Journal of Science and Technology 11(2013): 37-44

AN APPLICATION OF FACTOR ANALYSIS ON BANK WISE INTEREST RATE STRUCTURE IN BANGLADESH

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Received 05 September, revised 27 November 2012, accepted 25 February 2013

ABSTRACT

Banks are responsible for promoting economic growth and development of the country. The objective of this study was to find out the significant interest rate factors based on different interest rates of banks of Bangladesh in borrowing and lending to different sectors. In this regard, the interest rates determined by various banks for the period of January 2011 were used. Multivariate technique was employed to analyze data. KMO-Bartlett's test was performed to test whether the data were suitable for factor analysis. The principal component analysis was carried out and four underlying factors: (a) deposit factor - different types of deposit rates; (b) individual and business loan factor – agricultural loan, loans to large and medium scale industry; loans to small scale industry and consumer credit; (c) industry factor - loans to large and medium scale industry and (d) house loan factor - housing loan were identified. Finally, a comparison was made on the basis of factor scores, which exhibited the contribution of different banks to diverse economic sectors. The foreign banks were found to be dominant over the local banks (state owned, specialized and commercial banks) in terms of their investment pattern in different economic sectors of the country while, Mercantile bank and Bank Asia put major focus on deposit.

Key words: Factor analysis, factor loading, factor score, KMO-Bartlett's test

INTRODUCTION

A bank is an institution which draws surplus money from the people who are not using it at the time, and lend to those who are in a position to use it for productive purposes. It plays a vital role in maintaining confidence in the monetary system of the country. A new system of interest rate determination was developed with deposit & lending rates under the financial sector reform programs that better reflects market conditions. The new interest rate policy mainly aims at introducing flexibility into the deposit rates permitting individual banks to establish their own rates fixed by themselves. Flexibility in the interest rate policy was introduced on July 12, 1999 permitting banks to set different interest rates to individual borrowers except for lending to exporters only and for other sectors; lending rates would be decided by the banks themselves (Monthly Economic Trends, 2011).

It is very important to know which of the banks are emphasizing on which sectors and how much they contribute to the development of the country's economy. The aim of this paper is to identify some meaningful factors that can better explain the variability in interest rates for deposits and investment in different sectors.

MATERIALS AND METHODS

Data and variables: Fourteen sectors were considered in this study on which interest rate structure was developed. These are:

1. saving deposit
2. fixed deposit for 3 months and above but less than six months
3. fixed deposit for 6 months and above but less than one year
4. fixed deposit for 1 year and above but less than two years
5. fixed deposit for 2 years and above but less than 3 years
6. fixed deposit for 3 years and above
7. Agricultural loan
8. Loans to large and medium scale industry
9. Loans to small scale industry
10. Loans to working capital
11. Loans to trade financing
12. Housing loan
13. Consumer credit
14. Others

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Every sector was considered as a variable in this study and we tried to reduce 14 variables to few underlying factors that might explain the variation in different types of interest rates effectively. This was done by performing factor analysis. It was assumed that many of these sectors would be related to each other and hence, the variables could be grouped by their correlations with each other. Within a particular group, variables might be highly correlated among themselves but might have relatively small correlations with variables in a different group. It was comprehensible that each group of variables represents a single underlying factor, which was responsible for the observed correlations among the variables of that group.

Data source: The data were collected from the "Monthly Economic Trends, January 2011, Volume XXXVI No.1 which is published by Statistics department of Bangladesh Bank. Data on interest rate in percent per annum by type of deposit and loan product provided by all the state owned commercial banks, specialized banks, private banks and foreign banks were given in details over there. These data were collected under the supervision of Banking Regulation and Policy Department of Bangladesh Bank. In this study, 38 banks (Appendix I) were considered.

Test of Adequacy of Sample for Factor Analysis

KMO and Bartlett's test of sphericity were employed to check the adequacy of the sample for factor analysis.

