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Nonlinearity and Asymmetries in Iranian Business Cycle: Through Markov Switching Auto Regression Model

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Abstract

This paper presents the results of an empirical investigation of business cycle nonlinearities and asymmetries in the Iranian economy. Seasonal Gross Domestic Products (GDP) time series are subjected to nonlinearity and asymmetry tests. The recessions and expansions states are modeled with Markov-Switching Autoregressive models (MSM). The paper shows that allowing for three regimes for the finding of asymmetry and nonlinearity in Iranian business cycle fluctuations. The paper also provides evidence on the usefulness of a non-linear model as compared with a linear alternative in the context of business cycle research in an emerging economy using LR test.

Keywords: Business Cycle; Markov Switching Model; Asymmetry

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Introduction

Economists have long been interested in cyclical properties of macroeconomic variables such as gross domestic product and other macroeconomic time series. An important characteristic of business cycles is the "cyclical asymmetry". It is imperative to detect nonlinearities that might be present in business cycles for several reasons. For instance, nonlinearities imply that the effects of expansionary and contractionary monetary policy shocks on output are not symmetric. Sichel (1993) defines an asymmetric business cycle as the one 'in which some phase of the cycle is different from the mirror image of the opposite phase; for example contractions might be steeper, on average, than expansions' [1]. If the economy behaves differently over the phases of business cycles, then the policy conclusions from the linear time series models will potentially be misleading. To ascertain properties of business cycles empirically, one needs to determine the dates of turning points for recessions and expansions. Once turning points are determined, can be analyzed business cycles and apply asymmetry tests. The methods used to identify business cycle turning points can be classified as parametric and non-parametric [2]. In the parametric approach, a statistical model for the series is specified and used to identify turning points.

Since Hamilton's (1989) analysis of US business cycles using the regime switching AR model, non-linear parametric methods has become the leading approach for dating business cycles [4]. An attractive feature of MS models is that they provide a flexible framework in which aggregate level of economic activity has a certain probability of switching among a number of states. The purpose of this paper is to contribute to the empirical literature on business cycle analysis in Iranian economy.

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Methodology

Markov Switching Model

Consider a single equation Markov switching model whose parameters are; at least partly, unconditionally time varying but constant when conditioned on an unobservable discrete regime of variable $s_t \in \{1.\cdots.M\}$:

$$(y_t - \mu_{st}) = \phi_1(y_{t-1} - \mu_{st-1}) + \phi_2(y_{t-2} - \mu_{st-2}) + \cdots + \phi_P(y_{t-p} - \mu_{st-p}) + \sigma_{st}\varepsilon_t \quad (1)$$

In (1) y_t is a $(n \times 1)$ vector of dependent variable at time t, vector of regression coefficients which are regime dependent, and ε_t is a Gaussian error term subject to changes of regime. The MS-AR model provides a very flexible framework for modeling time series subject to regime shifts. While all parameters of the conditional model can be made dependent on the state s_t of the Markov chain, in practice, only some parameters of interest will be regime dependent while the others will be regime invariant. In order to establish a unique notation for each model, we specify with the general MS(M) term the regime-dependent parameters:

M: Markov Switching **Mean**,
I: Markov Switching **Intercept**,
A: Markov Switching **Autoregressive**,
H: Markov Switching **Heteroscedasticity**

The MS-AR setting also allows for a variety of specifications. Krolzig established a common notation to provide simplicity in expressing the models in which various parameters are subject to shifts with the varying state [4]. Table 1 gives an overview of the MS-AR models.

Table 1. Types of MS-AR models

Notation	μ	ν	Σ	ϕ_i
	Mean	Intercept Terms	Variance	autoregressive parameters
MSM(M)-AR(p)	varying		invariant	invariant
MSMH(M)-AR(p)	varying		varying	invariant
MSI(M)-AR(p)		varying	invariant	invariant
MSIH(M)-AR(p)		varying	varying	invariant
MSIAH(M)-AR(p)		varying	varying	varying

The description of the dynamics is complete after defining a probability rule of how the behavior of y_t changes from one regime to another. Markov chain is the simplest time series model for a discrete-valued random variable such as the unobserved state variables_{t-1}. In all MS-AR specifications it is assumed that the unobserved state s_t follows 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}.

$$P\{S_t = j|S_{t-1} = i.s_{t-2} = k.\cdots\} = P\{S_t = j|S_{t-1} = i\} = P_{ij} \quad (2)$$

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

These transition probabilities can be indicated in a $(n \times n)$ transition matrix, denoted as P. Each element in the transition matrix p_{ij} represents the probability that event i will be followed by event j.

