Relationship between Treasury Bill Rates in India: An Empirical Analysis

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ABSTRACT

Objective of the present paper is to see whether there exists any relationship between Treasury Bill rates of various maturities in India, in post interest rate deregulation period. Stationarity of the series as well as the residuals have been tested by Augmented Dickey-Fuller (ADF) test statistic. Further Engle-Granger (EG) cointegration technique has been used to find long run co-integration followed by Error Correction Mechanism (ECM).The results show that 6M and 3M Treasury Bills are co integrated and 0.32 of the discrepancy in the rates in previous month gets eliminated in present month. This implies long run relationship and short run correction in Treasury Bill rates, which is important for the market of Treasury Bills of various maturities to run efficiently.

Keywords: *Government borrowing, Treasury bill rate, Cointegration, Error Correction*

I. Introduction

In a Developing Economy, demand for resources to provide social and economic infrastructure has to be balanced with its resource generating capacity.In most of the underdeveloped countries the vicious circle of poverty (as predicted by Nurkse, 1962) continues. To break this vicious circle and move towards self sustaining growth path, large amount of initial investment is necessary. This need for resources can be met either through tax and non tax sources of revenue or through Government borrowing, also called as public debt.

Interest rate on Government borrowing has two-way implications. Higher rate may bring in more lenders and hence increased availability of funds, but will also lead to higher interest payment burden on the revenue account, apart from the interest burden on future generations. Moreover, in a market driven capitalistic economy, most markets follow a reference or benchmark rate. Generally, a risk neutral rate, such as Treasury Bill rate is taken as benchmark because of its gilt edged character. This, coupled with the realization about growing integration of financial markets worldwide, makes an important argument in favour of studying the pattern of Treasury Bill interest rates in India.

II. Review of Literature

The issue of public debt is not a contemporary one. In the history of economic thought there have been discussions and divided opinions regarding benefits and cost of public debt. Hume (1742) was one of the first English writers to address specifically on the subject of public credit. Smith (1776) devoted 40 pages of *wealth of nations* to public debt. Economists like Keynes (1936) supported deficit budgeting, giving the argument that it would help in creating effective demand in the economy. The Keynesian view envisaged that an increase in autonomous government expenditure, whether investment or consumption, financed by borrowing would cause output to expand through a multiplier process.

Studies available on post-reform public debt scenario have concentrated mainly on sustainability of debt, as that of Rangarajan and Srivastava (2003), Rajaraman and Mukhopadhyay (2005). There are significant studies by Domar (1944), Barro (1974), Moorthy, Singh and Dhal (2000) which have focused on issues like bond financing, interest rates and burden of debt.

As far as Treasury Bill rate dynamics are concerned, in International literature, one of the foremost studies by Hall, Anderson and Granger (1992) showed that yields of U.S. Treasury Bills are cointegrated post 1982. This cointegrating relationship further implied a single non-stationary common factor underlining the time series behaviour of each yield to maturity. The study concluded that for US economy, an error correction model which uses spreads as the error correction terms is unstable over the Federal Reserve's policy regime changes.

In a 1992 study, Hafer, Hein and MacDonald compared four readily available 1-quarter-ahead forecasts of the 3-month U.S. Treasury-Bill rate. The forecasts considered were: a prediction from the futures market, a forecast derived from an implicit forward rate calculation, a survey-gathered forecast, and a no-change forecast. Each forecast was examined for general forecast accuracy and for the extent of bias contained in each forecast over the 12-year period 1977-88. Results indicated that the futures rate statistically dominates the other three forecasts, while the survey and forward rate projections generally are found to be the least accurate and most biased.

In their 1992 NBER working paper, Hendershott and Peek sought to identify the underlying determinants of the major movements in real six-month Treasury Bill rates. They showed that the rise in real interest rates between the middle 1970s and early 1980s resulted from a variety

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of factors like OPEC shock, which lowered investment demand and increased world saving by transferring wealth from the high-consuming developed countries to OPEC. Secondly, tight money, high inflation, and heightened nuclear fear all contributed to real rates becoming unusually high in the early 1980s. They concluded that the decline in real rates to more normal levels in the 1986-88 period was due to multiple factors like lower inflation, declining marginal tax rates, and easy monetary policy.