Kmo measure of sampling adequacy: The Kaiser-Meyer-Olkin (KMO) statistic is a measure of sampling adequacy, both overall and for each variable (Kaiser, 1970; Cerny and Kaiser, 1977; Dzuiban and Shirkey, 1974). It is an index used to examine the appropriateness of a sample for performing factor analysis (Malhotra, 2009). The KMO statistic varies between 0 and 1. A value close to 1 indicates that patterns of correlations are relatively compact and factor analysis should yield distinct and reliable factors (Field, 2005). Kaiser (1974) recommends that a sample with a KMO value greater than 0.5 is acceptable for performing factor analysis.

Bartlett's Test of Sphericity: Bartlett's test of Sphericity is a test statistic used to examine the hypothesis that the variables are uncorrelated in the population (Malhotra, 2009). It tests the null hypothesis that the original correlation matrix is an identity matrix; each variable correlates perfectly with itself (r = 1) but has no correlation with the other variables (r = 0). For a sample to be adequate for factor analysis, Bartlett's test of Sphericity should be significant.

The Orthogonal Factor Model: Let the observable random vector $\mathbf{X}$, with p components, has mean μ and covariance matrix $\sum$. The factor model postulates that $\mathbf{X}$ is linearly dependent upon a few unobservable random variables $F_1, F_2, \cdots\cdots, F_m$, called *common factors*, and p additional sources of variation $\varepsilon_1, \varepsilon_2, \cdots\cdots, \varepsilon_p$, called *error* or, sometimes, *specific factors*. Then the factor analysis model is,

$$X_1 - \mu_1 = l_{11}F_1 + l_{12}F_2 + \cdots\cdots + l_{1m}F_m + \varepsilon_1$$
$$X_2 - \mu_2 = l_{21}F_1 + l_{22}F_2 + \cdots\cdots + l_{2m}F_m + \varepsilon_2$$
$$\vdots$$
$$X_p - \mu_p = l_{p1}F_1 + l_{p2}F_2 + \cdots\cdots + l_{pm}F_m + \varepsilon_p$$

In matrix notation,

$$\underset{(p\times 1)}{\mathbf{X} - \boldsymbol{\mu}} = \underset{(\mathrm{p}\times\mathrm{m})}{\mathbf{L}}\ \underset{(\mathrm{m}\times 1)}{\mathbf{F}} + \underset{(\mathrm{p}\times 1)}{\boldsymbol{\varepsilon}} \tag{1}$$

Here, μ_i is the *mean* of i^{th} variable, F_j is the j^{th} *common factor*, $L = l_{ij}$, $i = 1,2,..,p,\ j = 1,2,..,m,$ is the matrix of factor loadings where l_{ij} is the loading of i^{th} variable on j^{th} common factor and ε_i is the i^{th} *specific factor.*

The unobservable random factors **F** and ε satisfy the following assumptions:

$$E(\mathrm{F}) = \underset{(m\times 1)}{0},$$
$$Cov(\mathrm{F}) = \underset{(m\times m)}{\mathrm{I}},\ E(\boldsymbol{\varepsilon}) = \underset{(p\times 1)}{\mathbf{0}}\ Cov(\varepsilon) = \underset{(p\times p)}{\psi},$$

Where $\boldsymbol{\psi}$ is a diagonal matrix. The covariance matrix of $\mathbf{X}$ can be easily obtained as

$$\begin{aligned}\Sigma &= Cov(\mathrm{X}) = E(\mathrm{X} - \mu)(\mathrm{X} - \mu)' \\ &= \mathrm{LL}' + \psi\end{aligned}$$

Where, $Cov(\mathrm{X}, \mathrm{F}) = \mathrm{L}$. Therefore,

$$\begin{aligned}Var(X_i) &= l_{i1}^2 + l_{i2}^2 + \cdots + l_{im}^2 + \psi_i \\ \mathrm{Cov}(X_i, X_k) &= l_{i1}l_{k1} + \cdots + l_{im}l_{km}\end{aligned} \tag{2}$$

$$\mathrm{Cov}(X_i, F_j) = l_{ij}$$

The model is used for quantifying the communality. Communalities measure how strongly the variables are explained by the factors. A factor analysis model contains both common factors and specific factors. Therefore, the variability in the observation is also split up by common factors and specific factors. The proportion of variability of the i^{th} variable $\left(V\left(X_i\right)=\sigma_{ii}\right)$ contributed by the common factors is called the i^{th} communality. The proportion of variance due to the specific factors is often called the uniqueness or specific variance. Let us denote the i^{th} communality by h_i^2.

