

# 4. A DURATION-DEPENDENT REGIME SWITCHING MODEL FOR AN OPEN EMERGING ECONOMY

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## Abstract

*We employ duration-dependent Markov-switching vector auto-regression (DDMSVAR) methodology to construct an economic cycle model for an emerging economy. By modifying the software codes for DDMSVAR methodology written by Pelagatti (2003), we show how to estimate the economic cycles in an emerging economy where macroeconomic shocks are suddenly observed and their levels are deep. The monthly values of net international reserves, domestic debt, inflation and industrial production in the Turkish economy from January 1989 to July 2007 are used for constructing the empirical analysis. Empirical evidence shows that DDMSVAR model can be successfully used in an emerging economy to estimate the cycles using basic macroeconomic indicators.*

**Keywords:** duration dependent regime switching model, economic cycles, Markov models, Turkish economy

**JEL codes:** E32, E37, O11, C53

## 1. Motivations and Literature

Business cycles are estimated by alternative methodologies in the economic theory. Switching regression is the main methodology for business cycle analysis in the literature. Its methodology dates back to Quandt (1958), Goldfeld and Quandt (1973), Barber, Robertson and Scott (1977) and Lindgren (1978) proposing a Markov switching model, where the latent state variable is serially dependent. By extending the Markov switching model to the case of dependent data, Hamilton (1989) creates a two-state regime-switching model. Hamilton's model (1989) estimating the probability of recession or expansion in the US economy has become very popular for business cycle analysis in the economics literature. The model combines model parameters into

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one system, and which set of parameters are applied varies on the regime the system is likely in at the time period. In that sense, a Markov switching model enables the economy to be in one of  $n$  different regimes. The transition probability from state  $x$  at time  $t$  to state  $y$  at time  $t+1$  is only affected by the state at time  $t$  and not by any previous state (Alexander and Kaeck, 2008).

Researchers under alternative or additional motivations and assumptions have extended the model. For example, the model is applied to examination of government expenditure (Rugemurcia, 1995), labor market recruitment (Storer, 1996), the influences of oil prices on the U.S. GDP growth (Raymond and Rich, 1997). The early version of the Markov regime-switching model has been employed for other areas apart from finance and economics, such as for speech recognition (Juang and Rabiner 1990), DNA composition (Churchill 1989) and ion channels (Fredkin and Rice 1992). The hidden Markov model as the Markov variable is unobservable volatility has been used for estimating equity returns, exchange rates and interest rates (Turner, Startz and Nelson, 1989; Pagan and Schwert, 1990; Pagan, 1996; Perez-Quiros and Timmermann, 2000; Taylor, 2005; Bansal *et al.*, 2004; Alexander and Dimitriu, 2005; Cheung and Erlandsson, 2005; Francis and Owyang, 2005; Clarida *et al.*, 2006). Constantinou *et al.* (2006) use two-state Markov switching model combined with artificial neural networks to predict returns in the Cyprus stock markets. Alvarez-Plata and Schrooten (2006) analyze the currency crisis in Argentina in 2002 using a Markov switching model. They conclude that the crisis, although associated with weak fundamentals, cannot be explained by the macroeconomic factors alone. Estimating a Markov-switching model shows that shifts in the agents' beliefs also play a crucial role.

The basic Markov-switching model is univariate and the probability of transition from one state to the other is constant. Since the economic cycles appear as the results of co-movements of many macroeconomic variables, the model needs to be modified for a dynamic prediction [Pelagatti (2003)]. In this research paper, we use the duration dependent Markov-switching vector auto regression (DDMSVAR) methodology proposed by Pelagatti (2002, 2003) to shape an economic cycle model for an emerging market. The methodological roots of DDMDVAR model date back to the duration-dependent Markov switching auto regression model of Durland and McCurdy (1994). They create an alternative filter for the unobservable state variable by exploiting the asymptotic maximum likelihood theory. A recent criticism to the approach of Durland and McCurdy (1994) comes from liboshi (2007), who employs a Bayesian analysis of an extended duration dependent Markov regime switching model to the case of the Japanese economy. liboshi (2007) suggests a regime-switching model with duration dependence that employs the Weibull model. It has an advantage over the approach of Durland and McCurdy (1994) in that it relaxes a constraint of the Markov-switching model in favour of time-varying transition probabilities. liboshi (2007) uses Bayesian inference to provide a solution for the drawbacks of the maximum likelihood estimation. The empirical results with data from the Japanese economy show that the Japanese business cycle displayed positive duration dependence during the last two decades.