Chan et al. (1992) made an empirical comparison of alternative models of the short-term interest rate by estimating and comparing a variety of continuous-time models of the short-term riskless rate using the Generalized Method of Moments, and found that that the most successful models in capturing the dynamics of the short-term interest rate are those that allow the volatility of interest rate changes to be highly sensitive to the level of the riskless rate.

Duffee (1996) showed increase in the importance of two types of variation in Treasury Bill yields for US economy beginning in the early 1980s and suggested that idiosyncratic variation in individual short-maturity (less than three months) Bill yields reflects increased market segmentation. Sarno and Thornton (2003) examined the dynamic relationship between two key US money market interest rates––the federal funds rate (FF) and the 3-month Treasury Bill rate using daily data over the period from 1974 to 1999.They found that long-run relationship between these two rates was remarkably stable across monetary policy regimes of interest rate and monetary aggregate targeting.

Vuyyuri (2004) employed monthly short-term interest rate data over the 1992-2002 period to investigate the influence that the Japanese and the American interests exert on interest rates in India; using cointegration and causality tests to find the existence of a steady-state relationship of short-term interest rates in India with both US and Japan. The findings indicated that interest rates in India responded well to those in US and Japan and confirmed that the national short-term interest rate linkage was a steady state, long-run phenomenon, and rates were cointegrated. Dua and Raje (2010) examined the determinants of the Government yields in India using weekly data from April 2001 through March 2009,covering Treasury Bills with residual maturity of 15-91 days and Government securities of residual maturity one, five and ten years respectively. Their empirical estimates showed that a long-run relationship exists between each of these interest rates and the policy rate, rate of growth of money supply, inflation, interest rate spread, foreign interest rate and forward premium. At the same time, the empirical results also showed that the relative importance of the determinants varies across the maturity spectrum. The normalized generalized variance decompositions suggested that the policy rate and the rate of growth of high powered money are less important in explaining the proportion of variation in longer term interest rates. Sanati (2010) against the backdrop of financial liberalisation examined India's financial integration, both on the domestic and international fronts. For 2001-2007, empirical evidence revealed high liquidity in the Indian capital market. The Johansen and Juselius cointegration test, in a multi-equation framework revealed co-movement among the domestic money, capital and foreign exchange markets with strong co-movement between the short-term money and foreign exchange markets. Using a stochastic time series analysis, paper showed that the Law of One Price (LOOP) holds for Indian call money market rates. The findings on the 91-day Treasury Bill rate and the 10-year government bond yield reveal very weak cross-border cointegration.

III. Objectives

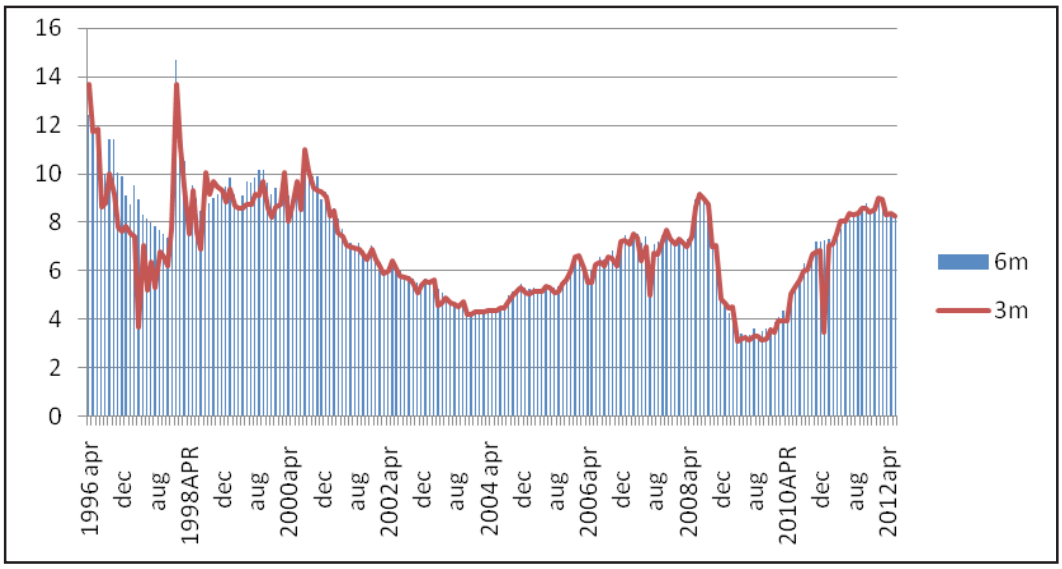
- To see whether there is any long run co-integration between three month and six month Treasury Bill rate in India.
- To examine the short run relationship between three month and six month Treasury Bill rate in India.

