ISSN: 2278-3369
International Journal of Advances in Management and Economics
Available online at www.managementjournal.info

RESEARCH ARTICLE

Maximum Run Algorithm for Non-Performing Assets Problem

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Abstract

The problem of Non-Performing Assets (NPA) has been a major concern for the banks worldwide. With the help of the process of restructuring of loans, banks have been trying to mitigate the problem of NPA. But the scenario is challenging and it's difficult to conclude how far the restructuring of loans is actually helping the banks to reduce its gross NPA. This paper is an attempt to provide an answer to the question backed by an in depth analysis of the problem. The paper discusses a new approach called "Maximum Run Algorithm", and thereby implements it on the data of amount of NPA and amount of restructured loans for Indian banks to have a deeper insight into the problem. The algorithm has been given a detailed mathematical structure and it is expected to be useful for data analysis in other fields as well. The consistency of the results of the algorithm has been compared with the VAR model and Impulse response functions on NPA and restructuring data.

Keywords: *Non-performing assets, Restructured amount, Length of a run*

Introduction

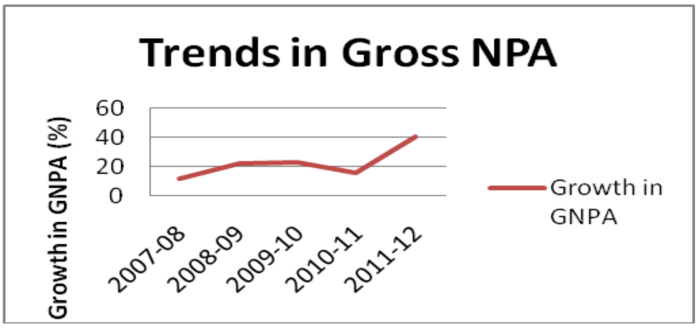
An asset is said to be a Non-performing Asset (NPA) if there is a due in the form of principal and/or interests that are not paid by the borrower for a specified period. In the Indian context, the overdue norm for identification of NPAs was till 180 days which later on in the year ending of March 2004, was modified to 90 days to ensure greater transparency [1]. In 2004, Reserve Bank India (RBI) decided to introduce graded higher provisioning according to the duration of NPAs in doubtful category for more than three years, which came into effect from March 31, 2005 [2]. In the paper by Dong He [3], it has been shown that the high stock of NPAs has a number of negative consequences for the Indian economy and the banking system.

Advances (loans) are debts evidenced by a note which specifies among other things, the principal amount, interest rate, and date of repayment and the advances which are not NPA are referred to as standard assets. Restructuring of loans is an operation by which a company or bank endeavors to reorganize its outstanding obligations. The importance of restructuring of loans lies in the mutual benefits of both the borrowers and the lenders. To enhance the soundness and financial stability of Indian banks, RBI advised them to ensure that they keep the total provisioning of coverage ratio, including floating provisions more than 70 percent [4]. Financial distress can be efficiently solved through private re-negotiation in the situations when more of the firm's assets are intangible, and relatively more debt is owed to banks and the possibility of success is low when there are more distinct classes of outstanding debts [5].
Recently, corporate debt restructure (CDR) mechanism has allowed companies and banks to increase its ability to meet the obligations.

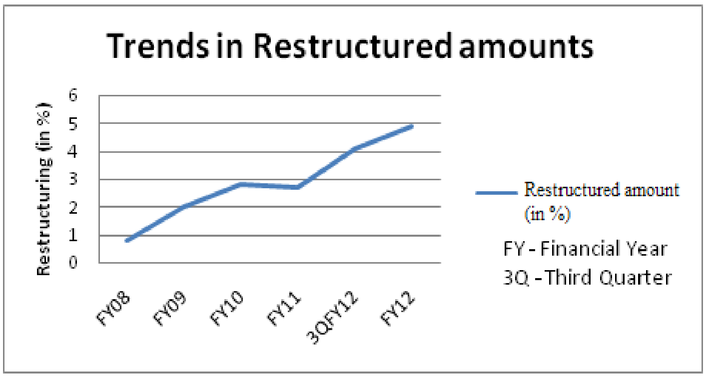
The reports of Narasimham committee II highlight the need of the zero non-performing assets for all Indian banks with international presence [6]. The result by Beck T. et al [7] suggests that if there is active bank supervision, this would help ease information costs and improve the integrity of bank lending. Some prerequisites for effective asset management policies which includes - an effective legal system, a sound financial and supervisory network, a stable macroeconomic environment and a neutral tax framework has been suggested by David Woo [8].

