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Distribution of Internal Rural-Urban Migration in Bangladesh: Application of Probability Models

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Abstract

The study of migration through probability models is very crucial for an in-depth understanding of the pattern, the volume of migration, and factors acting on it. The study is devoted to the application of probability models to describe the pattern of household-level migration in Bangladesh. The probability models have been tested using a nation-wide representative dataset of Bangladesh generated by the project "Rural-urban Migration and its Implications for Food Security in Bangladesh" under the National Food Policy Capacity Strengthening Programme (NFPCSP) of the Government of Bangladesh with the technical support of FAO and FPMU. The analysis revealed that the inflated logarithmic series distribution and mixture of two displaced geometric distribution describe the distribution of adult male migrants and total number of migrants respectively at household level in Bangladesh. The suitable application of the designated probability models for both micro-level (Hossain's Comilla survey 2000) data and nation-wide survey data (RUM-2012), directed the time-invariant applicability of these models on both micro-level samples to sizeable national sample for Bangladesh. The findings indicated that the incidence of single-migrant households is on the rise over time and the internal rural-urban migration flow from the west region is higher than that from the east region of Bangladesh.

Keywords: Internal migration, International migration, Modeling of migration, Probability models, Mean-zero frequency method, Maximum likelihood method

1. Introduction

Model building in migration studies at the micro level has received greater importance because it describes the pattern, trend, diversity, volume, and factors acting on it. Among different types of models, the application of probability models is very important because it helps to understand the pattern of migration very concisely. It is always a point of interest for the researchers to study the pattern of migration as distribution of migrants at household and community levels. Throughout the years, migration scholars have developed several models in this respect, and these models received much attention by stakeholders too. In a broad sense, migration from a household can be classified into two types: the first type indicates an adult male (?15 years of age) migrates alone to a place of destination; and the second type deals with a person migrates with his core family members (wife and children).

The study of migration through a probability model at the household level was first initiated by Singh and Yadava [1]. Subsequently, many researchers worked on the same fashion to describe the pattern of rural out-migration using probability models in terms of the distribution of households according to the number of migrants [2-12]. In a reference book, Yadava critically reviewed a number of the migration models and tested the suitability of these models using the several sets of data collected from the Northern India [13].

In the context of Bangladesh, Hossain [2] studied probability models to describe the distribution of households according to the number of migrants using the primary data collected from the Comilla district. In addition to the probability models, the study has tested some well-known migration models, including Zipf's gravity models, single-origin and multiple destinations migration models, empirical models to describe the distribution of distance for marriage migration in the context of Bangladesh [14-16]. Regarding the pattern of migration, Hossain proposed a probability model with underlying assumptions to describe the distribution of households according to the adult (aged 15 years and above) male migrants and applied the model to the micro-level data collected under the Varanasi survey as well as Comilla survey [2]. The proposed model viz., logarithmic series distribution, was found very much suitable to describe the distribution of adult male migrants better than the previous models proposed by other researchers [17]. Besides, the study offered a new

estimation technique to the model of adult male migrants proposed by Sharma [7]. The study also employed maximum likelihood estimation technique to the models proposed by Yadava [9] and Singh [18] for the total number of migrants and found a better fit of the distribution. In a comparative study, Shukla and Yadava [19] attempted to assess the suitability of some previously proposed models on the pattern of migration under different assumptions by applying the models to the data collected from northern India. The study found that inflated logarithmic series distribution and an inflated geometric distribution are more suitable to describe the pattern of out-migration for adult male migrants.

Pandey and Tiwari [20] proposed an inflated geometric model in order to structure the total number of migrants from a household and applied the model segregating the data in remote, semi-urban, and growth center separately. The study has adopted the most widely used method of moments and maximum likelihood for estimating the parameters of the proposed model, and the model was further tested by applying it to three different datasets on migrants at the household level, namely "RDPG - a sample survey (1978)", "Rural Areas of Comilla Districts, Bangladesh-2000" and "Rewa Survey - 2002". The estimated risk of migration under this proposed model was found higher for the households from 'Remote areas', which typically depicts the real picture of the society. Further, the model was found to fit well for all the datasets mentioned above.

