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ON FORECASTING DENOMINATIONAL REQUIREMENTS OF CURRENCY IN INDIA

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In this paper we have attempted at providing forecasts for the requirements of currency of various denominations in India for the years 1992-93 through 1994-95. Towards this end we have proposed a regression model to forecast the total value of currency of all denominations taken together, and then used the model suggested by Ghosh *et al.* (1991) to predict the required currency composition for the forecast periods. In this study while published data were used for estimating the regression model, transaction data generated through simulation were used for estimating the required currency composition since data on transactions from consideration of requirements of currency of various denominations are not available. (JEL E59)

1. INTRODUCTION

In a developing country like India, a large part of economic transactions are performed in cash. This is reflected by the fact that in India (as also in other developing countries) a huge volume of currency exists with the public at any point of time.[1] Naturally, such transactions are facilitated if currency of different denominations are available in required amounts. In fact, a major task of the Reserve Bank of India (RBI) in this regard is to

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1. For instance, such volume which was Rs. 3764 crore at the end of 1969 in India increased to Rs. 43534 crore at the end of 1989, thus registering more than tenfold increase over a span of twenty years.

ensure that the supply of currency of different denominations more or less match the corresponding demands at any point of time. And this can best be ensured if the future requirements of currency of various denominations are properly predicted so that the requisite amounts of currency of various denominations may be put into curculation by the RBI in appropriate times. The problem, however, is not at all simple mainly because the denominationwise actual demands for currency by the public are unknown. Also, on standard method for estimating such demands is available in the literature.

The problem of forecasting denominationwise requirements of currency in a country like India can really be viewed as two separate exercises. The first exercise relates to predicting the requirement of the *total* value of currency i.e., value of currency of all denominations taken together for a future period, and the second to estimating the shares of required quantities of currency of individual denominations in this total i.e., denominationwise currency composition for this period. The first exercise is somewhat easy and simple, because how much total value of currency will exist with the public at any point of time is determined mainly by the behaviour of the public,[2] and hence figures on currency with the public which are published regularly by the RBI are likely to give their total demand for currency.[3] In addition, there are well-developed theories of demand for currency or its broader aggregates i.e., money (see, for example, Bain (1970), Friedman (1970) and Newlyn (1971) for a discussion of these theories), and one can very well use these theories to set up behavioural relations explaining the total demand for currency in terms of appropriate variables. Regression technique can then be applied to identify the significant explanatory variables. The estimated relation thus obtained can be used to predict the requirement of total value of currency for any future period.

The second exercise *viz.*, that of estimating the required denominationwise currency composition is, however, a difficult one since it is not known whether the existing volume of currency of a given denomination at a time matches or differs substantially from the amount required by the public at that time. Hence one rarely finds any time series data on the quantity of a given denomination of currency demanded by the public. Further, there is no conceived theory in the literature which helps one to identify the determinants of such demands. As a solution to this problem, Ghosh *et al.* (1991) proposed a stochastic model based on the notion of currency demand originating in individual transactions involving payments in cash. The model entails specific rules for determining the denominationwise requirements of currency for a given transaction. Then they suggested a method for estimating the model in situations where actual data on transactions were not available. The purpose of this paper is to carry out the above-mentioned two exercises for the Indian economy based on the model of Ghosh *et al.* (1991) so as to obtain short-term forecasts of the requirement of currency of different denominations in India from 1992-93 till 1994-95. The format of the paper is as follows. Section 2 summarizes the model for estimating

2. As Rakshit (1988 p. 25) has rightly observed, "Under the monetary system currently prevailing in India there is no simple mechanism by which the supply of only M_1 can be affected by the Bank. In fact, the amount of M_1 can be taken to be determined basically by the preference of the public in respect of cash, demand deposits and time deposits".

3. It may also be added than given the way currency gets issued and circulated in our economy, the total value of currency in circulation does not seem to have ever fallen short of the same required by the public and the banks. For a description of the mechanism through which currency in the country gests cirulated, see Reserve Bank of India (1983, ch. 2).

required currency composition. The regression model for estimating the total value of currency in India is discussed in Section 3. While the actual estimation of the required currency composition in the base year is described in Section 4, the forecasts of currency requirements by denomination from 1992-93 till 1994-95 are given in Section 5. The paper ends with some concluding remarks in Section 6.