Pelagatti (2002, 2003) contributes to the literature by introducing a multi-move Gibbs sampler enabling Bayesian and finite sample likelihood inference. A similar but

univariate model is introduced by Kim and Nelson (1999). However, the inference on the state variable includes employing a single-move Gibbs sampler, which might have slow convergence to the invariant distribution, as according to Pelagatti (2002). In the model, the reliability of the inference does not depend on the sample size of the real-world data. In addition, inference on the latent variables is not conditional on the estimated parameters, but incorporates also the parameters' variability [Pelagatti (2003)]. Under those methodological concerns, Pelagatti (2003) introduces the DDMSVAR model. He defines his model as a mixture of two VAR processes switching according to a two-state Markov chain with transition probabilities depending on how long the process has been in a state. Pelagatti (2003) successfully applies his model to estimate the US business cycle using time series of industrial production, total nonfarm employment, total manufacturing and trade sales in million of 1996 USD, personal income less transfer payments in billions of 1996 USD from January 1960 to August 2001.

The academic research on examining business cycles in Turkey is limited. Saltoglu *et al.* (2002) use Pelagatti's model (2002) to examine business cycles in Turkey by employing the real gross national product, composite leading indicator, total manufacturing industry production index, and aggregate consumption. They show that there were five recessionary periods experienced by the Turkish economy between 1988 and 2002.

Recently, Akay and Yilmazkuday (2008) analyze the currency crises and business cycles in the Turkish economy between 1987 and 1992 by employing a time-varying dynamic factor model and a three-state univariate Markov-switching model, respectively. In their first model, Akay and Yilmazkuday (2008) estimate the important indicators of the currency crises in Turkey and conclude that the deterioration of the net international reserves and domestic credits are the two leading indicators for the currency crises. In the second stage of their research, Akay and Yilmazkuday (2008) examine the business cycles by employing a three-state univariate Markov-switching model. They conclude that most of the recessionary periods of the Turkish economy between 1987 and 1992 can be attributed mostly to currency crises. In our research, we provide an economic point of view to the variables in our model, though Akay and Yilmazkuday (2008) provide econometrical analysis, as well. As our aim is to extend the model of Pelagatti (2003) to an emerging economy, our focus will be on economics rather than econometrics. We also extend the sample period to provide further evidence with current data.

In this research paper, we modify the software codes for DDMSVAR methodology for different macroeconomic variables to estimate the business cycles in an emerging economy, in order to test if the model is valid in a chaotic environment with sudden and high economic fluctuations and can be successfully implemented with different macroeconomic variables. Apart from those general interests, the paper also represents a business cycle analysis of the Turkish economy between 1986 and 2007 for the domestic interest. In that sense, it provides a comparison

## **2. The Macroeconomic Framework for Our DDMSVAR Model**

The developing economies are sensitive to macroeconomic shocks. Transition from stability to chaos is sudden and coincides with high volatilities in the financial markets. In that sense, estimation of regime switches is crucial for both market practitioners and policy makers to create strategies in the new regime.

We choose the Turkish economy for our empirical analysis because of its high volatility during the last decades. To set up a duration dependent regime switching model for such kind of economy will enhance the credibility of the model.

