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The Effect of Oil Price on Economic Growth in Lebanon: A Markov-Switching Approach†

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Abstract

This paper investigates the regime changes in the Lebanese economy using Markov Switching Auto Regressive models. Using the industrial production index and various variables, including oil prices, we identify two distinct regimes. The findings reveal that the Lebanese growth cycles are largely driven by seasonal effects and random shocks. The findings also indicate that the average duration of the instable and slow growth regime is much longer than that of the expansion and high growth regime. Finally, the probabilities of switching from one regime to another are rather very low but nearly zero for switching from the instable slow growth regime to the expansion and high growth regime. Hence, the estimated transition probabilities indicate the danger of the slowdown growth regime becoming permanent in Lebanon.

Keywords: Crude oil price, Economic growth, Lebanon, MS-AR model

JEL Codes: C32, C34, E32, O40

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1. Introduction

Lebanon is a small country with a sectarian based parliamentary system with a population over 6 million. The economy is primarily service based, representing roughly 60% of the economy, down from 70% in the 1970s. Service and banking sectors together contribute 70 % of the economy, agriculture generates 10% and industrial sector forms the remaining 20% of the economy.[1] In some sources, on the other hand, the share of industry is reported as low as 8.3%.[2] The tourism industry in Lebanon goes back to the 1960s when Beirut, was also known as "the Paris of Middle East" (Abosedra et.al., 2015, p. 4). Service sector employs roughly 40% of the labor force, and this high percentage indicates Lebanon's vulnerability to any kind of shock (Saab & Ayoub, 2010).

The Lebanese economy has faced numerous challenges due to the civil war in the period of 1975-1990, assassination of ex-prime minister Rafik Hariri in 2005, war with Israel in 2006, and clashes between the opposing government alliances from 2006 till 2008. After the 2006 Israeli war, Lebanon's economy stimulated by rising nonresident deposits, an elevated number of tourist arrivals, and a vigorous real estate market. Nevertheless, regional political turmoil and the unrest in Lebanon's neighbor and a significant trading partner Syria since 2011 has challenged the Lebanon's economic prospects. As a results, both tourist arrivals and expats' housing demand in the real estate sector have slowed down in 2011. (Abosedra et.al, 2015, p.4). Further, the recent turmoil and antigovernment protests in the country and the sustained fighting in Syria and seem to continue to challenge Lebanon's economic prospect.

Though the declining oil prices since 2008 have helped Lebanese economy by freeing up resources to recover internal and external balances, this was more than offset due to lack of measures that boosted revenues and fiscal deficit has widened (World Bank, 2016). Hence, the Lebanese economy continuous to be vulnerable to be internal and external shocks, including the oil price shocks.

Policy makers and academicians often concerned with economic growth and the price of oil. In fact, this is true of both oil producer and oil importer economies. However, for non-oil producing countries, fluctuations in oil prices might have severe adverse impacts on economic variables such as growth and consumer prices as oil is a major input in the production process. As well, oil price and growth series may exhibit nonlinear behavior due to factors such as crises and policy changes. Hence, the price of oil is particularly important for oil importing countries such as Lebanon.

The aim of this study is to contribute to the literature by examining the impact of sudden changes in the price of imported crude oil on economic growth for Lebanon as a developing country. In addition to the price of oil, the paper also attempts to determine the effects of some macroeconomic variables on regime changes such as the Public Debt for Foreign Currency and the number of Total Tourist Arrivals which are vital for the Lebanese economy.

Non-stationarity/stationarity and non-linearity of the series are investigated by various tests. For the stationary but non-linear series, analyzes are made using Markov Switching models for the purpose of the study. These models are helpful to investigate the nonlinear linkages among the variables of interest. Markov regime models introduced by Hamilton (1989) are used in the modeling of time series that exhibit asymmetry and nonlinear behavior. Previously Goldfeld and Quandt (1973) introduced a hidden Markov chain into a regression model in order to deal with time series data that depend on exogenous variables. Hamilton (1989) extended this model by developing autoregressive Markov switching models which are able to characterize macroeconomic fluctuations in the presence of structural breaks or shifts. These approaches allow researchers to overcome the shortcomings of linear models in dealing with the asymmetry between expansion and contraction phases of business cycles.

Estimating MS models that are based on Hamilton's (1989) algorithm consists of two steps. In the first step, population parameters, including the joint probability density of unobserved states, are estimated, and in the second step probabilistic inferences about the unobserved states are made using a nonlinear filter and smoother. Letting s_t be the random variable representing the regime, filtered probabilities are inferences about s_t conditional on information up to time t, and smoothed probabilities are inferences about s_t using all information available in the sample.

The study examines the period of 2002(01)-2018(09) by Markov-switching autoregressive (MS-AR) models which are successful to capture the nonlinear properties of variables. We try various models using the approach proposed by Krolzig (1998) and the Likelihood Ratio (LR) test. The results indicate that there are two regimes in the period analyzed. In addition, the paper identifies regime changes and economic cycles. Finally, the paper also attempts to identify the effects of changes in the price of crude oil and other variables on growth in different regimes with the purpose of enabling us to determine the variables that are more effective in contraction / expansion regimes. Though, the model selection procedure does not favor the models that allow the AR coefficients change between the regimes.

According to the regime probabilities, the likelihoods of staying in the same regime and the average periods of stays are determined. The findings reveal that the average duration of the instable and slow growth regime is far longer than that of the expansion and high growth regime. The findings also indicate that there is a low possibility of transition from the instable low growth regime (recession) to the expansion high growth regime and vice versa. However, the probability of switching from the instable low growth regime turns out to be circa nil. These results appear to be robust to the inclusion of various control variables to MS-AR models, including various measures of the price of oil, Total Tourist Arrivals and the Public Debt for Foreign Currency. Remaining of the paper is organized as follow. In section 2, methodological issues, data used in the analysis and model selection procedures are explained. Also in this section, model specifications and estimation results are presented and the findings are interpreted. In the last section, which concludes the paper, the findings are summarized and suggestions are indicated for future research.

2. Empirical Analysis and Results

In this section, we present the results of econometric models specified for the modeling of Lebanese business cycles with monthly data between 2002(01) and 2018(09). We will begin by introducing the data set and the results from the model selection procedure. Then, we will interpret the findings.

2.1 Data Analysis

In the empirical analysis, the Industrial Production Index (IPI) as a proxy for Gross Domestic Product (GDP), the Global Price of Brent Crude Oil (Dollars per Barrel), the Cost of Crude Oil Imports from OPEC (Dollars per Barrel), the Cost of Crude Oil Imports from non-OPEC (Dollars per Barrel), Total Tourist Arrivals (unit), and the Public Debt for Foreign Currency (million USD) are used. Except the IPI which is used as the dependent variable, all other variables are selected as the control variables among the variables that are considered to be important for the Lebanese economy. However, some other variables initially included in the analysis such as the General Government Credit (million USD), the Flow of Passenger

Arrivals (unit), Direct Investment in Lebanon (million USD), etc. are excluded from the analysis because they were either statistically insignificant in all delays (beginning with 12 delays) or the estimation procedure did not converge in the MS-AR models defined for growth of IPI (GR-IPI.) All data, except oil prices which obtained from the Federal Reserve Bank of Saint Louise[3], were collected on a monthly basis from the Banque Du Liban website[4] and data covers the period from January 2002 to September 2018.

Table 1: Descriptive Statistics of Variables

	DL(IndustProdIndex) GR-IPI	DLGlobalPriceBrentCrude DLGPBC	DLCostCrudeOilImpNon-OPEC DLCCOINon-OPEC
Mean	0.00088939	0.0069914	0.0062160
Std.Devn.	0.023310	0.086422	0.084821
Skewness	-0.49405	-0.96337	-1.2666
Excess Kurtosis	0.85358	1.5232	3.2083
Asymptotic test: Chi^2(2) =	14.208 [0.0008]***	50.270 [0.0000]**	139.25 [0.0000]**
Normality test: Chi^2(2) =	8.7632 [0.0125]**	29.04[0.0000]**	40.951 [0.0000]**
	DLCostCrudeOilImpOPEC DLCCOI-OPEC	DLPublicDebtforCurrency DLPDebtCurr	DLTotalTouristArrival DLTTouristArr
Mean	0.0070835	0.0065499	0.0032257
Std.Devn.	0.072945	0.064611	0.22973
Skewness	-1.4524	5.2397	0.45570
Excess Kurtosis	3.8105	63.180	4.5057
Asymptotic test: Chi^2(2) =	191.32 [0.0000]***	34179. [0.0000]**	176.10 [0.0000]**
Normality test: Chi^2(2) =	56.940 [0.0000]***	208.07 [0.0000]*	75.041 [0.0000]**

p values are in brackets, [ ]; *, **, *** significant at 10, 5 and 1 percent.