2. THE MODEL FOR ESTIMATING REQUIRED CURRENCY COMPOSITION

In this section we briefly describe the stochastic model of Ghosh *et al.* (1991) for estimating the required share of each denomination of currency in the total value of currency.

2.1 *The Model*

We begin with the basic premise that during a given period transactions involving cash payments take place randomly—each sample transaction being a random drawing from a size distribution of transactions of a given type. We then draw repeated samples of transactions of a fixed size. The denominationwise currency need of each sample transaction is then found by using one or the other of the two alternative procedures described below.

The first procedure considered for this purpose is designated as the Deterministic Procedure (D.P.). This procedure presumes that (*i*) a transaction is carried out using minimum number of pieces of currency, and (*ii*) there is only one-way cash flow from the cash-payer to the cash-receiver. Although the D.P. helps to determine the demand for individual denominations of currency *uniquely*, the procedure is somewhat restrictive since the pieces of currency actually used in a transaction may differ from those implied by the D.P. if the transactor does not possess enough number of pieces of the required denominations. In the latter case the transactor's use of currency may be restricted to the pieces of different denominations available to him. Thus, for instance, if the D.P. calls for the use of a note of Rs. 100 in a transaction and if the transactor does not possess such a a note, he is likely to substitute this with an appropriate number of notes of lower denominations. These probabilities of substitution of currency of higher denominations by those of lower denominations are often obtained as the observed shares of different denominations of currency in the total value of currency in circulation during a given period (see, for details, Ghosh *et al.* (1991). This, in fact, is the essence of the second procedure which is being termed as the Probabilistic Procedure (P.P.). Obviously, the P.P. is more general (as D.P. itself can be thought of as a special case of P.P.); it also seems to be closer to reality.

The prediction of required currency composition for a future time period is, however, a two-step procedure in the proposed model. The first-step consists of identifying the size distribution of transactions for a base period. A base period for our purpose is defined to be a time period in the recent past during which the existing denominational composition of currency, as supplied by the currency authorities, could be taken to broadly *match* the composition required to make various transactions during that period. In order to obtain the transaction distribution for the forecast period, we note that this distribution relates to the nominal rather than the real values of the transactions, and hence the change in the transaction distribution between the base and the forecast periods, particularly in case of long-term forecasting, is likely to be mostly due to inflation. We take this into account in a simplistic way by assuming that the transaction distribution shifts over time in a particular way, *viz.*, $x_f = c_f x_o$, $c_f > 0$, where xo and x_f denote the values of a random transaction in the base and the forecast periods respectively, and c_f is the proportion by which the value of a transaction changes between these two periods. The simplest choice of c_f is the proportion by which the price level changes between the two periods.

2.2 *Estimation of the Model*

The primary difficulty for estimating the model both for the base as well as the forecast periods is the non-availability of any direct transaction data which truly reflect the requirements of currency of various denomination by the public. Ghosh *et al.* (1991) have therefore suggested estimation of the model based on transaction data generated artificially i.e., by simulation. This is described below.

Suppose there are K denominations in the descending order of their nominal values with π_i ($> \pi_{i+1}$) being the nominal value (in Rs.) of piece of currency of the i-th denomination. Suppose further that from an assumed *transaction distribution* a large number of independent samples, each of size m, are randomly drawn. Following either D.P. or P.P. we can find the requirements of currency of different denominations for each of these transactions. At this stage we need to introduce the notion of transaction velocity since during a given time interval a piece of currency is likely to be used a number of times. Lt Vi be the average number of times a piece of currency of the *i-th* denomination is used in transactions (i.e., it change hands) during the given time interval. V_i may be called the average transaction velocity of the i-th denomination and V_i ($= V_i/V_1$) its relative transaction velocity, where Vi is the average transaction velocity of notes of denomination Rs. 100. The required share of currency of the i-th denomination in the total value of currency can therefore be estimated as

$$\hat{w}_i = \frac{\pi_i \bar{n}_{i\cdot}/v_i}{\sum_{j=1}^{k} \pi_j \bar{n}_{j\cdot}/v_j}, \quad i = 1, 2, \ldots, k \tag{2.1}$$

where $\bar{n}_{i\cdot}$ is the average of $n_{i\cdot}$'s over all independent samples and n_i is the total number of pieces of currency of the i-th denomination required in any independent sample of size m.