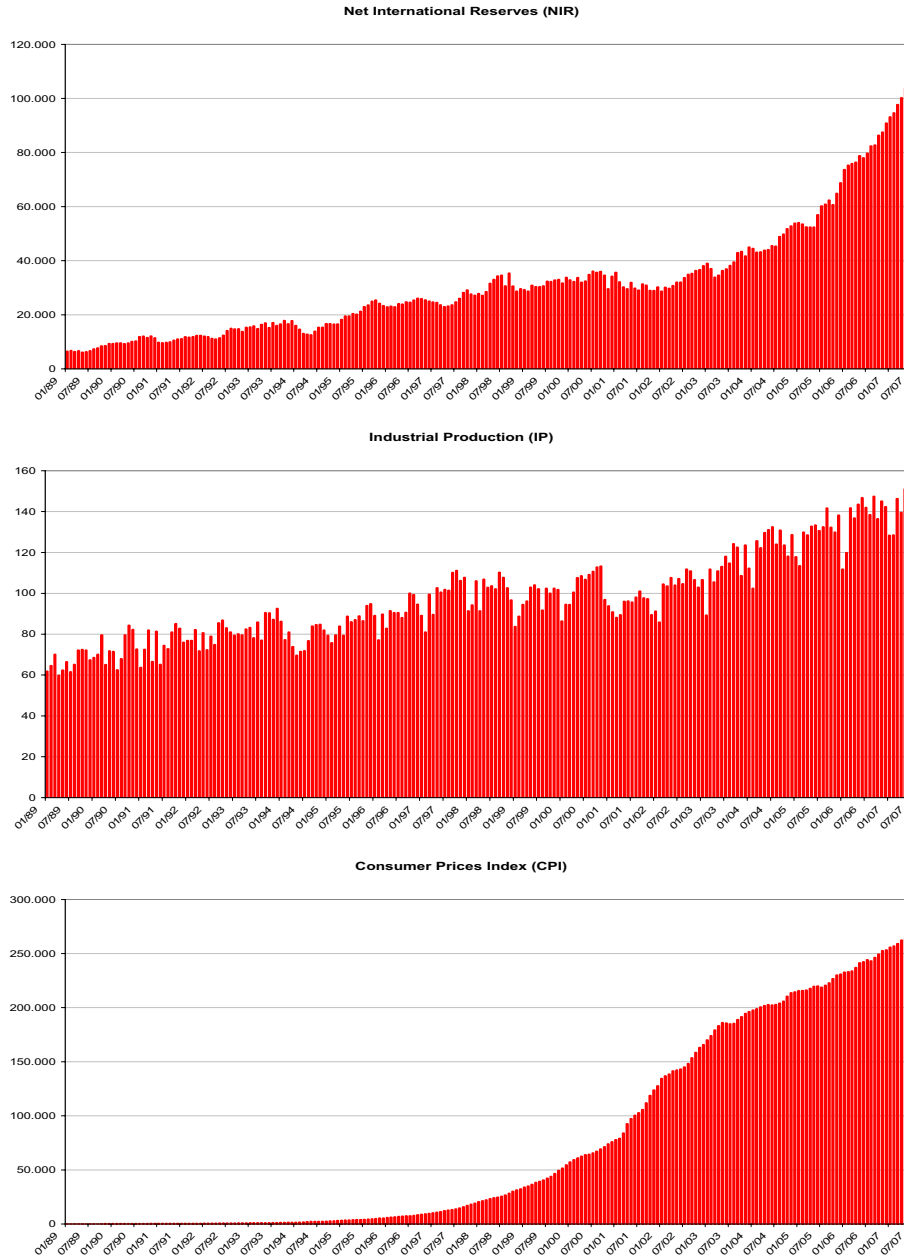
Before 1980, Turkey had a closed economy where import substituted regime survived. After the 1980' military intervention, the Turkish economy has become export driven. Between 1982 and 1988, years which can be called as "transition period", Turkey has had an open economy with the implementation of liberal policies. Those developments in the economic policies have created a structure more sensitive to macroeconomic shocks.

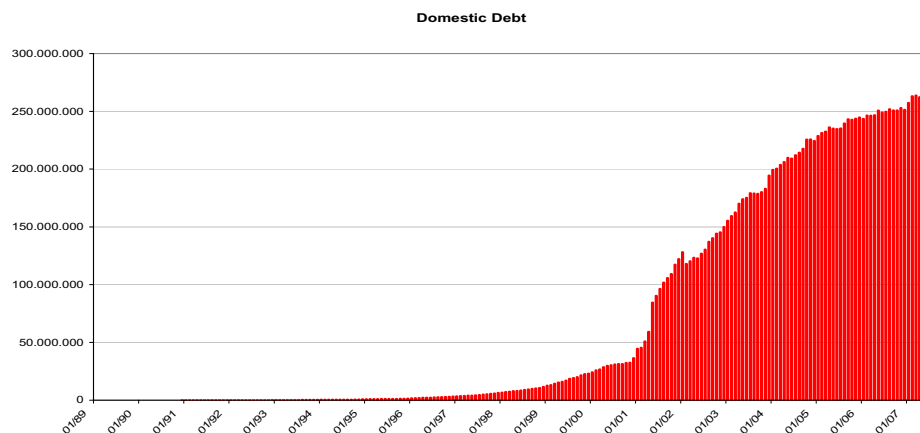
We create an empirical model for estimating business cycles in an open emerging market with macroeconomic variables including net international reserves, domestic debt stock, inflation and industrial production. Those variables are selected to reflect the effects of international shocks on the domestic economy. We follow the recession definition of the National Bureau of Economic Research (NBER). In that definition, the four macroeconomic variables that the NBER uses to date the business cycle are the industrial production, the total nonfarm employment, the total manufacturing and the trade sales (trade), and the personal income less transfer payments (income). However, for our model, we prefer to use the net international reserves, domestic debt and consumer price index and industrial production. We select the net international reserves because the emerging economies are sensitive to external shocks, as observed in Turkey's case in 2001. For many developing markets like Turkey, Argentina or Brazil, unstable domestic debt and high consumer price index create structural breaks in the economy.

