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# Markovian Migrational Models a Dynamics of Repeat Migration: A Markov Chain Analysis and Application

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## ABSTRACT

We develop a systematic approach to Markovian Model onto an effective displaced diffusion (Migration), and work out a set of computationally efficient formulas valid for a large class of Markovian underlying processes. While the literature has established that there is substantial and highly selective return migration, the growing importance of repeat migration has been largely ignored. Using Markov chain analysis, this paper provides a modeling framework for moves of migrants between the host and home place. The Markov transition matrix between the states in two consecutive periods is parameterized. Using a variant of maximum likelihood estimation technique, this paper utilizes data to provide estimates of transition probability matrices. The probability of rural to rural migration ($0 \to 0$) is the lowest (0.2583) whereas the probability of making from urban to urban migration ($1 \to 1$) is the highest (0.8499). The rural to urban migration (0.7417) is greater than the urban to rural migration (0.1898). Again we fit the Markovian Migration Model (MMM) to find the effect of the explanatory variable which is influenced to migration. Simulations with our estimated models have shown that while the probability to return home remains low as time passes. Our results point to the fact that repeat migrants are indeed labor migrants, who go to home to work and earn money, and that there is no evidence that they finally attempt to return to the home place.

**Keywords:** *Markov Model, Transition Probabilities, MMM*

## 1. INTRODUCTION OF THE STUDY

The literature on migration has established that return migration is considerable and highly selective. The study of migrational data has gained importance increasingly over time due to the advantage of such models in explaining the problems more comprehensively. On the other hand, the cross sectional studies deal with only single measures at a particular point in time. In a migrational study, we observe repeated measures at different times within a specified study period. We can observe both the outcome and explanatory variables at different times. This provides the opportunity to examine the relationship between the outcome and explanatory variables over time in terms of the changes in the status of the outcome variables. This also poses a formidable difficulty in developing appropriate models for analyzing migrational data mainly due to correlation among the outcomes on the same individual / item at different times as well as due to formulation of a comprehensive model capturing the huge information generated by transitions during the period of study.

Once an out-migration has taken place, migrants are soon more prone to move again. The phenomenon of repeat migration has not been sufficiently studied. While there are some theoretical contributions to model this phenomenon, and there is some empirical research on repeat migration, there is hardly any empirical evidence in the context of international migration.

## 2. MIGRATIONAL PROBABILITY CATEGORIES

| Current State | State Constructed Dependent Variable | Meaning |
|---|---|---|
| In Home | Migration Type: $0 \to 0$, $\pi_{00}$ | Probabilities of staying in home place |
| | Migration Type: $0 \to 1$, $\pi_{01}$ | Probabilities of migration from home to other place |

| | | |
|---|---|---|
| In Migration | Migration Type: $1 \rightarrow 0,\ \pi_{10}$ | Probabilities of return to the home place |
| | Migration Type: $1 \rightarrow 1,\ \pi_{11}$ | Probabilities of not return to the home Place |

## 3. MODEL SPECIFICATION

A Markovian Modeling Framework we model the movement of immigrant's one location to other of the home country by a discrete-time discrete-space Markov process. We assume that the status of the immigrant at any period $t$ is described by a stochastic process $\{E_t\}$ that takes values in a finite discrete n state space $S = \{0, 1\}$. A Markov chain is a sequence of random values whose probabilities at a time interval depend upon the value of the number at the previous time (Papoulis, 1984). We embody the idea that if an individual knows the current state, it is only this current state that influences the probabilities of the future state. At each time, the Markov chain restarts a new using the current state as the new initial state. We assume that this Markov chain has two states, 0 and 1, indicating that an individual is in one location and in the other place respectively. The vector containing the long-term probabilities, denoted by $\pi$ , is called the steady-state vector of the Markov chain.

## 4. COVARIATE DEPENDENCE TWO STATE FIRST ORDER MARKOV MODEL

Let us consider an experiment for a specified time period for a sample of size n. In the experiment, we have data from several follow-ups. At each follow-up, each of n units is observed. The n units in the sample produce data on the dependent variable, Y, and covariate vector $X' = (1, X_1, X_2, \cdots, X_P)$ . Let us assume that the dependent variable Y can take two values, 0 and 1.

If $Y = 1$ , then it indicates the migrants migration from one place to another,

$Y = 0$ , otherwise

For the $i-th$ unit at the j-th follow-up, the respondent can be expressed as follows

$Y_{ij} = 1$ , if the i-th unit experiences the event of interest at the $j-th$ follow-up,

$Y_{ij} = 0$ , Otherwise;

$X_{ij\,q} = x_{ijq}$ , value of the covariate $X_q$ for the $i-th$ unit at the $j-th$ follow-up.