Since $\hat{w}_i$ depends on v_i's, it is imperative that we know the values of v_i's. It is to be noted, however, that v_i's (or, for that matter V_i's) are not known *a priori*.

Now, the observed share of currency of the i-th denomination, denoted by $\tilde{w}_i$, is obtained as

$$\tilde{w}_i = \pi_i N_i / \left(\sum_{j=1}^{k} \pi_j N_j\right), \quad i = 1, 2, \ldots, k \tag{2.2}$$

where N_i is the average number of pieces of currency of the i-th denomination which were in circulation during the reference period. Obviously, data on N_i's are available in the RBI publications. We now use a grid search method in order to estimate the parameters of the assumed transaction distribution for the base period. For each set of plausible values of the parameters of the transaction distribution, $\hat{w}_i$'s are calculated and then compared with $\tilde{w}_i$'s by a distant measure D defined as $D = \sum_{i=1}^{k} |\hat{w} - \tilde{w}_i|$.[4] The base period transaction distribution of the assumed type is identified to be that set of values of parameters for which D is minimum.[5] In principle, this search procedure should be carried out for plausible alternative transaction distributions as well. It may also be noted that the identification of the base period transaction distribution by the above criterion is justified on the ground of our definition of the base period *viz.*, a period in the past when the requirement and the supply of currency broadly matched for every denomination. After the transaction distribution for the base period has been estimated, we obtain the estimates of the parameters of the transaction distribution for the forecast period from consideration of the shift in the base period distribution, and then estimate the shares of different denominations (*vide* equation (2.1)) using simulated data on transaction from the forecast period distribution. Obviously, alternative forecasts can be obtained depending on whether the D.P. or the P.P. has been used. Since we shall be using both these procedures, the stochastic model based on D.P. for finding the denominationwise currency need of each sample transaction would henceforth be called the Deterministic Model (D.M.). Likewise we shall have Probabilistic Model (P.M.) based on P.P.

3. ESTIMATION OF THE TOTAL VALUE OF CURRENCY

We have already stated that in order to predict the requirements of currency[6] of various denominations in an economy during a given period, we need, apart from the composition of currency requirements, an estimate of the total value of currency for the economy during that period. We now describe the procedure for estimating this total for India in a given year.

How much of total currency would be held by the public at a time is something which is not controlled by either the government or the banking authority, but is dependent on the behaviour of the public. Since currency is a stock variable, we look for the determinants of the average holding of currency by the public during a year, to be denoted by

4. It may be noted that D depends on the choice of values for v_i's. As already stated, v_i's are unknown *a priori*. Further, at any time these values may be affected by the supply of currency of different denominations relative to their demands. Since v_i's are exogenous insofar as the transaction distribution is concerned, the best that could be done in a situation like this is to fix plausible values for the v_i's, based on the knowledge and experiences of the authorities (on currency management) on the frequency of use of a piece of currency of any given denomination.

5. Here in defining D we have preferred the absolute value criterion to the usual quadratic criterion for the following reason. From the supply data on currency we observe that the share of lower denominations in the total value of currency supply is much smaller compared to those for higher denominations. In such a case, use of the quadratic criterion is likely to yield an estimated transaction distribution for which $\hat{w}_i$'s for higher denominations are closer to the corresponding $\tilde{w}_i$'s. In other words, rather than giving more or less equal importance to the differences $(\hat{w}_i - \tilde{w}_i)$ for all the denominations, the quadratic criterion would attach more importance to the difference for the few higher denominations only.

6. In the empirical exercise that follows, we have considered currency notes only, coins have been excluded since they constitute an insignficant proportion in the total value of currency.

CP. There are some empirical studies which try to identify the possible determinants of the stock of currency held by the public in the Indian economy (see, for detailed references, Coondoo *et al.* (1990) and Lahiri *et al.* (1984)). These studies consider such explanatory variables as nominal national income or its sectoral aggregates, some shrot-term rate of interest reflecting the opportunity cost of holding currency *vis-a-vis* other short-term assets etc. We now describe the results of our own empirical exercise.