The monthly time series data starts from the end of the transition period, specifically January 1989, to July 2007. In that period, Turkey had experienced three major recessions, in 1994, 1998 and 2001; all of them coincided with the high volatility in the international markets. The log return series of the variables in Graph 1 display the high volatilities in those periods. For that reason, we label the years of 1994, 1998 and 2001 as "recession regimes". That labeling is consistent with the National Bureau of Economic Research (NBER)'s definition of recession, according to which the growth rate is negative in two consecutive months. In this respect, the definition of recession in this paper differs from the definitions of OECD and Akay and Yilmazkuday (2008). In reality, the NBER does not define a recession as two consecutive quarters of decline in real GDP. In NBER's definition, a recession is a significant decline in economic activity and remarkable in real GDP, real income, employment, industrial production, and wholesale-retail sales.

Graph 1

Macroeconomic variables from January 1989 to July 2007





The descriptive statistics of the variables in Table 1 and results of Augmented Dickey-Fuler (ADF) tests in Table 2 also show the instability and nonlinearity in the economy.

**Table 1**

**Descriptive statistics of log returns of variables**

Variables	Net International Reserves (NIR)	Domestic Debt	Industrial Production (IP)	CPI
Mean	1.26	4.09	0.39	3.52
Standard Error	0.35	0.32	0.55	0.19
Median	1.40	3.03	0.25	3.25
Standard Deviation	5.20	4.77	8.24	2.86
Sample Variance	27.09	22.75	67.91	8.17
Kurtosis	0.99	13.05	0.32	8.58
Skewness	-0.42	2.78	-0.06	1.55
Range	30.33	43.83	44.60	28.51
Maximum	-15.79	-8.21	-22.22	-6.43
Minimum	14.54	35.62	22.38	22.08
Observations	222	222	222	222

Pelagatti (2003) used a DDMSVAR model for estimation of the U.S. business cycle with monthly data on industrial production, total nonfarm employment, total manufacturing and trade sales in million of 1996 USD and personal income less transfer payments in billions of 1996 USD from January 1960 to August 2001. The model estimates business cycles using macroeconomic variables not reflecting the sensitivity or strength of the economy against external shocks as the concern is the US economy.

Table 2

The ADF tests for the variables

Exogenous: Constant, Linear Trend  
 Lag Length: 0 (Automatic based on SIC, MAXLAG=14)

		Null Hypothesis: DLOG(NIR) has a unit root		Null Hypothesis: DLOG(CPI) has a unit root		Null Hypothesis: DLOG(IP) has a unit root		Null Hypothesis: DLOG(Domestic Debt) has a unit root	
		t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
ADF Test statistic		-14.821	0.0000	-10.843	0.0000	-5.522	0.0000	-11.843	0.0000
Critical values	1% level	-4.000		-4.000		-4.002		-4.000	
	5% level	-3.430		-3.430		-3.431		-3.430	
	10% level	-3.139		-3.139		-3.139		-3.139	

\*Mackinnon (1996) one-sided p-values.

However, since the developing economies have sensitivities against external shocks, our model includes net international reserves to reflect the power of the economy in the case of external stocks. The net international reserves used as a peg by the IMF are selected since it is one of the main explanatory variables of portfolio flows into the economy. In addition, Turkey, as many developing markets like Argentina or Brazil, suffers domestic debt and consumer price index which are other two structural variables in our model. The theoretical background explaining the effects of domestic debt and industrial production on the economic growth is strong in the economic literature. Industrial production is the main pillar of business cycle models as it is in our and Palegatti's (2003) model.

### 3. Duration Dependent Markov-switching VAR Methodology

In this part, we explain the methodological aspect of DDMSVAR model within the framework drawn by Pelagatti (2002, 2003).

The duration-dependent MS-VAR model is defined as follows:

$$y_t = \mu_0 + \mu_1 S_t + A_1(y_{t-1} - \mu_0 - \mu_1 S_{t-1}) + \dots + A_p(y_{t-p} - \mu_0 - \mu_1 S_{t-p}) + \varepsilon_t \quad (1)$$

where  $y_t$  is a vector of observable variables,  $S_t$  is a binary (0-1) unobservable random variable following a Markov chain with varying transition probabilities,  $A_1, \dots, A_p$  are coefficient matrices of a stable VAR process, and  $\varepsilon_t$  is a Gaussian white noise with covariance matrix  $\Sigma$ .

To create duration dependence for  $S_t$ , a Markov chain is set up for the pair  $(S_t, D_t)$ , where  $D_t$  is the duration variable defined in Equation 2.

$$D_t = \begin{cases} D_{t-1} + 1 & \text{if } S_t = S_{t-1} \\ 1 & \text{if } S_t \neq S_{t-1} \end{cases} \quad (2)$$

A sample of  $(S_t, D_t)$  is presented in Table 3. A maximum value,  $\tau$ , for the duration variable  $D_t$  should be fixed.

