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STATISTICAL MODELING BY USING MARKOV'S SWITCHING ALGORITHM TO PREDICT IN THE UNEMPLOYMENT RATES AT JORDAN FOR THE PERIOD (2015-2020)

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ABSTRACT

This study aims to apply the statistical modeling by using Markov's Switching algorithm to predict of the unemployment rates at Jordan for the period (2015-2020). To achieve the study objectives, the study is mainly based on the secondary data related to Unemployment rates selected from the annual reports of the Jordanian department of statistics for the period (2000-2014). The study findings a number of results, including the following:

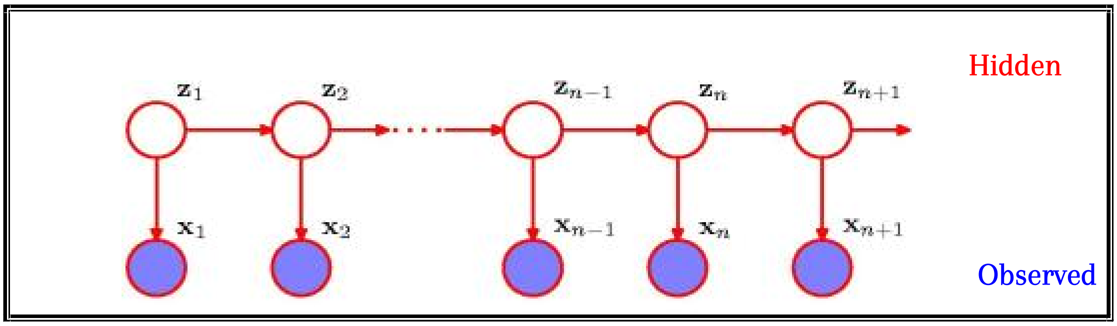
- The Unemployment rate (Observed) is relatively unstable because the variance (fluctuations) between its observations bigger than the variance of the uncertain unemployment (Hidden).

- The forecasting of the Unemployment Rates in Jordan for the period (2015-2020) seems decreases in the short term.

KEYWORDS: *Hidden Markov Models, Markovs' Switching Algorithm, Smoothed Probabilities, Unemployment.*

1. INTRODUCTION

Hidden Markov Model (HMM) is a stochastic model which provides a high level of flexibility for modeling the structure of an observation sequence. It consists of a number of non-observable (Hidden) states and an observable sequence, generated by the individual hidden states (Eyad & Hameed, 2012: 144). Also, the (HMM) is a statistical model which establishes a model for every word through the statistical analysis of large amounts of data with a nite number of states, each associated with a probability distribution. The transitions between states cannot be directly measured (hidden), but in a particular state an observation can be generated. It is the observations and not the states themselves which are visible to an outside observer (Ke & et al., 2008: 305). In another word, Hidden Markov Model represents a sequence of random variables $z_1, z_2,....,z_n$,where the future state z_{n+1} is dependent only on the current state z_n . Instead we observe an extra stochastic process x_n which is dependent on our unobservable state z_n. We refer these unobservable states as hidden states where all inferences about the hidden states is determined through the observed x_n , as shown in the following Figure No.(1):



Source: *Nemeth C., (2011: 2).*

Figure1. Hidden Markov Model with observed X_n and hidden states Z_n

In order to solve the Hidden Markov Models (HMM) can be used as one of the applications of this type of models which is (Markov Switching Model) for two hidden states, which will be explained in detail in subsequent items.

The objectives of this study can be summarized as follows:-

a. Analysis of the unemployment problem in Jordan during the period (2000-2014), and identify the causes of the instability of the time series observations.

b. Estimation the parameters of the Markov Switching Model by maximum likelihood estimation (MLE) method.

c. Estimation the parameters of the General Trend Equation.

d. Predict of the Unemployment Rates in Jordan for the period (2015-2020).

2. THEORETICAL PART

2.1. Hidden Markov Models:-

Hidden Markov models is a statistical tool used for modeling generative sequences characterized by a set of observable sequences. The HMM are widely used in science, engineering and many other areas (speech recognition, optical character recognition, machine translation, bioinformatics, computer vision, finance and economics, and in social science, forecast the weather state, determining the cognitive aspect of the educational process). The HMM framework can be used to model stochastic processes where (Touama, 2009: 297):

a. The non-observable state of the system is governed by a Markov process.

b. The observable sequences of system have an underlying probabilistic dependence.