We first tried a linear regression equation for CP with income, a short-term rate of interest (r) and time as three explanatory variables. We considered twenty one annual observations[7] on these variables from 1970-71 to 1990-91. The estimated equation was found to be very good in terms of values of $\bar{R}^2$ and the Durbin-Watson (DW) Statistic. However, coefficients of only income and time turned out to be significant.[8] We, therefore, re-estimated this equation after dropping r, and the re-estimated equation was satisfactory in all respects. However, the equation did not turn out to be stable as exercises like fitting the same equation by omitting the last few observations or dividing the entire time period into two sub-periods and then fitting the equation separately to each sub-period did not yield good results.[9] In these exercises the coefficient of time turned out to be insignificant and the values of DW statistic were not always satisfactory. It seemed that over this long period covering about two decades time certainly had some influence on currency demand, and that the best possible way to capture its effect was to divide the entire period into two or more subperiods and then to examine whether, and to what extent, the relation between CP and income had shifted over these subperiods.

On an examination of the scatter diagram of CP and income, the following two subperiods appeared to be structurally different, viz., period I consisting of the first eight years from 1970-71 to 1977-78 and period II having the remaining thirteen years from 1978-79 to 1990-91. Accordingly, we introduced two dummy variables—one for the intercept and the other for the slope—and obtained the following regression equation.

$$CP = \underset{(1.2625)}{1064.7235} + \underset{(6.0157)}{0.0881\,Y} - \underset{(-2.8644)}{2664.9013\,D} + \underset{(2.4013)}{0.0354\,D.Y} \qquad (3.1)$$

$$\bar{R}^2 = 0.998, \qquad DW = 1.972$$

where Y is national income (i.e., net national product at factor cost) at current prices,

7. As regards the data, we considered figures of currency with the public as at the end of different months. Monthly average stocks of currency holdings were obtained by taking averages of pairs of consecutive monthly values. The average value of currency with the public in a year (CP) was then obtained by taking a further average of these monthly averages corresponding to the year in question. The rate of interest tried was the yearly average call money rate. Data on these two variables were collected from various issues of the Reports on Currency and Finances published by the RBI. Data on income were taken from the Economic Survey for 1991-92 published by the Government of India. The regression equations reported here were all estimated by the method of ordinary least squares (OLS).

8. Presumably, variations in over this period were too small to have exercised any significant impact on CP.

9. We are indebted to an anonymous referee whose comments prompted us to examine the stability of the estimated relation over time.

D is a dummy variable assuming the value 0 for each year from 1970-71 to 1977-78 and the value 1 for each of the remaining years from 1978-79 to 1990-91, and the figures within parentheses below the estimated coefficients are their t-ratio values. We observe from this estimated equation that all the coefficients are statistically significant and the values of $\bar{R}^2$ and DW statistic are very satisfactory from the point of view of model selection.[10] We have, therefore, chosen the relation in (3.1) as the equation to be used for forecasting CP for different years in the future.[11]

However, the total that we needed for the purpose of prediction of required quantities of different denominations of currency is the average stock of total value of *all notes in circulation* in a year (to be denoted by NC). Hence a relation between CP and NC was needed to be found out. We observed from the past data on these variables published by the RBI that NC and CP in any year during the aforesaid period were very close to each other and that the proportion between these two variables had remained stable at 1.0166 over the years. We, therefore, considered this particular relation *viz.*,

$$NC = 1.0166\ CP \qquad (3.2)$$

to be the relation of our interest.

For the purpose of our forecast, we required the projected values of national income at *current* prices (the variable Y in equation (3.1) for each of the three years (i.e., from 1992-93 to 1994-95) for which CP and NC were to be predicted. We predicted an annual rate of growth of 15 per cent for Y for all the four years from 1991-92. By using quations (3.1) and (3.2) we then obtained forecasts for CP and NC for these years. These forecasts are given in TABLE 1 below.

Table 1

Forecasts of Currency with the Public (CP) and Notes in Circulation (NC) : 1992-93 to 1994-95

Forecast variable	*Average stock (in Rs. crore) during the year*		
	1992-93	1993-94	1994-95
CP	65219	75241	86768
NC	66304	76492	88211

10. A positive coefficient of the slope dummy implies that a unit increase in income in the second period would require a larger increase in currency holdings than that in the first period. This may be due to the fact that the degree of monetisation in the second period was greater than that in the first period.