IV. Data Sources and Methodology

The study is based on monthly data on three and six month Treasury Bill interest rates collected from RBI 'Handbook of Statistics on Indian Economy' for the period April 1996 to June 2012. Both the chosen rates are taken in per cent form. The methodology firstly involves test of stationarity of Treasury Bill series using Unit root test (Augmented Dickey-Fuller Test). If a series is found to be non stationary, spurious regression problem may arise from regressing a non stationary time series on one or more non stationary time series. In such a situation, one must transform a non stationary time series to make it stationary (Gujarati, 2007). Further I have used Engle-Granger test to show the long run co-integration between two series. Engle-Granger Error Correction Mechanism is used to reveal the nature of short run relationship. The choice of the time period is on the basis of issuance of Treasury Bills. Slight gaps in the data have been filled on the basis of linear interpolation.

Figure I graphically shows the relationship between two rates for a total of 195 observations. Per cent yield on T-Bills is shown on vertical axis, whereas time is shown on horizontal axis. The Treasury Bill rate in India has shown quite a variation in the period under consideration. The three month Treasury Bill rate has varied between 13.7 per cent in April 1996, and January 1998 to 3.1 per cent in July 2009. Similarly fluctuations are seen in six month Treasury Bill rates (as shown in figure I). Figure I also reveals that more or less both rates are moving in tandem with each other.

Figure I
3M and 6M Treasury Bill Rates (1996-2012) in Percentage



Source: Data from *Handbook of Statistics on Indian Economy* (2011-12), Reserve bank of India , table 182,p. 309.

V. Empirical Estimation:

On the basis of unit root test of stationarity, 3M T Bills was found to be stationary at 5% level while taking only intercept, though this series was found to be non-stationary at 5% when intercept and trend both were taken, but trend was not significant . Similarly 6M T Bills series was found to be stationary at level (with drift). For three month Treasury Bill rate,

Null Hypothesis: 3MTBR has a unit root/ is not stationary

Alternate Hypothesis: 3MTBR does not have unit root/ is stationary

Stationarity in a time series is important, because if a time series is non stationary, one can study its behaviour only in the time period under consideration and it is not possible to generalise the results to other time periods. Even if series comes out to be nonstationary at level; (i.e. if null hypothesis is accepted),attempt has to be made to see the order at which it becomes stationary (at first difference or at second difference and so on) so that order of cointegration could be found. According to Engle Granger methodology if two series should be stationary at same order I (d), only then one can find the cointegration between them.

Table I
ADF Test Results for Three Month Treasury Bill Rates

3MTBR	Constant and Trend	Constant	Result
At Level	-3.133095	-3.359294*	Reject null Hypothesis at level
	(-3.433278)	(-2.876356)	with constant
	(Trend was found to be insignificant)	{0.0137}	

Notes : *Augmented Dickey-Fuller (tau) test statistic is shown in ( ) brackets, **MacKinnon (1996) one-sided p-values are given in { } brackets., ***All results are at 5 per cent level of significance.

Similarly, for six month Treasury Bill rate,

Null Hypothesis: 6MTBR has a unit root/ is not stationary

Alternate Hypothesis: 6MTBR does not have unit root/ is stationary

If six month T-Bill series is not stationary at level, then one can see the long run relationship between three and six month Treasury Bills only if it becomes stationary at same level of differencing (first difference or more) as that of three month T-Bill rate.

Table II
ADF Test Results for Six Month Treasury Bill Rates

6 M TBR	Constant and Trend	Constant	Result
At Level	-2.684606	-2.917742*	Reject null Hypothesis at level
	(-3.433156)	(-2.876277)	with constant
	(Trend was found to be insignificant)	{0.0082}	

Notes : *Augmented Dickey-Fuller (tau) test statistic is shown in ( ) brackets, **MacKinnon (1996) one-sided p-values are given in { } brackets., ***All results are at 5 per cent level of significance.

