

TIME SERIES INVESTIGATION OF TURKISH BUSINESS CYCLES USING REGIME SWITCHING MODELS

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ABSTRACT

Last fifteen years have witnessed an explosion of interest among researchers in using nonlinear models. The idea that time series are subject to change over time gave rise to the development of regime switching models in which dynamic behaviour is state dependent. This paper employs various models of this class to analyze the cyclical pattern of the Turkish economy. Following Hansen (1997) and Hamilton (1989), Threshold Autoregression (TAR), Self-Exciting Threshold Autoregression (SETAR) and Markov-switching (MS) models are fitted to post-1987 quarterly GNP and post-1986 monthly IPI data. The method to determine endogenous structural breaks suggested by Hansen (2001) is also applied to assess the estimation results. In a highly non-standard testing environment, specification tests of the models are conducted by taking advantage of the simulation methods. We capture the asymmetry over the different phases of the business cycle in which recessions are short and abrupt while expansions are moderate and highly persistent. We also discuss the striking events of the time in the light of our results. Most importantly, we find strong evidence that the Turkish economy has experienced structural breaks in the considered period, of the type presented in the literature.

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1. INTRODUCTION

Every economic structure undergoes fluctuations in aggregate activity known as business cycles. During the formation of cycles, behavior of economic time series change temporarily or permanently due to various events such as wars, financial crisis or dramatic changes in government policies.

In this paper we model the fluctuations of the Turkish economy between 1986-2002 since the quarterly real GNP and monthly IPI data are not available for the preceding years. As a result of this we focus on the period in which the economy is linked with the external markets. However it should be noted that Turkish economy experienced severe fluctuations before this period as well. During the 1945-1985 period, Second World War, Korea and Cyprus Wars, two oil shocks in 1970s and the three military interventions in 1960, 1971 and 1980 are accompanied by declines in aggregate economic activity.

Over the last two decades, Turkish economy attained high growth rates in spite of high inflation. However growth was erratic since the economy also recorded significant negative growth interrupting the expansionary periods. There are five deep recessionary periods for the last fifteen years in 1988, 1991, 1994, 1999 and 2001. Some of them were caused by external shocks while the others by endogenous dynamics inherent in the data generating process. A brief look at the striking events of Turkish economy during 1986-2002 clearly displays that macroeconomic instability is the hallmark of this period.

In early 1980s, Turkey liberalized the trade and started the financial liberalization few years later. During the second half of 1980s, growing public deficits and increasing inflation set the stage for an instable financial market which triggered a run from TL. In February 1988, a stabilization package is introduced. The objectives of the program were to increase the demand for TL, improve trade balance and decrease public expenditures. However, productivity slowdown as a result of high interest rates and public sector inflation led to a recessionary period starting from the second quarter of the year.

In 1989, final phase of the liberalization program is completed with the capital account liberalization. However, financial openness could not be accompanied by structural reforms. At that time Turkey was experiencing large fiscal and external deficits. After the introduction of convertibility in 1989, capital inflows increased due to high interest rates. TL appreciated deteriorating the trade balance. Large current account deficits and increasing dollar demand in consequence started to put a limit to the capital inflows. This led to an increase in the volatility of domestic markets since the economy has already become addicted to “hot money”. As a result of this, Turkish economy is seriously affected by the Gulf War in 1991 which led to large withdrawals of domestic and foreign currencies from the banking system.

As stated by Ersel (1996), the period following 1989 is clearly different on many grounds from the 1984-1989 period. Turkey started to finance a greater portion of its’ investment through foreign savings. The country also became able to sustain higher capital account deficits which led to a risk accumulation. All these factors made the economy more vulnerable than the preceding period. As a result of intensive speculative capital inflows, deterioration was observed in many macroeconomic variables. This points out to a structural break in the Turkish economy at some point through this time.

The openness of the economy with fiscal imbalances also complicated the macroeconomic management. High inflation and capital inflows led to an appreciation of the real exchange rate during the 1990-1993 period. In late 1993, Treasury started to cancel most of the auctions and Central Bank expanded credit to the public sector. The desire to reduce interest rates often declared by the political authority at that time. This turbulent environment led to a run from TL. Central Bank intervened the foreign exchange market. The result was a sudden loss of half of the reserves and record levels for overnight interest rates. The parity has more than doubled from about 19.000 TL/\$ in January 1994 to 38.000 TL/\$ in April 1994. On the 5th of April 1994, the government declared a new stabilization package. The treasury could not finance itself from domestic markets till the end of May 1994.

Most of the studies on 1994 Currency Crisis stress the policy mistakes instead of weak fundamentals preceding the crises. Özatay (1994) points out that weak fundamentals makes an economy fragile and set the stage for speculation. But the exact timing of the crises

depends upon shocks that affect the expectations. In 1994, these shocks were the cancellation of domestic public debt auctions and the domestic credit expansion of the Central Bank. The result was a severe recession which marks the beginning of the three-digit inflation period.

From the beginning of 1996 till the Russian crisis in July 1998, Turkish economy attained high rates of growth due to large capital inflows. During this period TL appreciated by 10 percent. The Russian crisis that was triggered by East Asia Crisis in 1998 increased the risk of many emerging economies including Turkey. Starting with late 1998, capital outflows were observed. The interest rates were increased in order to defend the TL. Increasing interest rates and decreasing foreign demand led to a decline in industrial production. The recession was deepened by two earthquake disasters and the increased taxes afterwards. The economy shrunk at an annual rate of -6.4%.

Next year started with a new disinflation program. Three main strategies were to provide the fiscal discipline, determine the exchange rates under a pre-announced crawling peg system and implement the structural reforms. Optimistic expectations of market participants led to an abrupt decline in interest rates, from an annual average yield of 106% to 36.4% in the first month of 2000. That was signalling a danger for the aim of halting inflation since postponed consumption demand came into play. At the beginning of November, banking sector is forced to a rapid transition with new regulations. This led to a discomfort and more liquidity demand in order to close short positions. The natural consequence was a further increase in interest rates which mostly affected the banks that were carrying Treasury securities in their portfolios. By injecting liquidity, Central Bank tried to avoid a second crisis but the belief that the authorities would no longer be able to defend the exchange rate led to the abandonment of the parity on February 21. The float of the TL also adversely affected the fight against inflation. The result was a chaotic environment dominated by uncertainty.

The instability in the GNP growth rate has been the main indicator of the cyclical pattern of the Turkish economy. Almost every period of accelerated growth has been followed by a period of slowdown in the last fifteen years. Since these swings in output influence all the agents in an economy, policy-makers are interested in monitoring and forecasting the cyclical behavior.

Recent literature on the analysis of Turkish business cycles concentrates at large part on methods like leading economic indicators. In the context of predictability of currency crisis, some contributions made by Rijckeghem *et al* (1998) and Kibritçioğlu *et al* (1998). These studies define relationships between indicators and indices in order to form an early warning system. However, the risk of false signals in the presence of structural breaks constitutes a drawback. The fact that Turkish economy experienced structural breaks in the last fifteen years as demonstrated by this study, put forward the need for alternative methods.