In India, one of the main factors attributing to growth of NPA is legal impediment and time consuming nature of asset disposals process [9]. In the recent past, there is an increasing trend of restructuring of loans and NPA in India (Fig.1). In 2012-13, gross non-performing assets of banks has increased to 31.8 per cent while the advances rose to 13.7% only .The increasing trend of nonperforming assets (NPA) is lowering the profits of the state-owned banks. Till 31st March 2013 a total of 522 cases have been referenced for debt recast with an aggregate amount of Rupees 2, 98,141 crores.

Moreover the recent changes brought about by the Central Bank whereby the newly restructured account has been raised to 5 percent from June 1, 2013 from 2.75 percent now and from April 1, 2015, restructured account would be treated as NPA, has enforced an increased pressure over the commercial banks. There are various channels of recovery available to banks for dealing with bad loans, the SARFAESI (Securitization and Reconstruction of Financial Assets and Enforcement of Security Interest Act, 2002) Act and the Debt Recovery Tribunals (DRTs) are the most effective ones. The amount recovered as percentage of amount involved was the highest under the DRTs, followed by SARFAESI Act [10].



(Source: "Report of the Trend and Progress of Banking in India", RBI, various issues)



(Source: RBI, CDR India and CARE Research)

Fig. 1: Recent trends in gross NPA and restructured amount for Indian banks.

The RBI's Financial Stability Report of June 2012 shows that the growth rate in restructured advances is nearly three times the growth rate in corporate advances [11]. So, in the present scenario, due to the increase in NPAs (which forms a part of either the fresh advances or the restructured advances), the banks are incurring a huge amount of losses. Although every year banks are restructuring loans to get rid of NPA's, yet it has been observed that the amount of NPA each year on a rising trend which is definitely arousing a sense of doubt on the policy of restructuring of loans and hence a natural question comes to one's mind that whether the restructuring of loans is really helping out the banks to reduce their mounting pressure of NPA's. The answer to the question will surely attract the banks to have a closer look on the consequences on of restructuring of loans. The present study deals with a completely new approach to give a deeper insight into the problem.

The approach is an algorithm which converts the given time series data into the states of possible solutions one looks for and finally determines the most dominant state that has occurred in the specified time duration, based on those data points. It focuses more on inferences that can be derived about the interrelationship between the two time series variables based on their past values rather than making a direct future prediction. In the analysis presented here, the public domain data on scheduled Indian commercial banks have been used which are obtained from the various reports, publications and journals of RBI. Following sections deals with the detailed formulation of the algorithm for the problem of non-performing assets.

Maximum Run Algorithm

Step 1

Suppose there are $B_1, B_2, B_3, \dots, B_n$ banks whose data is under analysis. Let the total advances at a time t (in years) issued by bank B_i be $A_{B_{i,t}}$. Every year, it is seen that some portion of total advances has become NPA and some of its portion has been restructured. A closer look of the data reveals that the total amount has NPA for each year has been increasing which is natural, since the amount of total advances is non-decreasing. However, the fraction of total advances that has turned into NPA doesn't seem to follow this trend. Similar situation is true for fraction of total advances which has been restructured. Keeping this in mind, we focus our analysis on these fractions and hence we define,

$$N_{B_{i,t}} = \frac{(NPA)_{B_{i,t}}}{A_{B_{i,t}}} \text{ and}$$

$$R_{B_{i,t}} = \frac{(Rest)_{B_{i,t}}}{A_{B_{i,t}}}$$

Where $(NPA)_{B_{i,t}}$ is the total amount from the advances $A_{B_{i,t}}$ which has turned into a non performing asset and $(Rest)_{B_{i,t}}$ is the total restructured amount from $A_{B_{i,t}}$ for bank B_i at time t.

