definition of money, the correlation between time deposits alone and income may then be (1) higher than either or (2) lower than one or both, suppose it is higher than either, the higher correlation of the broader than the narrow definition with income may reflect simply the inclusion of an item highly correlated with income (i.e. time deposits), rather than the inclusion of a substitute for other items. It may reflect the determination of time deposits by income and not the converse. The appropriate reason for including time deposits is not simply that they are highly correlated with income but are too close substitutes for other monetary items and therefore, it is preferable to treat them as if they were perfect substitutes than to omit them. And, therefore, the F.M. criterion whether time deposits are sufficiently close substitutes for other items is that if income is highly correlated with their sum than with each component separately.

But Strong (1967) points out that the F.M. criterion implicitly assumes some preconceived ordering of the components and does not represent a 'pure' empirical test. The F.M. criterion has been re-examined and extended by Kaufman (1969) and Chatlett (1971). Kaufman point out that one should also take into consideration the lead lag problems. Theleltt using distributed lag model of money on nominal national income argues that the empirical definition of money on the basis of F.M. criterion has not corresponded to the money demand
The F.M.* criterion of giving uniform weightage to each component in money definition has been questioned and the weights are, it is argued that, should be given on the basis of the degree of moneyness of each and every financial asset. On these lines Chetty (1969) using generalised CES functions derives adjusted money stock series as weighted sum of currency, demand deposits, deposits of mutual savings banks and liabilities of savings and loan associations.

* One of the points in the F.M. criterion which Friedman does not explicitly make clear is that whether the F.M. dual criterion is applicable to currency and demand deposits separately. Friedman already preconceives that currency and demand deposits are money and he applies his dual criterion to know only whether time deposits are to be included in the money definition or not. David Laidler in a recent personal letter has pointed out that the F.M. dual criterion is only applied to the definition of autonomous expenditure and not to money definition. Even though Laidler in that letter does not explain the reason for his statement, we presume that this may be because the F.M. criterion is not applicable to currency and demand deposits separately, and Friedman already takes it for granted that they are money. This strength or weakness of the F.M. criterion of money definition is applicable to our methodology of empirically defining money through factor analysis because we had to start with the premise that currency is in any case money and we include those financial variables which move with currency as money. We cannot include bank credit, bank reserves and time deposits as money even if they themselves move together over time.
Chetty (1969) concluded that several possible substitutes for money were almost perfectly substitutable for money so that monetary aggregates could reasonably and appropriately be very broadly defined. But Boughton (1977) points out that the simplest CES versions impose strong separability and homotheticity constraints that may produce specification errors in estimating equations; the methods that have been used to relax these constraints produce non-homothetic equations that are difficult to interpret as proper utility functions. All studies so far have used unfiltered data on financial assets--nominal stock measured in current levels. This practice may introduce spurious common trends in the data series and thus bias upward the estimated substitutability between them, though the importance of implicit interest rates on demand deposits have been well established in other contexts. Studies of the elasticity of substitution have treated money as having zero yield; and proper account has not yet been taken of the relationship between adjustment periods and measured elasticities (i.e., that elasticities rise as length of the data interval increases).

Boughton has extended the elasticity of substitution model for financial assets by partially relaxing its separability assumption while resorting homotheticity with respect to income. Compared to the original model this extended version offers substantially lower and more normally distributed
(and less serially correlated) estimated residuals. The finding brings evidence from the extended model, suggesting that there exists only weak substitution between money narrowly defined and other broader financial assets.

John Rea (1973) has done an empirical study of the trends and cycles of money and bank credit for U.S. economy. His four monetary aggregates were (1) narrow money supply ($M_1$); (2) broad definition of money supply ($M_2$); (3) Bank credit proxy; (4) bank credit. Applying principal component analysis, he compared the similarity of movements of various monetary aggregates over times. His first component explained 87 per cent of total variations of the different aggregates over 1948-1971. All the coefficients in the first component have the same sign and he concludes that the expansion and contraction phase coincides in all four aggregates. However, he also concludes that the narrow money supply $M_1$ have a separate characteristic because the cyclical movements missed by the first component are those of narrow money. In the first component, there was no difference in magnitude of weights of narrow money and broad money. His results do not throw any light on the issues of empirical definition of money.