Other recent contributions to Turkish business cycle literature includes the studies of Alper (1998) and Aruoba (2001). Following the RBC tradition, Alper (1998) adopted the standard methodology introduced in Kydland and Prescott (1990) to investigate the nominal stylized facts of Turkish business cycles. He found evidence for a supply-driven model for the Turkish economy. Aruoba (2001) used the same methodology to explain the determinants of business cycles. The aim of his study is to provide an appropriate ground for building an RBC model of Turkish economy. Uygur (1999) constructs estimable equations for GDP cycles. His results suggest that fiscal imbalances, inflation and financial volatilities significantly explain output fluctuations. In a recent study, Ertuğrul and Selçuk (2001) explain the formation of boom-bust cycles after 1989 by taking a descriptive approach.

The contribution of this paper with respect to the existing studies on Turkish business cycles is that we characterize the nonlinear dynamics of the time series by using a regime switching framework. We employ discrete nonlinear regime-switching models in which Turkish business cycles are empirically represented by state dependent dynamic behavior. The focus in our study is on the determination of business cycle turning points in order to set up a useful forecasting framework.

The regime switching framework used in this paper does not require a substantial amount of ex-post data. This is an important superiority of the methodology employed in this thesis since a real-time recognition of a recession has crucial importance in the effectiveness of countercyclical policy.

Empirical results suggest that a satisfactory representation of the sample data is obtained by modelling business cycles subject to shift in regimes. We capture the asymmetry over the different phases of the business cycle. The models detects all five recessionary

periods overviewed above. Recessions are short and abrupt while expansions are moderate and highly persistent. Especially the first two recessionary periods in the sample in 1988 and 1991 are very short. However the persistency increases for more recent recessions that took place in 1994, 1999 and 2001. The MS model identifies expansions, when the economy grows at an annual rate of 1.8 % and recessions when the economy displays a negative growth of 6.1%. In TAR application we obtain a threshold estimate of 6.14 which is very high to discriminate between recessionary and expansionary periods. However this should not be regarded as a drawback since it complements the MS model by identifying the higher growth phases in which the industrial production index increased more than 6.14. We also analyze the characteristics of the breakpoints via a structural change AR model. In this context, whether business cycle formations of Turkish economy are endogenous or exogenous is an interesting point for which this thesis provides an empirical evidence.

The plan of the paper is as follows. Section 2 introduces TAR class of models and Hamilton's MS model. The empirical application takes place in Section 5. Specification testing of the models with nonstandard procedures take place at the end of each application. Section 6 presents the summary of the findings of the thesis and directions for future research.

2. THE MODELS

2.1 The TAR Model

Threshold Autoregression (TAR) Models are introduced to the time-series literature by Tong (1978, 1990). TAR model assumes that, the regime switches according to the observable past history of the system. The value of the threshold variable γ which can be found by statistical techniques, determines the regime in which the system was in at each time t .

If observed data is (y_1, \dots, y_n) , a two-regime TAR model takes the following form

$$(2.1) \quad y_t = (\alpha_0 + \alpha_1 y_{t-1} + \dots + \alpha_p y_{t-p})(1 - I[q_{t-1} > \gamma]) \\ + (\beta_0 + \beta_1 y_{t-1} + \dots + \beta_p y_{t-p})I[q_{t-1} > \gamma] + \varepsilon_t$$

where $I[A]$ is an indicator function with $I[A] = 1$ if event A occurs and $I[A] = 0$ otherwise and $q_{t-1} = q(y_{t-1}, \dots, y_{t-p})$ is a known function of the data. This model allows the regression parameters to differ depending on the value of the threshold variable, γ that splits the sample. ε_t s are assumed to be an i.i.d. white noise sequence conditional upon past information.

TAR models allow for the analysis of complex systems by decomposing them into simpler subsystems which are separated by thresholds. In that sense, each of the states or regimes is a local approximation of the system. A special case of such models arises when the parameters of the model vary according to a lagged value of the time series itself. The resulting model is a subset of the class of TAR models called a Self-Exciting Threshold Autoregression (SETAR) Model.

Equation (2.1) can be expressed more compactly in the following form

$$(2.2) \quad y_t = x_t(\gamma)' \theta + e_t$$

where $x_t(\gamma) = (x_t' I [q_{t-1} \leq \gamma] \quad x_t' I [q_{t-1} > \gamma])'$ and $\theta = (\alpha' \beta)'$

As is obvious from the above statement, equation (2.2) is a regression equation where the parameters of interest are θ and γ .

Model parameters can be estimated by sequential conditional least squares since the regression equation is nonlinear and discontinuous. Under the additional assumption that the ε_t s are normally distributed, the least squares estimates are equivalent to maximum likelihood estimates.

For a given value of γ , the least squares estimate of θ is

$$(2.3) \quad \hat{\theta}(\gamma) = \left(\sum_{t=1}^n x_t(\gamma) x_t(\gamma)' \right)^{-1} \left(\sum_{t=1}^n x_t(\gamma) y_t \right)$$

with residual variance:

$$(2.4) \quad \hat{\sigma}_n^2(\gamma) = \frac{1}{n} \sum_{t=1}^n \hat{e}_t(\gamma)^2$$

First of all the least squares estimate of the threshold γ is obtained by minimizing Equation (2.4), that is:

$$(2.5) \quad \hat{\gamma} = \arg \min \hat{\sigma}_n^2(\gamma)$$

where $\Gamma = [\underline{\gamma}, \bar{\gamma}]$ denotes the set of all allowable threshold values.

Then, the least squares estimates of the autoregressive parameters are found as $\hat{\theta} = \hat{\theta}(\hat{\gamma})$ with sample variance $\hat{\sigma}_n^2 = \hat{\sigma}_n^2(\hat{\gamma})$.

2.2 The MS Model

Markov switching (MS) models have been used to describe the nature of switching regressions since the early 1970s. But they became quite popular after Hamilton's (1989) seminal contribution. Hamilton used Goldfeld and Quandt's (1973) Markov switching regression to characterize the parameter changes in an autoregressive process.

Markov chain is the simplest time series model for a discrete-valued random variable such as the unobserved state variable s_t in Markov-switching model. It is a stochastic process that exhibits dynamic behavior through the transitions among states. This process is useful for the analysis of random events whose likelihood depends on what happened past. It possesses short term memory in the sense that each random event is influenced, at least to some degree, by its most recent predecessor. That is, the random event which occurs at time t may be dependent upon the event which occurred at time $t-1$. Since the process does not contain direct information of earlier events, at time t , the knowledge of time $t-2$ is only implicitly stored in its memory of time $t-1$.

Suppose that the random variable s_t can take integer values $\{1,2,\dots,N\}$. If the probability that s_t equals j depends on the past only through the most recent value s_{t-1} , this process is described as an N -state Markov chain with transition probabilities, $\{p_{ij}\}_{i,j=1,2,\dots,N}$.

$$(3.1) \quad P\{s_t = j | s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j | s_{t-1} = i\} = p_{ij}$$

where p_{ij} gives the probability that state i will be followed by state j .