The review of the pieces of literature as mentioned above has identified lacuna that the probability models to describe the distribution of households according to the migrants have been tested using micro-level data rather than nationally representative datasets. Specifically, the study of migration patterns resorting to probabilistic models to test the relevance of their application on a country-wide representative dataset is missing in the Bangladesh literature. This knowledge gap is expected to address in the present study. The study is designed for the application of probability models to describe the distribution of households according to the adult male migrants and the total number of migrants using a nation-wide dataset of Bangladesh to assess whether these models are valid or not to describe the migration patterns at the household level with the changing demographic scenario in Bangladesh.

2. Model for Adult Male Migrants

In the pioneering work, Singh and Yadava [1] proposed negative binomial distribution to describe the distribution of households according to the number of male migrants (aged 15 years and above). They applied this probability distribution to the observed data taken from the Demographic Survey of Varanasi (1969-1970) and found that the migration pattern is satisfactorily fitted by a negative binomial distribution. This model was also examined by Sharma by applying it to another set of data from different groups of villages and found suitable to describe the migration pattern [7]. In addition, Sharma [7] has proposed the inflated geometric distribution for the number of adult male (aged 15 years and above) rural-out migrants with the assumptions of the probability of migrating and not migrating from a household is β and (1- β) respectively. If p represents the probability of migrating of a single individual from a household, then the migration pattern at the household level follows the geometric distribution as follows:

$$\left.\begin{aligned} P(\mathrm{x}=0) &= 1-\beta+\beta\,\mathrm{p} \\ P(\mathrm{x}=\mathrm{k}) &= \beta\, q^{k}\, p \quad \text{for } \mathrm{k}=1,2,3,\ldots. \end{aligned}\right\} \quad \ldots (1)$$

where p+q=1.

Sharma [7] has estimated the parameters (β and p) using the method of moments. However, the asymptotic estimators for variances and covariance have been derived using a multivariate central limit theorem. After a decade, Iwunor [3] attempted to estimate the parameters using an alternative estimation technique. Although the study proposed a likelihood function using the multinomial combination, but ultimately estimated the parameters by mean-zero frequency method. Considering the limitations of the estimation techniques used by the earlier researchers, Hossain [2] proposed an alternative technique based on the likelihood function by using all the observations to estimate the parameters. The study also derived the expressions for the exact estimate of variances and covariance of the parameters and compared the estimators obtained through Sharma's method and Iwnor's method. The main contribution of Hossain's study was to derive an improved estimation technique, including the expressions for variances and covariance. Hossain [2] also applied this model to the Bangladesh data and found it suitable to describe the distribution of adult male migrants.

It is worth mentioning that Hossain [2] has proposed another model to describe the distribution of migrants (male ≥ 15 years) considering the limitations of the earlier models and derived the maximum likelihood estimators of the parameters, including their variances and covariance. This model was applied to both Comilla (Bangladesh) and Varanasi (India) data. The comparison of the results obtained by Hossain [2] clearly indicates that the proposed model provided better fits than Sharma's model for most of the study cohorts. As the pattern of migration changes over time, it is required to verify whether this model is still applicable to describe the distribution of male migrants aged 15 years & above at the household level using a nation-wide dataset. It is to be noted that the model was applied earlier for a

micro-level data collected from 10 rural clusters from Comilla district of Bangladesh. Thus, this study attempted to apply the model proposed by Hossain [2] in order to describe the pattern of adult (age 15 years and above) male migration at the household level using a nationally representative dataset. The model, including the estimation procedure, is briefly described below.