Koot (1975) also applies the technique of principal component. In the second stage he applies F.M. criterion to
factor analytic results to determine the empirical definition of money. David Foster (1979) has done a study of the trends and cycles of the various monetary aggregates for the U.S. economy for the period 1959-78. He concludes that although the cyclical behaviour of the aggregates is similar in terms of timing, the various money supply measures differ noticeably in the degree of their cyclical variability. The standard deviation shows that the cyclical movements in $M_1$ are less volatile than cyclical movements in $M_2$ and cyclical movements in $M_2$ are less than that of $M_3$ (still broader definition of money).

Kamaiah and Bhole (1981) applied the canonical correlation approach to determine the empirical definition of money for India. The canonical correlation compares the best linear combination (in terms of the correlation) from one set of variables (various monetary aggregates) to the best linear combination from another set of variables (various interest rates). Firstly, how canonical correlation approach satisfies the F.M. criterion of substitutability of financial assets rather than mere correlation with a scale variable like income or an opportunity cost variable like interest rate, is not clear. For example, if component like time deposit is more closely related with a particular interest rate than other monetary components, it violates the F.M. criterion. Secondly,
it is not clear whether they are taking for granted an accepted theory between money and interest rates (if it is nominal money, whether Fisher or Keynes) and on that basis go to test the empirical definition of money or whether they are using canonical correlation approach to generate some hypotheses relating various monetary aggregates and interest rates. If they are using deflated series of money, they already assume that they are demand for money, and thereby the same stock adjustment lags for various definitions of money. So before starting the enquiry of an empirical money definition, one presumption is made that every monetary aggregate behaves uniformly.

Section - II

The Variables.

In the statistical analysis of monetary aggregates, we have gone beyond the strict scope of money definition to study other financial variables like Bank credit and Bank Reserves because in demand management the Reserve Bank of India often tries to control these variables when they speak of controlling money supply. It is also enlightening to know that how far the movements are associated with money supply over time. The variables that we have used are the following.
The period of study is from January 1951 to December, 1976. The data were collected from R.B.I. Bulletins and Reports on Currency And Finance.

The Bank Credit (BC) : This variable refers to the loans and advances given by all commercial (Scheduled) Banks.

The Bank Reserves (BR) : The Bank Reserve forms part of the high powered money.

The Currency (CR) : Currency forms part of the high powered money as well as part of all definition of money.

The Demand Deposits (DD) : Currency subtracted from narrow definition of money gives demand deposits.

The Time Deposits (TD) : Time deposits form part of the broad definition of money.

Section III

Methodology.

In view of the fact that the basic data on monetary aggregates relate to each month (January 1951 to December, 1976), the presence of common trend and seasonalities are quite likely to be present in our data set. The presence of common seasonal and trend factors may bias upwards the statistical
evidence in favour of substitutability and common movements criterion between all variables. So initially we have deseasonalised and detrended the monthly monetary aggregates.

The methodology broadly consists of (1) examining the seasonal fluctuations and trend in the series on monetary aggregates and (2) examining the deseasonalised, detrended data for their similarities and dissimilarities in the movements over time through Principal Components analysis. (3) In order to examine the similarity/dissimilarity of the movements of different aggregates they are also defined in the growth form and the same procedure (principal component analysis) has been adopted.

For arriving at the series of the monetary aggregates after removing trend and seasonalties the following steps are adopted.

(1) Initially Wald's (1936) Moving Regression Coefficient Method has been used to deseasonalise the data.