In Hamilton's Markov-switching model (1989), s_t is assumed to be a first-order Markov-process. The implication is that the current regime s_t depends only on the regime one period ago, s_{t-1} . Transition probabilities should be nonnegative to define proper probabilities and also the process must occupy one of its N states. For a two state first-order Markov process, the transition probabilities of moving from one state to the other is as follows:

$$(3.2) \quad \begin{aligned} P(s_t = 1 | s_{t-1} = 1) &= p_{11}, P(s_t = 2 | s_{t-1} = 1) = p_{12} \\ P(s_t = 1 | s_{t-1} = 2) &= p_{21}, P(s_t = 2 | s_{t-1} = 2) = p_{22} \end{aligned}$$

The original Markov-switching model focuses on the mean behaviour of variables. This model is also known as the *MS-Mean* Model since only the means of both states are subject to change between regimes. In his seminal paper, Hamilton (1989) used a two state model with AR(4) specification. This original model is as follows:

$$(3.3) \quad \begin{aligned} y_t - \phi_{0,s_t} &= \phi_1(y_{t-1} - \phi_{0,s_{t-1}}) + \phi_2(y_{t-2} - \phi_{0,s_{t-2}}) \\ &+ \phi_3(y_{t-3} - \phi_{0,s_{t-3}}) + \phi_4(y_{t-4} - \phi_{0,s_{t-4}}) + \varepsilon_t \end{aligned}$$

where $\varepsilon_t \sim N(0, \sigma^2)$ and $s_t = 1, 2$

This model admits two dynamic structures, depending on the value of the state variable s_t which controls the switching mechanism between two states. In this case, there are two distributions with two distinct means that govern y_t . If $s_t = 1$, the economy is in low growth state associated with the recessionary periods of the economy. If $s_t = 2$, the economy is

in high growth state indicating the expansionary periods. The model is completed by defining the two dimensional P matrix containing the probabilities of transition between two states. All transition probabilities are also assumed to be constant over the entire sample.

$$P = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix}$$

Hamilton (1989) suggests an algorithm to estimate this classical model which consists of two parts. Let α be the vector including the estimated parameters:

$$\alpha = (\phi_{0,1}, \phi_{0,2}, \phi_1, \phi_2, \phi_3, \phi_4, \sigma^2, p_{11}, p_{22})$$

The first step of Hamilton's procedure is to solve for the actual marginal likelihood function for y_t and maximize it with respect to population parameters. However, in order to write the density of y_t given past information ψ_{t-1} , we need to know s_t and s_{t-1} . To solve this problem, we first write the joint density of y_t , s_t and s_{t-1} and obtain the marginal density of y_t , by integrating s_t and s_{t-1} out of the joint density. For the two-state case, integration yields

$$(3.4) \quad f(y_t | \psi_{t-1}) = \sum_{s_t=1}^2 \sum_{s_{t-1}=1}^2 f(y_t | s_t, s_{t-1}, \psi_{t-1}) \times P(s_t, s_{t-1} | \psi_{t-1})$$

The loglikelihood function for the case of unobserved states takes the following form:

$$(3.5) \quad \ln L = \sum_{t=1}^T \ln \left\{ \sum_{s_t=1}^2 \sum_{s_{t-1}=1}^2 f(y_t | s_t, s_{t-1}, \psi_{t-1}) \times P(s_t, s_{t-1} | \psi_{t-1}) \right\}$$

where

$$P(s_t, s_{t-1} | \psi_{t-1}) = P(s_t = j | s_{t-1} = i) \times P(s_{t-1} = i | \psi_{t-1}) \quad i, j = 1, 2$$

Equation (3.5) is maximized with respect to the arguments of vector α . However, the objective of the estimation procedure is not only to estimate the parameters in the models and the transition probabilities, but also to estimate the state that occurs at each t in the sample

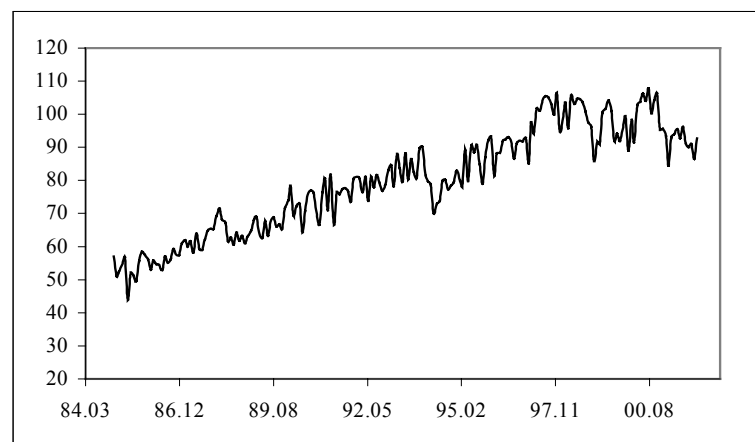
period. So, in the second part of the algorithm, probabilistic inferences about the unobserved states are made. Hamilton developed a nonlinear filter and smoother for this purpose. Filtered probabilities are inferences about s_t conditional on information up to time t and smoothed probabilities are inferences about s_t by using all the information available in the sample.¹

3. DATA

In the empirical application of the models represented in this thesis we worked with two sets of data. The first one is the monthly industrial production index which is available for the post-1985 period. This data set is used in the estimation of TAR and SETAR models since monthly frequency is needed. The second data set is the quarterly real GNP which is available for the post-1987 period. It is used in the MS application. Both data sets are obtained from the database of Central Bank of Turkish Republic via internet. They are seasonally adjusted by using the multiplicative moving average method. Since ADF (1979) test points out to unit roots in both series, we transformed the series to achieve stationarity using one hundred times their log first difference in MS and using a simple differenced series in TAR.

The data of monthly industrial production index (IPI) from the first month of 1985 through the first month of 2002 is plotted in Figure 1. Seasonally adjusted quarterly real GNP from the first quarter of 1987 to the fourth quarter of 2001 is plotted in Figure 2.

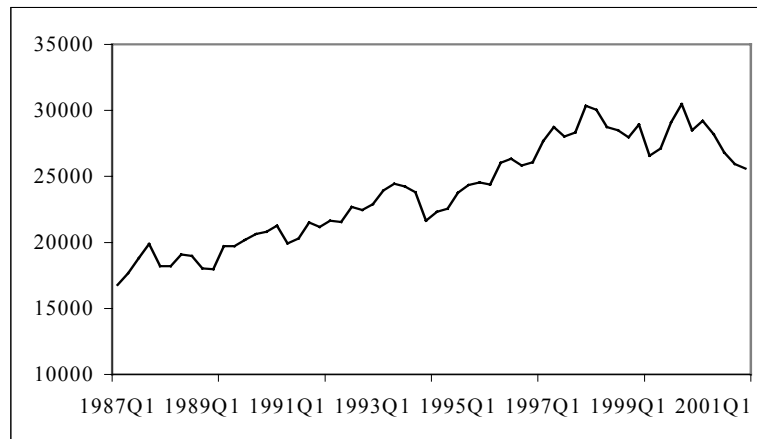
Figure 1: Industrial Production Index (1985:M1-2002:M1)*



* M denotes the monthly frequency of the data

¹ See Hamilton (1989) for the explicit derivation of filtered and smoothed probabilities.