Model and Estimation

Hossain [2] has proposed the probability model for describing the pattern of the number of male out-migrants aged 15 years & above at the household level with two assumptions: (i) the probability of migration is α for the households exposed to the migration risk, (ii) the probability of migration is decreasing as the number of migrants increasing. Thus, the pattern of migration at the household level is a decreasing function and can be described with the following logarithmic series distribution:

$$P(x = k) = 1 - \alpha$$

$$= \alpha \left[\frac{-\lambda^k}{k \log (1-\lambda)}\right] \text{ for } k = 1, 2, 3....; \quad 0 < \lambda \alpha \text{ ..... (2)}$$

Hossain (2000) has derived the likelihood function for the random sample (X_1, X_2, ...X_n) assuming that nk (k= 0, 1, 2...m) is the number of observations of the k-th cell with $\sum n_k = n$ and expressed as:

$$L = (1-\alpha)^{n_0} \prod_{k=1}^{m} \left[\alpha \left(\frac{-\lambda^k}{k \log (1-\lambda)}\right)\right]^{n_k}$$

The solution of the likelihood function yielded the estimators of α as

$$\hat{\alpha} = \frac{n - n_0}{n}$$

On the other hand, the estimating equation of λ was found as

$$(1-\lambda) \text{ Log } (1-\lambda) \sum_{k=1}^{m} n_k x_k + (n - n_0)\lambda = 0$$

Results

The model (2) has been applied to the observed data collected from 60 rural clusters (primary sampling units of BBS) of Bangladesh. The relevant data of the 60 rural clusters has been extracted from the data collected in the project "Rural-Urban Migration and its Implication for food security in Bangladesh" (RUM-2012), sponsored by FAO and NFPCSP funded by GoB, USAID, European Union [20]. Table 1 shows the estimated values of the parameters, variances and covariance, observed and expected number of households according to the number of male migrants (aged 15 years & above) for the surveyed households of RUM-2012. In order to comparison of the pattern of migration over time, the table also displayed the findings of Hossain [2] for Comilla dataset. The high insignificance value of χ^2 indicates the adequacy of the model to describe the pattern of adult male rural-urban migration at household level.

The model (2) has also been applied to the two household cohorts according to the east-west divide of Bangladesh. The World Bank has introduced and executed the east-west divide in the poverty assessment study of Bangladesh [22]. It is to be noted that the economic opportunities vary between the two regions that reflect their migration behavior. Hossain et al. [21] reported that the percentage of internal migrant households was higher in the west region (27.22%) in comparison to the east region (19.19%). On the other hand, the percentage of international migrant households was markedly higher in the east region (15.67%) than that of the west region (4.65%). Table 2 shows the estimated values of the parameters along with other relevant results for the East and the West region of Bangladesh. The χ^2 values indicate that the model fits well for both the household cohorts - the east region and the west region.

Discussion

The estimated value of the risk parameter α for the model (2) was found 0.1556 for the nation-wide data set, while it was estimated as 0.1765 for the Comilla data set. On the other hand, the estimated value of the shape parameter λ was found 0.3044 for the present dataset, while it was reported at 0.4875 for the Comilla dataset. The results lead to conclude that the household-level migration intensity for the Comilla dataset was higher in comparison to the present dataset, maybe because of the fact that Comilla dataset considered the rural-out migration (included both internal and international migrants) from a household rather than internal rural-urban migration.

Based on the east-west divide, the estimated value of the risk parameter α was found remarkably high in the west region (0.2010) than that of the east region (0.1250), indicating that the internal rural-urban migration intensity was considerably high in the west region. This might be due to the historically less intensity for international migration among the people of the west region of Bangladesh compared to the east region. In a population monograph of Bangladesh Bureau of Statistics (prepared by the Department of Statistics, Rajshahi University), it is estimated from the census-2011 data that the international migrant-sending households was highest in the Chittagong division (32.5%), followed by Dhaka division (27.5%), Khulna division (13.4%), Sylhet division (12.2%), Barisal

division (6.9%), Rajshahi division (4.6%) and Rangpur division (2.7%) [23]. Factually, the vulnerable people (affected by monga, river erosion, flood, drought, etc.) of the west region has not enough opportunity other than adopting internal rural-urban migration for their livelihood. The findings clearly corroborate the findings of Hossain et al. [21] regarding the percentage of internal and international migrant-sending households according to the east-west divide. The estimated values of were found 0.2610 and 0.3470 for the west and the east regions, respectively.