Step 2

From step 1, we have now two new time series viz. $N_{B_{i,t}}$ and $R_{B_{i,t}}$. In this step, we convert each time series into a two valued data sequence by using the following transformation: Let X_t be a time series and $T: X_t \to \{0,1\}$ be a transformation such that

$$T(X_t) = \begin{Bmatrix} 1 \; if \; X_t \geq X_{t-1} \\ 0 \; if \; X_t \leq X_{t-1} \end{Bmatrix}$$

where $t \geq 2$ and $T(X_1) = 1$.
Applying above transformation we obtain,

$$T\left(N_{B_{i,t}}\right) = \{1, \{a_t\}\}$$

and

$$T\left(R_{B_{i,t}}\right) = \{1, \{b_t\}\}$$

where $\{a_t\}$ and $\{b_t\}$ are two valued sequence containing zeroes and ones. An important point to note here is that for a given time series, $\{a_t\}$ and $\{b_t\}$ are unique.

Step 3

In this step we form a $2 \times n$ matrix (denoted by M_{B_i} for each bank B_i whose each column is an element of $S = \left\{\binom{1}{1}, \binom{1}{0}, \binom{0}{1}, \binom{0}{0}\right\}$. An element in k^{th} row and l^{th} column of matrix M_{B_i} is given by,

$$M_{B_i}(k,l) = \begin{Bmatrix} T\left(N_{B_{i,l}}\right) \; for \; k = 1 \; and \; l \in \{1,2,\ldots,t\} \\ T\left(R_{B_{i,l}}\right) \; for \; k = 2 \; and \; l \in \{1,2,\ldots,t\} \end{Bmatrix}$$

Step 4

A run in a finite sequence $\{k_n\}, n \in A \subset \mathbb{N}$ is defined as a subsequence of $\{k_n\}$, such that each of the elements of the subsequence is identical. The length of a run (l) is the number of elements in the subsequence and $1 \leq l \leq |A|$. It is evident from the construction of matrix above that two or more consecutive columns can be identical. Now in this step our goal is to calculate the length of each non identical element in the sequence. Knowing that the non-identical columns of matrix M_{B_i} are elements of S, we define four states as following,

$$S_1 = \binom{1}{1}; S_2 = \binom{1}{0}; S_3 = \binom{0}{1}; S_4 = \binom{0}{0}$$

where S_1 denotes the state in which NPA amount increases with increase in the restructured amount, S_2 denotes the state in which NPA amount increases with decrease in the restructured amount, S_3 denotes the state in which NPA amount decreases with increase in the restructured amount and S_4 denotes the state in which NPA amount decreases with decrease in the restructured amount. One can easily conclude that states S_1 and S_4 together depicts a positive relation between the two time series variable while states S_2 and S_3 together points a negative a relation. However, the further analysis treats each state as a distinct state and just stated fact is taken care of while making the final conclusion.