(2) Month to Month growth rates are worked out for the deseasonalised data as

\[
\frac{M_t - M_{t-1}}{M_{t-1}}
\]

where \(M_t\) is the deseasonalised monetary aggregate at time 't'.

\[
\frac{M_t - M_{t-1}}{M_{t-1}}
\]
(3) The deseasonalised data has been examined for the presence of a time trend. After experimenting with alternative trend equations, fourth degree polynomial is found to be appropriate, in the present context and deseasonalised data has been detrended by using the estimated polynomial, for arriving at the cycles. Thus at the final stage sample period for examining the movements of the monetary aggregates through principal component analysis is from June 1952 to July, 1975.

(7) Factor Analysis.

Factor analysis is based on the assumption that there are a number of general relations between variables to arise. It aims at a reduction of the n dimensional vector space of the variables $z_i$ to $m$ space, spanned by $m$ factors $f_j$ ($j=1,2,\ldots,m$). This reduction enables the most important relationships among the variables $z_i$ in the original n-dimensional space to be included in the smaller $m$ dimensional space of the factors $f_j$. The factors $f_j$ will be represented by the axes of this factor space, which are determined by the means of principal axes method either through pure geometric solution or algebraic and statistical methods like principal component analysis.
The aim of the factor analysis is to group by means of a kind of transformation the unarranged empirical data of the variables under examination in such a way that: (1) a smaller whole is obtained from the original material, where by all information given is reproduced in summarised form; (2) factors are obtained which each produce a separate pattern of motion or relation between the variables; (3) the pattern of motion can be interpreted logically.

The solution procedure of a factor model permits different solutions, of which each one satisfies the solution conditions. If there are n variables in a factor examination, then n solutions of n relations between variables are theoretically possible, of which only one system of n relations is possible at the same time. Therefore a selection must be made from this theoretically possible number of n systems. The number of general influences (fj factors) which affect the variables from the outside, will usually be much smaller than the number of variables (n) involved in the examination, then only in practical sense a meaningful or so to say (a good result) of factor analysis can be said to be arrived at though as it is already made clear earlier in theory there is nothing like a 'good result' or 'bad result' as far as factor
analysis is concerned, as factor analysis can as well be used to show that all variables (n number) are independent of each other.

In general factor analysis does not begin with the original observations of the variables. It sets about normalizing them in a certain way to make mutual comparison possible. Normalization is done by expressing the deviations from the original observations with regard to their arithmetical mean in their standard deviations. The number of observations range from 1 to T and the number of variables from 1 to n and Z_i represents a variable for which the observations have been normalized.

Factor analysis is the analysis of the common factors f_j and their corresponding coefficients, which we call factor loadings. The practical working model of factor analysis expressed in normalized observations is:

\[ Z_{it} = a_{i1} f_{1t} + a_{i2} f_{2t} + \ldots + a_{im} f_{mt} \]

\( i = 1, 2, \ldots, n \)

In matrix notation

\[ Z = AF \]
where $Z$ = the matrix of the normalized observations $Z_{it}$

$$Z_{it} = (i = 1,2,...; t = 1,2,...,T)$$

$A$ = the matrix of factor loadings $a_{ij}$

$A_{ij} = (i=1,2,...,n; j = 1,2,...,m)$.

$F$ = the matrix of factors $f_j$ with elements $f_{jt}$

$$f_{jt} = (j = 1,2,...,m; t = 1,2,...,T)$$

It is also logical that a factor model can also be expressed in a vector representation of normalized variables $Z_i$.

Then the representation of the model takes the following form:

$$Z(t) = A \cdot f(t)$$

where $Z(t)$ = the column vector of the normalized variables $Z_i$ ($i = 1,2,...,n$) at period $t$.

$A$ = the matrix of the factor loadings $a_{ij}$

$$A_{ij} = (i = 1,2,...,n; j = 1,2,...,m)$$

$f(t)$ = the column vector of the factors $f_j$

$f_j = (f_j = 1,2,...,m)$ at period $t$.

And finally, as a common practice, in applied factor analysis little attention is paid to specific and error
factors and exclusively concerned with common factors.