Though both series were found to be stationary, as the paper wanted to find both long run as well as short run relationship between Treasury Bill rates, I have used Engel-Granger cointegration regression to find long run relationship followed by error correction mechanism (ECM) for short run relationship.

I have used the following cointegration regression:

$TB6_t = \alpha_0 + \alpha_1 \ TB3_t + U_t$ .....(1)

Where $U_t = TB6_t - \alpha_0 - \alpha_1 \ TB3_t$

Regressing the 6-month TBR on 3-month TBR following regression was obtained:

$\widehat{TB6_t} = 0.52 + 0.974\ TB3_t$ .....(2)

t = (2.8127) (37.61)

p (.005) (.000)

F-statistic = 1414.395 Prob. (F-statistic) = 0.000000

R^2 = 0.8799 (88%) =0.8793

The value of R square and adjusted R square was very high. Then i applied the unit root test to the residuals obtained from this regression, residuals were found to be stationary (Table III). Stationarity of residual (error term) shows long run relationship between two Treasury Bill rates .Both were found to be integrated at order zero I(0).

Null Hypothesis: Residual U has a unit root/ is not stationary

Alternate Hypothesis: Residual U does not have unit root/ is stationary

Table III
ADF Test Results for Residual Term U

RESIDUAL STATIONARITY	Constant and Trend	Result
At Level	-5.411483* (-3.433278) { 0.0001} Significant trend	Reject null Hypothesis at level with constant and trend

Notes : *Augmented Dickey-Fuller (tau) test statistic is shown in ( ) brackets, **MacKinnon (1996) one-sided p-values are given in { } brackets., ***All results are at 5 per cent level of significance.

Error Correction Mechanism (ECM)

As I also wanted to see short run behaviour of Treasury Bills, I further used error correction model (ECM) represented as,

$\Delta TB6_t = \alpha_0 + \alpha 1 \ TB3_t + \alpha_2 \ U_{t-1} + \alpha_t$ .....(3)

and got following results:

$= -.006 + 0.517 \ \Delta TB3_t + 0.318$

t = (-0.192) (15.337) (-6.901)

Sig. (0.848) (0.000) (0.000)

Where is the lagged value of the error correction term from the preceding period.

R^2 = 0 .559 (56%) =0.554 Durbin-Watson = 2.002

VI. Discussion of the Results

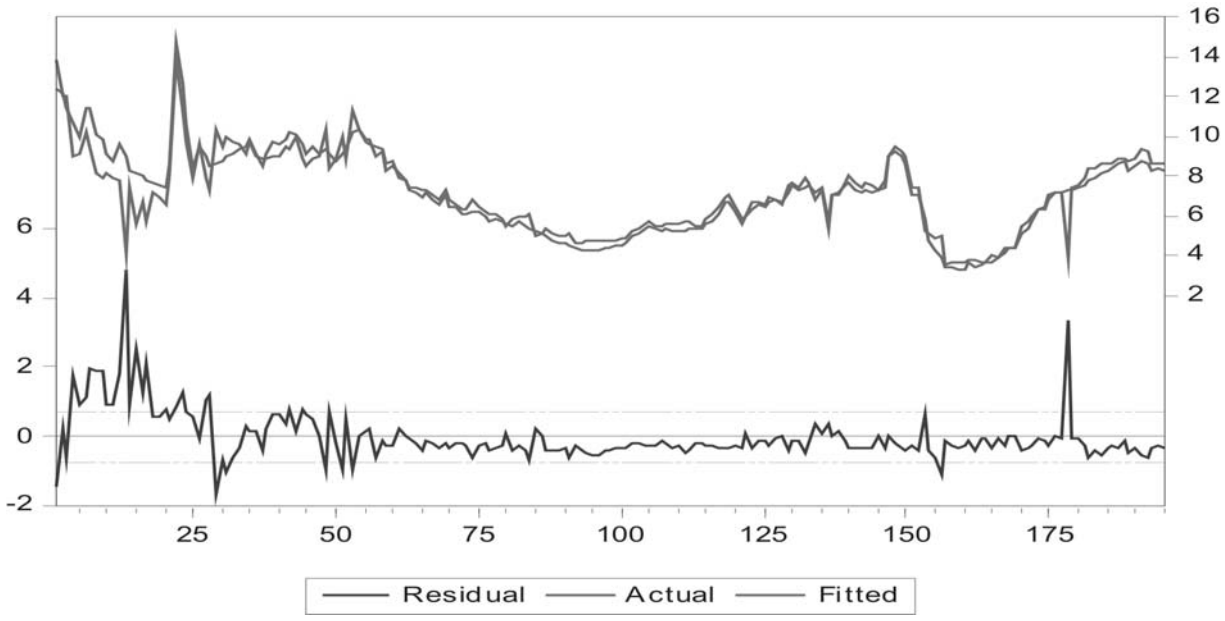
For any analysis based upon financial time series, it is important to see whether the time series is stationary or not. Stationary series means the mean and variance of the series are constant over time and the value of covariance between the two time periods depends only on the distance between the two time periods and not the actual time at which the covariance is computed. Stationarity is important because if a time series is nonstationary one can study its behaviour only for the time period under consideration, and it will not be possible to generalise it to other time periods. That means for the purpose of forecasting, a nonstationary time series may be of little practical value. Gujarati, 2007. Furthermore, regression of a nonstationary time series on other nonstationary time series may produce spurious regression. In such a situation, one solution is to see whether two series are cointegrated or not. Two (or more) variables are said to be cointegrated if they have a long term relationship between them. According to Granger (1986), a test for cointegration can be thought as a pre-test to avoid spurious regression.