Step 5

Clearly each of the state S_j for $j \in \{1,2,3,4\}$ has a non-zero count for number of runs in the matrix M_{B_i}, for each bank $B_i, i \in \{1,2,3 \ldots, n\}$. Let $L(S_j^{B_i})$ denote the length of the run for the state S_j corresponding to bank B_i. In this step we calculate the maximum length of run for each state $S_j, j \in \{1,2,3,4\}$ present in $M_{B_i}, i \in \{1,2,3 \ldots, n\}$ among all possible runs for S_j. For this using the following function, $L_{B_i}^{\max}: S \rightarrow \mathbb{N}$

$$L_{B_i}^{\max}\{S_j\} = Max\left(L\left(S_j^{B_i}\right)\right) for \; j \in \{1,2,3,4\} \; and \; i \in \{1,2,3 \ldots, n\}.$$

Step 6

In this step, we take average of all $L_{B_i}^{\max}\{S_j\}$ for $j \in \{1,2,3,4\}$ *and* $i \in \{1,2,3 \ldots, n\}$ as defined below:

$$\bar{L}(S_j) = \frac{1}{n}\sum_{i=1}^{n} L_{B_i}^{max}(S_j)$$

For example, $\bar{L}(S_1) = \frac{1}{n}\sum_{i=1}^{n} L_{B_i}^{max}(S_1)$. It is the average of maximum length of run averaged over all banks. Let $L = \{\bar{L}(S_1), \bar{L}(S_1), \bar{L}(S_1), \bar{L}(S_1)\}$. As mentioned above, S_1 and S_4 together depicts a positive relation between the two time series variable while states S_2 and S_3 together points a negative a relation. Denote S^+ as the state which takes into account the combined effect

$S_1$and S_4 and S^-as the state which takes into account the combined effect $S_2$and S_3. Define, $\bar{L}(S^+) = \bar{L}(S_1) + \bar{L}(S_4)$ and $\bar{L}(S^-) = \bar{L}(S_2) + \bar{L}(S_3)$ and test statistic, $\sigma = \frac{|\bar{L}(S^+) - \bar{L}(S^-)|}{T}$, where T is the number of data points in the given time series. Division by T helps to eliminate the effect of dependence of $|\bar{L}(S^+)$ *and* $\bar{L}(S^-)$ on number of points in the data series. For NPA problem, based on the algorithm described above, the final conclusion is based following definitions:

1. If $\bar{L}(S^+) > \bar{L}(S^-)$ then the state $S^+$is said to dominate the state S^- by a factor of dominance σ.

2. If $\bar{L}(S^+) < \bar{L}(S^-)$ then the state $S^-$is said to dominate the state S^+ by a factor of dominance σ.

3. If $\bar{L}(S^+) = \bar{L}(S^-)$ then none of the states S^+ and S^- are dominant and in this case the factor of dominance, $\sigma = 0$.

The factor of dominance helps to determine the extent of dominance of a state. Clearly σ has the minimum value 0. Further, higher the value of σ with, more dominant is the state. A state is perfectly dominant if $\sigma = 1$. As the value of sigma approaches 0, both the states lose its dominance and it's difficult to conclude a suitable relationship for the data. For practical purposes, we will ignore the dominance of a state if we find $\sigma < 0.05$.

Empirical Analysis

The restructuring and NPA data for the period of 2004 - 2012 of 17 different banks across the country have been used for analysis. The banks are denoted by $B_1, B_2, \ldots, B_{17}$. The length of maximum run $L_{B_i}^{max}(S_j)$ for each state and each bank are mentioned in Table 1.

Table 1: Length of maximum run of each state corresponding to each bank

The bank(B_i)	$L_{B_i}^{max}(S_1)$	$L_{B_i}^{max}(S_2)$	$L_{B_i}^{max}(S_3)$	$L_{B_i}^{max}(S_4)$
B_1	1	2	2	1
B_2	1	0	2	2
B_3	1	0	2	4
B_4	1	0	2	2
B_5	1	0	1	4
B_6	3	1	1	1
B_7	1	1	1	2
B_8	1	2	2	2
B_8	2	0	1	1
B_9	2	0	1	3
B_{11}	1	2	1	2
B_{12}	2	0	2	2
B_{13}	1	1	1	3
B_{14}	2	1	1	2
B_{15}	1	1	2	1
B_{16}	2	0	2	2
B_{17}	2	1	1	4