11. We had also considered a further subdivision of the second period into two and introduced an additional set of slope and intercept dummies. However, the results were not better than those obtained for the equation (3.1). To examine the predictive efficiency of this equation, we estimated the equation (3.1) on the basis of a smaller sample size covering observations from 1970-71 to 1988-89. The equation so estimated was then used to predict CP for both 1989-90 and 1990-91, using the observed values of the regressors in the respective years. The percentage error of prediction (i.e., the difference between the observed and the predicted values of CP as a percentage of the former) was found to be only 3.79 and 3.25 for these two years, respectively.

4. ESTIMATION OF REQUIRED CURRENCY COMPOSITION IN THE BASE YEAR

In order to forecast the requirements of currency of different denominations from 1992-93 upto 1994-95, we first need to find the shares of currency of different denominations in the base year. This in turn necessitates identification of the transaction distribution for the base year. The base year, it may be recalled, was defined to be a year in the recent past when there was no appreciable discrepancy between the demand for and the supply of currency of any of the denominations in circulation. The year 1980-81 was assessed to be year which satisfied this criterion very closely. Hence this year was chosen as the base year. As regards the choice of the transaction distribution, we chose the lognormal distribution. Theoretically the choice of lognormal distribution can be justified on the grounds that (*i*) the transactions (X) assume only positive values, and (*ii*) the probabilities of occurance of relatively smaller values of X are far too large compared to those of larger values. This latter assertion holds for a developing country like India where (*i*) the per capita consumer expenditure of a very large section of the population is quite low, (*ii*) an overwhelming proportion (about 30 to 40 per cent) of population live in abject poverty, and (*iii*) the income distribution is characterized by a high degree of inequality (cf. Bhattacharya *et al.* (1991)). Empirically also, the lognormal distribution produced a very small value of D, the distance measure described in Section 2.

It has already been stated that in the absence of ary direct transaction data, we have used transaction data generated in an artificial way. As regards the empirical exercise, 1000 independent samples of transactions, each sample being of size 25, were randomly drawn from a lognormal distribution $\bigcap(\mu, \sigma^2)$ for every probable choice of the parameter (μ, σ^2) values. Based on 1000 replications, shares of different denominations of currency in the total value were then calculated using the equation (2.1) and then compared with the observed shares (given by (2.2) using the distance criterion D. The estimates of μ and σ^2 for the base year was chosen to be those values of μ and σ^2 for which the value of D turned to be the minimum among all probable choices for (μ, σ^2). It may be noted that although our grid search method was very extensive yielding a unique minimum in the range and accuracy level of our search, it was not possible to check analytically if the criterion D indeed assured a unique minimum in the parameters.

Before, reporting and analysing these results, it should be noted that in India no reliable estimates of the velocity of circulation of currency notes of different denominations exist. Hence, as stated in footnote 4, we had to use the official knowledge (based on years experiences) regarding the frequency of use of notes of different denominations for fixing some plausible values for the relative velocities. Accordingly, the relative velocities (i.e., v_i's) corresponding to the seven denominations which were in circulation during the period in question were taken as follows : $v_1 = 1$, $v_2 = v_3 = 2$, $V_4 = v_5 = 3$ and $v_6 = v_7 = 10$. (Note that the relative velocity of notes of the highest denomination Rs. 100 is 1.) Although these figures on velocity are not very reliable, in the absence of any better data on them we had to work with these figures.

We now report the results of this exercise. In Table 2 we have presented the estimates of the required shares of different denominations of currency for the base year. The observed shares are presented in column (4) of the same table. It is clear from the figures that the substitution of notes of denomination Rs. 20 by those of Rs. 10 in the

Table 2

Estimate of Currency Composition for 1980-81

Denomination (Rs.)	*Estimated share in the total value of currency in circulation*		*Observed share*
	Deterministic Model	*Probabilistic Model*	
(1)	(2)	(3)	(4)
100	0.5084	0.5144	0.5091
50	0.1437	0.1605	0.1596
20	0.1948	0.0478	0.0782
10	0.0776	0.2021	0.1608
5	0.0571	0.0584	0.0466
2	0.0140	0.0133	0.0196
1	0.0044	0.0035	0.0261
Total	1.0000	1.0000	1.0000

P.M. improved their shares considerably bringing them closer to observed shares. The distance measure was found to be 0.2543 and 0.1186 for the D.M. and the P.M., respectively. Further, the estimates of μ and σ^2 were obtained as Rs. 1.78 and Rs. 1.50 for the D.M., and Rs. 2.18 and Rs. 1.36 for the P.M. The average value of transcation given by $\bar{x} = exp\ (\mu + \frac{1}{2}\ \sigma^2)$ was obtained as Rs. 17.93 and Rs. 22.07 for the D.M. and the P.M., respectively. These estimates of average value of transactions possibly indicate the relative abundance of transactions of smaller sizes in India during that year.