Then from the covariance structure in (2), we can write

$$\underbrace{\sigma_{ii}}_{Var(X_i)} = \underbrace{l_{i1}^2 + l_{i2}^2 + \cdots + l_{im}^2}_{communality} + \underbrace{\psi_i}_{specific\ variance} = h_i^2 + \psi_i$$

Where, $h_i^2 = l_{i1}^2 + l_{i2}^2 + \cdots + l_{im}^2,\ i = 1,2,...,p$, the i^{th} communality which is the sum of squares of loadings of the i^{th} variable on m common factors (Johnson and Wichern, 1982).

Estimation of parameter: In factor analysis, we try to describe the covariance relationships among many variables in terms of a few underlying common factors. Due to the sample covariance matrix S is an unbiased estimator of the unknown population covariance matrix Σ (Johnson and Wichern, 1982), we usually perform factor analysis on the sample covariance matrix S or the sample correlation matrix R. For a factor analysis to be meaningful, the variables have to be highly correlated. That means, the off-diagonal elements of the covariance matrix (or equivalently of the correlation matrix) have to be very different from zero. Thus, if Σ is significantly different from a diagonal matrix, factor analysis model is then entertained and the initial problem is to estimate the factor loadings l_{ij} and the specific variances ψ_i.

The most popular methods of estimation of parameters of factor analysis are the principal component method and the maximum likelihood method. The principal component analysis transforms the correlation matrix into new, smaller sets of linear combinations of independent (i.e., uncorrelated) principal components (Zillmer and Vuz, 1995). Principal component analysis is a separate technique from the ML method because it partitions the variance of the correlation matrix into new principal components (Zillmer and Vuz, 1995). In this study, principal component method was applied.

Method of principal component: The principal component factor analysis of the sample covariance matrix **S** is specified in terms of its Eigen value-Eigen vector pairs $\left(\hat{\lambda}_1, \hat{e}_1\right), \left(\hat{\lambda}_2, \hat{e}_2\right), ..., \left(\hat{\lambda}_p, \hat{e}_p\right)$ where $\hat{\lambda}_1 \ge \hat{\lambda}_2 \ge \cdots \ge \hat{\lambda}_p \ge 0$. Let m < p be the number of common factors.

The matrix of estimated loading $\{\tilde{l}_{ij}\}$ is given by

$$\tilde{\mathbf{L}} = \left[\sqrt{\hat{\lambda}_1}\,\hat{\mathbf{e}}_1 \quad \sqrt{\hat{\lambda}_2}\,\hat{\mathbf{e}}_2 \quad \cdots \quad \sqrt{\hat{\lambda}_m}\,\hat{\mathbf{e}}_m\right] \quad (3)$$

The estimated specific variances $\tilde{\psi}_i$ are provided by the diagonal elements of the matrix $\mathbf{S} - \tilde{\mathbf{L}}\tilde{\mathbf{L}}'$, so

$$\tilde{\psi} = \begin{bmatrix} \hat{\psi}_1 & 0 & \cdots & 0 \\ 0 & \hat{\psi}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{\psi}_p \end{bmatrix} \text{ with}$$

$$\tilde{\psi}_i = s_{ii} - \sum_{j=1}^{m} \tilde{l}_{ij}^2 \quad (4)$$

Communalities are estimated as

$$\tilde{h}_i^2 = \tilde{l}_{i1}^2 + \tilde{l}_{i2}^2 + \cdots + \tilde{l}_{im}^2 \quad (5)$$

The principal components are computed from **R** (sample correlation matrix) in place of **S** (sample covariance matrix) which is an estimate of the true correlation matrix (Sneyers *et al.*, 1989).