Using Table 1, values $\bar{L}(S_j)$ for j = 1, 2, 3, 4 have been calculated and they are mentioned below:

$$\bar{L}(S_1) = \frac{1}{17}\sum_{i=1}^{17} L_{B_i}^{max}(S_1) = \frac{24}{17} = 1.41,$$

$$\bar{L}(S_2) = \frac{1}{17}\sum_{i=1}^{17} L_{B_i}^{max}(S_2) = \frac{12}{17} = 0.70,$$

$$\bar{L}(S_3) = \frac{1}{17}\sum_{i=1}^{17} L_{B_i}^{max}(S_3) = \frac{25}{17} = 1.47,$$

$$\bar{L}(S_4) = \frac{1}{17}\sum_{i=1}^{17} L_{B_i}^{max}(S_4) = \frac{38}{17} = 2.24,$$

$$\bar{L}(S^+) = \bar{L}(S_1) + \bar{L}(S_4) = 3.65$$

$$\bar{L}(S^-) = \bar{L}(S_2) + \bar{L}(S_3) = 2.17$$

From the above calculations, it is evident that $\bar{L}(S^+) > \bar{L}(S^-)$, which implies that the state S^+

dominates S^{-}.The factor of dominance is given by, $\sigma = \frac{|\Sigma(s^{+})-\Sigma(s^{-})|}{T} = \frac{3.65-2.17}{9} = 0.16$ which is certainly quite bigger than 0.05 which establishes that there has been a positive relation between restructuring of loans and amount of NPA. This leads to a conclusion that if the amount of restructuring is increases, the amount of NPA also increases which in turn implies that restructuring of loans has not helped banks so far.

Results for VAR and Impulse Response Functions

The gross NPA and total restructured amount have been modeled with VAR for the data collected from the period of 2003-04 to 2011-12 from the RBI publications on bank wise gross non-performing assets, gross advances and gross NPA ratio of scheduled commercial banks. The results of Augmented Dickey Fuller tests show that the original data of the NPA and Restructured Loans are not stationary, the first order difference of the given time series are stationary, hence for further statistical tests, the first order differenced stationary time series of the given series has been taken into consideration. The stationary series has been tested for checking the causality relationship using the Granger Casualty Tests.

The value of f statistic (3.9×10^{30} is found to be very much large (Table 2) as compared to the critical value of F distribution (10.12) indicating that the restructuring amount is actually Granger Causing NPA. The NPA and Restructured loans are then tested for autocorrelations. Ljung Box test has been used for this purpose and the computed p values were 0.5 and 0.2for NPA and restructuring respectively (Table 3), both of which were greater than 0.05 which leads to failure to reject the null hypothesis that the data is independently distributed and autocorrelations are absent.

From Granger Causality tests in the previous section it is observed that the Restructuring of loans has been granger causing NPA or in other words the restructuring of loans have an influence on the NPAs. To find the interrelationship between the variables VAR model has been used. VAR has been computed using the OLS (Ordinary Least Square) method [12] which is more efficient than MLE (Maximum Likelihood) method.

At first the model is fitted using the first order differenced time series variable of NPA and Restructuring amount. The appropriate order of VAR has been selected based on minimum information criteria as well as other diagnostics i.e. using the AIC (Alkaline Information Criterion) and BIC (Bayesian Information Criterion) (Table 4) and VAR (1) model is found to be the most appropriate.

Table 2: Granger Casualty Test of NPA and Restructuring

Data Used	Value of f statistic	Critical value
NPA Restructured loans	3.9×10^{30}	10.1280

Table 3: Ljung box tests results

Data used	p-value
NPA	0.537
Restructured loans	0.2085

Table4: AIC and BIC diagnosis

Lags	AIC	BIC
1	56.64147	56.43323
2	NaN	NaN

The estimation results of VAR (1) model are tabulated below. The notations d1npa and d1res represent first order differenced stationary time series of NPA and restructured amount.