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{N1} \\ p_{12} & p_{22} & \cdots & p_{N2} \\ \vdots & \vdots & \ddots & \vdots \\ p_{1N} & p_{2N} & \cdots & p_{NN} \end{bmatrix} \quad (3)$$

With $\sum_{j=1}^{N} p_{ij} = 1.$ where $i = 1.2.\cdots.N$ and $0 \leq p_{ih} \leq 1$.

Estimation

Hamilton's (1989) classical algorithm consists of two steps [3]. 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 by using a nonlinear filter and smoother. Filtered probabilities $P(s_t = j\,|\psi_t)$ are inferences about s_t conditional on information up to time t and smoothed probabilities $P(s_t = j\,|\psi_T)$ are inferences about s_t by using all the information available in the sample where $t = 1.2.\cdots.T$.

Parameters are to maximize the log-likelihood function and then use these parameters to obtain the filtered and smoothed inferences for the unobserved state variable s_t [5-6].

Data Analysis

In the empirical analysis, growth rates of ag gregate series, namely the real Gross Domestic Product (GDP) in growth rate form are used. It is crucial to note that the series that are frequently used in business cycle analysis like employment, wages and aggregate hours worked are not available in quarterly frequency for the considered sample period. GDP is seasonally adjusted

Results

In this section we will present the results of the econometric specifications used for modeling the Iranian business cycles between 1988: Q2 and 2008: Q3.

Choosing the Appropriate MSM Specifications

Our model selection process consists of two steps. In the first step, for choosing among different MS specifications, Akaike Information (AIC), Hannan-Quinn (HQ) and Schwarz Bayesian criteria (SBC) are used. The alternative specifications were MS models which mean, intercept that are allowed to switch across regimes. Then, all models are tested for linearity by taking the linear model as the null hypothesis and the regime-switching model as the alternative. We applied these selection criteria both for Univariate MS Models.

Table 2 reports the specification test results of these alternative models. As is obvious from the table, the performance of all three MS models are better than that of the nested linear AR(3) model. Hamilton's classic MSM(3)-AR(3) specification appeared to be statistically most satisfactory on the basis of AIC, HQ and SBC. This shows that it is an appropriate starting point for the analysis of Iranian business cycles.

In order to test between linearity versus non-linear regime switching specifications a testing procedure developed by Ang and Bekaert (2001) is used [7]. In this paper it is suggested that the underlying distribution can be approximated by a distribution where q represents the number of restrictions and nuisance parameters that are not defined under the null hypothesis. Table 3 presents the results of this testing procedure.

Table 2. Diagnostic statistics of various MS-AR & Linear models.

	MSM(3)-AR(2)	MSIH(3)-AR(2)	MSIA(3)-AR(2)	MSIAH(3)-AR(3)
Log L	-83.1241	-81.4912	-81.1479	-87.1785
No. P.	12	14	14	16
AIC	2.3554	2.3873	2.4287	2.5186
HQ	2.4986	2.5544	2.6197	2.5640
SBC	2.7127	2.8041	2.9051	2.8622
	MSMH(2)-AR(3)	**MSIH(3)-AR(3)**	**MSI(3)-AR(3)**	**Linear AR(3)**
Log L	-82.1277	-78.9390	-79.9899	-91.5670
No. P.	9	15	13	5
AIC	2.4070	2.3783	2.3842	2.4447
HQ	2.5652	2.5584	2.5604	2.5048
SBC	2.8770	2.8281	2.8441	2.5947

Note: Log L = Log Likelihood, No.P.= Number of Parameters, AIC = Akaike Information Criterion, HQ = Hannan-Quinn Information Criterion, SBC = Shawarz Bayesian Information Criterion

LR statistics shows that all four models confidently reject the null of linearity with significance levels indicated in brackets. The LR statistics for all models support the presence of regime shifts.