The proportion of total sample variance due to the j^{th} factor is

$$\begin{pmatrix} \text{Proportion of total} \\ \text{sample variance due} \\ \text{to j th factor} \end{pmatrix} = \begin{cases} \dfrac{\hat{\lambda}_j}{s_{11} + s_{22} + \cdots + s_{pp}} & \text{for factor analysis of S} \\ \dfrac{\hat{\lambda}_j}{p} & \text{for factor analysis of R} \end{cases} \quad (6)$$

RESULTS AND DISCUSSION

A principle component analysis was carried out on bank wise interest rate structure in Bangladesh except Islamic banks. In this study, 38 banks were considered. Here factor analysis was applied to a matrix of correlation coefficients. From the correlation matrix (Appendix II), it was found that there was a good pair wise linear relationship among most of the pairs.

Table 1. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0 .639
Bartlett's Test of Sphericity	Approx. Chi-Square	19.92
	Df	41
	Sig.	.000

Table 1 represents that the value of KMO is 0.639 and Bartlett's test of Sphericity is highly significant (P<0.001), which indicated that the patterns of linear relationships were strong and consistent and the sample was adequate enough to perform factor analysis.

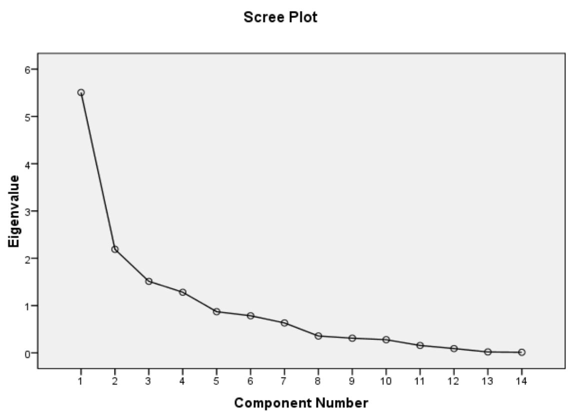

Figure 1. Screen plot of Eigen values against component number

The results displaying in Table 2 showed that the first four components yielded Eigen values 5.507, 2.190, 1.512 and 1.282 respectively, which were greater than unity and together they explained almost 75% of total variance. Thus, the first four components represented the major components in explaining variation of interests in different sectors for lending and borrowing.

Table 2. Initial eigenvalues and total variance explained by the components

Component	Eigen value	% of variance	Cumulative %
1	5.507	39.335	39.335
2	2.19	15.64	54.975
3	1.512	10.798	65.774
4	1.282	9.156	74.929
5	0.87	6.217	81.146
6	0.784	5.602	86.748
7	0.633	4.52	91.269
8	0.356	2.546	93.815
9	0.31	2.212	96.027
10	0.278	1.988	98.015
11	0.157	1.118	99.132
12	0.091	0.648	99.78
13	0.019	0.138	99.918
14	0.012	0.082	100

The Scree plot shows the magnitude of an Eigen value against its component number. Figure 1 indicated that the first four Eigen values loaded highly on the observed variables. Therefore, a factor model with 4 common factors was conceivable. The resulting estimated factor loadings and communalities are presented in the Table 3.

1. The first six variables with different types of deposit rates showed large positive loadings on the first factor. This factor might be labeled as deposit factor.
2. Agriculture, loans to large and medium scale industry, loans to small scale industry and consumer credit- these four variables have large loadings on the second factor and this factor might be labeled as individual and business loan factor.
3. Loans to large and medium scale industry loaded moderately high on the third factor. This factor could be renamed as industry factor
4. Housing loan loaded highly on the fourth factor. This factor could be labeled as house loan factor.

SORTED FACTOR SCORES

The estimated values of the common factors are called factor scores which are used for diagnostic purposes as well as inputs to a subsequent analysis. Factor scores explain what the factors mean with such scores. In this study the four factors were defined in the following manner:

Factor 1: Deposit factor
Factor 2: Individual and business loan factor
Factor 3: Industry factor
Factor 4: House loan factor

The factor scores sorted in descending order by banks for the principal component approach were obtained using regression method.