The time path graphs of the series are examined and it is seen that they are not stationary in both variance and mean. Then, in order to maintain stationarity in variance, logarithmic transformation is performed to the series and the stationarity is obtained by taking the logarithmic difference. Besides, the seasonal characteristic observed in the IPI and the growth rate of IPI, growth of IPI (GR-IPI =Ln IPI (t)-Ln IPI (t-1)) is concluded to be deterministic with statistically significant seasonal dummies. Ghysels et al. (1996), Luginbuhk and de Vos (2003) and Matas Mir and Osborn (2004) indicate seasonal adjustment may affect the nonlinear property of a series, mask non-linearity or eliminate it or may cause the series to be nonlinear. In particular, Matas Mir and Osborn (2004, p. 5) point out that "seasonal adjustment interferes with the tracking of underlying regime, with the main effect being a belated detection of the end of a recession." Following this consideration, the analysis continued without seasonal adjustment. The time paths of logarithmic differences of the variables used in the analysis and the descriptive statistics are given in Figure 1 and Table 1 respectively.

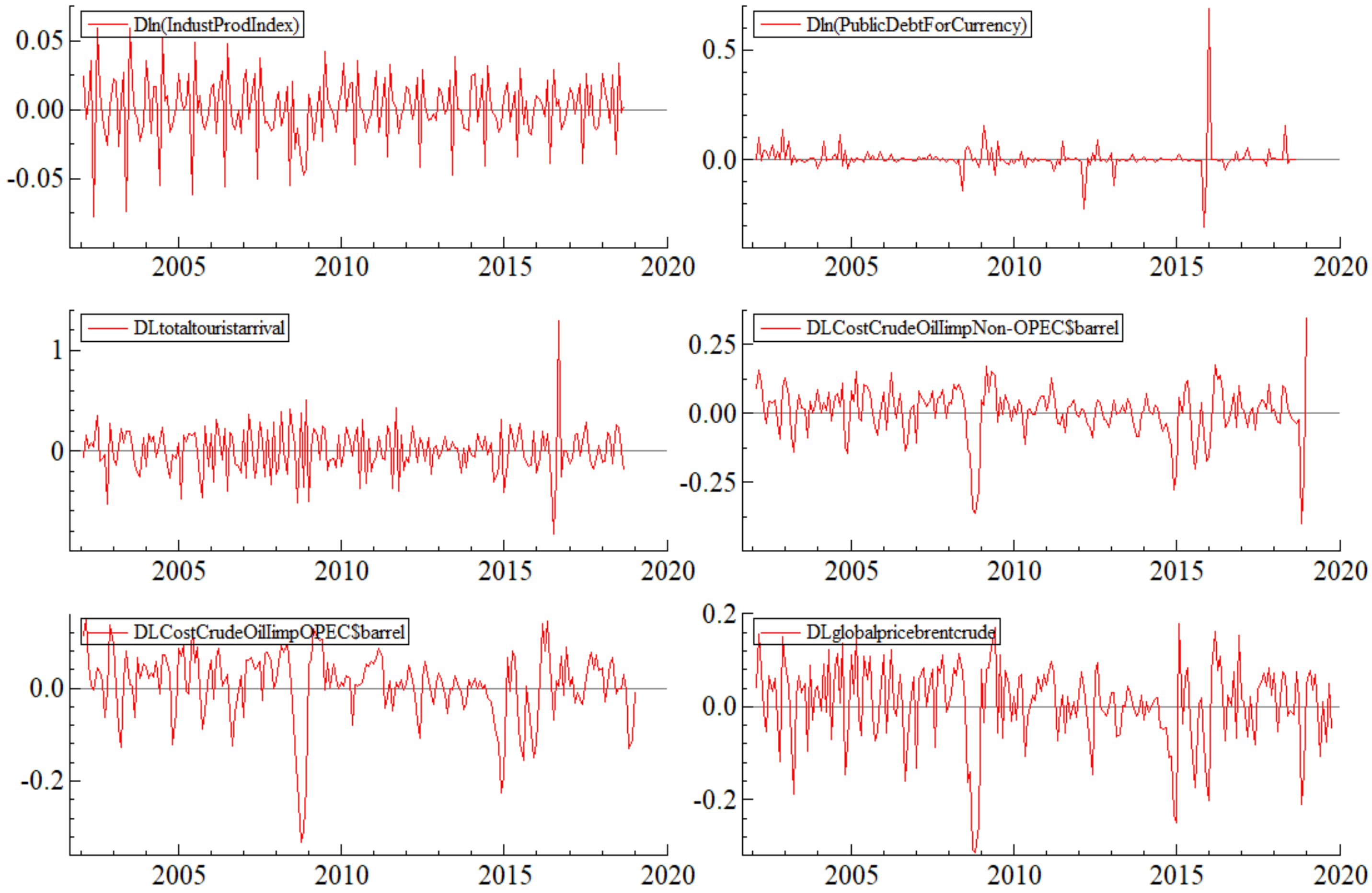


Figure 1: Time Paths of Variables.

Before the specification of the Markov switching models, nonlinearity and unit root tests are necessary to describe the important features of the data at hand. Firstly, to detect nonlinearity of the data, tests developed by Brock, Dechert and Scheinkman (1987) (BDS henceforth) and Tsay (1989) are used. We also employ nonlinear unit root tests namely MS-ADF (Markov Switching-ADF) test by Hall, Psaradakis and Sola (1999) and KSS test by Kapetanios, Shin and Shell (2003). Table 2 and Table 3 below, report the results.

Table 2: Unit Root and Nonlinearity Tests Results

Variables	KSS	MS-ADF Regime 0 (prob)	MS-ADF Regime 1(prob)	BDS	TSAY (lags)
DLINDPRODINDEX	-0.312	-5.623 (0.001)	-5.801(0.000)	Ho rejected	12.84 (2)***
DLGLOBALBRENTOILPRICE	-4.013***	-3.347(0.029)	-5.753(0.000)	Ho rejected	2.99 (2)**
DLCOSTCRUDEOILIMPNON-OPEC	-4.19***	-4.912(0.003)	-4.256(0.007)	Ho rejected	6.05 (3)***
DLCOSTCRUDOIL IMPOPEC	-3.064***	-4.235(0.008)	-4.019(0.009)	Ho rejected	4.45 (2)***
DLTOURISTARRIVAL	1.416	-4.013(0.012)	-4.147(0.010)	Ho rejected	8.62 (1)***
DLPUBLICDEBTCURR	-12.38***	-4.803(0.004)	-6.107(0.000)	Ho rejected	3.086 (12)***

Critical values for KSS test: %1 -2.82; %5 -2.22; %10 -1.92; *, **, *** significant at 10, 5 and 1 percent.

Table 3: The Results of BDS Test statistics

Dim.	DLPUBLICDEBTCURR			DLINDPROD INDEX/ GR-IPI			DLGLOBALBRENTOILPRICE		
	Bds stat	z-stat	Prob	Bds stat	z-stat	Prob	Bds stat	z-stat	Prob
2	0.019685	1.969944	0.0488	0.035008	5.969382	0.0000	0.033721	5.973336	0.0000
3	0.047475	2.965255	0.0030	0.044501	4.773254	0.0000	0.054807	6.095659	0.0000
4	0.058837	3.058220	0.0022	0.038397	3.457572	0.0005	0.063421	5.911120	0.0000
5	0.058365	2.882956	0.0039	0.037185	3.211702	0.0013	0.064433	5.749870	0.0000
6	0.049195	2.494963	0.0126	0.039208	3.510494	0.0004	0.063824	5.893811	0.0000

	DLCOSTCRUDEOILIMPNONOPEC			DLCOSTCRUDOIL IMPOPEC			DLTOURISTARRIVAL		
	Bds stat	z-stat	Prob	Bds stat	z-stat	Prob	Bds stat	z-stat	Prob
2	0.048017	7.177046	0.0000	0.059491	9.027201	0.0000	0.005929	1.304639	0.1920
3	0.071466	6.706496	0.0000	0.090807	8.635471	0.0000	0.012132	1.678490	0.0933
4	0.084740	6.661876	0.0000	0.104801	8.334403	0.0000	0.016061	1.865208	0.0622
5	0.097468	7.333223	0.0000	0.114781	8.720536	0.0000	0.017541	1.953764	0.0507
6	0.102140	7.948139	0.0000	0.115277	9.042591	0.0000	0.023260	2.685870	0.0072

Table 2 summarizes the KSS, MS-ADF, BDS and Tsay test results and Table 3 provides detailed information from the BDS test. The BDS test is a nonparametric approach for testing for serial dependence and non-linear structure in a given time series. The results of both BDS and Tsay tests in Table 2 show that all variables are nonlinear.

The BDS test results in Table 3 indicate that there is nonlinearity effect in the Lebanon's industrial production index and other variables with the exception of Total Tourist Arrivals at dimension 2. However, when dimension increases linearity is rejected at 10 % significance level, and when dimension is equal to 6 it is rejected at 1%. For all the other variables in all dimensions p values are lower than 5%, implying a rejection of the null hypothesis that the series is linearly dependent for each case. Given these results we conclude that all differenced variables are nonlinear.

Since it is determined that the series are nonlinear, it is appropriate to use nonlinear unit root tests. For this purpose, KSS and MS-ADF tests were applied and the calculated test statistic values are given in Table 2. All the results in Table 2 suggest that all differenced variables are nonlinear and stationary with the exception of KSS test for the IPI. However, the null of nonstationarity is rejected by MS-ADF test strongly at 1%. Hence, we conclude that all variables of interest are stationary but nonlinear. In light of the results above, we proceed with the selection and estimation of Markov Switching (MS) models.