Table 5: Estimated coefficients of VAR (1) model for NPA (d1npa)

Coefficients	Estimate	Standard Error	t-value	Pr(>|t|)
$d1npa.l1$	-1.096	5.015×10^{-1}	-2.186	0.1167
$d1res.l1$	-1.250×10^{-1}	3.109×10^{-2}	-4.020	0.0276
$const$	-3.921×10^{6}	8.370×10^{5}	-4.684	0.0184
$trend$	1.116×10^{6}	2.038×10^{5}	5.473	0.0120

Multiple R-Squared: 0.9745, Adjusted R-squared: 0.9491

Table 6: Estimated coefficients of VAR (1) model for restructuring (d1res)

Coefficients	Estimate	Standard Error	t-value	Pr(>|t|)
$d1npa1.l1$	1.507×10^{1}	4.966	3.035	0.0561
$d1res.l1$	-3.815×10^{-1}	3.079×10^{-1}	-1.239	0.3034
$const$	2.453×10^{7}	8.288×10^{6}	2.959	0.0596
$trend$	-6.127×10^{6}	2.018×10^{6}	1.036	0.0561

Multiple R-Squared: 0.7744, Adjusted R-squared: 0.5488

In the fit plot of VAR (1) in Figure 1, it is observed that VAR (1) for NPA and Restructuring in terms of lag 1 of respective NPAs and Amount of Restructured loans produces a good fit. This is also supported by autocorrelation functions and partial auto-correlation functions, since it is evident that there are no autocorrelations at any lag in the ACF and PACF plot of residuals. From the values of R^2 and adjusted R^2 so obtained it can be seen that there is good measure of agreement between observed and modeled values.

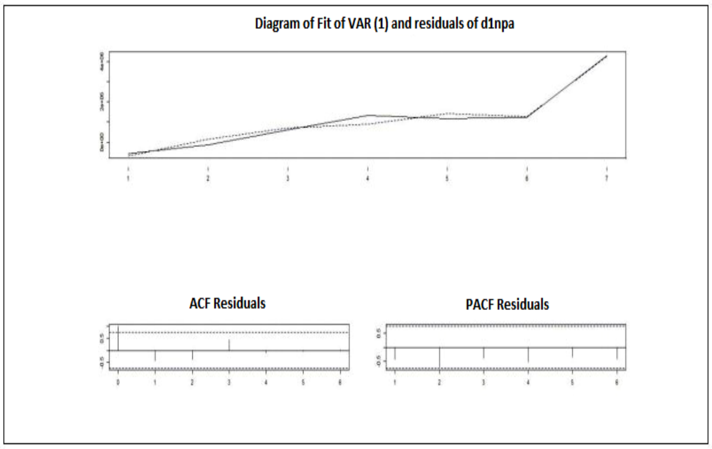


Fig. 3: VAR (1) fit and ACF and PACF plots for NPA and restructured amounts.

When the t values and the corresponding probabilities of the estimated coefficients are compared, it can be observed that the coefficients of NPA (d1npa) and restructuring (d1res) are statistically significant implying that Restructuring affects the NPA. However since the coefficient of Restructuring are not very high so it can be said that this is not the only factor affecting it. The equations obtained from VAR (1) for NPA and Restructuring are mentioned below.

$$(\Delta\, NPA)_t = -3.92057 \times 10^6 + (-1.0960)(\Delta\, NPA)_{t-1} - 0.1250)(\Delta Rest)_{t-1} + (\varepsilon)_t$$

$$(\Delta Rest)_t = -2.4526 \times 10^7 + (15.0720)(\Delta\, NPA)_{t-1} - 0.3814)(\Delta Rest)_{t-1} + (\varepsilon)_t$$