State owned commercial banks: Among the state owned commercial banks, Agrani Bank emphasized on deposit and industry sector. Similarly Sonali and Rupali bank focused on the loan to individual and business purpose and housing sector, respectively.

Foreign commercial banks: Among the foreign commercial banks, NBP, SBI and HBL bank focused on Factor 1 whereas HSBC, SBI, NBP concentrated on Factor 2. Woori bank which became the lowest in Factor 2 became first in Factor 3, i.e., focused on medium and large scale industry. Standard Chartered, City NA, Woori bank concentrated their investment on housing sector.

Specialized banks: Among specialized banks, RAKUB focused on different types of deposits whereas BKB focused on agricultural, small, medium and large industry. BASIC bank emphasized their investment on housing sect

Table 3. Estimated factor loadings using Principal Component Method

Variables	Four factors solution Estimated factor loadings				Communalities
	F_1	F_2	F_3	F_4	h_1^2
Saving deposit	0.465	0.208	-0.776	0.046	0.864
3 months & above but less than 6 months	0.944	0.086	-0.124	-0.103	0.924
6 months & above but less than 1 year	0.957	0.1	-0.172	-0.081	0.962
1 year & above but less than 2 years	0.96	0.1	-0.065	-0.064	0.94
2 years & above but less than 3 years	0.902	-0.216	0.064	-0.161	0.89
3 years & above	0.681	-0.16	0.374	0.141	0.648
Agriculture	-0.165	0.623	-0.064	0.22	0.467
Loans to large & medium industry	0.042	0.631	0.503	-0.176	0.683
Loans to small industry	0.027	0.638	0.446	0.242	0.665
Working Capital	0.473	-0.286	0.215	0.434	0.54
Trade financing	0.724	-0.127	-0.064	0.439	0.737
Housing loan	0.261	0.253	-0.052	0.791	0.761
Consumer credit	-0.076	0.766	0.148	0.26	0.682
Others	0.658	0.323	0.415	0.008	0.803

Table 4. Position of state owned commercial banks by factor scores

Position	Factor 1		Factor 2		Factor 3		Factor 4	
	Bank	Factor score	Bank	Factor score	Bank	Factor score	Bank	Factor score
1	Agrani	0.092	Sonali	0.818	Agrani	0.74	Rupali	0.335
2	Rupali	-0.006	Agrani	0.925	Rupali	0.103	Sonali	-0.209
3	Sonali	-0.018	Rupali	-1.254	Sonali	-0.564	Agrani	-0.266
4	Janata	-0.362	Janata	-1.803	Janata	-1.864	Janata	-0.885

Table 5. Position of specialized banks by factor scores

Position	Factor 1		Factor 2		Factor 3		Factor 4	
	Bank	Factor score	Bank	Factor score	Bank	Factor score	Bank	Factor score
1	RAKUB	-0.179	BKB	-0.7	BKB	-0.996	BASIC	-0.41
2	BKB	-0.205	BASIC	-1.218	RAKUB	-1.848	RAKUB	-1.302
3	BASIC	-0.353	RAKUB	-1.514	BASIC	-1.901	BKB	-1.845

Table 6. Position of foreign commercial banks by factor scores

Position	Factor 1		Factor 2		Factor 3		Factor 4	
	Bank	Factor score	Bank	Factor score	Bank	Factor score	Bank	Factor score
1	NBP	0.809	HSBC	1.55	Woori	2.115	SCB	2.489
2	SBI	0.692	SBI	0.925	HSBC	1.498	Citi NA	0.856
3	HBL	0.3	NBP	0.306	SBI	0.861	Woori	0.261
4	Woori	-0.756	SCB	0.265	SCB	0.422	HBL	0.03
5	CBC	-1.357	CBC	0.229	Citi NA	0.319	CBC	-0.047
6	Citi NA	-1.751	Citi NA	-0.235	HBL	0.315	NBP	-0.056
7	HSBC	-2.41	HBL	-0.675	CBC	-0.292	SBI	-0.178
8	SCB	-3.883	Woori	-0.897	NBP	-0.293	HSBC	-3.657