Objective of the present study is to see if there is any relationship between Treasury Bills of various maturities in India. Though on plotting, various Treasury Bills (14 day,91 day,181 day and 364 day),seemed to follow approximately similar trends ,aim was to prove the relationship empirically. The analysis was done using data on Treasury Bills of three month (91 days) and six month (181 days) maturity. Individually, the T Bill series were found to be stationay at level and empirical analysis shows that there is a stable long term relationship between them. The residual error term was found to be stationary showing that the two series were cointegrated i.e. there is there is long term equilibrium relationship between them.

Despite having a long term equilibrium relationship, there may be disequilibrium in Short run. The error term U_t in equation (1) can be called as equilibrium error and can be used to tie the short run behaviour of T-Bill rates to their long run behaviour. For this, I have used error correction mechanism (ECM) as shown in equation (3).

ECM equation (3) shows that change in six month T-Bill rate ($\Delta TB6_t$) depends on change in three month T-Bill rate ($\Delta TB3_t$) as well as on equilibrium error term, Where Δ is first difference operator, is random error term and U_{t-1} is one period lagged value of error term from equation (1).The absolute value of β_2 decides the quickness with which equilibrium is restored between two rates.

Figure II: Plots of Actual, Fitted and Residual Series of 6M TBR



The results show that 6M and 3M Treasury Bills are co integrated and 0.31 of the discrepancy in the rates in previous month gets eliminated in present month. Since T-Bill rates are taken in per cent form, results show that if the six month Treasury Bill rate was higher than three month Treasury Bill rate more than expected in previous month, this month it will be reduced by 0.318 i.e. 32 per cent to restore the long run equilibrium relationship between the two rates.

VII Conclusion

Prior to April 1997 RBI was a captive holder to government for the sale of these Treasury Bills according to RBI report on currency and finance (2004-05).The origins of *ad hoc* Treasury Bills to finance Government deficit can be traced to the First Five Year Plan, although their volume was to be limited to the extent that it was non inflationary. However, an operational arrangement in early 1955, which was reached between the Government of India and the Reserve Bank of India, enabled automatic creation of *ad hoc* Treasury Bills to restore Central Government's cash balance to the minimum stipulated level. Although initially it was supposed to be a temporary arrangement but with time ad hoc Treasury Bill financing as well as their funding into dated securities became a regular feature. As it was leading to monetisation of debt, as a part of post reform financial market restructuring, an agreement between RBI and Government led to phasing out of ad-hoc T-Bills since 1.4.1997. It is after 1997 that Treasury Bill market in India has started becoming independent. The results of present paper show long run relationship and short run correction in Treasury Bill rate, which is important for the market of Treasury Bills of various maturities to run efficiently.

References :

Barro, R.J. (1974). Are Government Bonds Net Wealth? ***Journal of Political Economy***, 82, November/December, 1095-1118.

Chan, K.C., Karolyi, G.A., Longstaff, F A. and Sanders, A.B. (1992). An Empirical Comparison of Alternative Models of the Short-Term Interest Rate. ***The Journal of Finance***, 47, 1209–1227.