Let us consider a single stationary process $(Y_{i1}, Y_{i2}, Y_{i3}, \cdots, Y_{ij},)$ representing the past and present status for subject $i$ ( $i = 1, 2, \cdots, n$) at follow-up $j$ ($j = 1, 2, \ldots, n_i$ . $Y_{ij}$ is the migration at time$t_{ij}$ . We can think of $Y_{ij}$ as an explicit function of past history of subject $i$ at follow-up $j$. The transition models for which the conditional distribution of $Y_{ij}$ given the past history depends on r prior observations, $Y_{ij-1}, Y_{ij-2}, \ldots, Y_{ij-r}$ is considered as the model of order $r$. Then the first order Markov Model can be expressed as

$$\mathrm{P(Y_{ij}/\ past\ history)} = \mathrm{P(Y_{ij}/Y_{ij-1})}$$

and the corresponding transition probability matrix is given by as follows

$$\pi = Y_{ij-1}\ \begin{matrix} 0 \\ 1 \end{matrix} \overset{\begin{matrix} & Y_{ij} & \\ 0 & & 1 \end{matrix}}{\begin{bmatrix} \pi_{00} & \pi_{01} \\ \pi_{10} & \pi_{11} \end{bmatrix}}$$

$$\text{alternatively,} \quad \pi = Y_{ij-1}\ \begin{matrix} 0 \\ 1 \end{matrix} \overset{\begin{matrix} & Y_{ij} & \\ 0 & & 1 \end{matrix}}{\begin{bmatrix} 1-\pi_{01} & \pi_{01} \\ 1-\pi_{11} & \pi_{11} \end{bmatrix}}$$

The probability of migration from 0 at time $t_{j-1}$ to 1 at time $t_j$ is

$\pi_{01} = P(Y_{ij} = 1/Y_{ij-1} = 0)$ and

Similarly the probability of a transition from 1 at time time $t_{j-1}$ to 1 at time $t_j$ is

$$\pi_{11} = P(Y_{ij} = 1/Y_{ij-1} = 1)$$

For covariate dependence, let us define the following notations

$X'_{ij-1} = [1, X_{ij-1,1}, X_{ij-1,2}, \ldots, X_{ij-1,p}]$ = vector of covariates for the $i-th$ person at the $(j-1)th$ follow-up.

$\beta'_0 = [\beta_{00}, \beta_{01}, \beta_{02}, \ldots, \beta_{0p}]$ = vector of parameters for the transition from 0.

$\beta'_1 = [\beta_{10}, \beta_{11}, \beta_{12}, \ldots, \beta_{1p}]$ = vector of parameters for the transition from 1.

Then the transition probabilities can be defined in terms of functions of the covariates as

 

$\pi_{s1} = P(Y_{ij} = 1/Y_{ij-1} = s, X_{ij-1}) = \frac{e^{\beta_s' X_{ij-1}}}{1+e^{\beta_s' X_{ij-1}}}$, $(s = 0,1)$

## 4.1 Likelihood Function

Then the likelihood can be defined as

$$L = \prod_{s=0}^{1} \prod_{m=0}^{1} \prod_{i=1}^{n} \prod_{j=1}^{n_i} \left[\{\pi_{sm}\}^{\delta_{smij}}\right]$$

Where $n_i$ = total number of follow-up observations since the entry into the study for the i-th individual, $\delta_{smij} = 1$ if a transition type s-m is observed during j-th follow-up for the i-th individual. Then taking logarithm of the above equation we can express the log likelihood function as $lnL = lnL_0 + lnL_1$

Where $L_0$ and $L_1$ correspond to $s = 0$ and $s = 1$ respectfully.

Hence, $\mathrm{lnL_0} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[\delta_{01ij}\{\beta'_{01}X_{ij-1}\} - (\delta_{00ij} + \delta_{01ij}) \ln\left\{1 + e^{\beta_{01}' X_{ij-1}}\right\}\right]$

and $lnL_1 = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[\delta_{11ij}\{\beta'_{11}X_{ij-1}\} - (\delta_{10ij} + \delta_{11ij}) \ln\left\{1 + e^{\beta_{11}' X_{ij-1}}\right\}\right]$

Differentiating the above equation with respect to the parameters and solving the following equations we obtain the likelihood estimates for $2(p + 1)$ parameters.

$$\frac{\delta lnL_0}{\delta \beta_{01q}} = 0 \ , q = 0, 1, \ldots, p$$

and $\frac{\delta lnL_1}{\delta \beta_{11q}} = 0 \ , q = 0, 1, \ldots, p$

**The first** derivatives with respect to the first set of parameters in the above equations are

$$\frac{\delta lnL_0}{\delta \beta_{01q}} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[X_{ij-1,q}\left\{\delta_{00ij} - (\delta_{00ij} + \delta_{01ij}) \frac{e^{\beta_{01}' X_{ij-1}}}{1+e^{\beta_{01}' X_{ij-1}}}\right\}\right] \quad (1)$$