5. FORECASTS OF THE SHARES AND THE DENOMINATIONAL REQUIREMENTS OF CURRENCY

Given our definition of the base year, the distribution of the currency composition as obtained in the base year is nothing but the distribution (of the currency composition) from the point of view of requirements by the public in the base year. Now, given our assumption about the shift in the transaction distribution in the forecast year as stated in Section 2 viz., $x_f = c_f\, x_o$, $c_f > 0$, we now have to estimate the parameters of the transaction distribution in the forecast year which, given this assumption, also follows a log-normal distribution with parameters, say, μ_f and σ_f. Since the forecast periods for this exercise are not too far off from the base period, we assume, mainly for the sake of simplicity and yet being not too unrealistic, that $\sigma_f = \sigma_o$, where σ_o stands for the value of the parameter σ in the base period. We know that for this model $\mu_f = \mu_o + \ln c_f$, where μ_o denotes the value of μ in the base period. Based on available data on wholesale price index (WPI) numbers, we computed the value of c_t for the 3 years from 1992-93 upto 1994-95 with base at 1980-81 = 1. For the computation of WPI's over these 3 years, we assumed an annual growth rate of 10 per cent.[12]

We now discuss about the alternative sets of (short-term) forecast of the shares (w_i's) and the requirements of currency of different denominations for India for the years 1992-93 through 1994-95. As before, we have estimated these for the specified future years following both the D.P. and the P.P. In the P.P. we have further used two alternative schemes about the nature of probability substitution of one denomination by the others in individual transactions. Under the first alternative we have considered only limited substitution. In particular, we have assumed that a currency of denomination Rs. 500, Rs. 100. Rs. 20, Rs. 10 and Rs. 2 required for a transaction may be substituted by the notes of immediately lower denominations, and the probabilities of using the larger and the smaller denominations are same.[13] For denominations Rs. 50 and Rs. 5 we have used the following scheme of substitution : a currency of denomination Rs. 50 may be substituted by any of the following four alternatives viz., (*i*) one piece of Rs. 50, (*ii*) two piece of Rs. 20 and one

Table 3

Projected Currency Composition and Denominationwise Values of Required Currency Notes for 1992-93 Through 1994-95 : Deterministic Model

Denomination of currency notes (Rs.)	*Percentage share in total value of all notes for the year*			*Value of required currency notes (Rs. crore) for the year*		
	1992-93	1993-94	1994-95	1992-93	1993-94	1994-95
(1)	(2)	(3)	(4)	(5)	(6)	(7)
500	28.81	31.63	32.89	19102	24194	29013
100	43.23	42.36	42.51	28663	32402	37499
50	10.41	9.84	9.54	6902	7526	8415
20	11.47	10.70	10.08	7605	8165	8892
10	3.30	2.97	2.73	2188	2272	2408
5	2.19	1.98	1.78	1452	1515	1570
2	0.47	0.41	0.37	312	314	326
1	0.12	0.11	0.10	80	84	88
Total	100 00	100.00	100.00	66304	76492	88211

12. The annual average of WPI in 1991-92 was 2.276 with base 1980-81 = 1.

13. It may be noted that notes of denomination Rs. 500 came into curculation in the second half of the last decade and its velocity relative to that of Rs. 100 was assumed to be 0.7.

piece of Rs. 10, (*iii*) one piece of Rs. 20 and three pieces of Rs. 10, and (*iv*) five pieces of Rs. 10, with equal probability. Similar rules of substitution are specified for a currency of denomination Rs. 5 as well. This case will be referred to as Probabilistic (*L*) Model.