Figure 2: Seasonally Adjusted Real GNP (1987:Q1-2001:Q4)**



** Q denotes the quarterly frequency of the data.

As is obvious from Figures 2 and 3, these two series have quite similar behavior in almost all points of the sample. This implies that both series can be used in order to characterize the fluctuations in aggregate economic activity. In MS and TAR estimations, we used quarterly data and monthly data respectively. Since MS model is an autoregressive model with 4 lags it is appropriate to work at quarterly frequency. On the other hand, one should work at monthly frequency in TAR model since the model has 12 lags to reflect short-run dynamics.

4. EMPIRICAL RESULTS

4.1 TAR Models of Turkish Business Cycles

TAR model is estimated by using the data of monthly industrial production index (IPI) from 1985:M1 through 2002:M1 which is plotted in Figure 1. The model is also estimated by modifying the code to work for quarterly frequency. Data of post-1987 quarterly GNP is used as in the case of MS estimation. But the performance of the model was poor probably due to requirement of large sample of data in the form of monthly.

For a monthly frequency, TAR model is estimated with two choices of the threshold variable γ_t . The first one is a standard delay lag in the following form

$$(4.1) \quad \gamma_t = \Delta y_{t-d} \quad \text{for } d \leq 12$$

As in this case, the threshold variable γ_t is the lagged value of the differenced time series itself, this is a Self-Exciting Threshold Autoregression (SETAR) model.

The second choice for the threshold variable is a function of the known data which is defined as a long difference model with

$$(4.2) \quad \gamma_t = y_{t-1} - y_{t-d}$$

This is a TAR model in its broadest definition since the threshold variable is defined to be a known function of the time series. AR order in the resulting model is again 12 since it appears appropriate to describe short-run dynamics when using monthly data.

Table (5.1) reports the results from the estimation of 24 models where d shows the the delay lag. First 12 regressions that take place in the upper part of the table constitute the SETAR group which chooses a standard delay lag as a threshold variable. Other 12 regressions belong to TAR group which defines a long difference model as a threshold variable. *P-value* is the bootstrap calculated asymptotic value for the test of the null of linearity against the particular threshold model. It is calculated using 1000 replications since no parametric critical values are available. Since the parameter for delay lag d is also unknown, it should be estimated as well. It is estimated along with the other model parameters through the minimization of the sum of squared errors. As a result of this estimation procedure, we come across with nd regressions instead of n regressions.

Table 5.1 TAR Models for the Industrial Production Index: 1986:1-2002-1

$\gamma_t = \Delta y_{t-d}$												
$d =$	1	2	3	4	5	6	7	8	9	10	11	12
SSE	2465	2392	2340	2565	2522	2468	2293	2393	2342	2294	2520	2534
p -value	0.159	0.345	0.734	0.405	0.484	0.503	0.186	0.850	0.023	0.062	0.784	0.602
$\gamma_t = y_{t-1} - y_{t-d}$												
$d =$	2	3	4	5	6	7	8	9	10	11	12	
SSE	2428	2457	2400	2387	2506	2428	2209	2465	2382	2400	2446	
p -value	0.059	0.058	0.024	0.268	0.708	0.750	0.014	0.378	0.155	0.511	0.306	

TAR model for a threshold choice of $\gamma_t = y_{t-1} - y_{t-8}$ minimizes the sum of squared errors among 24 regressions. The threshold estimate of this model is 6.14. For the current choice of the delay lag in TAR model, p -value is 0.014 which is the smallest of all the 24 regressions. This means that among our 1000 bootstrap replications, there were only 14 simulated test statistic that exceeded the sample value. The implication is that the TAR model with threshold variable $\gamma_t = y_{t-1} - y_{t-8}$ is highly significant for a 95% significance level.

When we make the comparison between the results of SETAR and TAR models, we can confidently say that the second one fits much better to Turkish data. If we select the delay lag to be 8 in this group, the model provides the best estimates among 24 regressions by minimizing the residual variance.

Figure 3 shows the confidence interval construction for the threshold. For an estimate of 6.14, the 95% confidence interval is [5.42 , 6.48]. It is calculated by adjusting the LR for residual heteroskedasticity using a kernel estimator for the nuisance parameter as suggested by Hansen (1997). The confidence interval is very tight indicating that the threshold estimate is precise. Notice that for this value of the threshold, $LR(\hat{\gamma}) = 0$.

Figure 3: Confidence Interval Construction for the Threshold

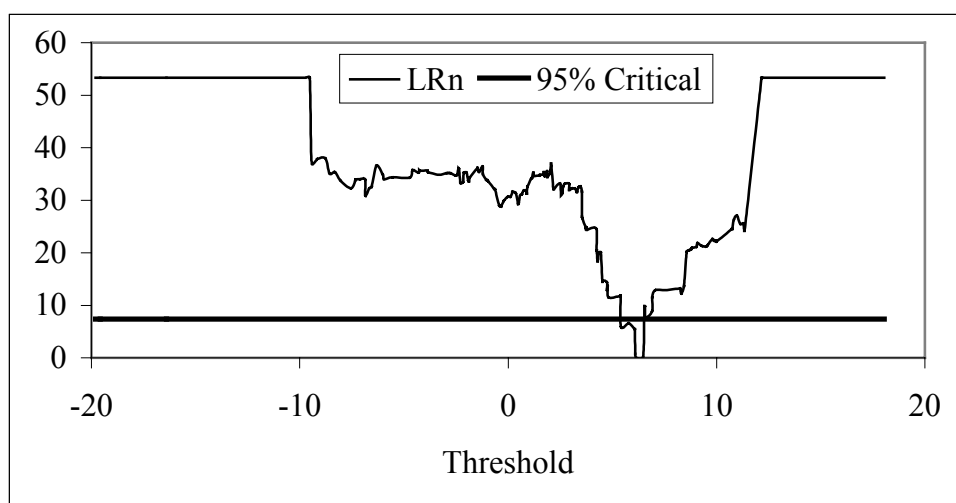


Table (5.2) reports the parameter estimates, heteroskedasticity consistent standard errors and the 95% confidence region for the threshold. The estimate of the threshold which is 6.14 splits the sample into two regimes. When $y_{t-1} - y_{t-8} > 6.14$, this means that the period is characterized by regime 2 that corresponds to strong expansions. Otherwise regime 1 is prevailing that characterizes all the periods when the change in the index for $d = 8$ is lower than 6.14. In this case we can not treat regime 1 as contractions. This is a natural result of the magnitude of the threshold estimate that minimizes the residual variance.