Similarly the first derivatives we get for the second set

$$\frac{\delta lnL_1}{\delta \beta_{11q}} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[X_{ij-1,q}\left\{\delta_{10ij} - (\delta_{10ij} + \delta_{11ij}) \frac{e^{\beta_{11}' X_{ij-1}}}{1+e^{\beta_{11}' X_{ij-1}}}\right\}\right] \quad (2)$$

Where $q = 0,1, \ldots, p$

We can solve for the sets of parameters by the equation the above to zero.

Then t**he second** derivatives are

$$\frac{\delta^2 \ln L_0}{\delta \beta_{01q} \delta \beta_{01l}} = -\sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[X_{ij-1,q}X_{ij-1,l}\left\{ (\delta_{00ij} + \delta_{01ij})\pi_{00}(X_{ij-1})\pi_{01}(X_{ij-1})\right\}\right] \quad (3)$$

$$\frac{\delta^2 \ln L_0}{\delta \beta_{11q} \delta \beta_{11l}} = -\sum_{i=1}^{n} \sum_{j=1}^{n_i} \left[X_{ij-1,q}X_{ij-1,l}\left\{ (\delta_{10ij} + \delta_{11ij})\pi_{10}(X_{ij-1})\pi_{11}(X_{ij-1})\right\}\right] \quad (4)$$

Here the above (3) and (4) equations are obtained from the (1) and (2) equations.

## 5. METHODOLOGY

The Bangladesh Demographic and Health Survey (BDHS), is a nationally representative survey in Bangladesh that started in 1984 in the Bangladesh with a sample of about 12,000 respondents, 3,000 of whom were legal immigrants. The construction and the coding of the dependent variable following the Markovian approach. The dependent variables in the logit specification are the transition probabilities $\pi_{00}$ and $\pi_{01}$. These transitions are distinct choices conditioned on the current state. Recall that by construction $\pi_{01} = 1 - \pi_{00}$ and $\pi_{11} = 1 - \pi_{10}$ , since these are conditional probabilities. Therefore, it is sufficient in the sequel to the model. We implement this by coding two dummy variables which measure whether there was a repetitive move or not.

## 6. APPLICATION AND COMMENT

In this study we have employed of Bangladesh Demographic and health Survey (BDHS) data.

Table2 presents the parameter estimate parameters. For the second order model, we have four independent models for four types of migration. In all the models, each explanatory variable has highly significant association with the mobility index data. The response variable we have used to the Migrational Index data. We have defined two states, 0 for no migration and 1 for migration from one place to other. Eight explanatory variables Gender, social status, educational status, age of the respondents, financial status, health status, occupation status, religion status are used. The full data set contains data for a total 11,440 respondents. We display the results obtained for the first order model. Table1 shows the pooled number of transitions during two consecutive follow-ups. This reveals that the probability of remaining in state of no migration (0) is the lowest (0.2583) whereas probability of making transition from previous two consecutive follow-ups in migration (1) and currently in migration (1) is the highest (0.8499). The transitions are driven by behavior based on individual characteristics and exogenous forces. Hence, a social status measures are entered as covariates in the model. Our main interest is in how these characteristics influence individual migrants to make the transition from one state to the other. The education variable includes both pre- and post-migration education. For education in home place we consider three levels of education: (1) primary-secondary education, (2) higher education, and (3) no schooling in home place, which is the omitted category.

Having a job in home place and the socioeconomic prestige of that job are two other determinants of repeat migration. They indicate attachment, integration, and success in the financial status. For the socioeconomic prestige of the job we use Treiman's international prestige scale that defines the actuality of the job. We expect that those immigrants who have a secured job in Germany will be less likely to repeat migration.

We find that the odds of returning, for those who have a job in home place (occupation status 0.721). Next, we find that married immigrants are less likely to leave home place. However, when their spouse is left in the home place immigrants have a higher probability to return. Likewise, when they have children in the home country they have a higher probability to return.

The quadratic specification of the age variable is significant. Immigrants who are in their home place are less likely to go back to home with each additional year when they are younger. However, $\pi_{01}$ increases as they get older. Whereas the years since first arrival variable is not statistically significant, we find that this variable has an economic significance and it enlightens the repeat migration behavior of immigrants. Considering the relevant range of age between 16 and 60, this table2 shows that the probability $\pi_{01}$ is quite high when the immigrants are young (around 20 years of age) but it first decreases at a decreasing rate as they get older. The probability to return to home place from home reaches a minimum of age and then it increases steadily. This suggests that repeat migration occurs mostly after 35 years of age. The evolvement of the transition probabilities with increasing age suggests that the absorbing state is rather home than the other place.