Hidden Markov Model (HMM) is a variant of a finite state machine having a set of hidden states, Q, and output alphabet (observations), O, transition probabilities, A, output (emission) probabilities, B, and initial state probabilities, ®. The current state is not observable. Instead, each state produces and output with a certain probability (B). Usually the states, Q, and outputs, O, are understood, so an HMM is said to be a triple **(A, B, ®)**.

The parameters set of Hidden Markov Model (HMM) is represented by **Λ = (A, B, ®)** (Nemeth, 2011: 3):

Whereas:

1. Matrix **A** represent the transition probabilities matrix which explain the movement between states, and could be clarified by the following formula:

$A = \{a_{ij}\}$, Where $a_{ij} = P[q_{t+1} = S_j \mid q_t = S_i]$, $1 \le i, j \le N$ and $\sum a_{ij} = 1$ ...(1)

Whereas:

S: Individual states and are denoted as, $S = \{S_1, S_2, \ldots, S_N\}$.

N: Number of the model states.

2. **B:** represent the observation probabilities matrix, and could be clarified by the following formula:

$B = \{b_j(k)\}$, Where $b_j(k) = P[O_t = V_k \mid q_t = S_j]$, $1 \le k \le M$, $1 \le j \le N$ ...(2)

Whereas:

O_t : Observation symbol at time t.

M: Number of distinct observation symbols per state.

V: Observation symbols and are denoted as $V = \{V_1, V_2, \ldots, V_M\}$.

3. ®: represent the initial state probabilities, and could be clarified by the following formula:

® = $\{\pi_i\}$, Where $\pi_i = P[q_1 = S_i]$, $1 \le i \le N$, $\pi_i \ge 0$ & $\sum \pi_i = 1$ ...(3)

2.2. Markov's Switching Algorithm:-

It is one of the applications of Hidden Markov Models (HMM) , and it is defined as a time series with change the systems of the hidden variable (non-observable), and distribution the generated observation which is based on non-observable or hidden variable, and this variable is governed by a Markov Chain System.

The concept of Markov's Switching belongs to the (state space model) where assumes implicitly in switch the models between different systems, where the data resulting from the process and that are subject to sudden changes may be due to political, environmental, and economic events and others.

The instability of the model sometimes is defined as (switching) in the regression equation from system to another. In most cases, the researchers in that field faces a dilemma about study the behavior of time series, and predictability about when and at any time to change the model parameters and then build their expectations in light of these timings.

In order to solve the means and variances for two states (systems) of (Markov's Switching algorithm), we use the following form (Yousif & Mardan, 2013: 338 -342):

$y_t = [\mu_0 (1-q_t) + \mu_1 q_t] + [\sigma^2_0 (1-q_t) + \sigma^2_1 q_t] \ \varepsilon_t$ ...(4)

Whereas:

y_t : Represent the unemployment rates in Jordan.

$\varepsilon_t \sim N(0,1)$, q_t take (0 or 1).

And the observation (y_t) of the first and second systems in time t, are given through the following formulas (Andrew & et al., 2001: 7-8):

$y_t = \{q_t = 0\} = \mu_0 + \sigma^2_0 \varepsilon_t$ ...(5)

$y_t = \{q_t = 1\} = \mu_1 + \sigma^2_{1\ t}$ ...(6)

Such that;

Eq.(5): means that the observation y_t according to the first system in time t.

Eq.(6): means that the observation y_t according to the second system in time t.

μ_0, μ_1: Represent the arithmetic means for the first & second systems respectively.

σ^2_0, ${}^2_1$: Represent the variances for the first & second systems respectively.