2.2 Specification and Estimation of MS Models for Lebanese Growth[5]

The MS-AR model requires that the researcher choose (i) the number of regimes, (ii) the model specification (changing intercepts, regime-dependent AR coefficients and heteroscedasticity), and (iii) the order of the lag polynomial in a model specification. The choice of the regime can be accomplished using a variety of approaches, including visual inspection of the data, the use of the Likelihood Ratio (LR) test and criteria such as the Akaike Information criterion (AIC) and the Schwarz criterion (SIC). The various model selection criteria can be used determine the number of regimes for a fixed AR lag length p. Given the number of regimes m, a variety of model selection criteria can be applied to choose the AR lag length p for each model. Two common alternatives, among others, are the use of the AIC and SIC for choosing the lag length. According to Kapetanios (2001), the AIC tends to choose longer lag lengths in MS-AR models whereas the SIC tends to select more parsimonious models. Among the alternative specifications are MS models with intercepts, AR coefficients and variances that are allowed to switch across regimes. Then, all models are tested for the null of linear model against the alternative regime-switching model. The study uses combinations of above criteria together to choose the appropriate model in each case.

Firstly, in order to determine the number of regimes, MS (2) model is tested against MS (3) model. Moreover, examining the corresponding 3-regime models with AR (1), AR (2), AR (3) and AR (4) processes, we experienced lack of convergence with the Expectation Maximization (EM) algorithm as well as problems of very low transition probabilities for the 3th regime, indicating the existence of only two regimes. Hence, we decided that two regimes were appropriate to capture the cyclical dynamics of the Lebanese economy. Given two regimes, we defined the Regime-0 as a low growth state indicating the slowdown of the economy, while the Regime-1 is defined a high growth state associated with the expansion of the economy.

After determining the number of regimes, it is necessary to determine the lag length of the AR part of the model, i.e. what p will be in the MS (2)-AR (*p*) model. However, MS (2)-AR (*p*) models and linear AR (*p*) models have to be compared before, and it is necessary to decide whether the MS model is suitable or not. Testing the MS (2)-AR (*p*) models against linear AR (*p*) models by the likelihood ratio (LR) test, we decided that MS (2)-AR (*p*) models were superior, hence more suitable against all linear AR (*p*) models. In the results reported in Table 4, all the linear specifications are rejected in favor of MS-AR models based on the values of the LR statistics.

Table 4: LR Linearity Test Results

	Linearity (LR) test statistics	Results
MS(2)-AR(1) vs AR(1)	12.398	Linear AR(1) rejected
MS(2)-AR(2) vs AR(2)	17.815	Linear AR(2) rejected
MS(2)-AR(3) vs AR(3)	18.660	Linear AR(3) rejected
MS(2)-AR(4) vs AR(4)	32.39	Linear AR(4) rejected

After all, we solve all specifications of the MS-AR model with changing intercepts, variances, and autoregressive coefficients (MSI-AR, MSIH-AR, MSIA-AR or MSIAH-AR). Hence, the models studied involve specifications with changing intercepts only (MSI-AR), changing intercepts and variances (MSIH-AR), changing intercepts and autoregressive coefficients (MSIA-AR), changing intercepts, variances, and autoregressive coefficients (MSIAH-AR). In the model selection stage, we use the likelihood ratio (LR) test to test against the null of linear AR (*p*) specification as mentioned before. In addition, we chose models on the basis of model selection criteria such as the AIC and SIC. Models are estimated using the EM algorithm, using ergodic probabilities to start recursion and results obtained with robust standard errors.

Following the estimation of models, we examine the properties of the standardized residuals, the general fit of the model, and how well the models perform in regime classifications. All models are chosen to perform as well as possible based on the results of the diagnostic tests. We also check models' forecasting performance within the last 24 months.

Results obtained show the estimated regime-specific intercepts (constants), variances, autoregressive coefficients and the durations of regime for each specification of Lebanese GR-IPI. Results also provide values of the log-likelihood function, the Akaike information criterion (AIC), the Schwartz information criterion (SIC) and the Likelihood Ratio statistics for testing a linear specification of AR model against MS-AR model

The first models are specified for GR-IPI with no control variables and estimated starting with the maximum AR lag of 5 (MS (2) -AR (5)). However, because the sum of AR coefficients of the MS (2) -AR (5) model turned out to be greater than 1, it was not preferred as it did not meet the dynamic stability condition. Hence, the results for the MS (2)-AR (4), the best performing model based on the criteria discussed above are given in Table 5. The bottom panel of Table 5 provides the results for the diagnostic tests for the estimated model. The portmanteau test indicates that errors are not serially correlated. The ARCH test reports the homogeneity of the residual variance, and the normality test indicates that the residuals are found to be normally distributed. Finally, the LR test shows that the null of linearity is rejected in favor of the MS-AR model.

Table 5: Estimation Results for MSIH (2)-AR (4) Model for GR-IPI

	Coefficient	***Std.Error***	***Robust - SE***	***t-value***	***t-prob***
AR-1	-0.228	0.073	0.081	-2.82	0.005
AR-2	0.035	0.073	0.090	0.391	0.696
AR-3	0.261	0.070	0.086	3.02	0.003
AR-4	0.194	0.070	0.073	2.65	0.009
Seasonal	0.023	0.002	0.002	9.34	0.000
Seasonal_1	0.025	0.002	0.003	9.35	0.000
Seasonal_3	0.011	0.002	0.002	4.65	0.000
Seasonal_4	0.028	0.002	0.002	15	0.000
Seasonal_5	-0.038	0.002	0.003	-14.5	0.000
Seasonal_6	0.043	0.002	0.003	15.6	0.000
Seasonal_7	0.008	0.002	0.002	3.97	0.000
Seasonal_8	0.008	0.002	0.002	3.59	0.000
Seasonal_9	-0.006	0.002	0.002	-2.84	0.005
Seasonal_10	-0.006	0.002	0.002	-2.51	0.013
Constant(0)	-0.007	0.001	0.002	-4.44	0.000
Constant(1)	-0.012	0.004	0.004	-2.97	0.003
sigma(0)	0.006	0.0004			
sigma(1)	0.015	0.002			
log-likelihood	671.578				
AIC	-6.649				
SC	-6.314				

Linearity LR-test Chi^2(4) = 43.282 [0.0000]***
Descriptive statistics for scaled residuals:
Normality test: Chi^2(2) = 3.7142 [0.1561]
ARCH 1-3 test: F(3,159) = 0.67995 [0.6392]
Portmanteau(36): Chi^2(36) = 30.016 [0.7482]

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

All the coefficients in Table 5 are significant with the exception of the AR-2 coefficient. Lebanese growth seem to be driven by past monthly growth rates and seasonal effects. Base growth rates for both regimes are negative, and ironically the magnitude of the high growth regime is larger than the slow growth regime. Accepting these results at the face value imply that growth in both regimes, particularly the high growth regime might have been driven largely by random shocks. However, this particular result could also be attributed the model's not including any control variables and the quality and suitability of data. In particular, given the small share of industry in Lebanon's economy, the IPI may not be a good proxy to represent Lebanese growth. These issues deserve further scrutiny, nonetheless, regime classifications, transition probabilities, average durations of each regime and within and out of sample predictions obtained from the model appears to be reliable. Another result that should be noted is that intercepts estimates are close to one another but variance estimates for regimes are not. Comparing the 95% confidence intervals one can easily verify that intervals for intercepts overlap whereas intervals for variances do not. This fact appears to be the driving force in determining two episodes of high growth regime in contrast to the models below where there is only one episode of high growth regime when variances do not differ significantly.

Table 6: Transition Probabilities and Average Duration

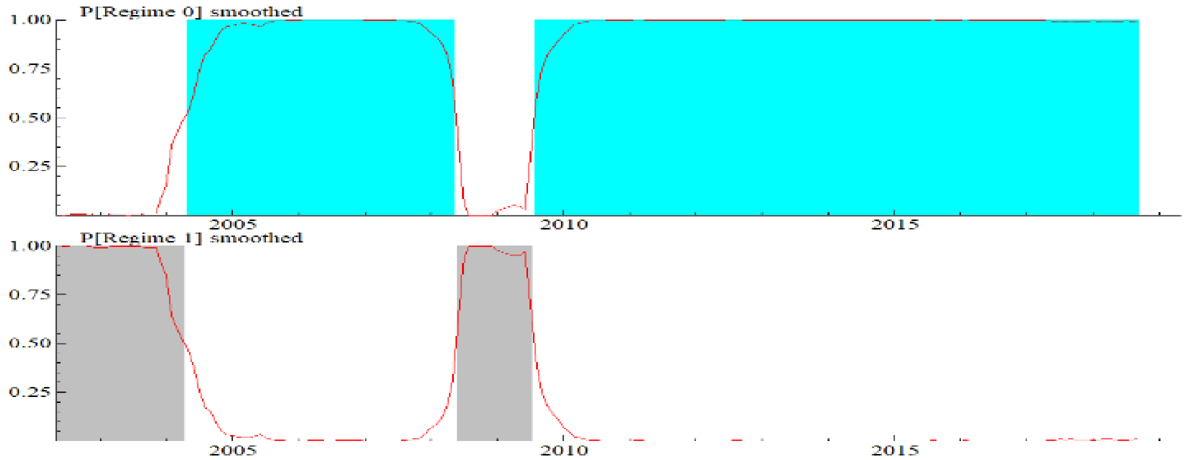
	Regime 0,t	Regime 1,t	Average Duration
Regime 0,t+1	0.99234	0.055068	79.50 months
Regime 1,t+1	0.0076557	0.94493	18.50 months