Private commercial banks: Among the private commercial banks, the Mercantile, Banks Asia, Standard, NBL etc. had more concentration on different deposits policy like 6 months, 1 year, 2 year and 3 year; where as EBL, ABBL, BRAC were not focusing on this factor. Individual and business loan sector were being highly focused by OBL, BCBL, BRAC, ABBL and Southeast bank. Loans to Small, Medium and Large scale industry were being focused by City, DBL, Mercantile, Bank Asia and Prime Bank. They have many SME center over the country which help invest in different industries whereas ABBL, Standard, UCBL, BRAC etc. banks paid heed to the housing sector.

Table 7. Position of Private Commercial Banks by factor scores

Position	Factor 1		Factor 2		Factor 3		Factor 4	
	Bank	Factor score	Bank	Factor score	Bank	Factor score	Bank	Factor score
1	Mercantile	1.307	OBL	1.409	City	1.832	ABBL	1.968
2	Bank Asia	1.01	BCBL	1.294	DBL	0.991	Standard	0.681
3	Standard	0.954	Brac	1.241	Mercantile	0.936	UCBL	0.478
4	NBL	0.82	ABBL	1.201	NBL	0.927	Brac	0.43
5	OBL	0.818	Southeast	1.176	Bank Asia	0.523	Pubali	0.406
6	DBL	0.809	EBL	1.129	Prime	0.498	Uttara	0.348
7	BCBL	0.657	Jamuna	1.072	DBBL	0.427	MTBL	0.335
8	Premier	0.652	IFIC	0.866	Pubali	0.295	DBL	0.334
9	Southeast	0.613	Bank Asia	0.684	Premier	0.279	OBL	0.265
10	Jamuna	0.604	DBBL	0.637	Jamuna	0.197	Premier	0.259
11	Trust	0.579	NCCBL	0.588	UCBL	0.176	Bank Asia	0.252
12	MTBL	0.512	Premier	0.586	Uttara	0.114	City	0.239
13	Prime	0.414	Prime	0.502	IFIC	0.039	Mercantile	0.204
14	NCC	0.393	Trust	0.481	NCC	0.023	Southeast	0.193
15	UCBL	0.322	MTBL	0.38	EBL	-0.046	BCBL	0.187
16	IFIC	0.269	NBL	0.201	Trust	-0.071	NCC	0.154
17	Uttara	0.042	UCBL	-0.11	Southeast	-0.19	Jamuna	0.152
18	DBBL	0.041	Standard	-0.561	BCBL	-0.294	Prime	0.1
19	Pubali	0.022	DBL	-0.792	OBL	-0.403	Trust	0.079
20	City	-0.066	Mercantile	-0.891	Standard	-0.421	NBL	0.044
21	ABBL	-0.097	Uttara	-1.115	MTBL	-0.46	DBBL	-0.038
22	EBL	-0.492	City	-1.56	ABBL	-1.296	EBL	-0.042
23	Brac	-0.746	Pubali	-1.654	Brac	-2.689	IFIC	-2.147

CONCLUSION

Following conclusions follow from the results of this study:

- Fourteen variables (deposits and loans) have been reduced to four meaningful factors namely,
    1. deposit factor - different types of deposit rates
    2. individual and business loan factor – agricultural loan, loans to large and medium scale industry, loans to small scale industry and consumer credit
    3. industry factor - loans to large and medium scale industry
    4. house loan factor - housing loan
- Among 38 banks, SCB, Woori and HSBC scored highest on housing, industry, and individual and business loans, respectively. While, Mercantile bank scored highest on different types of deposits.
- The foreign banks are dominant over the local banks (state owned, specialized and commercial banks) in terms of their investment in different sectors of the economy, while, Mercantile bank and Bank Asia put major focus on deposit.

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