Table 1: Observed and expected number of households according to the number of adult male migrants in Bangladesh

Number of migrants per household	Household Cohort			
	RUM-2012 (Origin)*		Findings of Hossain (2000) for Comilla Dataset	
	Observed	Expected	Observed	Expected
0	6782	6781.98	1941	1941.00
1	1042	1048.28	296	303.38
2	165	159.55	79	73.95
3	38	32.38	29	24.04
4	4	9.19	9	14.63
5	1		3	
Total	8032	8031.38	2357	2357.00
χ^2		3.73		2.02
d.f.		2		2
Parameter estimation				
α (risk of migration)		0.1556		0.1765
λ (shape parameter)		0.3044		0.4875
V(α)		1.64×10^{-5}		6.17×10^{-5}
V(λ)		2.65×10^{-4}		7.60×10^{-4}
COV(α, λ)		0.0000		0.0000

* RUM-2012 (Origin) indicates the data of the origin households covered by Rural-Urban Migration Survey 2012.

Table 2: Observed and expected number of households according to the number of adult male migrants for the East and the West region of Bangladesh

Number of migrants per household	Household Cohort of RUM-2012 (Origin)			
	West Region		East Region	
	Observed	Expected	Observed	Expected
0	2589	2588.76	4193	4193.00
1	557	561.98	485	487.71
2	80	73.34	85	84.62
3	13	15.78	25	19.58
4	1		3	6.51
5	0		1	
Total	3240	3239.86	4792	4791.42
χ^2	0.98		3.06	
d.f.	1		2	
Parameter estimation				
α	0.2010			0.1250
λ	0.2610			0.3470
V(α)	4.95×10^{-5}			2.28×10^{-5}
V(λ)	0.0005			0.0006
Covariance (α, λ)	0.0000		0.0000	

3. Model for the Total Number of Migrants

Among the proposed models to study the distribution of households according to the total number of migrants, Hossain [2] applied the probability model proposed by Yadava [9] in the context of Bangladesh by using the Comilla dataset. In addition, Hossain [2] developed the expression to estimate the variances and covariance of the parameters by employing maximum likelihood method to estimate the parameters. Needless to mention that Hossain [2] found better fitting of the model than that of by Yadava [9], including the estimate of variances and covariance of the parameters. This study attempts to re-apply this model to verify its suitability for describing the migration pattern using a nation-wide dataset of Bangladesh. It is to be noted that Hossain [2] had fitted the model with a micro-level rural-out migration (both internal and international) data. This study is confined to fit the model with a nationally representative dataset that solely deals with internal rural-urban migration.

Model

It is assumed that (i) β are the proportion of households with at least one migrant and ζ be the share of household with only one migrant from β portion; (ii) π be the share of the household from which only adult males migrates from the remaining (1-ζ) β amount of households, and therefore (1-π) be the share of households that resembles both type of migrants. Considering both the π and (1-π) proportion of households, the number of migrants from a household follows a combination of two displaced geometric distribution, where p1 and p2 be the probability of migration of a person from π and (1-π) proportion of households, respectively. Thus, the probability model for the total number of migrants, x, is expressed as:

$p(x=k) = 1-\beta, \quad$ for $k = 0$

$= \xi\beta, \;$ for $k=1$

$= (1-\xi)\beta \; \{\pi\, p_1\, q_1^{k-2} + (1-\pi)\, p_2 q_2^{k-2}\}$, for k=2, 3, … …(3)

If it is assumed that $p_1 = p_2 = p$ (probability of migration from both types of households are equal), then the probability model can be expressed as:

$p(x=k) = 1-\beta,$ for $k=0$

$= \zeta\beta, \quad$ for $k = 1$

$= (1-\zeta)\, \beta\, pq^{k-2}$, for k=2, 3, … ….... … ..... (4)

Estimation

To estimate the parameters ζ , β and p of the model (4), Hossain [2] expressed the likelihood function for a given sample $(x_1, x_2, \ldots, x_n)$ as

$$L = \prod_{k=0}^{m}[p(x=k)]^{n_k} = (1-\beta)^{n_0}(\xi\beta)^{n_1}\prod_{k=2}^{m}\left[(1-\xi)\beta p q^{k-2}\right]^{n_k}$$

$$= (1-\beta)^{n_0}\xi^{n_1}\beta^{n-n_0}(1-\xi)^{n-n_0-n_1}p^{n-n_0-n_1}q^{\sum_{k=3}^{m}(k-2)n_k} \quad ...(5)$$

where nk (k = 0, 1, 2, ..., m) be the number of observations corresponding to the value of k and $\sum_{k=0}^{m} n_k = n$ after solving the likelihood equations,