Table 7: Regime Classification based on Smoothed Probabilities

Regime 0	Months	Avg.Prob.	Total Months
2004(5) - 2008(5)	49	0.946	159
2009(8) - 2018(9)	110	0.987	
Regime 1			
2002(6) - 2004(4)	23	0.932	37
2008(6) - 2009(7)	14	0.934	

The transition between the states is characterized by a first order Markov chain and duration independency is also assumed. The estimated transition probabilities in Table 6 show that there is a higher probability that the system stays in the same regime thus implying few switches between the regimes. For example, the results indicate an over 99% probability of staying in the instability and slowdown growth regime and a circa zero probability of switching to the expansion and high growth regime. Correspondently, when the system is in a high growth regime, there is a 94 % probability of staying in the high growth regime and again a lower probability of 5% switching to the slow growth regime. Hence, the estimated transition probabilities indicate that the slowdown growth regime becomes permanent since the estimated transition probability from *Regime* (0, t) to *Regime* (0, t+1) is almost one.

As shown in Figure 2.a and Table 7, both regimes have the same number of episodes; two episodes of slowdown during the period 2004(5) to 2008(5) and 2009(8) to 2018(9) and two episodes of high growth during the period 2002(6) to 2004(4) and 2008(6) to 2009(7). Two episodes of high growth regime appear to be driven by differences in variances for slow and high growth regimes as pointed out above. Expected durations of regimes that are calculated from these transition probabilities are 80 months for the instability and slowdown state and 18 months for the high growth or expansion state. The results imply that Lebanon is in the slowdown regime for an average of 80 months and in the high growth regime for an average of



18 months (Table 6). This finding indicates the asymmetric nature of the Lebanese growth in different stages of the business cycle.

Figure 2.a: Smoothed Regimes for Regime 0 and Regime 1

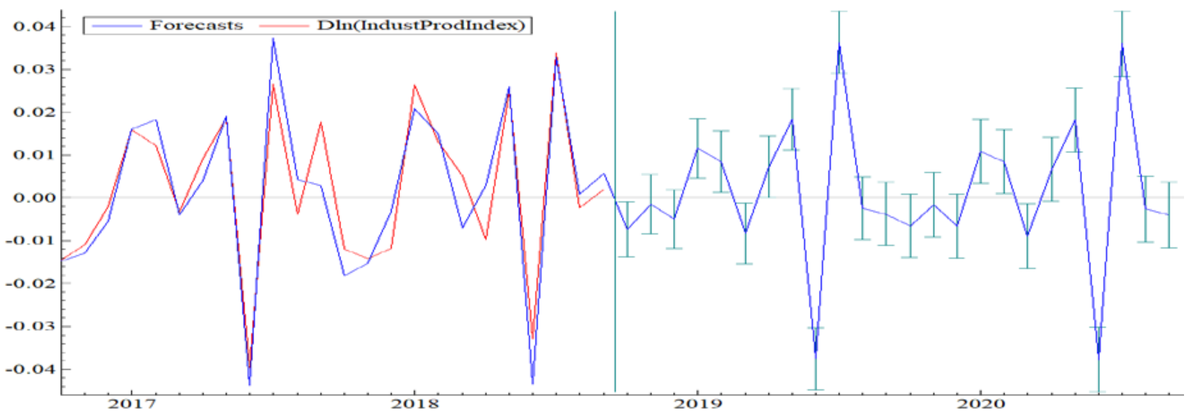


Figure 2.b: Forecast of GR-IPI with MSIH (2)-AR (4)

In order to support the reliability of the findings, a graph of the forecasts obtained with the MSIH (2) -AR (4) model including the 24-month ex-ante forecast and 24-month ex-post forecast are given in Figure 2.b. It can be said that the model is quite successful in terms of within and out of sample forecasting in the period investigated. This suggests that the presence of 2 regimes with 2 episodes for the Lebanese growth of IPI is a reasonable finding.

The aim of the study was to see whether oil prices, which are of great importance for oil importer countries, especially for developing ones, will lead to a change in growth in a particular regime. For this purpose, the initial MS model built for GR-IPI is expanded with control variables such as oil prices, the Public Debt for Foreign Currency and Total Tourist Arrivals. We should note that a great number of specifications are made to capture the dynamics of Lebanese GR-IPI by adding different explanatory variables individually, and numerous models are estimated before the final model is chosen.

Table 8: Estimation Results MSIH (2)-AR (2)-X Model for GR-IPI

	Coefficient	*Std. Error*	*Robust SE*	*t-value*	*t-prob*
AR-1	-0.333	0.079	0.087	-3.810	0.0000
AR-2	-0.166	0.078	0.103	-1.620	0.1080
Seasonal	0.026	0.003	0.003	8.900	0.0000
Seasonal_1	0.025	0.003	0.003	8.500	0.0000
Seasonal_3	0.011	0.002	0.003	4.000	0.0000
Seasonal_4	0.028	0.002	0.002	13.800	0.0000
Seasonal_5	-0.037	0.002	0.003	-14.400	0.0000
Seasonal_6	0.043	0.002	0.002	19.000	0.0000
Seasonal_7	0.008	0.002	0.002	3.600	0.0000
Seasonal_8	0.008	0.002	0.002	3.470	0.0010
Seasonal_9	-0.006	0.002	0.002	-2.740	0.0070
Seasonal_10	-0.005	0.003	0.002	-2.230	0.0270
DLGlobalPriceBrentCrude	0.016	0.006	0.006	2.690	0.0080
DLGlobalPriceBrentCrude_2	0.015	0.006	0.006	2.470	0.0150
DLGlobalPriceBrentCrude_4	0.015	0.006	0.006	2.330	0.0210
Constant(0)	-0.007	0.001	0.002	-4.330	0.0000
Constant(1)	-0.016	0.003	0.004	-4.240	0.0000
sigma(0)	0.006	0.000			
sigma(1)	0.016	0.003			
Log-likelihood	647.883				
AIC	-6.741				
SC	-6.376				

Linearity LR-test Chi^2(4) = 47.145 [0.0000]***
Descriptive statistics for scaled residuals:
Normality test: Chi^2(2) = 0.24396 [0.8852]
ARCH 1-3 test: F(3,159) = 0.65521 [0.5808]
Portmanteau(36): Chi^2(36) = 37.175 [0.4147]

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

All of the MS (2)-AR (*p*)-X models are estimated to determine the variables which had significant impact on economic growth in different regimes[6]. In these models intercept, variance and/or AR parameters are allowed to change; statistical significance of parameters and significant statistical differences between variances are taken into account; lag lengths are determined; and the results of the most appropriate models are presented. Additionally, the graphs of the original values and fitted values of the growth variable are also taken into account in the selection of the most appropriate model.

To this end, three variables representing oil prices and two variables which are thought to be effective on growth in Lebanon are added to MS (2) -AR (*p*) models. The results are presented in Tables 8-10, 11-13, 14-16, 17-19 and 20-22 for the Global Price of Brent Crude Oil, the Cost of Crude Oil Imports from OPEC, the Cost of Crude Oil Imports from non-OPEC, Total Tourist Arrivals and the Public Debt for Foreign Currency respectively.

Results in Tables 8-10 and Figures 3.a-b are similar to those of findings from the base GR-IPI model presented above. The estimated transition probabilities in Table 9 show that there is a higher probability that the system stays in the same regime. Specifically, if the system is in Regime-0 there is an over 99% probability of the system staying in the same regime and near zero probability of switching to the expansion and high growth regime. Correspondently, when the system is in a high growth regime, there is a 91% probability of staying in the high growth regime a low probability of nearly 9% of switching to the slowdown growth regime.

Table 9: Transition Probabilities and Average Duration

	Regime 0,t	Regime 1,t	Average Duration
Regime 0,t+1	0.99215	0.08689	82 months
Regime 1,t+1	0.007853	0.91310	11 months

Table 10: Regime Classification based on Smoothed Probabilities

Regime 0	Months	Avg.Prob.	Total Months
2003(10) - 2007(11)	50	0.954	164
2009(4) - 2018(9)	114	0.995	
Regime 1			
2003(4) -2003(9)	6	0.898	22
2007(12) - 2009(3)	16	0.966	

As shown in Figure 3.a and Table 10, both regimes have the same number of episodes; 2 episodes of slowdown of Lebanese growth during the period 2003(10) to 2007(11) and 2009(4) to 2018(9) and 2 episodes of high growth during the period 2003(4) to 2003(9) and

2007(12) to 2009(3). The average duration of each regime in Table 9 is compatible with this classification. Expected durations of regimes that are calculated from these transition probabilities are 82 months for the instability and slowdown state and 11 months for the high growth or expansion state. It implies that Lebanese growth will be in the slowdown growth regime for an average of 82 months and in the high growth regime for an average of 11 months (Table 9).