Table 3

Sample Processes of  $S_t$  and  $D_t$ .

T	1	2	3	4	5	6	7	8	9	10	11	12
$S_t$	1	1	1	1	0	0	0	1	0	0	0	0
$D_t$	3	4	5	6	1	2	3	1	1	2	3	4

Source: Pelagatti 2003, pp. 3.

The  $(S_t, D_t)$  is defined on the finite state space

$$\{(0, 1), (1, 1), (0,2), (1,2), \dots, (0, \tau), (1, \tau)\} \quad (3)$$

$$P = \begin{bmatrix} 0 & p_{01}(1) & 0 & p_{01}(2) & 0 & p_{01}(3) & \dots & 0 & p_{01}(\tau) \\ p_{10}(1) & 0 & p_{10}(2) & 0 & p_{10}(3) & 0 & \dots & p_{10}(\tau) & 0 \\ p_{00}(1) & 0 & 0 & 0 & 0 & 0 & \dots & 0 & 0 \\ 0 & p_{11}(1) & 0 & 0 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & p_{00}(2) & 0 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & 0 & p_{11}(2) & 0 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & 0 & \dots & p_{00}(\tau) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \dots & 0 & p_{11}(\tau) \end{bmatrix}$$

From the definitions of  $p_{ij}(d)$  and of the transition matrix ( $P_{ij} = \text{Prob}(S_{t+1}=j|S_t=i)$ )  $P$  is transposed with following finite transition matrix.

$$P' = \begin{bmatrix} 0 & p_{10}(1) & p_{00}(1) & 0 & 0 & 0 & \dots & 0 & 0 \\ p_{01}(1) & 0 & 0 & p_{11}(1) & 0 & 0 & \dots & 0 & 0 \\ 0 & p_{10}(2) & 0 & 0 & p_{00}(2) & 0 & \dots & 0 & 0 \\ p_{01}(2) & 0 & 0 & 0 & 0 & p_{11}(2) & \dots & 0 & 0 \\ 0 & p_{10}(3) & 0 & 0 & 0 & 0 & \dots & 0 & 0 \\ p_{01}(3) & 0 & 0 & 0 & 0 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & p_{10}(\tau) & 0 & 0 & 0 & 0 & \dots & p_{00}(\tau) & 0 \\ p_{01}(\tau) & 0 & 0 & 0 & 0 & 0 & \dots & 0 & p_{11}(\tau) \end{bmatrix}$$



In the matrix,  $p_{i|j}(d) = \Pr(S_t = i | S_{t-1} = j, D_{t-1} = d)$ . In case of equality between  $D_t$  and  $\tau$ , only four events have non-zero probabilities:

$$(S_t = i, D_t = \tau) | (S_{t-1} = i, D_{t-1} = \tau) \quad i = 0, 1 \quad (4)$$

$$(S_t = i, D_t = 1) | (S_{t-1} = j, D_{t-1} = \tau) \quad i \neq j, \quad i, j = 0, 1 \quad (5)$$

It shows that when the economy has been in state  $i$  at least  $\tau$  times, the additional periods in which the state remains  $i$  influence no more the probability of transition. By using the extended state variable,  $S_t^* = (D_t, S_t, S_{t-1}, \dots, S_{t-p})$ , comprehending all the possible combinations of the states of the economy in the last  $p$  periods, it is possible to calculate the likelihood function.

The transition matrix  $P^*$  of the Markov chain  $S_t^*$  is a  $(u \times u)$  matrix with a maximum number  $2\tau$  of non-zero elements. If the number  $(2\tau)$  of non-zero elements in  $P^*$  to be estimated is wanted to reduce, a probit specification can be employed. The process can be followed in the linear model below:

$$S_t^* = [\beta_1 + \beta_2 D_{t-1}] S_{t-1} + [\beta_3 + \beta_4 D_{t-1}] (1 - S_{t-1}) + \varepsilon_t \quad (6)$$

with  $\varepsilon_t \approx N(0,1)$ , and  $S_t^*$  latent variable expressed by

$$\Pr(S_t^* \geq 0 | S_{t-1}, D_{t-1}) = \Pr(S_t^* = 1 | S_{t-1}, D_{t-1}) \quad (7)$$

$$\Pr(S_t^* < 0 | S_{t-1}, D_{t-1}) = \Pr(S_t^* = 0 | S_{t-1}, D_{t-1}) \quad (8)$$

The equations 6 and 7 show that the model holds, theoretically.

$$p_{1|1}(d) = \Pr(S_t = 1 | S_{t-1} = 1, D_{t-1} = d) = 1 - \Phi(-\beta_1 - \beta_2 d) \quad (9)$$

$$p_{0|0}(d) = \Pr(S_t = 0 | S_{t-1} = 0, D_{t-1} = d) = \Phi(-\beta_3 - \beta_4 d) \quad (10)$$

In the Equations above,  $d = 1, \dots, \tau$ , and  $\Phi(\cdot)$  is the standard normal cumulative distribution function [Pelagatti (2003)].