In light of the above, we can calculate the parameters (μ_j, σ_j) by the following formulas:

$\mu_j^{(k)} = \sum^T_{t=1} y_t\, p(q_t=j \mid y_T; \lambda^{k-1}) / \sum^T_{t=1} p(q_t=j \mid y_T; \lambda^{k-1})$ ...(7)

$\sigma^{2\,(k)}_j = \sum^T_{t=1}(y_t - \mu j^{(k)})(y_t - \mu j^{(k)}).p\,(q_t = j \mid y_T; \lambda^{k-1}) / \sum^T_{t=1} p\,(q_t = j \mid y_T; \lambda^{k-1})$ ...(8)

And for Markov's Switching Model of the first order, and for two hidden states there for the transition probability matrix are given as follows:

$$P = \begin{bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{bmatrix} \quad ...(9)$$

Whereas:

$P_{ij} = Pr\,[q_t = j \mid q_{t-1} = i]$, $\sum^L_{j=0} P_{ij} = 1$, $\forall i$ ...(10)

$Pr\,(q_t = 0 \mid q_{t-1} = 0) = P_{00}$, $P_{01} = 1 - P_{00}$ ...(11)

$Pr\,(q_t = 1 \mid q_{t-1} = 1) = P_{11}$, $P_{10} = 1 - P_{11}$ ...(12)

Based on the foregoing, can be calculated the transition probabilities ($P_{00,} P_{11}$) by the following formulas:

$$P_{00}^{(k)} = \sum^{T}_{t=2} p(q_{t=0,}\ q_{t-1=0} \mid y_T;\ \lambda^{k-1}) \,/\, \sum^{T}_{t=2} p(q_{t=0,}\ q_{t-1=0} \mid y_T;\ \lambda^{k-1}) \qquad ...(13)$$

$$P_{11}^{(k)} = \sum^{T}_{t=2} p(q_{t=1,}\ q_{t-1=1} \mid y_T;\ \lambda^{k-1}) \,/\, \sum^{T}_{t=2} p(q_{t=1,}\ q_{t-1=1} \mid y_T;\ \lambda^{k-1}) \qquad ...(14)$$

2.3. Estimation the Parameters of the General Trend Equation:

The parameters (α and β) of the general trend equation can be estimated by the (**Ordinary leastsquares: OLS**) method, and selected by **minimizing** the criterions (RMSE, MAPE or MAE). And we can forecast of the future values (Y_t) by the following formula:

$$\hat{Y}_t = \acute{\alpha} + ß'\, T_i \qquad ...(15)$$

2.4. Forecasting Accuracy Tests:-

There are three important criterions to test the **Accuracy** of the forecasting values, which calculated by the general trend equation, as follows (Touama, 2014: 21):

a. Root Mean Square Error (RMSE):
$$RMSE = \sqrt{\sum e_t^{\,2} / n} \qquad ...(16)$$

b. Mean Absolute Percentage Error (MAPE):
$$MAPE = \sum [\,| e_t | / Y_t] / n \qquad ...(17)$$

c. Mean Absolute Error (MAE):
$$MAE = \sum | e_t | / n \qquad ...(18)$$

3. THE APPLIED PART

3.1. Collection Data:-

The study is mainly depend on the secondary data related to Unemployment in Jordan, selected from the annual reports of the Jordanian Department of Statistics. The researcher select the period (2000-2014), in order to achieve the study objectives. As shown in the following Table No.(1):

Table 1. The Unemployment Rates in Jordan during the period (2000-2014)

Years	(1) Unemployment Rates (Y_t)	(2) Estimation of Unemployment (Y_t)	(3) Uncertain Unemployment (e^2)
2000	13.70	14.50	0.6400
2001	14.70	14.35	0.1225
2002	15.30	14.20	1.2100
2003	14.50	14.05	0.2025
2004	12.50	13.90	1.9600
2005	14.80	13.75	1.1025
2006	14.00	13.60	0.1600
2007	13.10	13.45	0.1225
2008	12.70	13.30	0.3600
2009	12.90	13.16	0.0676
2010	12.50	13.00	0.2500
2011	12.90	12.86	0.0016
2012	12.20	12.71	0.2601
2013	12.60	12.56	0.0016
2014	13.40	12.41	0.9801

(1) Actual values of Unemployment Rates (Y_t) in Jordan during the period (2000-2014), **source:** Annual Reports of the Jordanian Department of Statistics.

(2) Estimation of Unemployment (v_t), obtained through applying the (OLS) method to estimate the general trend .... $v_t = 13.453 - 0.149\ T_i$).

(3) Uncertain Unemployment, obtained through of the square of errors (e^2), where ($e = Y_{t} - v_t$), and calculated by (SPSS) program.