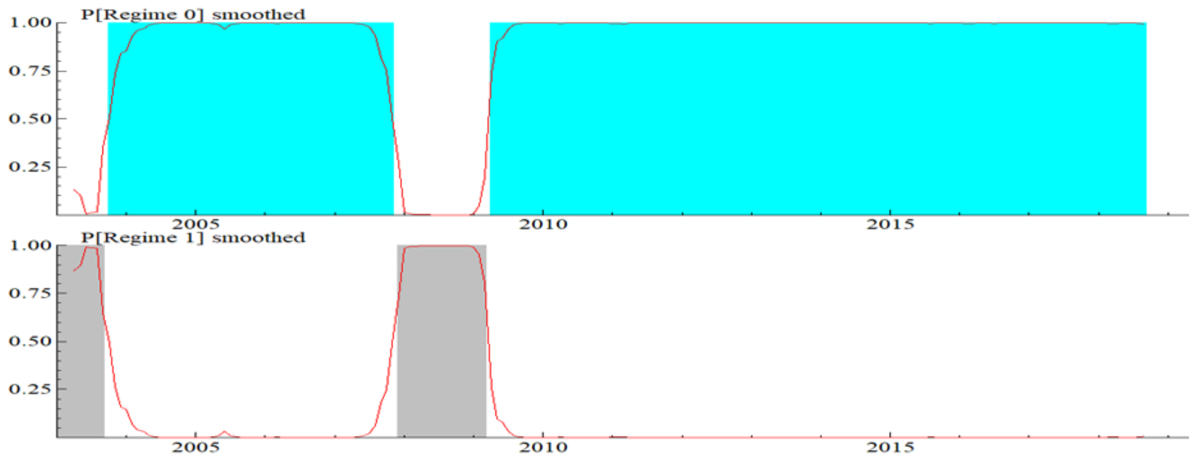


Figure 3.a: Smoothed Regimes for Regime-0 and Regime-1

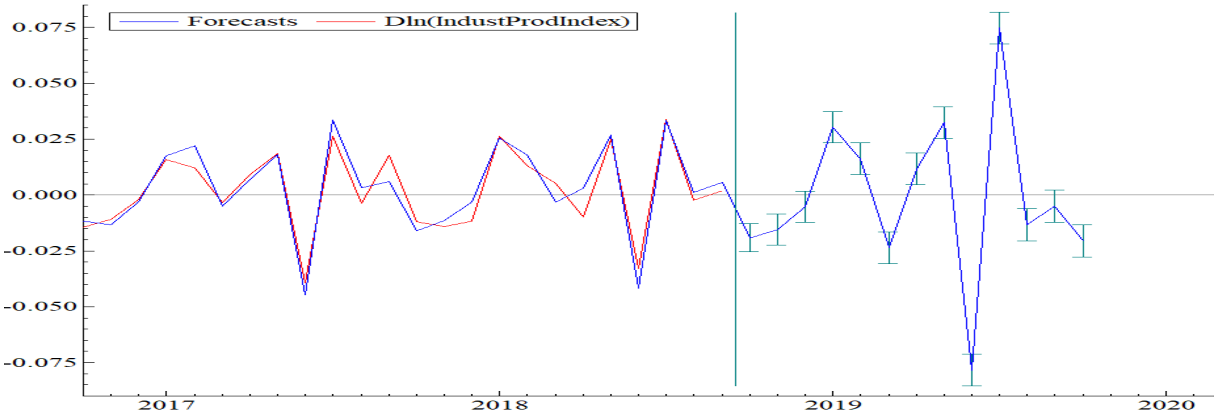


Figure 3-b: Forecast of GR-IPI / MSIH (2)-AR (2)-X: DLGlobalPriceBrentCrude; Out of sample forecast is limited by the availability of data on the control variable.

Results in Table 11 with an alternative measure of oil price, namely the Cost of Crude Oil Imports from OPEC, are similar to the earlier findings. One noteworthy difference from the results in Table 5 and Table 8 here is that variance estimates of regimes are fairly close to one another while the size of intercept estimates are quite different. More specifically, 95% confidence intervals for variances overlap while for intercepts do not. As can be seen in Table

13 and Figure 4.a, this fact reduces the number of episodes in the high growth regime to one, in contrast to the results presented above.

The estimated transition probabilities in Table 12 show that there is a higher probability that the system stays in the same regime. The results indicate a 99% probability of staying in the instability and the slowdown growth regime and a circa zero probability of switching to the expansion and high growth regime. Correspondently, when the system is in a high growth regime, there is a 93% probability of staying in the high growth regime and again a lower probability of approximately 7% switching to the slowdown growth regime.

Table 11: Estimation Results MSIH (2)-AR (2)-X Model for GR-IPI

	Coefficient	*Std. Error*	*Robust SE*	*t-value*	*t-prob*
AR-1	-0.383	0.072	0.084	-4.54	0.0000
AR-2	-0.260	0.071	0.086	-3.02	0.0030
Seasonal	0.026	0.003	0.003	9.59	0.0000
Seasonal_1	0.025	0.003	0.003	9.26	0.0000
Seasonal_3	0.010	0.003	0.003	3.39	0.0010
Seasonal_4	0.027	0.002	0.002	11.2	0.0000
Seasonal_5	-0.039	0.002	0.003	-12.8	0.0000
Seasonal_6	0.044	0.002	0.003	17.4	0.0000
Seasonal_7	0.008	0.002	0.003	3.16	0.0020
Seasonal_8	0.007	0.002	0.002	3.14	0.0020
Seasonal_9	-0.006	0.003	0.002	-2.82	0.0050
Seasonal_10	-0.006	0.003	0.002	-2.35	0.0200
DLCostCrudeOilIimpOPEC	0.021	0.008	0.009	2.39	0.0180
DLCostCrudeOilIimpOPEC_2	0.026	0.006	0.006	4.08	0.0000
DLCostCrudeOilIimpOPEC_8	0.024	0.008	0.008	2.94	0.0040
DLCostCrudeOilIimpOPEC_9	-0.019	0.008	0.008	-2.41	0.0170
Constant(0)	-0.006	0.001	0.002	-3.96	0.0000
Constant(1)	-0.021	0.002	0.002	-8.42	0.0000
sigma(0)	0.007	0.000			
sigma(1)	0.008	0.002			
Log-likelihood	656.968				
AIC	-6.82761				
SC	-6.44607				
Linearity LR-test Chi^2(4) =	56.884 [0.0000]***				
Descriptive statistics for scaled residuals:					
Normality test: Chi^2(2) =	1.1194 [0.5714]				
ARCH 1-3 test: F(3,158) =	2.1120 [0.1009]				
Portmanteau(36): Chi^2(36) =	39.4530 [0.3182]				

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

Table 12: Transition Probabilities and Average Duration

	Regime 0,t	Regime 1,t	Average Duration
Regime 0,t+1	0.99427	0.06779	85
Regime 1,t+1	0.005734	0.93220	16

Table 13: Regime Classification based on Smoothed Probabilities

Regime 0	Months	Avg.Prob.	Total Months
2003(4) - 2007(11)	56	0.991	170
2009(4) - 2018(9)	114	0.999	
Regime 1			16
2007(12) - 2009(3)	16	0.989	

As shown in Figure 4.a and Table 13, regimes have different episodes; 2 episodes of slowdown of Lebanon's growth during the period 2003(4) to 2007(11) and 2009(4) to 2018(9) and one episode of high growth regime during the period 2007(12) to 2009(3). The average (expected) duration of each regime is in line with this finding. Expected durations of both regimes that are calculated from these transition probabilities are 85 months for the instability and slowdown state and 16 months for the high growth or expansion state. It implies that Lebanon will be in the slowdown regime for a total of 170 months and in the high growth regime for only 16 months (Table 13).