The other alternative schemes of substitution used for the P.P. is based on a random selection of denominations for a transaction. Under this scheme (to be referred to as Probabilistic (*R*) Model), currency notes of different denominations are picked up at random till the total value of currency notes thus picked up equals the value of any given transaction.

To obtain the forecasts, a single empirical exercise based on simulated data was done separately for each of the years from 1992-93 till 1994-95 under each of the three alternative schemes. Each such exercise was based on, as in the case for base year, 1000 replications, each of size 25 transactions, drawn from the (estimated) lognormal distribution for the year in question. For each of the five years $\hat{w}_i$'s were then calculated using the same values for v_i's as in the base year. Finally, yearly projection of denominationwise requirements of currency notes for each of the forecast years was obtained by disaggregating the projected total value of currency in circulation during that year (given in Table 1) in accordance with the predicted currency composition for the same year. The alternative sets of projections are given in Tables 3 through 5.

Table 4

Projected Currency Composition and Denominationwise Values of Required Currency Notes for 1992-93 Through 1994-95 : Probabilistic (L) Model

Denomination of currency notes (Rs.)	*Percentage share in total value of all notes for the year*			*Value of required currency notes (Rs. crore) for the year*		
	1992-93	1993-94	1994-95	1992-93	1993-94	1994-95
(1)	(2)	(3)	(4)	(5)	(6)	(7)
500	17.09	16.30	16.64	11331	12468	14678
100	39.41	41.58	43.32	26130	31805	38213
50	17.54	17.88	17.28	11630	13677	15243
20	11.31	10.70	10.09	7499	8185	8900
10	10.98	10.21	9.74	7280	7810	8592
5	2.52	2.30	2.01	1671	1759	1773
2	0.46	0.41	0.36	305	314	318
1	0.69	0.62	0.56	458	474	494
Total	100.00	100.00	100.00	66304	76492	88211

Table 5

Projected Currency Composition and Denominationwise Values of Required Currency Notes for 1992-93 Through 1994-95 : Probabilistic (R) Model

Denomination of currency notes (Rs.)	*Percentage share in total value of all notes for the year*			*Value of required currency notes (Rs. crore) for the year*		
	1992-93	1993-94	1994-95	1992-93	1993-94	1994-95
500	20.61	22.57	23.16	13665	17264	20430
100	32.09	32.14	33.59	21277	24585	29630
50	16.52	16.45	16.12	10954	12583	14220
20	15.10	14.36	13.69	10012	10984	12076
10	7.98	7.41	6.94	5291	5668	6122
5	5.89	5.43	5.01	3905	4154	4419
2	1.07	0.99	0.90	709	757	794
1	0.74	0.65	0.59	491	497	520
Total	100.00	100.00	100 00	66304	76492	88211

6. CONCLUSIONS

In this paper we were primarily concerned with finding forecasts for requirements of currency of different denominations in India. Towards that end, we have carried out a regression exercise for predicting the total value of currency (of all denominations taken together) in circulation in the country in a given year. We have also used the model suggested by Ghosh *et al.* (1991) for estimating the shares of required quantities of currency of various denominations in this total both for the base year as well as for the forecast years. This model was based on the notion of currency demand originating in individual transactions involving payments in cash. It also required (*i*) an assumption about the size distribution of transactions, (*ii*) some specific rule(s) for determining denominationwise demand for currency for each transaction, and (*iii*) fixing some plausible values for average relative velocities of currency notes of various denominations.

We obtained the forecasts of the total value of currency in India as well as of the required currency composition for the years 1992-93 till 1994-95 using the aforesaid models. The yearly projections of denominationwise requirements of currency notes for these years were obtained by disaggregating the projected total values in accordance with the estimated currency composition for the respective years.

We conclude the paper by noting that the forecast figures presented here might suffer from two limitations. Both the limitations, however, arise because of non-availability of requisite data in India. First, the values of the relative transaction velocities of various denominations used in this study may not be very accurate because these were considered on the basis of notional knowledge on the frequency of use of currencies of various denominations in transactions. Secondly, the exercise required estimation of the transaction distribution for the base year which was defined to be a year in the recent past during which observed shares of different denominations in the total value of currency notes in circulation broadly matched the corresponding shares from consideration of requirements by the public to carry out various transactions in that year. Since no relevant official data for identifying such a year were available, our choice of 1980-81 as the base year might not have been the most appropriate.

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