## 4. Empirical Analysis

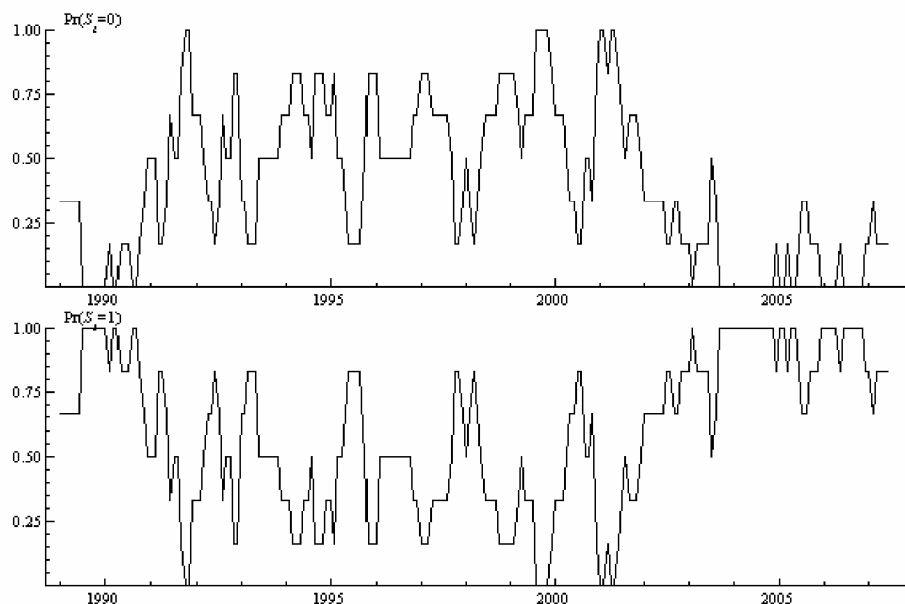
The empirical model is applied to 100 times logarithmic returns of four selected macroeconomic variables introduced before. The scalar maximum duration is equalized to 20 days, while the Gibbs sampler iterations are determined as 5.

In Graph 2,  $S_t=0$  state shows the probability of recession, while  $S_t=1$  state does show the probability of expansion. Thus, accordingly, the initial state is  $S_t=1$ , as the transition matrix is a transpose matrix.

As the Graph 2 indicates, the estimated recession probability moves between 25% and 75% over the period 1990-2000. The probability of recession increases its peak levels in 1994, 1998 and 2001, as it is expected. Though it has been very low since 2001, it should be emphasized that the recession probability has increased to 25% level, recently.

Graph 2

**Smoothed probability of recession and expansion and business cycles in Turkish economy**



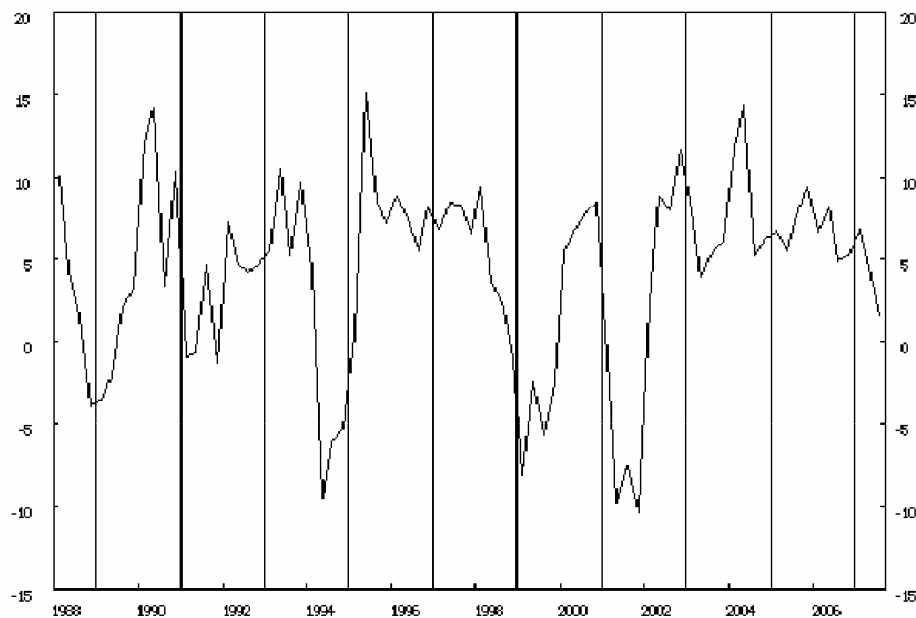
The Markov chain with the transition matrix  $P$  is regular, which implies that the transitions can be in a finite number of steps with non-zero probability, which suggests that the Markov chain is ergodic.