For the current estimate of the threshold, the model detects regime 2 as the high-growth state and regime 1 as the sum of recessions and the periods that the index has an upward trend not stronger than 6.14. In other words, the last component also captures the “normal” times of the economy in addition to the recessionary periods. The result indicates that there is a significant change in the autoregressive structure between the periods that the index increases more or less than 6.14.

**Table 5.2 Estimates of TAR Model for the Industrial Production Index:
1986:M1-2000:M1**

$y_{t-1} - y_{t-d} \leq 6.14$							
Variable	Intercept	y_{t-1}	y_{t-2}	y_{t-3}	y_{t-4}	y_{t-5}	y_{t-6}
$\hat{\alpha}$	0.82	-0.44	0.06	-0.09	-0.28	-0.04	0.03
St. Error	(0.360)	(0.074)	(0.094)	(0.115)	(0.097)	(0.097)	(0.095)
95%confidence	[-0.1,1.6]	[-0.6,-0.3]	[-0.1,0.3]	[-0.3,0.1]	[-0.5,-0.0]	[-0.2,0.2]	[-0.2,0.2]
Variable		y_{t-7}	y_{t-8}	y_{t-9}	y_{t-10}	y_{t-11}	y_{t-12}
$\hat{\alpha}$		0.11	0.04	-0.08	-0.07	0.05	0.40
St. Error		(0.090)	(0.092)	(0.080)	(0.080)	(0.086)	(0.073)
95%confidence		[-0.1,0.3]	[-0.1,0.2]	[-0.3,0.1]	[-0.2,0.0]	[-0.1,0.2]	[0.3,0.5]
$y_{t-1} - y_{t-d} > 6.14$							
Variable	Intercept	y_{t-1}	y_{t-2}	y_{t-3}	y_{t-4}	y_{t-5}	y_{t-6}
$\hat{\beta}$	-1.75	-0.20	0.08	0.22	0.28	0.11	-0.18
St. Error	(1.626)	(0.155)	(0.147)	(0.168)	(0.183)	(0.197)	(0.164)
95%confidence	[-5.5,1.6]	[-0.5,0.1]	[-0.2,0.4]	[-0.1,0.6]	[-0.1,0.7]	[-0.3,0.6]	[-0.5,0.2]
Variable		y_{t-7}	y_{t-8}	y_{t-9}	y_{t-10}	y_{t-11}	y_{t-12}
$\hat{\beta}$		-0.67	-0.37	-0.52	-0.72	-0.05	0.44
St. Error		(0.179)	(0.165)	(0.117)	(0.077)	(0.112)	(0.063)
95%confidence		[-1.0,-0.2]	[-0.7,0.0]	[-0.8,-0.3]	[-0.9,-0.6]	[-0.3,0.2]	[0.3,0.6]

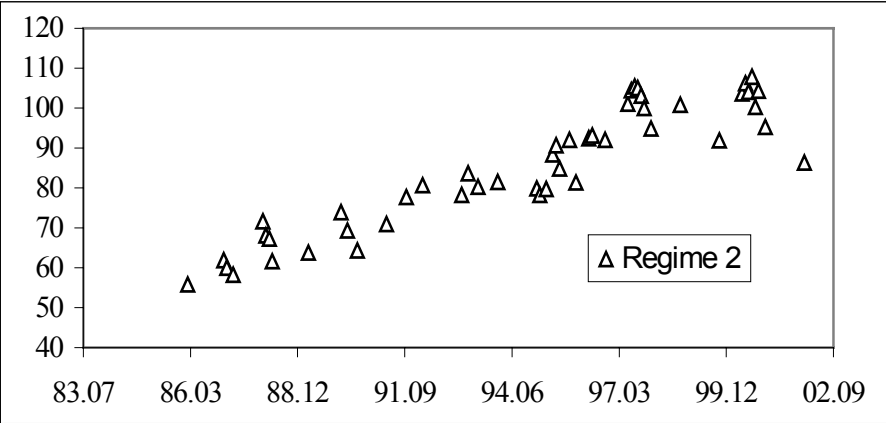
The most significant switches in parameters take place in the intercept and in the autoregressive parameters at lags 4, 7 and 10. In regime 1, AR parameters at lags 3, 4 and 5 points out to a negative serial correlation with a positive mean. In regime 2, both the intercept and the AR(1) coefficient are negative. Positive AR parameters at recent lags are generally near zero while negative AR parameters seems more significant implying that negative serial correlation is much stronger for the regression representing regime 2.

Among the 192 observations in the sample, 47 months are determined as regime 2, associated with strong expansions. In order to make an assessment of the precision of γ , observations that fall in the 95% confidence interval for the threshold are marked as uncertain. In our application, only 6 of the 192 observations fall into the uncertain category. This points out to the precision of the threshold estimate determining the regimes.

Figure 4 shows the points classified as periods at which the index increased more than the threshold estimate 6.14, namely regime 2. We plotted only the points marked as regime 2, since the rest of points in the sample are marked as regime 1 excluding the few uncertain points. The high value of the threshold estimate makes possible to distinguish strong expansions from moderate growth phases.

In 1990s, except in 1991, 1994 and 1999, Turkish economy achieved high growth rates in each year. This is reflected in Figure 4 where this period is characterized by strong persistent expansions except for the mentioned dates. It is apparent from the figure that after the financial liberalization in 1989, the tendency of the economy to grow at high rate significantly increased. This points out to the fact that capital inflows played a central role in the growth of Turkish economy during 1990s.²

Figure 4: Classification by Regime 2



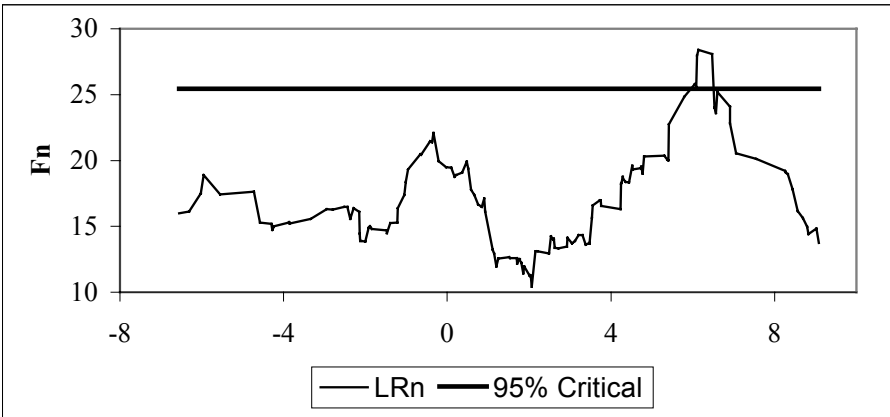
² See for example Celasun *et al.* (1999) for the discussion of this point.

A closer look at this period indicates that most strong expansions took place in the second half of 1990s. In 1996 and 1997, net capital inflows reached at significant levels exceeding the 4% of GNP. During the first half of 1998, there were even higher capital inflows to the economy which gave rise to a prosperity. Another period that the increase in the industrial production index is high and persistent is 2000. The positive market sentiment due to the credibility of the disinflation program that was launched in December 1999 led to dramatic declines in interest rates. The recovery after 1999 was strong. However another shift in regime took place in the proceeding period as a result of two crisis in November 2000 and February 2001. The failure of the program marked the end of the expansion.