3.2. RESULTS AND DISCUSSION

3.2.1. Estimation of Markov's Switching Model by Maximum likelihood Method:-

By depending on the relations (7, 8, 13, and 14) we got the Maximum Likelihood Estimates (MLE) the parameters of Markov's Switching Model for the Unemployment Rates (Y_t) and the Uncertain Unemployment (e^2) by using MATLAB program. As shown in the following Table No.(2):

Table 2. Maximum likelihood estimates of Markov's Switching Model

States (systems)	Parameters	Estimates
Unemployment Rates	μ_1	13.453
	$\sigma^2{}_1$	0.976
	P_{11}	0.618
Uncertain Unemployment	μ_0	0.496
	$\sigma^2{}_0$	0.326
	P_{00}	0.615

The results incoming in Table (2) previously, can be adopted to distinguish between the unemployment rate (Y_t) and the uncertain unemployment (e^2) according to the values of the means and variances, **where the results refers to:**

a. The unemployment rate system (Y_t) (Observed) is relatively unstable because the variance (fluctuations) ($\sigma^2_1 = 0.976$) between its observations bigger than the variance of the uncertain unemployment system (e^2) (Hidden) ($\sigma^2_0 = 0.326$), and can be considered the uncertain unemployment system is relatively stable system, because the mean of this system ($\mu_0 = 0.496$) lessthan the mean of the unemployment rate ($\mu 1 = 13.453$), and the variance (fluctuation) ofthe uncertain unemployment less than the variance (fluctuations) for the unemployment rate.

b. The estimates of the transition probabilities (0.618) and (0.615), indicates to fixed of continuity for the two systems and its rapprochement with a very slight differences between them.

3.2.2. Estimation the Parameters of General Trend Equation of the Time Series:-

The results in Table No. (3), refers to estimate the parameters of the general trend equation of the time series during the period (2000-2014), as follows:

Table 3. Results of estimation the parameters of the general trend equation

Model	Estimate	Std. Error	t - value	Sig.
Constant (α)	13.453	0.195	68.842	0.000
Slope (ß)	- 0.149	0.045	- 3.293	0.006

The estimation of the parameters related to the general trend equation, which stated in Table (3), explained that the estimation of the parameters were statistically significant, because the statistical significant (Sig.) are equals to (0.000 and 0.006) respectively were less than the significant level ($\alpha = 0.05$).

According to the estimation of the parameters of the general trend equation, the **forecasting equation** was explained by the following formula:

$$\hat{Y}_t = 13.453 - 0.149\ T_i$$

3.2.3. Test the Adequate of the General Trend Equation:-

The results in Table No. (4), refers to the testing criterions of accuracy of the general trend equation in order to forecast the Unemployment Rates (Y_t), as follows:

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The results in Table No. (4), refers to the testing criterions of accuracy of the general trend equation in order to forecast the Unemployment Rates (Y_t), as follows:

Table 4. Results of the Criterions for testing the Forecasting Accuracy

Model	Accuracy Criterions		
	RMSE	MAPE	MAE
General Trend - model	0.704	0.044	0.589

The results of the criterions for testing the forecasting accuracy of the general trend equation incoming in Table (4), indicates to the **forecasting accuracy by the General Trend Equation is very high,** because all the values of the accuracy criterions (RMSE, MAPE, and MAE) were **very low** and less than the critical value (10).

3.2.4.Forecasting of the Unemployment Rates in Jordan

The results in Table (5), indicates to the forecasting results of the **Unemployment Rates** in Jordan for the period (2015-2020), as follows:

Table 5. Forecasting the Unemployment Rates for the period (2015-2020)

Years	2015	2016	2017	2018	2019	2020
Forecasting	12.261	12.112	11.963	11.814	11.665	11.516

The forecasting results of the Unemployment Rates in Jordan listed in Table (5) above, seems decreases in the short term.

4. CONCLUSIONS

This part includes the most important conclusions in light of the results, as follows:

a. The Unemployment rate (Y_t) (Observed) is relatively unstable because the variance (fluctuations) (σ^2_1= 0.976) between its observations bigger than the variance of the uncertain unemployment (e^2) (Hidden) (σ^2_0 = 0.326).

b. The results of the unemployment rates estimation in Jordan during the period (2000-2014) according to the estimation model (v_t = 13.453 – 0.149 T_i).

c. The forecasting results of the Unemployment Rates in Jordan for the period (2015-2020) seems decreases in the short term.

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