**Vari - Max, Orthogonal Rotation of Axes:**

The weights found out in our principal component analysis can be verified by rotating the axes. In social sciences, the usual transformation made is an orthogonal rotation by Vari-Max method.

The weights associated with each monetary aggregate in each component index and in that of the rotated matrix gives us an idea of the movements of the monetary aggregates over time.

An important issue to be settled in the empirical definition of money is whether the currency and demand deposits, or the currency and time deposits are close substitutes. In this respect, for other countries conflicting empirical results are reported. This issue is also important for an understanding of the money multiplier process. From the result of the factor analysis, we are able to judge whether the movements are taking place between currency and demand deposits, or between currency and time deposits, or between demand deposits and time deposits, and therefore are able to infer indirectly about the substitution
criterion of definition of money. The other issue of money definition i.e., their movements over time, implicitly assuming some uniform correlation with a scale variable, can also be known from the results of factor analysis.

**Standard deviations (SD's) and Coefficient of Variation (CV).**

The degree of variability of the cyclical movements and growth rates of various monetary aggregates are found by examining the SD and CV.

*Section - IV*

See Tables (No. 1, 2, 3, 4 and 5)

In cycles, the four components explain 97.55 per cent variation, and 94.19 per cent in the monthly growth rates. As the first component in cycles explain only 37.56 per cent variation and 33.44 per cent in the monthly growth rates, the first interpretation can be given that in the five monetary series, there are many independent factors determining the movements. Their movements over time are more dissimilar rather than similar. But recall that we have first removed the seasonal factors which would have perhaps added much to their common movements. Another plausible reason for more independence in our set of five
### Table 1

**Principal Components of the Cycles in Monetary Aggregates**

*Monthly data - June, 1952 to July, 1975*

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Coefficients</th>
<th>First Component</th>
<th>Second Component</th>
<th>Third Component</th>
<th>Fourth Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>(1)</td>
<td>Bank Credit</td>
<td>0.1185</td>
<td>-0.6885</td>
<td>0.5363</td>
<td>0.4719</td>
</tr>
<tr>
<td>(2)</td>
<td>Bank Reserves</td>
<td>0.1270</td>
<td>0.8190</td>
<td>0.0007</td>
<td>0.5574</td>
</tr>
<tr>
<td>(3)</td>
<td>Currency</td>
<td>-0.9537</td>
<td>0.0236</td>
<td>0.0595</td>
<td>0.1707</td>
</tr>
<tr>
<td>(4)</td>
<td>Demand Deposits</td>
<td>0.9684</td>
<td>0.0118</td>
<td>0.0155</td>
<td>0.0288</td>
</tr>
<tr>
<td>(5)</td>
<td>Time Deposits</td>
<td>-0.0260</td>
<td>0.4349</td>
<td>0.8444</td>
<td>-0.3129</td>
</tr>
</tbody>
</table>

**Total variation of Aggregates**

|                       | 37.564 | 26.6929 | 20.0727 | 13.2250 |

**Total Cumulative Variation Explained (Percentage)**

|                | 97.55  |

**In All Components**

|                |        |
### Table 1: 2

**Principal Components of the Growth Rates (Monthly) of the de-seasonalised monetary aggregates**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>First Component</th>
<th>Second Component</th>
<th>Third Component</th>
<th>Fourth Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Bank Credit</td>
<td>0.1755</td>
<td>0.8316</td>
<td>-0.0737</td>
<td>-0.5015</td>
</tr>
<tr>
<td>(2) Bank Reserves</td>
<td>0.2255</td>
<td>0.5313</td>
<td>0.6227</td>
<td>0.5277</td>
</tr>
<tr>
<td>(3) Currency</td>
<td>-0.8472</td>
<td>0.3890</td>
<td>-0.0386</td>
<td>0.0011</td>
</tr>
<tr>
<td>(4) Demand Deposits</td>
<td>0.9212</td>
<td>0.0177</td>
<td>-0.0360</td>
<td>-0.1078</td>
</tr>
<tr>
<td>(5) Time Deposits</td>
<td>-0.1543</td>
<td>-0.3083</td>
<td>0.8237</td>
<td>-0.4484</td>
</tr>
</tbody>
</table>