Notice that some of the observations for which the industrial production index increased more than 6.14 fall into the period of 1986-1990. However since the frequency of the data is monthly, we consider only the periods that exhibit persistency in order to make a clear identification of high-growth periods.

The TAR model is also compared with a linear benchmark model. Due to the identification problem of the threshold parameter γ , the asymptotic distribution of F_n is not χ^2 in this testing procedure. Using a bootstrap procedure, Hansen (1997) produces the asymptotically correct null distribution. In Figure 5, LR sequence is plotted as a function of the breakdate.

Figure 5: F Test for the Threshold



As $\hat{\gamma}$ which is obtained by setting $d = 8$ in the long difference model minimizes the residual variance among all candidates, F_n yields the supremum value which is 28.39 for the current choice of the TAR model. As is obvious from Figure 5, F statistic exceeds the asymptotic critical value for the estimate of the threshold. P -value associated with the estimated model is 0.014 indicating that the null of linearity is confidently rejected in favour of the TAR model.

4.2 MS Model of Turkish Business Cycles

Hamilton's MS(4) model is applied to Turkish data on seasonally adjusted real GNP between the second quarter of 1988 and fourth quarter of 2001 plotted in Figure 4. As described in Equation (3.3), only the means of the regimes are subject to change over time. The autoregressive parameters and the variance are assumed to be constant among different regimes. When $s_t = 2$, the economy is in a high growth state associated with expansions. When $s_t = 1$, the economy is in a low growth state indicating the recessions. The transition between states is characterized by a first order Markov chain and duration independency is also assumed.

The dependent variable is the percentage change in the log of real GNP for the considered time period. The Markov process is a latent variable that is used to define the different phases of cyclical fluctuations underlying real GNP. Optimal inferences of turning points are obtained from the smoothed probabilities of the Markov states. Due to the decision rule proposed by Hamilton (1989), if $P(s_t = 1 | y_T, y_{T-1}, \dots, y_{-r+1}) > 0.5$ the economy is in a recession, otherwise it is in an expansion.

Table (5.3) reports the maximum likelihood estimates obtained by the numerical maximization of the conditional log likelihood function for the quarterly data. $\phi_{0,1}$ refers to the average quarterly growth rate of real GNP in state 1 whereas $\phi_{0,2}$ is the average quarterly growth rate of real GNP in state 2. As is obvious from the table, state 2 which is associated with expansions has an approximate positive mean growth rate of 1.8 % per quarter. On the other hand state 1 exhibits an approximate negative mean growth rate of 6.1 % per quarter indicating the recessionary periods of the economy. The results points out to the volatility of output growth during periods of recessions and expansions. This implies that, in terms of

mean growth rates, the model captures the asymmetric behavior of output growth in the various phases of cycles.

AR coefficients except the fourth one which is near zero are all negative. This implies that the change in the growth rate of real GNP is negatively serially correlated. Transition probabilities of regimes are 0.359 for regime 1 and 0.888 for regime 2. In other words a recession is generally not followed by another recession but this is not true for expansions. Expected durations of regimes are 1.6 quarters for recessions and 8.9 quarters for expansions. The implication is that expansions are highly persistent whereas recessions are not. This is an important finding which points out to the asymmetric nature of Turkish real GNP over the different phases of the business cycle.

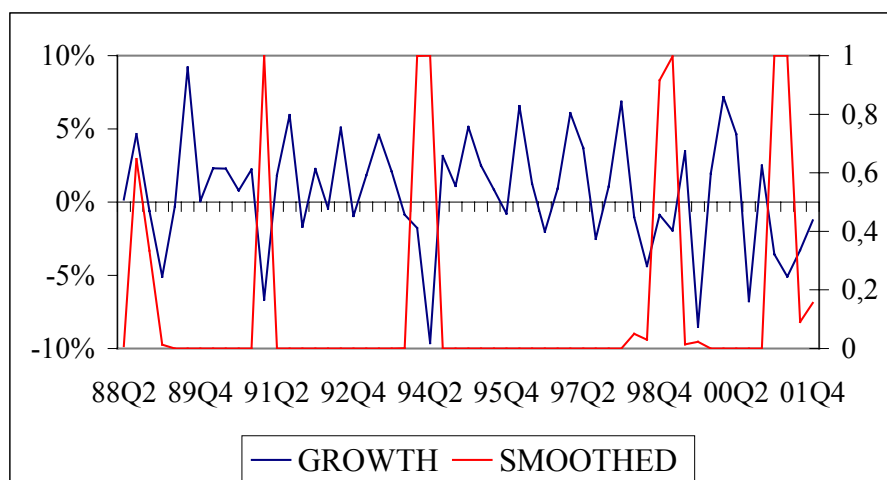
Table 5.3 Maximum likelihood estimates of MS(4) model based on data for Turkish quarterly GNP: 1988Q2 – 2001Q4

Parameter	Estimate	Standard error
$\phi_{0,1}$	-6.058	0.706
$\phi_{0,2}$	1.789	0.139
p_{11}	0.359	0.174
p_{22}	0.888	0.050
ϕ_1	-0.662	0.155
ϕ_2	-0.783	0.174
ϕ_3	-0.557	0.161
ϕ_4	0.007	0.170
σ	2.292	1.035
<i>Log-likelihood</i>	-93.41	
<i>Expected duration of recessions</i>	1.6	
<i>Expected duration of expansions</i>	8.9	

In terms of statistical significance, the growth rates for both the expansions and contractions are statistically significant at the 5% probability level. Tests of the transition probabilities indicate that the one for expansions (p_{22}) is statistically significant whereas the the one for recessions (p_{11}) is not. This result explains the reason behind unusually short recessionary periods. Notice that MS model endogenously determines a recession for a mean growth rate of -6.1% which may remain lower than some of the contractions.

The model identifies a state with negative mean and shorter average duration as recessions. The other state exhibits a positive mean and much longer average duration which characterizes expansions. As is obvious from table (5.3) and from Figure 6 showing the growth rates of quarterly real GNP and smoothed probabilities, downswings are abrupt, severe and much shorter while upswings are more gradual and highly persistent. The transition from deep crisis to persistent recovery periods are generally easy. One important reason is that capital inflows contribute to economic growth through their impact on private consumption and investment. However they also render monetary policy ineffective and makes the economy vulnerable by setting the stage for speculation. Note that the economy suffers from problems like chronic inflation and high interest rates even in the periods of high growth rates. This is due to weak fundamentals characterizing the Turkish economy like high public deficits and underdeveloped financial markets.

Figure 6: Growth Rate of Quarterly RGNP and Smoothed Probabilities



A closer look at the information obtained from the smoother provide valuable information about the cyclical structure. Table (5.4) reports the dating of the turning points of Turkish business cycles determined by the smoothed probabilities. Peaks refer to the beginning of recessions where troughs refer to their end.

