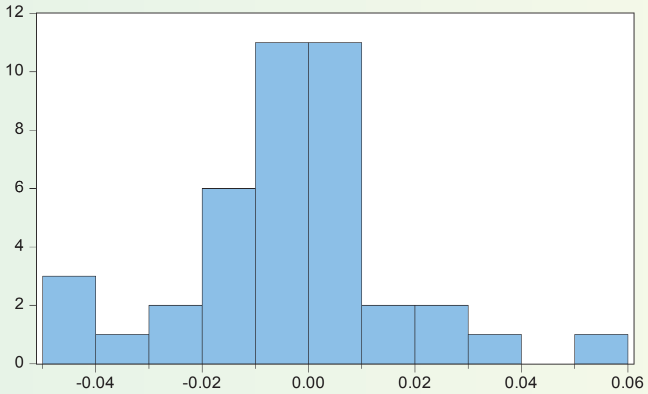
*Probabilities may not be valid for this equation specification.

3.3: Normality Test



Series: Residuals
Sample 1974 2013
Observations 40

Mean	-0.003656
Median	-0.001224
Maximum	0.057497
Minimum	-0.049879
Std. Dev.	0.020421
Skewness	0.091331
Kurtosis	4.692244
Jarque-Bera	4.828424
Probability	0.089438