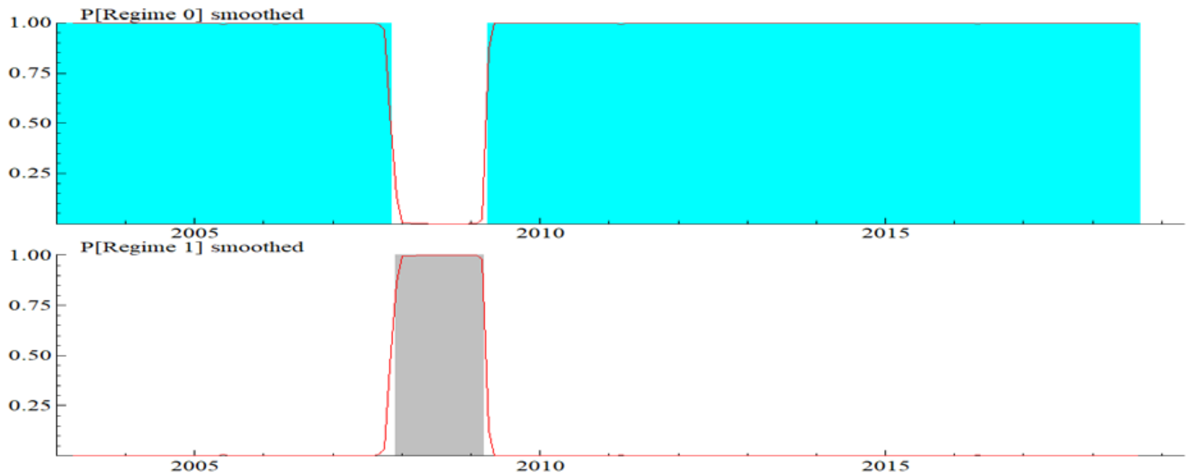


Figure 4-a: Smoothed Regimes for Regime 0 and Regime 1

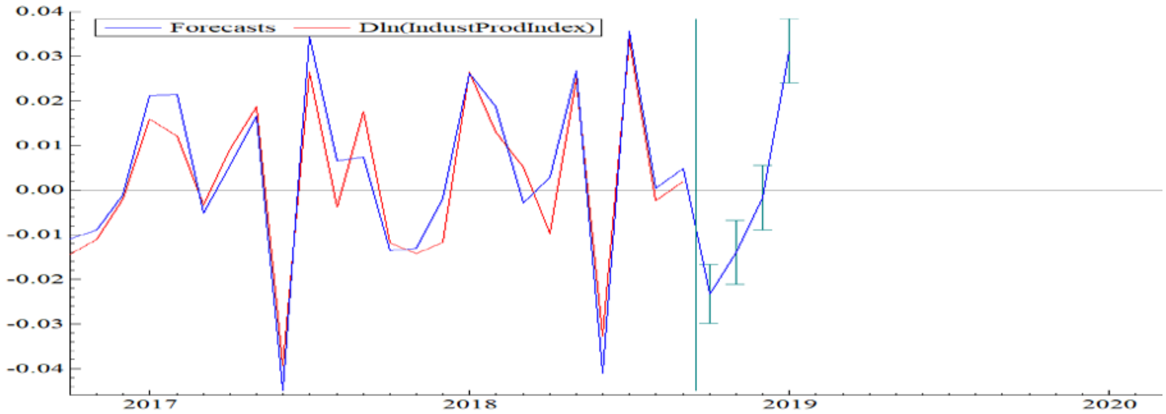


Figure 4-b: Forecast of GR-IPI / MSIH (2)-AR (2)-X: DLCostCrudeOilIimpOPEC; Out of sample forecast is limited by the availability of data on the control variable.

Now turning to the model with another measure of oil price that is the Cost of Crude Oil Imports from non-OPEC as a control variable, we obtain the results given in Tables 14-16 and Figures 5.a and 5.b. Findings below are very similar to the outcomes of the previous model. Again the estimated transition probabilities shows that there is a higher probability that the system stays in the same regime. The results in Table 15 indicate an over 99% probability of system staying in the instability and slowdown growth regime and just over half a percent probability of switching to the expansion and high growth regime when the regime is slow growth regime. Correspondently, when the system is in the high growth regime, there is a 93% probability of staying in the high growth regime and again a low probability of over 6% of switching to the slowdown growth regime.

Table 14: Estimation Results MSI (2)-AR (2)-X Model for GR-IPI

	Coefficient	*Std.Error*	*Robust-SE*	*t-value*	*t-prob*
AR-1	-0.410	0.072	0.084	-4.87	0.0000
AR-2	-0.278	0.072	0.095	-2.93	0.0040
DLCostCrudeOilIimpNon-OPEC	0.024	0.006	0.008	3.21	0.0020
DLCostCrudeOilIimpNon-OPEC_2	0.022	0.005	0.005	4.19	0.0000
DLCostCrudeOilIimpNon-OPEC_6	0.010	0.005	0.005	2.31	0.0220
Seasonal	0.028	0.003	0.003	11.1	0.0000
Seasonal_1	0.029	0.002	0.002	12.7	0.0000
Seasonal_3	0.013	0.002	0.003	4.68	0.0000
Seasonal_4	0.030	0.002	0.002	13.8	0.0000
Seasonal_5	-0.037	0.002	0.003	-12.8	0.0000
Seasonal_6	0.046	0.002	0.002	20.1	0.0000
Seasonal_7	0.011	0.002	0.002	4.77	0.0000
Seasonal_8	0.009	0.002	0.002	3.69	0.0000
Seasonal_9	-0.004	0.002	0.002	-1.98	0.0500
Constant(0)	-0.008	0.001	0.001	-6.85	0.0000

Constant(1)	-0.023	0.002	0.002	-9.82	0.0000
sigma(0)	0.007	0.000			
sigma(1)	0.008	0.002			
Log-likelihood	653.080				
AIC	-6.807				
SC	-6.460				

Linearity LR-test Chi^2(4) = 61.906 [0.0000]***
Descriptive statistics for scaled residuals:
Normality test: Chi^2(2) = 0.88890 [0.6412]
ARCH 1-2 test: F(2,160) = 3.7586 [0.0121]
Portmanteau(36): Chi^2(36) = 38.705 [0.3485]

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

As shown in Figure 5.a and Table 16, regimes have different episodes; 2 episodes of slowdown of the Lebanese growth during the period 2003(4) to 2007(10) and 2009(4) to 2018(9) and one episode of high growth during the period 2007(11) to 2009(3). The average (expected) duration of each regime supports this. Expected durations of both regimes that are obtained from these transition probabilities are 84.5 months for the instability and slowdown state and 17 months for the high growth or expansion state. It implies that the Lebanese economy will be in the slowdown regime for an overall 169 months and in the high growth regime for just 17 months (Table 16).

Table 15: Transition Probabilities and Average Duration

	Regime 0,t	Regime 1,t	Average Duration
Regime 0,t+1	0.99440	0.066879	84.50
Regime 1,t+1	0.0055990	0.93312	17.00

Table 16: Regime Classification based on Smoothed Probabilities

Regime 0	Months	avg.prob.	Total Months
2003(4) - 2007(10)	55	0.998	169
2009(4) - 2018(9)	114	0.999	
Regime 1			
2007(11) - 2009(3)	17	0.967	17

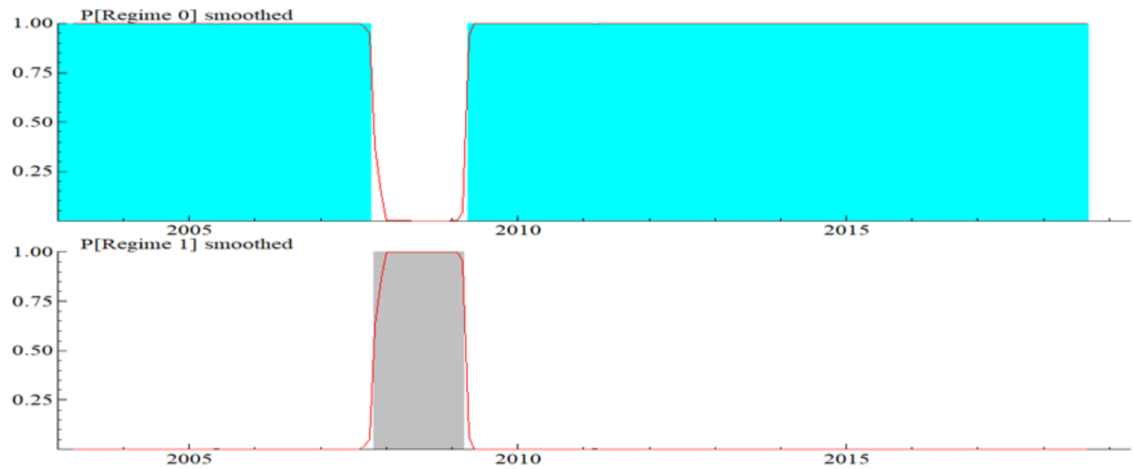


Figure 5-a: Smoothed Regimes for Regime 0 and Regime 1

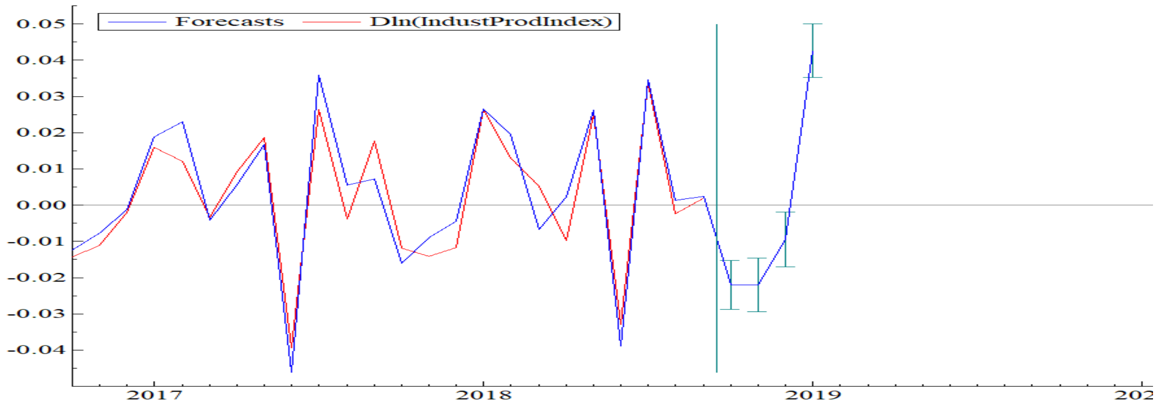


Figure 5-b: Forecast of GR-IPI / MSIH (2)-AR (2)-X: DLCostCrudeOilIimpNon-OPEC; Out of sample forecast is limited by the availability of data on the control variable.