Table 3. Diagnostic statistics of various MS & Linear Models for GDP

Models	Test statistic	LR - statistic	P-salue
MSM(3)-AR(2)	$\chi^2(2)$	22.5296	0.0000
MSIH(3)-AR(2)	$\chi^2(4)$	23.9753	0.0000
MSIA(3)-AR(2)	$\chi^2(6)$	24.6620	0.0000
MSIAH(3)-AR(3)	$\chi^2(10)$	48.7770	0.0000
MSMH(2)-AR(3)	$\chi^2(2)$	18.8785	0.0000
MSH(3)-AR(3)	$\chi^2(4)$	25.2559	0.0000
MSI(3)-AR(3)	$\chi^2(2)$	23.1541	0.0000

All of the above presented estimation statistics and the results of linearity tests highlight the need for nonlinear models to characterize cyclical dynamics. In the light of this finding, we will proceed with the estimation results of the MS models and their implications for the cyclical structure of Iranian economy.

Comments on Estimated MS Models

Table 4 reports the maximum likelihood estimates of MS models obtained by the EM algorithm. For the MSIH(3)-AR(3) model, refers to the average growth rate of quarterly GDP series in state 1 whereas is the average growth rate of GDP in state 2. For all other models the intercept, instead of the mean is assumed to be state dependent.

When we apply markov switching regime models to Iran real GDP, we find that the estimated business cycle is highly dependent on model specification, with the key distinction being between linear model that imply symmetric fluctuations around and nonlinear regime-switching models that imply asymmetric deviations away from trend.

In order to discriminate between the phases of the business cycle, we carry out formal hypothesis tests. The empirical results support a particular class of nonlinear regime switching models and an asymmetric business cycle.

Table 4. Maximum Likelihood estimates of MSIH(3)-AR(3) specifications.

Parameter	MSIH(3)-AR(3) specifications DLGDP		
	Coefficient	Standard error	t-statistic
ν_0	-0.266333	0.2273	-1.17
ν_1	0.455104	0.0357	12.7
ν_2	1.222720	0.1194	10.2
$DLGDP_{t-1}$	-0.244113	0.1028	-2.38
$DLGDP_{t-2}$	-0.173836	0.0973	-1.79
$DLGDP_{t-3}$	-0.506796	0.1022	-4.96
Σ_0	0.765247	0.1921	3.98
Σ_1	0.343363	0.0454	7.56
Σ_2	0.646734	0.1407	4.60