**Table 1: Estimate the Parameters for First Order Markov Model for Mobility Index Data**

| States | 0 | 1 |
|---|---|---|
| 0 | 0.2583 | 0.7417 |
| 1 | 0.1898 | 0.8102 |

**Table 2: Estimate the Parameters from Markovian Model for First Order Two State Migrational Data**

| Variable | Coefficient | Standard Error | Wald Statistic |
|---|---|---|---|
| Migration Type: 0 → 0 | | | |
| Constant | -5.9457 | 0.2056 | -28.9119 |
| Gender | 0.4828 | 0.0361 | 13.3644 |
| Age | -0.0385 | 0.0029 | -13.4445 |
| Religion status | -0.0813 | 0.0040 | -20.1833 |
| Financial status | -0.2145 | 0.0158 | 12.0223 |
| Educational status | -0.0984 | 0.0114 | 15.0214 |
| Occupation status | -0.9014 | 0.1001 | 20.2141 |
| Health status | 0.0101 | 0.2101 | 10.2542 |
| Social status | -0.5214 | 0.2708 | -11.2014 |
| Migration Type: 0 → 1 | | | |
| Constant | 3.8992 | 0.2895 | -13.4678 |
| Gender | 0.2907 | 0.0544 | -5.3403 |
| Age | 0.0404 | 0.0042 | 9.6990 |
| Religion status | 0.0489 | 0.0054 | 9.0715 |
| Financial status | 0.0121 | 0.0214 | 10.201 |
| Education status | 0.0021 | 0.2010 | 21.201 |
| Occupation status | 0.7251 | 0.1212 | 25.235 |
| Health status | 0.2101 | 0.2101 | 10.2542 |
| Social status | 0.5214 | 0.2708 | 11.2014 |
| Migration Type: 1 → 0 | | | |
| Constant | 1.6888 | 0.3025 | 5.5824 |

| | | | |
|---|---|---|---|
| Gender | 0.1946 | 0.0556 | 3.5014 |
| Age | -0.0187 | 0.0043 | -4.3333 |
| religion status | -0.0363 | 0.0057 | -6.3926 |
| Financial status | 1.2142 | 0.0181 | 2.0159 |
| pregnancy status | 0.2321 | 0.9852 | 9.3211 |
| Occupation status | 1.9871 | 0.0210 | 20.325 |
| Migration Type: 1 → 1 | | | |
| Constant | 1.4842 | 0.2480 | 05.9853 |
| Gender | 0.2149 | 0.0482 | 04.4626 |
| Age | 0.0349 | 0.0037 | -09.4385 |
| religion status | 0.0433 | 0.0039 | -11.0290 |
| Financial status | 0.8981 | 0.2121 | 20.2142 |
| Educational status | 0.0012 | 2.2101 | 09.3251 |
| Occupation status | 0.9985 | 0.2351 | 25.0211 |
| Health status | 0.2101 | 0.2101 | 10.2542 |
| Social status | 0.5214 | 0.2708 | 11.2014 |
| Likelihood Ration Test (LRT) | | | 2492.92 |

## 7. SUMMARY

In this paper we studied the behavior of immigrants who repeat their migration moves between the home place and others. Assuming a discrete time and space process where the status of a person is a random process in time, a Markov chain is an appropriate representation of the structure of the behavioral process of repeat migrants. The key feature of this model is that the future state depends solely on the current state.

Empirically, we estimated the transition probabilities through two binomial logits, conditioned on whether one is in home place or in the home place explained through various characteristics. Based on BDHS data, we estimated the repeat migration probabilities. Our study shows that more than 55% of the migrants in Bangladesh are indeed repeat migrants.

Whereas male immigrants are more likely to return to their home country than female immigrants, gender is not significant for the repeat move back to home place. The probability of repeating the migration move is high and decreases when one is young up to 35 years of age. The probability of repeating the migration move becomes an increasing function of age thereafter. Overall, repeat migrants are more likely to leave home place in the beginning of their immigrant career and when they have social and familial bonds in their home place. On the other hand, they are less likely to leave home when they have a job in home place.

Simulations with our estimated models have shown that while the probability to return home remains low as time passes. Our results point to the fact that repeat migrants are indeed labor migrants, who go to home to work and earn money, and that there is no evidence that they finally attempt to return to the home place. To the contrary, home place remains a magnet for these immigrants. Future research should study this closer. It also should examine the family dynamics and model the repeat migration process as a joint family decision.

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