Given the importance of the service sector, specifically the tourism industry for Lebanon, we next include Total Tourist Arrivals as a control variable in the model. The results in Tables 17-19 and Figures 6.a and 6.b are very similar to the previous models, but in particular to the previous two models in relation to the finding of a single episode of the high growth and expansion regime. As emphasized earlier, the reason for this particular result appears to be the variances not changing significantly between the two regimes.

Table 17: Estimation Results MSIH (2)-AR (1)-X Model for GR-IPI

	Coefficient	*Std.Error*	*Robust-SE*	*t-value*	*t-prob*
AR-1	-0.286	0.073	0.086	-3.32	0.0010
DLtotaltouristarrival	0.004	0.003	0.002	1.87	0.0630
DLtotaltouristarrival_3	0.005	0.003	0.003	2.15	0.0330

DLtotaltouristarrival_6	0.005	0.003	0.002	1.97	0.0500
DLtotaltouristarrival_12	0.010	0.003	0.002	4.47	0.0000
Seasonal	0.031	0.002	0.002	12.9	0.0000
Seasonal_1	0.030	0.002	0.002	13.2	0.0000
Seasonal_3	0.015	0.002	0.002	6.92	0.0000
Seasonal_4	0.033	0.002	0.001	22.8	0.0000
Seasonal_5	-0.038	0.002	0.004	-9.78	0.0000
Seasonal_6	0.047	0.002	0.002	23.3	0.0000
Seasonal_7	0.015	0.002	0.002	6.33	0.0000
Seasonal_8	0.010	0.002	0.002	4.71	0.0000
Constant(0)	-0.010	0.001	0.001	-13.7	0.0000
Constant(1)	-0.033	0.003	0.004	-8.96	0.0000
sigma(0)	0.007	0.000			
sigma(1)	0.010	0.003			
log-likelihood	647.252				
AIC	-6.719				
SC	-6.391				
Linearity LR-test Chi^2(4)	23.435[0.0001]***				
Descriptive statistics for scaled residuals:					
Normality test: Chi^2(2) =	2.5775 [0.2756]				
ARCH 1-2 test: F(2,164) =	2.5639 [0.0801]				
Portmanteau(36): Chi^2(36) =	38.249 [0.3677]				

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

Table 18: Transition Probabilities and Average Duration

	Regime 0,t	Regime 1,t	Average Duration
Regime 0,t+1	0.99290	0.12761	88.50
Regime 1,t+1	0.0070956	0.87239	10.00

Table 19: Regime Classifications based on Smoothed Probabilities

Regime 0	Months	Avg.Prob.	Total months
2003(3) - 2008(5)	63	0.995	177
2009(4) - 2018(9)	114	0.999	
Regime 1			
2008(6) -2009(3)	10	0.943	10

The estimated transition probabilities in Table 18 specify that there is a higher probability that the system stays in the same regime. The results indicate an over 99% probability of staying in the instability and slowdown growth regime and a nearly zero probability of switching to the expansion and high growth regime when the regime is the slow growth regime. Correspondently, when the system is in the high growth regime, there is an 87% probability of staying in the high growth regime and almost 13% the probability of switching to the slowdown growth regime.

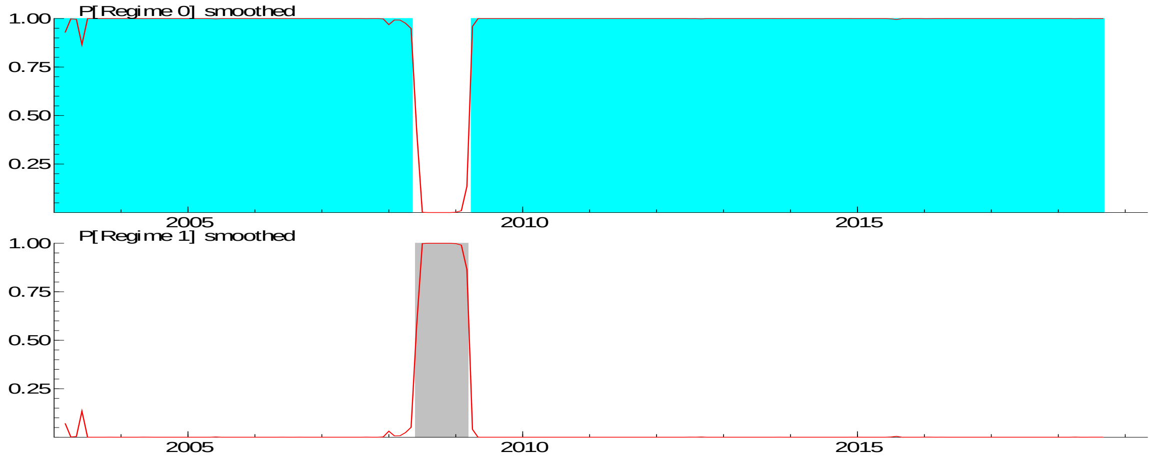


Figure 6-a: Smoothed Regimes for Regime 0 and Regime 1

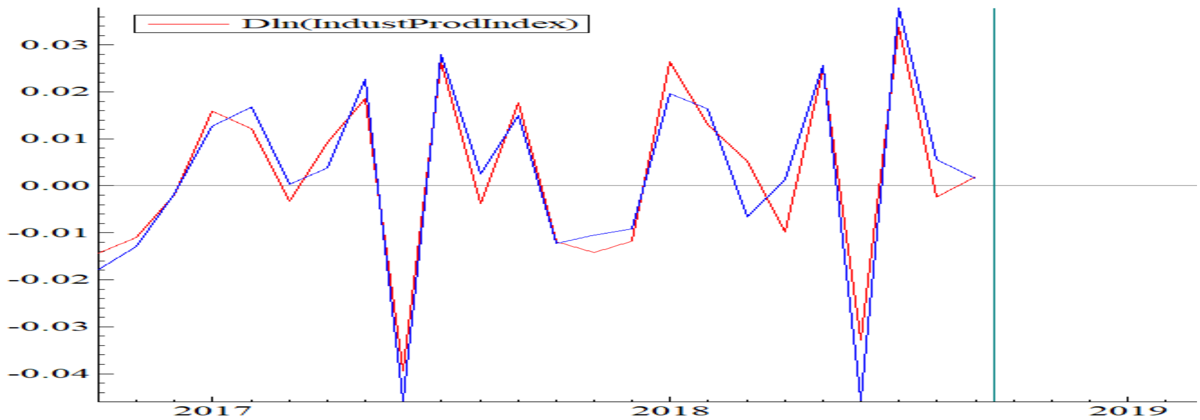


Figure 6-b: Forecast of GR-IPI / MSIH (2)-AR (2) - X: DLtotaltouristarrival; Out of sample forecast is limited by the availability of data on the control variable.

As shown in Figure 6-a and Table 19, regimes have different episodes; 2 episodes of slowdown of the Lebanon's growth during the period 2003(3) to 2008(5) and 2009(4) to 2018(9) and one episode of high growth during the period 2008(6) to 2009(3). The average (expected) duration of each regime is consistent with this finding. Expected durations of both regimes that are calculated from these transition probabilities are 88.5 months for instability and slowdown state and 10 months for the high growth or expansion state. Similar to the earlier findings, the results imply that Lebanon will be in the slowdown regime for a sum of 177 months and in the high growth regime for merely 10 months (Table 19).

Table 20: Estimation Results MSIH (2)-AR (1)-X for GR-IPI

	Coefficient	*Std.Error*	*Robust-SE*	*t-value*	*t-prob*
AR-1	-0.203	0.076	0.083	-2.45	0.0160

Seasonal	0.028	0.002	0.002	12.2	0.0000
Seasonal_1	0.029	0.002	0.002	13.0	0.0000
Seasonal_3	0.016	0.002	0.002	6.78	0.0000
Seasonal_4	0.032	0.002	0.002	19.3	0.0000
Seasonal_5	-0.033	0.002	0.003	-9.74	0.0000
Seasonal_6	0.047	0.002	0.002	21.8	0.0000
Seasonal_7	0.012	0.002	0.002	6.02	0.0000
Seasonal_8	0.011	0.002	0.002	5.39	0.0000
DLPublicDebtCurr_1	-0.016	0.008	0.007	-2.19	0.0300
DLPpublicDebtCurr_2	0.014	0.008	0.004	3.32	0.0010
DLPlpublicdebtcurr_3	-0.011	0.008	0.007	-1.68	0.0550
DLPpublicdebtcurr_11	0.012	0.008	0.004	2.99	0.0950
Constant(0)	-0.010	0.009	0.009	-11.3	0.0000
Constant(1)	-0.021	0.005	0.009	-2.47	0.0140
sigma(0)	0.075	0.000			
sigma(1)	0.017	0.003			
log-likelihood	638.999				
AIC	-6.638				
SC	-6.309				

Linearity LR-test Chi^2(4) = 50.589 [0.0000]***
Descriptive statistics for Scaled residuals:
Normality test: Chi^2(2) = 5.95220 [0.0510]
ARCH 1-2 test: F(2,164) = 0.60767 [0.5458]
Portmanteau(36): Chi^2(36) = 50.18200 [0.0584]

Note: p values are in brackets, [ ]; *** significant at 1 percent; insignificant seasonal effects dropped from the model; December is the base season; Seasonal is Jan, Seasonal_1 is Feb. etc.