Domar, E. (1944). The 'Burden' of Public Debt and National Income. ***American Economic Review***, 34, 798-827.

Dua, P. and Raje, N. (2010). Determinants of Weekly Yields on Government Securities in India. ***Working Paper No. 187***, Centre for Development Economics, Department of Economics, Delhi School of Economics.

Duffee, G. R. (1996). Idiosyncratic Variation of Treasury Bill Yields. ***The Journal of Finance***, 51, 527–551.

Economic Survey (2007-08). Government of India, Ministry of Finance.

Goyal, R. (2004). Does Higher Fiscal Deficit Lead to Rise in Interest Rates? An Empirical Investigation. ***Economic and Political Weekly***, 39(21), 2128-2150.

Granger, C.W.J. (1986). Development in the Study of Cointegrated Economic Variables. ***Oxford Bulletin of Economics and Statistics***, Vol. 48, 213-227.

Gujarati, D. N. (2007). ***Basic Econometrics***. Fourth edition. Tata McGraw Hill,811-850.

Hafer, R.W., Hein, S. E. and MacDonald, S.S. (1992). Market and Survey Forecasts of the Three-Month Treasury-Bill Rate. ***The Journal of Business,*** 65(1), 123-138.

Hall, A.D., Anderson, H.M. and Granger, C. W. J. (1992). A Cointegration Analysis of Treasury Bill Yields. ***The Review of Economics and Statistics***, 74(1), 116-126.

Handbook of Statistics on Indian Economy, Reserve Bank of India 2011-12.

Hendershott, P.H. and Peek, J. (1992). Treasury Bill Rates in the 1970s and 1980s. ***NBER Working Paper*** No. 3036, (Also Reprint No. r1735).

Hume, D. (1742).***Essays, Moral, Political and Literary***. Part II, Essay IX, Of Public Credit. Retrieved from http:/ www.econolib.org/library/LFBooks/Hume/

Keynes J.M. (1936). ***The General Theory of Employment, Interest and Money***. Book I, Chapter3: The Principle of Effective Demand. Retrieved from http://www.marxists.org/ reference/subject/economics/keynes/general-theory/

Mac Kinnon, J.G. (1990). Critical Values for Co-integration Test. Queen's Economics Department Working Paper No. 1227, retrieved from http://qed.econ.queensu.ca/ working_papers/papers/qed_wp1227.pdf

Moorthy, V., Singh, B. and Dhal, S. C. (2000). Bond Financing and Debt Stability: Theoretical Issues and Empirical Analysis for India. ***Development Research Group Study***, *19*, RBI, Mumbai.

Nurkse, R. (1962). ***Problem of Capital Formation in Underdeveloped Countries***. pp 4, Oxford University Press.

Rajaraman, I. and Mukhopadhyay, A. (2005). ***Sustainability of Public Debt*****, in Amresh Bagchi (ed.)** ***Readings in Public Finance***. 320-338, Oxford University Press.

Rangarajan, C. and Srivastava, D.K. (2003). Dynamics of Debt Accumulation in India: Impact of Primary Deficit, Growth and Interest Rate. ***Economic and Political Weekly***, Nov. 15, 4851-4858.

Report on Currency and Finance (2004-05). Reserve Bank of India.

Sanati, G. (2010). Integration of India's Financial Markets on the Domestic and International Fronts: An Empirical Analysis of the Post Liberalisation Period. ***Working Paper No. 431***, Centre for Development Economics, Department of Economics, Delhi School of Economics.

Sarno L. and Thornton, D. L. (2003). The Dynamic Relationship between the Federal Funds rate and the Treasury Bill rate: An Empirical Investigation. ***The Journal of Banking and Finance***, 27(6),1079-1110.

Smith, A. (1776). ***An Inquiry into the Nature and Causes of the Wealth of Nations***, Book V, 'Of the Revenue of the Sovereign or Commonwealth', Chapter III, 'Of Public Debts'. pp 1153-1208.London: W. Strahan and C. Kadell Publishers.

Vuyyuri, S. (2004). Linkages of Indian Interest rates with US and Japanese rates. ***Applied Econometrics and International Development***. AEEADE, Vol. 4-2.Retrieved from http://www.usc.es/econo met/aeid422.pdf

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Reference # Envision - C -11