The realization of growth in Turkish economy can be seen from Graph 3. The main driver of Turkish economy has been the domestic demand, which resulted in a net trade deficit and current account deficit. The structural problems in the economy have been ongoing for over 2 decades. And the problems in the international credit markets are capping private sector investments; the strong domestic and relatively weaker EU demand is slowing down the export growth; and the entire Turkish growth story is becoming highly leveraged to domestic credit expansion and the central bank policy rates.

The reason for choosing the variables such as net international reserves, domestic debt, inflation and industrial production has been to capture the shape the economy is in. The international reserves are typical indicators for capital flows showing the first signs of foreign outflows. In the emerging markets, inflation and domestic debt are important indicators to capture the stability of the economy and industrial production is a sign of growth in the manufacturing sector.

Graph 3

## The Turkish GDP graph



The 1980's were marked by the integration of the Turkish economy into the international markets, by adopting free market principles and outward-oriented growth strategies. As a natural outcome of these transformations, a new era of structural change has emerged in finance. The deregulation of interest and FX rates, the liberalization of capital flows and the foreign exchange regime have challenged the Turkish economy.

In terms of macroeconomic instability in the Turkish economy, the high and volatile inflation rates of 1990s, the boom-bust cycles of economic growth and the fragility of external capital inflows all contributed to the uncertainties and led to a domination of "short-term" behaviour of economic agents. The confidence in the Turkish lira also deteriorated leading to an extensive currency substitution. As a result, the maturity of bank funding sources has shortened substantially and the share of foreign currency liabilities in total liabilities has increased sharply. The Turkish economy recovered relatively quickly from the crisis occurred in 1994. In the following years, the GNP grew over the long term by 5 percent growth rate, while the annual average inflation came down to 86 percent, albeit higher than the level before the crisis. The public sector deficit, however, continued to remain high, putting pressures on the interest rates. One of the main policy changes was the money creation of the Central Bank, because the Parliament brought a limit on the Bank's direct lending to the government. This had a positive impact on the inflationary expectations and encouraged demand for the Turkish Lira. Currency substitution did almost stop, but

not yet reversed. Although Turkey made great strides in the 1990s, the financial crisis of 2000 and 2001, as well as the country's worst recession in more than 20 years, laid the finance sector low and exposed its weaknesses.

Also, the high public sector deficit resulted in a financing with high real interest rates from the domestic financial markets, which led to a sharp decline in the allocation of resources to the real sector. The arbitrage opportunities due to the high domestic real interest rates made it attractive for the banking sector to borrow abroad and finance public sector deficits leading to an increase in the foreign exchange open position of the banking sector. The estimation results are displayed in Tables 4 to 7.

**Table 4**

**mu0 (k X 1) vector of means when the state is 0**

mu0 (mean in state 0)					
	Mean	St.error	0.05%	50.00%	99.50%
dINIR	0.388	0.446	-0.349	0.451	1.029
dIDDebt	5.109	0.290	4.811	4.987	5.515
dIIP	0.286	0.404	-0.179	0.130	0.865
dICPI	4.753	0.386	4.231	4.817	5.334

**Table 5**

**mu1 (k X 1) vector of mean-increments when the state is 1**

mu1 (mean increment in state 1)					
	Mean	St.error	0.05%	50.00%	99.50%
dINIR	1.513	0.827	0.601	1.103	2.907
dIDDebt	-2.863	0.570	-3.568	-2.942	-1.848
dIIP	0.006	0.432	-0.569	0.157	0.549
dICPI	-2.674	0.888	-3.644	-2.988	-1.347

**Table 6**

**Sigma (k X k) covariance matrix of VAR error ( )**

Sigma (covariance matrix elements)					
	Mean	St.error	0.05%	50.00%	99.50%
(dINIR, dINIR)	26.994	2.564	22.185	27.587	29.511
(dINIR, dIDDebt)	3.445	2.325	1.032	2.082	7.191
(dINIR, dIIP)	4.638	3.297	-1.509	5.593	7.973
(dINIR, dICPI)	-0.724	1.678	-3.331	-0.401	1.764
(dIDDebt, dIDDebt)	23.862	50.723	20.013	22.072	33.596
(dIDDebt, dIIP)	-2.986	2.038	-6.270	-1.711	-1.014
(dIDDebt, dICPI)	4.784	5.427	1.262	2.426	15.273
(dIIP, dIIP)	71.875	5.412	63.679	72.472	78.399
(dIIP, dICPI)	-1.225	1.865	-3.706	-1.033	1.534
(dICPI, dICPI)	8.502	4.901	4.868	7.166	17.883