We finally turn our attention to the last model where we include the Public Debt for Foreign Currency as a control variable. The findings in general are similar to the preceding models, but particularly with the first two models in terms of the double episodes outcome of the high growth and expansion regime. The results in Table 20 indicate significant difference between the variances and relatively small difference between the intercepts in the two regimes. More specifically, the 95% confidence intervals for intercepts overlap while those of variances do not. As underlined earlier this particular fact appears to be generating two separate episodes for the high growth and expansion regime.

Table 21: Transition Probabilities and Average Duration

	Regime 0,t	Regime 1,t	Average duration
Regime 0,t+1	0.98758	0.080502	84.5
Regime 1,t+1	0.012419	0.91950	9

Table 22: Regime Classifications based on Smoothed Probabilities

Regime 0	Months	Avg.Prob.	Total Months
2003(9) - 2008(3)	55	0.956	169

2009(4) - 2018(9)	114	0.986	
Regime 1			
2003(3) - 2003(8)	6	0.878	18
2008(4) -2009(3)	12	0.916	

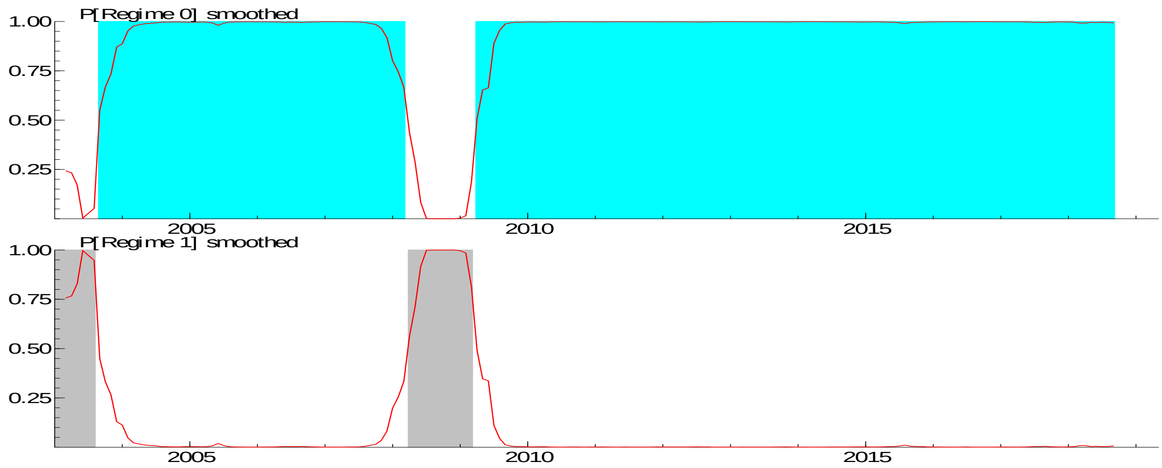


Figure 7-a: Smoothed Regimes for Regime-0 and Regime-1

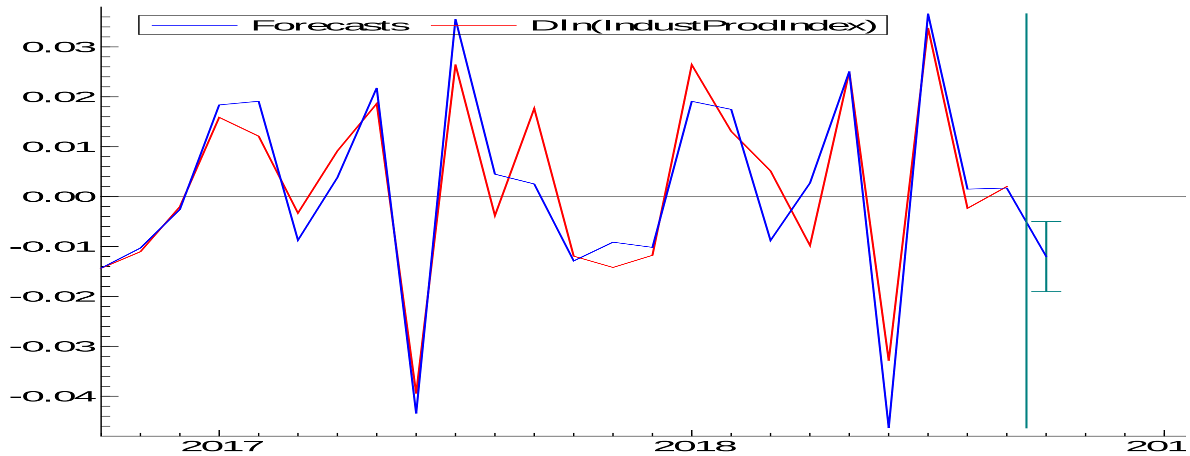


Figure 7-b: Forecast of GR-IPI /MSIH (2)-AR (2)-X: DLPublicDebtCurr; Out of sample forecast is limited by the availability of data on the control variable.

The estimated transition probabilities in Table 21 indicate that there is a higher probability that the system stays in the same regime. The results suggest an almost 99% probability of the system staying in the instability and slowdown growth regime and just over one percent probability of switching to the expansion and high growth regime when it is in the slow growth regime. Similarly, when the system is in the high growth regime, there is just about

92% probability of staying in the high growth regime and again a lower probability of 8% switching to the slowdown growth regime.

As shown in Figure 7-a and Table 22, regimes have different episodes; 2 episodes of slowdown of the Lebanese growth during the period 2003(9) to 2008(3) and 2009(4) to 2018(9) and two episodes of high growth during the period 2003(3)-2003(8) and 2008(4) - 2009(3). The average (expected) duration of each regime backs these outcomes. Expected durations of both regimes that are calculated from these transition probabilities are 84.50 months for the instability and slowdown state and 9 months for the high growth or expansion state. It suggests that Lebanese growth will be in the slowdown regime for an average 84.50 months and in the high growth regime for an average of 9 months (Table 22).

3. Conclusion

In this paper, we employed various specifications of MS-AR models to empirically characterize the state dependent dynamics of Lebanon's business cycles between January 2002 and September 2018. Our findings suggest that linearity of GR-IPI series and the explanatory variables are rejected implying that there is regime switching structure in Lebanese business cycles with strong seasonal effects. Further, the estimated base growth rates for both regimes are negative in all models, and paradoxically the magnitude of the high growth regime is larger than the slow growth regime.

Accepting the above results at the face value imply that growth in both regimes, particularly the high growth regime is driven largely by random shocks. However, this particular result could also be attributed to the quality and suitability of data set. In particular, given the small share of industry in Lebanon's economy, the IPI may not be a good proxy to represent Lebanese growth. These disputes certainly warrant further scrutiny of the Lebanese growth cycles. Yet, regime classifications, transition probabilities, average durations of regimes and within and out of sample predictions obtained from the models appears to be reliable, and estimated models form a reliable chronology of the turning points of business cycles for Lebanon.

Including control variables individually in the model, improves the models' performance with reference to one-step prediction errors. In the models specified by adding the Global Price of Brent Crude Oil and the Public Debt for Foreign Currency separately intercepts do not, but variances differ significantly between regimes as it is the case for the base industrial production index growth model. On the other hand, in the models identified by including the

Cost of Crude Oil Imports from OPEC, the Cost of Crude Oil Imports from non-OPEC and Total Tourist Arrivals individually, variances do not, but intercepts change significantly from one regime to another. According to these findings, the differentiation of intercepts or variances between regimes differentiates the number of episodes in the high growth regime. As a result, it can be said that while the constancy of variances between regimes decreases the number of episodes, the constancy of intercept does not change the number of episodes. In addition, this feature appears to reduce the fraction of sample under the high growth regime, and increase the fraction of sample under the instability and slowdown growth regime.

The results also disclose that the average duration of the instable and slow growth regime is much longer than that of the expansion and high growth regime. The probabilities of switching from one regime to another are rather very low but nearly nil for switching from the instable slow growth regime to the expansion and high growth regime. This finding is particularly disturbing as it implies the slowdown growth regime becomes permanent as the estimated transition probabilities from the slow growth regime at time *t* to the slow growth regime at time *t+1* is essentially one in all the models.

Notes

1. http://www.lebanonembassyus.org/the-economy.html (Accessed on Dec. 25, 2019).
2. https://www.executive-magazine.com/industry-agriculture/the-unido-view-on-lebanons-industrial-sector (Accessed on Dec. 24, 2019).
3. https://fred.stlouisfed.org/searchresults?st=lebanon (Accessed on Nov. 5, 2019).
4. https://www.bdl.gov.lb/webroot/statistics/ (Accessed on Nov. 1, 2019).
5. All computations were performed using package Ox-version 8.02.
6. X represents the vector of deterministic and control variables.

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