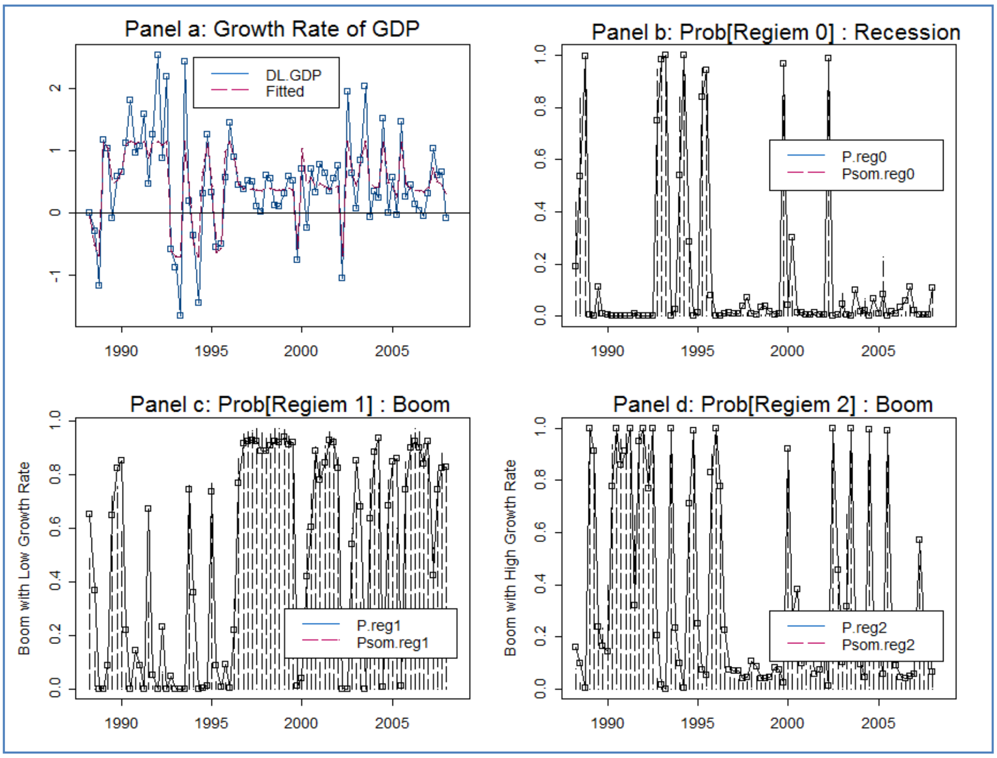

Figure 1. Dating of turning points through MSIH(3)-AR(3) model

Table 5. Regime properties of the MSIH(3)-AR(3) model

	Transition probabilities			Observations	Ergodic Prob.	Duration
Recession	0.53632	0.07774	0.17353	13.0	16.46%	2.17
Expansion	0.19348	0.92226	0.05813	48.0	60.76%	12.00
High growth	0.27020	0.00000	0.76834	18.0	22.78%	4.50

Table 6. Hypothesis symmetric testing for MSIH(3)-AR(3) model.

Hypothesis	Test statistic	LR test	P-value
Non sharpness	$\chi^2(3)$	0.2801	0.9637
$p_{12} = p_{32}$	$\chi^2(1)$	0.1199	0.7291
$p_{13} = p_{31}$	$\chi^2(1)$	0.0038	0.9506
$p_{21} = p_{23}$	$\chi^2(1)$	0.1705	0.6797

Table 6 indicates hypothesis asymmetric testing for Iranian Business cycle. All of the symmetric tests presented in the Table 6 highlight the need for nonlinear models to characterize cyclical dynamics and shows that symmetric business cycle hypothesis are non-acceptable.

Discussion and Conclusion

The classical business cycles are identified as recurrent phases of expansion and contraction in the levels of a large number of macroeconomic time series. Business cycles have been defined by Burns and Mitchell (1946) as:

"Fluctuation found in aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions and revivals which merge into the expansion phase of the next cycle; this sequence of change is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own."

Thus, business cycles are characterized by fluctuations in the aggregate economic activity of market oriented economies with co-movement between many economic activities and persisting for more than one year. Characterization of business cycle as a consensus of cycles in many economic activities is also highlighted by Zarnowitz and Boschan (1975). Although essence of the business cycle definition given by Burns and Mitchell (1946) among others is thus, reflected in the characterization of business cycle by NBER as recurrent sequences of alternating phases of expansion and contraction in the levels of a large number of economic time series [8]. These cyclical fluctuations are persistent and reflected in great variety of time series such as consumption, production, employment, prices, etc., with the duration of a cycle lasting for several years. The expansion phase of the business cycle tends to be longer than the contraction phase due to general occurrence of upward long-term trend in economic time series in market oriented economies. In sum, the classical business cycles should have the expansion phase longer and larger than the contractions, but either phase must be persistent and pervasive enough to allow for significant cumulative and interactive effects and the sequence of up and down phases that constitutes the business cycle must be recurrent and not periodic. But in this study, we consider business cycles as recurrent sequences of alternating phases of expansion and contraction in the of GDP.

In this paper, has been employed various specifications of MS-AR models to empirically characterize the state dependent dynamics of the Iranian business cycles between 1988:Q2 and 2008: Q3. Our findings can be summarized as follows. Linearity of GDP series is severely rejected, implying that there is regime switching structure in Iranian business cycles. Among the univariate models, changing variance specification seems to capture the persistency of recessions

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