Table 7

Beta: Probit model coefficients

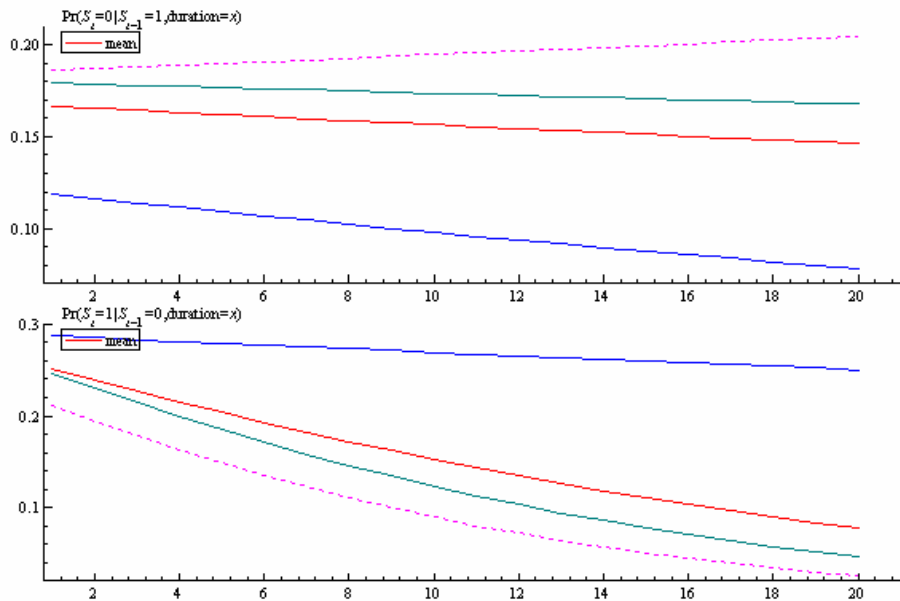
Beta (probit model coefficients)					
	Mean	St.error	0.05%	50.00%	99.50%
constant0	0.631	0.070	0.556	0.634	0.744
duration0	0.039	0.022	0.006	0.052	0.060
constant1	-0.964	0.104	-1.170	-0.916	-0.896
duration1	-0.004	0.006	-0.012	-0.002	0.004

Putting all these together, one may see from Graph 2 that the recession probabilities remained high during 1990's and captured the 2001 crisis, and it has been relatively stable until recent years. It is worth noticing that the recession probabilities have risen to 25% in the last quarters, which has also been due to the fact that the growth rate has been slowing down (see Graph 3).

The observed and estimated recessions over the period 1989-2007 are consistent, indicating that the DDMSVAR model constructed with net international reserves, domestic debt stock, consumer price index and industrial production is empirically useful. Additionally, one may see that the noise in the DDMSVAR model is lower than that in the Markov model used by Hamilton (1989).

Graph 4

Probability of moving from a recession into an expansion after d months of recession and probability of moving from an expansion to a recession after d months of expansion



In Graph 4, it is pointed out that the transition from recession to economic expansion depends on the durations of the recessions, but its effect seems to be limited in the Turkish case, which might be due to the fact that its effect seems to last longer.

## 5. Conclusion

In this applied research paper, we use the DDMSVAR methodology of Pelagatti (2003) to model the business cycles in an open emerging economy. In contrast to Pelagatti (2003), who gives an application with US data reflecting the internal dynamics of the US economy, we choose certain macroeconomic variables, namely net international reserves, domestic debt stock, consumer price index and industrial production, showing the strength of the economy against both external and internal dynamics. In parallel to NBER's definition of recession, specifically, the growth rate is negative in two consecutive months; we distinguish the years 1994, 1998 and 2001 as recession regimes in the Turkish economy and examine if the model is successful in foreseeing the business cycles.

The model empirically shows that our probabilities of recession are consistent with the NBER classification. In addition, after an expansion regime since 2001, the recent increase in the probability of recession is remarkable for the policy makers and market practitioners.

We think that our macroeconomic model estimating the business cycles can be used for the developing economies in which the external shocks are as important as the internal ones. The performance of the model may be re-examined by using data from other open developing economies, such as Argentina or Brazil, where the economy has had remarkable fluctuations arising from speculative attacks.

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