Total percentages explained: 33.4361 24.4093 21.4878 14.8532

Total cumulative percentage variation explained: 94.1864
Rotated (Varl-Max Orthogonal) Factor Matrix For Monthly Cycles

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Credit</td>
<td>0.00968</td>
<td>0.98362</td>
<td>-0.06250</td>
<td>0.08830</td>
</tr>
<tr>
<td>Bank Reserves</td>
<td>0.04375</td>
<td>0.08674</td>
<td>0.04257</td>
<td>0.99399</td>
</tr>
<tr>
<td>Currency</td>
<td>-0.91346</td>
<td>0.18492</td>
<td>-0.04035</td>
<td>0.01789</td>
</tr>
<tr>
<td>Demand Deposits</td>
<td>0.89460</td>
<td>0.21475</td>
<td>-0.09099</td>
<td>0.08449</td>
</tr>
<tr>
<td>Time Deposits</td>
<td>-0.03205</td>
<td>-0.06138</td>
<td>0.99587</td>
<td>0.04229</td>
</tr>
</tbody>
</table>

even though four iterations of rotation have been done, there is no change except in last decimals. So we report only one.
## Rotated (Varimax Orthogonal) Factor Matrix for Monthly Growth Rates of Monetary Aggregates

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Credit</td>
<td>0.01029</td>
<td>0.98531</td>
<td>-0.05993</td>
<td>0.07540</td>
</tr>
<tr>
<td>Bank Reserves</td>
<td>0.04619</td>
<td>0.07431</td>
<td>0.04054</td>
<td>0.99484</td>
</tr>
<tr>
<td>Currency</td>
<td>0.91369</td>
<td>0.17990</td>
<td>-0.06546</td>
<td>0.01846</td>
</tr>
<tr>
<td>Demand Deposits</td>
<td>0.89401</td>
<td>0.21050</td>
<td>-0.09422</td>
<td>0.08901</td>
</tr>
<tr>
<td>Time Deposits</td>
<td>-0.02981</td>
<td>-0.05913</td>
<td>0.99607</td>
<td>0.04040</td>
</tr>
</tbody>
</table>

Iterations do not make any remarkable change.
Table 5

Standard deviations and coefficients of variation of the Monthly Cycles and Monthly Growth rates of Monetary Aggregates

<table>
<thead>
<tr>
<th></th>
<th>Monthly Cycles</th>
<th>Monthly Growth Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S.D.</td>
<td>C.V.</td>
</tr>
<tr>
<td>Bank Credit</td>
<td>2747</td>
<td>17800</td>
</tr>
<tr>
<td>Bank Reserves</td>
<td>1488</td>
<td>5339</td>
</tr>
<tr>
<td>Currency</td>
<td>4423</td>
<td>13456</td>
</tr>
<tr>
<td>Demand Deposits</td>
<td>4270</td>
<td>8389</td>
</tr>
<tr>
<td>Time Deposits</td>
<td>1906</td>
<td>9668</td>
</tr>
</tbody>
</table>
variables may be that we have added the bank credit (BC) and bank reserves (BR) to the set of variables, which are not part of any type of money definition. This last speculation is more or less confirmed by the order of magnitude of weights of each variable in each component.

However, the results throw light on many important issues which are of fascination to monetary economists. In both, the cycles and money growth rates, the first component is explained by currency and demand deposits and other variables have no dominant influence. The currency's coefficient in first component of the cycles (Table : 1) is -0.9537 and that of demand deposits is 0.9684.* The coefficients of other variables are tending to zero either from positive or negative side in the first component. In the first component of the monthly growth rates (Table : 2), the coefficient of currency is -0.8472 and that of demand deposits is 0.9212. The coefficients of other variables are tending to zero in the first component of the monthly growth rates too. In Rotated Factor Matrix also (Table : 3), in the first component of both monthly cycles and monthly growth rates the coefficients of currency and demand deposits have the