Hossain [2] obtained the estimators as:

$$\hat{\beta} = \frac{n-n_0}{n}, \quad \hat{\xi} = \frac{n_1}{n-n_0} \quad \text{and}$$

$$\hat{p} = \frac{n-n_0-n_1}{(n-n_0-n_1)+\sum_{k=3}^{m}(k-2)n_k}$$

Using the facts, $E(n_0) = n(1-\beta)$, $E(n_1) = n\,\xi\beta$,

$E(n_k) = n(1-\xi)\beta p q^{k-2}$ for k=2,3...,m. and

$E(n-n_0) = np$, $E(n-n_0-n_1) = n\,\beta(1-\xi)$

the corresponding variances of the estimators can be obtained as:

$$\left.\begin{aligned} V(\hat{\beta}) &= \frac{1}{\phi_{11}}, \quad V(\hat{\xi}) = \frac{1}{\phi_{22}}, \text{ and} \\ V(\hat{p}) &= \frac{1}{\phi_{33}(a)} \quad \text{when m is small} \\ &= \frac{1}{\phi_{33}(b)} \quad \text{when m is large.} \end{aligned}\right\} \quad \ldots\ldots (6)$$

Where,

$$\phi_{11} = -E\left(\frac{\delta^2 \log L}{\delta\beta^2}\right) = \frac{E(n_0)}{(1-\beta)^2} - \frac{E(n-n_0)}{\beta^2} = \frac{n}{\beta(1-\beta)}$$

$$\phi_{22} = -E\left(\frac{\delta^2 \log L}{\delta\xi^2}\right) = \frac{E(n_1)}{\xi^2} + \frac{E(n-n_0-n_1)}{(1-\xi)^2} = \frac{n\beta}{\xi(1-\xi)}$$

$$\phi_{33} = -E\left(\frac{\delta^2 \log L}{\delta p^2}\right) = \frac{E(n-n_0-n_1)}{p^2} + \frac{E[\sum_{k=3}^{m}(k-2)n_k]}{(1-p)^2}$$

$$= \frac{n\beta(1-\xi)q + n(1-\xi)\beta p[1-q^{m-2}-(m-2)pq^{m-2}]}{p^2 q} \text{ for small m}$$

and

$$\phi_{33} = -E\left(\frac{\delta^2 \log L}{\delta p^2}\right) = \frac{n\beta(1-\xi)}{p^2 q}, \text{ for large m}$$

Results:

The model (4) has been applied to the observed data (RUM-2012) collected from 60 rural clusters of Bangladesh. The estimated values of the parameters along with relevant results are presented in Table 3. The value of χ^2 indicates that the model (4) describes very appropriately the distribution of households according to the total number of migrants. The model has also applied to the observed data according to the east-west divide of Bangladesh. Table 4 presents the estimated values of the parameters, variances, covariance, observed and expected frequencies for both east and west region. The values of χ^2 were found insignificant for both the datasets, indicating the suitability of the model to describe the distribution of total number of migrants for both east and west region of Bangladesh.

Discussion:

From the probability distribution (4), the average number of migrants per households can be obtained as $\zeta \beta + (1-\zeta) \beta (1+1/p)$. The average number of internal rural-urban migrants per household is estimated at 0.2608 for Bangladesh. Based on the Comilla dataset, Hossain [2] found the average number of migrants as 0.3339, which is higher than that of present country-wide dataset, might be due to the inclusion of both internal and international migration in the Comilla dataset. The average number of migrants is found higher for the households located in the west region (0.3087) than that of the east region (0.2284) (Table 4).