In the last fifteen years, there are five recessionary periods that took place in 1988, 1991, 1994, 1999 and 2001. The most abrupt declines in the real Turkish GNP occurred in the last three of them. In the second half of the sample, the recessions are also more persistent. The considered period does not exhibit a significant change in the frequency of crisis.³

Table 5.4 Dating of the Turkish Business Cycle Turning Points Using Smoothed Probabilities : 1988Q2 – 2001Q4

Peak	Trough	Duration*
1988Q3	1988Q4	1
1991Q1	1991Q2	1
1994Q1	1994Q3	2
1998Q4	1999Q2	2
2001Q1	2001Q3	2

* Duration denotes the length of a recession in quarters

We will now take a brief look at the recessionary periods in the light of the results provided by smoothed probabilities. The first slowdown of the sample period started in the third quarter of 1988 after the introduction of the stabilization package in February 1988. Increases in prices and interest rates mark the beginning of a slowdown in economic activity. Smoothed probabilities point out to a recession lasting for just one quarter at this point.

³ However if the sample period is extended, an obvious increase in the frequency of crisis is observed in the last fifteen years. We also applied the MS (4) model by using the data of post-80 quarterly real GNP provided by TUSIAD. The model did not detect any significant recession till 1991Q1. All recession probabilities were near zero up to that time except for the 1988Q1. Due to some problematic estimates like higher standard errors and doubts about the quality of the data, we preferred to work with the current choice of the sample.

The beginning of the proceeding recession is the first quarter of 1991, also the year of Gulf War. Turkish economy is seriously affected by this exogenous shock probably as a result of the structural changes starting from late 80s. The economy grew at a rate of 0.3 % which is much lower than the preceeding year.

Starting with the first quarter of 1994, the economy enters a low growth phase lasting for 2 quarters. In late 1993, Central Bank cancelled domestic public debt auctions and expanded domestic credit. The model identifies the recession just after these two shocks were given to the economy.

The other period that the model marks a recession starts at the fourth quarter of 1998 and lasts for two quarters. The Russian crises in July 1998 led to capital outflows. As a result of high interest rates, two earthquake disasters and the increased taxes afterwards, the economy shrunk at an annual rate of -6.4% . Smoothed probabilities point out to a recession lasting for two quarters.

The beginning of the most recent recession is the first quarter of 2001. Starting with late 2000, market participants were started to believe that TL was extremely appreciated as a result of the exchange rate rule declared at the beginning of the year. This belief led to the abandonment of the parity on February 21. A record level of contraction took place in 2001.

The above analysis indicates that smoothed probabilities successfully captures all the five recessionary periods. Due to macroeconomic indicators, some recessions prevailed longer than determined by the model. As stated before, MS model endogenously identifies a recessionary period with an approximate mean growth rate of -6.1% which may remain lower than the contraction in the stated period. That's why the recessions determined by the model are shorter than the periods characterized by negative growth. Beside this, smoothed probabilities capture the beginning of all recessionary periods and provide an early warning mechanism. This points out that Hamilton's model is useful for forecasting output fluctuations.

In testing the MS(4) model, we compare it with a linear benchmark AR(4) by taking the linear model as the null hypothesis and the regime-switching model as the alternative. In MS model, the transition probabilities p_{11} and p_{22} are unidentified nuisance parameters. The

implication is that conventional statistical theory is inapplicable and the critical values should be determined by relying upon simulation methods.

Following Hansen (1992), the test is also applied to an alternative Markov switching model in which the intercept term instead of the mean switches between states. This alternative model is a modified version of the original model in which an obvious analogue to the mean of the process is the switching parameter.

Table (5.5) gives the supremums of the standardized LR statistics of Hansen (1992) for Turkey. Since Hansen's (1992) asymptotic critical value for 5% critical value is approximately 3, we are unable to reject the null of a one-state autoregression in favour of the Hamilton's two-state Markov-switching mean model. The p -value is 0.401 which is far from being significant.

Table 5.4 Standardized LR statistics for Markov-switching models of quarterly real GNP of Turkey: 1988Q2 – 2001Q4

	MS-Mean Model	MS-Intercept Model
Internal Monte Carlo Replications	1000	1000
Standardized LR test	1.77	2.88
P-values	0.401	0.083

For the Markov-switching parameter model, the supremum of the standardized LR statistics is 2.88 which is much closer to the critical value. The p -value is 0.083 indicating that we are still unable to reject H_0 . But the improvement of the performance of the model is unambiguous. When we switch to the modified model, we are about to reject the linear AR model in favour of the nonlinear MS model. The implication is that there is room for the analysis of Turkish Business Cycles with extended versions of the original MS model since

relaxing the restrictive assumptions and letting alternative parameters to switch between the states led to a significant improvement. For example restricting the assumption of duration independency may solve the problem of insignificant transition probabilities. Null of linearity may be rejected in favor of such a model that is capable of capturing the switch in transition probabilities from time to time.

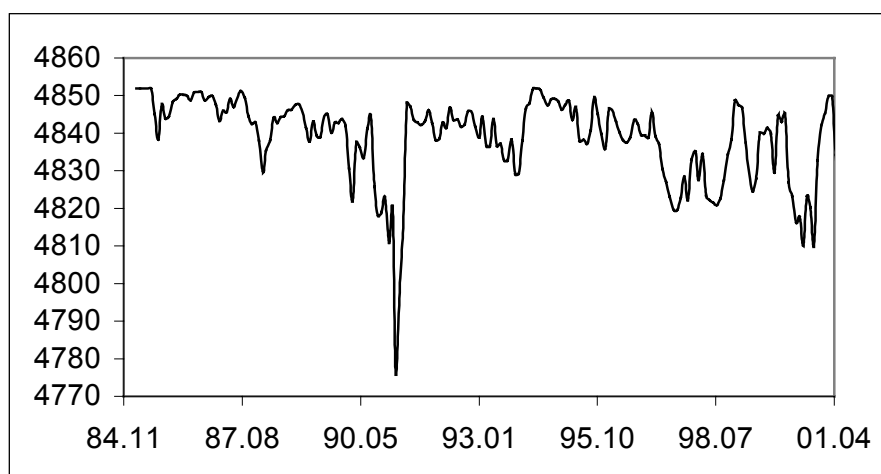
4.3 Structural Change AR Model of Industrial Production Index

After making an empirical characterization of Turkish business cycles by using nonlinear regime switching models like TAR and MS, we also estimated a structural change AR model in order to provide additional information about the characteristics of the points at which structural breaks take place. The algorithm intended to detect the endogenous breakpoints suggested by Hansen (2001) is applied to post-1985 monthly IPI data to distinguish between the different formations of cycles. The model used is a simple first-order autoregression. It works through the method of least squares. Sample is split at each breakdate and parameters are estimated. LS breakdate estimate is the date which minimizes the calculated sum of squared errors.

Figure 7 shows residual variance of the whole sample as a function of candidate breakdates. The sequence of residual variance reaches a minimum in 1991. This is an evidence of a structural break that takes place both in the mean and in the autoregressive parameter of the regression function. The first one points out to a change in the trend of the index while the second one points out to a change in the serial correlation of the dependent variable. The implication is that, both the long-run impact and the impulse-response of the industrial production index due to shocks are changed at this breakpoint.