* When interpreting the order of magnitude or the importance of a variable in a particular component, the sign can be ignored. Whenever the values tend to zero either from positive or negative side, its importance is negligible.
same pattern and other variables have less influence. Another important feature is that the sign of the factor loading of currency is negative in the case of first factor in all cases, whereas the sign of the factor loading of demand deposit is positive. Currency and demand deposits tend to move in opposite direction. This shows that the movements are taking place between currency and demand deposits. So the F.M. criterion of close substitutability for a proper definition of money is indirectly satisfied in the case of currency and demand deposits in Indian Situation. A possible reason for the movements between currency and demand deposits can also be given, as we have already removed the trend and seasonal factors earlier, from the point of view of some structural factors like urbanisation, spread of banking habits etc. This hunch is also confirmed by our subsequent results of the standard deviations and coefficient of variation of currency and demand deposits. Currency and demand deposits have higher variability than time deposits.

Here the particular way of testing the basic idea of Friedman Meixelman criterion of an empirical definition of money in both its correlation over time, and close substitutability of monetary assets is a way of interpreting results obtained by using a well known statistical technique. The
The interesting part of our findings is that time deposits do not qualify to be money in the context of India—a monetary asset which has grown by leaps and bounds. First of all, the movements of time deposits are more or less independent of the movements of demand deposits and currency. Secondly, there is no evidence in our results to show that substitution takes place between time deposits and currency or between time deposits and demand deposits. The F.M. criterion of including time deposits in money definition is that time deposits as close substitutes to narrow money produce nominal income, and there is a high correlation between time deposits and income, and not that income produces time deposits. According to that criterion, time deposits do not come in the spectrum of money in India. So it is not surprising that when time deposits are also included in money definition in India, money demand function shows a high permanent income elasticity and significant interest elasticity, as income growth has produced a large amount of time deposits. For money demand functions, the recent works of Trivedi (1981) Paul (1981), Kemenah and Paul (1981), Murthy and Paul (1981) show a very high permanent income elasticity for broader definition of money including time deposits for India.

It is very difficult to discern any common trend or pattern from the order of magnitudes of the index components.
and rotated factor loading of bank credit, bank reserves and time deposits. The second component is explained by the bank credit. The time deposits explain the third component. The fourth component is explained by the bank reserves. As we have already hinted, this perhaps, explains why there is so much independence in a set of five variables.

As far as the degree of the volatility of the movements of the monthly growth rate of different monetary aggregates are concerned, the standard deviations and coefficients of variations give us some idea. Both standard deviation and coefficients of variation of monthly growth rates of time deposits are less than that of currency and demand deposits. Even though the standard deviation of the cycles of time deposits are less than that of the currency and demand deposits cycles, the coefficient of variation of the cyclical component of time deposits is higher than the coefficient of variation of the cyclical component of demand deposits. In any case, as both the standard deviation and coefficient of variation of monthly growth rate of time deposits is less than that of the currency and demand deposits, this contradicts Foster's (1979) conclusion that as the monetary aggregates are becoming broader the variability becomes more volatile due to higher variation in market interest rates. In India, large amounts of movements between currency and demand deposits might have taken place due to
structural factors like urbanisation, literacy, the spread of the habit of transaction through cheques etc.

Conclusion:

The above ideas of Friedman and Meiselman - the close substitutability and correlation regarding the empirical definition of money when applied to India with different robust statistical tools show that the currency and demand deposit are qualified to be the candidates in the definition of money and time deposit does not do so, in the empirical sense. This study is at variance with Chetty's (1969) results that there exists a strong substitution between money (narrowly defined) and other broader liquid assets such as savings accounts, shares of thrift institution etc. But it corroborates with the empirical evidence based on extended Chetty's model - which relaxes the separability conditions implicit in Chetty's framework-, where weak substitutability is evinced between narrow money and the other broader liquid financial assets (Bougton (1977)).