Table 3: Observed and expected number of households according to the number of total migrants in Bangladesh

Number of migrants per household	Household Cohort			
	RUM-2012 (Origin)		Findings of Hossain (2000) for Comilla Dataset	
	Observed	Expected	Observed	Expected
0	6782	6782.00	1941	1941.00
1	1103	1103.00	292	292.00
2	256	252.43	67	56.17
3	86	95.48	37	33.95
4	47	36.12	17	20.52
5	10	13.66	6	12.40
6	3	8.14	7	7.50
7	1		3	11.46
8	1		5	
9	2		0	
Total	8291	8290.80	2357	2357.00
χ^2	5.58		7.35	
d.f.	3		5	
Parameter estimation				
β (proportion of households with at least one migrant)	0.1820		0.1829	
ξ (share of household with only one migrant from β portion)	0.7310		0.6728	
p (probability of migration of a person)	0.6217		0.3955	
V(**β**)	1.80×10^{-5}		6.29×10^{-5}	
V(ξ)	1.30×10^{-4}		5.07×10^{-4}	
V(p)	2.47×10^{-3}		7.12×10^{-4}	
Covariance	0.0000		0.0000	
Average number of migrants per household	0.2608		0.3339	

The estimated values of the parameters showed that the proportion of households having only one migrant (ζ) is 0.73095 for the surveyed households, which is greater than the proportion (0.67281) found by Hossain [2] for the Comilla district dataset. This implies that the proportion of single migrant households is increasing over time. The estimated value of the parameter ζ (proportion of households having only one migrant) was found higher for the households of the west region (0.7665) than those for the east region (0.6951), which indicates that households from the west region have a greater tendency of sending single internal rural-urban migrants.

The estimated value of the parameter β was found 0.1820, which is almost equal to the estimate (0.1829) found by Hossain [2] for the data of the Comilla district. However, the estimated value of the β parameter was found higher for the west region (0.2265) in comparison to the east region (0.1519), indicates that the west region has more migrant-sending households.

The estimated probability of migration of a person (p) was found 0.6217, which is significantly higher than that of found by Hossain in 2000 using the Comilla data (0.3955), indicating an increasing trend of likelihood of migration over time. The estimated value of p was found almost equal based on east-west divide. The overall findings depict that the internal rural-urban migration rate at the household level has shown an increasing trend in Bangladesh.

Table 4: Observed and expected number of households according to the total number of migrants for the East and the West region of Bangladesh

Number of migrants per household	Household Cohort of RUM-2012 (Origin)			
	West Region		East Region	
	Observed	Expected	Observed	Expected
0	2589	2589.00	4193	4193.00
1	581	581.00	522	522.00
2	114	113.93	142	138.71
3	39	40.60	47	54.68
4	19	14.47	28	21.56
5	3	7.97	7	13.90
6	0		3	
7	1		0	
8	0		1	
9	1		1	
Total	3347	3346.97	4944	4943.85
χ^2	2.62		3.49	
d.f.	2		2	
Parameter estimation				
$\boldsymbol{\beta}$	0.2265		0.1519	
ξ	0.7665		0.6951	
$\boldsymbol{\rho}$	0.6436		0.6058	
V($\boldsymbol{\beta}$)	5.20×10^{-5}		2.60×10^{-5}	
V(ξ)	2.36×10^{-4}		2.82×10^{-4}	
V($\boldsymbol{\rho}$)	5.66×10^{-3}		4.38×10^{-3}	
Covariance ($\boldsymbol{\beta}$ ξ)	0.000		0.000	
Average number of migrants per household	0.3087		0.2284	

4. Conclusion

The analysis revealed that the inflated logarithmic series distribution describe very reasonably the distribution of adult male migrants at household level in Bangladesh. In addition, the findings indicate that mixture of two displaced geometric distribution is suitable for the distribution of total number of migrants at household level in Bangladesh. The better fitting of the probability models for both datasets - Hossain's Comilla survey 2000 and nation-wide survey (RUM-2012) indicated the

time-invariant applicability of these models on both small regional sample to national sample of Bangladesh. The key findings from this analysis reveal that the incidence of single-migrant households is on the rise over time, and the rural-urban migration flow from the west tends to be higher than that from the east. The study may provide a good lesson for the researchers dealing with modelling the observed phenomenon to rethink regarding derivation of new models, improved estimation techniques, and applicability of the model over time.

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