The economic events of the time are in line with our findings. After the financial liberalization in 1989, Turkey attracted capital as a result of high real interest rates. The government abandoned the exchange rate rule. However this new period started under conditions of high public deficits and chronic inflation. The openness of the economy against a background of persistent macroeconomic imbalances led to the appreciation of TL in real terms. The financial system started to operate under an instable environment which set the appropriate stage for speculative movements in the proceeding years.

Figure 7: Residual Variance as a Function of the Breakdate

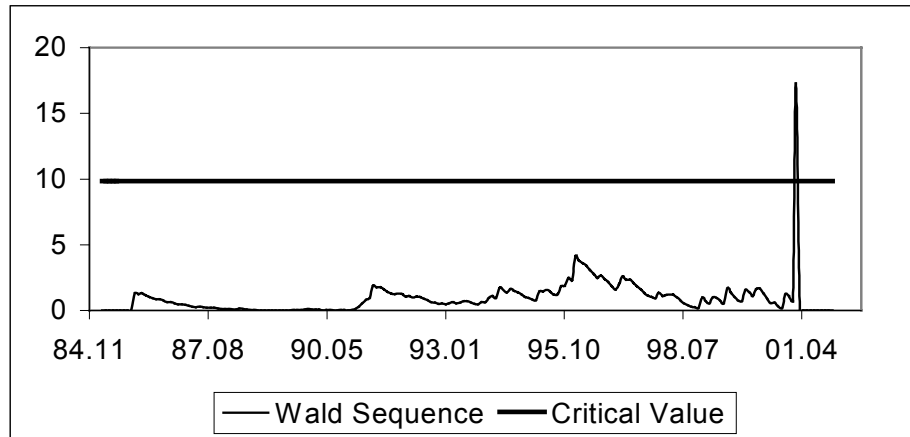


The structural break AR model also marks a breakpoint in February 2001. This is the date of the abandonment of the parity prevailing since the beginning of year 2000. The failure of the disinflation program after two crisis following each other marks the end of an expansionary period. The model identifies an endogenous break at this point.

However the characteristic of this breakpoint is different from that of 1991. The break takes place in the variance implying a change in the volatility of the index. This is reflected in Figure 8 which shows the Wald sequence for variance. It reaches a maximum in 2001 with an asymptotic p -value of 0.001.

The structural break AR model successfully captures the endogenous breakpoints in 1991 and 2001. The other turning points identified by the smoothed probabilities of the MS model like 1994 and 1999 are not detected as endogenous structural breaks since the recessions at these points were caused by exogenous shocks.

Figure 8: Wald Sequence for Variance



The results of this model makes clear that characteristics of the breaks may not be the same at each point of time. The break may take place in the different parameters of the regression function. Models that ignore this point may remain restrictive in reflecting all the nonlinearity in the sample.

5. CONCLUDING REMARKS

5.1 Summary of the Findings

The macroeconomic setting of Turkey in the last fifteen years has been dominated by large fiscal deficits, chronic inflation and volatile output growth. As a result of increasing instability in aggregate economic activity over the last two decades, the analysis of swings in output especially in the context of predictability of crisis revived interest in recent macroeconomic research.

The approach and methodology employed in this thesis is quite different from that of other studies on the cyclical behavior of Turkish economy. We investigate Turkish business cycles by using a regime switching methodology and capture all five recessions in 1988, 1991, 1994, 1999 and 2001 in the last fifteen years. Empirical evidence suggests that the classic model of Hamilton (1989) is an appropriate starting point for the time series investigation of Turkish business cycles. The Markov states capture the asymmetric nature of cycles by distinguishing abrupt and short downswings with an average negative growth of

6.1% from gradual and highly persistent upswings with a moderate growth rate of 1.8%. In that sense it performed well in identifying subperiods having quite different characteristics. However, given the restrictions imposed by Hamilton's (1989) classic model, it becomes important to shift the focus to extended versions that allow for shifts in other parameters in order to catch all the nonlinearity in the sample. Our findings from tests in favor of a Markov-switching intercept model instead of a Markov-Mean model support this view.

In the case of TAR class of models, the best specification is obtained by using a long difference model with a delay lag of 8 months. Results indicate that shift in regime is observed for a high threshold value which is unable to distinguish between recessions and expansions. This should not be regarded as a shortcoming since it complements the MS model by identifying the relatively higher-growth phases in which the industrial production index increased more than 6.14. The findings display the increased volatility of output growth especially in the second half of 1990s. As in the MS case, results highlight the importance of nonlinearities in the data generating process.

We also estimate a structural break AR model suggested by Hansen (2001). This approach provides us more information about the characteristics of breakpoints. We find strong evidence for two endogenous structural breaks over the last twenty years. The first one which implies a change in the trend and in the serial correlation of the index takes place in February 1991. The other one that points out a change in the volatility of the index takes place in February 2001.

Main finding of this paper is that regime switching framework constitutes a strong alternative to conventional methods by providing a better understanding of Turkish business cycles. This type of representation is proved to be a good device for being a useful tool for ex-ante prediction of turning points which may serve for countercyclical policies in reducing the amplitudes of recessions.

5.2 Directions For Future Research

There remains a considerable scope for further research in order to improve the forecasts. The framework of this thesis may be extended to include potentially interesting properties that are inherent in the data generating process.

Among regime switching models that assume observable regimes, Smooth Transition Autoregression (STAR) which provide a continuous time representation may be used. By assuming that the economy can be in one of two states with distinct dynamics or in transition between these states, more of the nonlinearity in the sample may captured. Some other extensions are also possible for discrete time representations. For example a commonplace assumption of no unit roots for TAR estimation may relaxed. As suggested by Caner and Hansen (2001), joint application of tests for a threshold and for a unit root makes possible to distinguish between nonstationarity and nonlinearity. Such a consideration provides evidence whether the time series under investigation is a unit root process or a stationary TAR process.

For regime switching models that assume unobservable states, there exist a variety of extensions. Modified versions of the Hamilton's (1989) original MS model may provide a better understanding of the cyclical structure of the economy by relaxing some restrictive assumptions. One alternative is to allow for occasional discrete shifts in autoregressive parameters and in variance in addition to the mean. The model may also extended to include some exogenous variables to the regression function. The EM algorithm that offers an alternative method for maximizing the likelihood function is an appropriate tool for such considerations. In this respect it would be interesting to see whether the transitions between states are correlated with political events. Another extended version of the MS model can be obtained by relaxing the assumption of duration independency. Linear benchmark model may be rejected in favor of such a model that is capable of capturing the switch in transition probabilities from time to time.

For a more detailed analysis, synthesis models that include both linear dynamics and nonlinearity via the Markov-switching factor can be used. Incorporating both comovement and nonlinearity into the modelling process results in a multivariate dynamic regime switching setting. This is a new direction for further development of the empirical business cycle models that also revived interest in recent research.

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