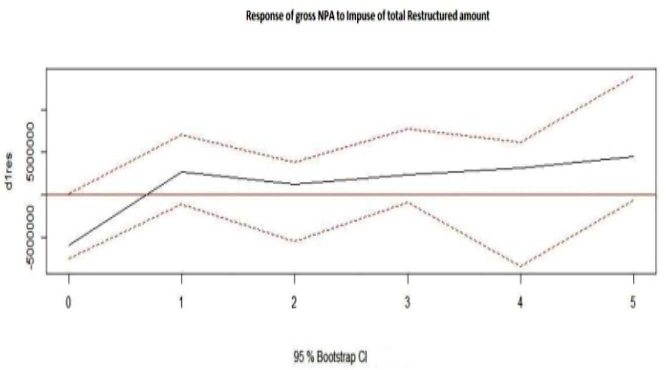


Fig. 4: IRF plot for VAR (1) model for gross NPA and restructured amounts

From the Impulse Response Function (IRF) plot for above VAR (1) (Fig. 4), it can be seen that up to the first year for an unit change of restructuring of loans there is a sharp rise in the NPA whereas from first year to the second year there is a slight decrease of the NPA depicting that the restructuring is reducing the NPA although not in a huge amount. As we move further, the graph clearly shows that the NPA has a rising trend although not steep thereby revealing the fact that in the long run i.e. after two years or so the restructuring of loans cannot help in curbing the mounting amount of NPAs. The stability of the model was checked based on the roots of the characteristic polynomial. Since it has been found that the characteristic roots lie outside the unit circle so it can be concluded that the selected model has been found to be fulfilling the necessary and sufficient condition of stability.

Conclusions

The data analysis using Maximum Run Algorithm shows that with the increase in the amount of restructuring, the amount of NPA has also increased implying that restructuring of loans has not actually helped the banks so far. The output of algorithm is based on that data of all major commercial banks of the country. The analysis of responses of gross NPA on the impulse of total restructured amounts suggests that although the lenders and the borrowers are resorting to the restructuring of loans in order to decrease the mounting pressure of NPAs, in the long run it will not help in decreasing the NPAs. Rather the NPAs will show a rising trend thereby causing huge losses especially on the lenders accounts. Prima facie, restructuring of loans may seem to be a relief from NPAs but in the long run restructuring cannot not ease the situation as restructuring of loans is often a way of showing cosmetic decrease of NPAs. Hence concrete provisions must be made to face the upcoming situations in such a way that both the lenders and the borrowers are not much affected due to NPAs.

A deeper look at maximum run algorithm approach to deal with NPA problem would reveal that the method gives the solution to the problem in a much easier way even though it is non-predictive in nature. Although the results of both VAR model and the algorithm boil down to the same conclusion that restructuring of loans is not actually helping the banks to reduce their gross NPAs, but the former approach takes into account the scenario of each major banks in the country then arrives at a conclusion, while the results of VAR model is based only on total restructured amount and gross NPA of all banks together. However, the results of impulse response functions of VAR (1) model above may not be same if we consider individual banks and if the VAR individually applied on each banks data, the calculations would become too tedious. In this respect, maximum run algorithm is very advantageous. It captures the scenario of each individual banks as well as the overall situation. For this particular property, the algorithm will surely find its application in various fields where data analysis of similar situation would be required. An important question may arise that why do we consider only that run whose length is maximum, why not length of each run? This is done to capture which state has been dominating continuously for substantial amount of time. If we take all runs into consideration, then we tend to choose states which are close to each other with small length of runs. And if different states are together with small lengths of run for certain time duration, then it is actually difficult to say which state is dominating for that time duration. This can be well verified by applying maximum length algorithm and calculating σ for the duration. Further, it is easy to see that values of $\bar{L}(S_j)$ for j = 1, 2, 3, 4 are constrained by the value of T i.e$\sum_{j=1}^{4} \bar{L}(S_j) \leq T$. This means that if one of $\bar{L}(S_j)$ has a large value, then other values would be small. This ensures that if the maximum value of length of run of each state is not much different from the values of the lengths of other runs, then values of $\bar{L}(S_j)$ tend to come close to each other and σ will tend to zero which would imply that none of the states are dominant.

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