CRISPUS

General and Social Science: Current Trends
CAO Yirany, et al. Gen Soc. Sci. Cur. Tr. 2019:1:1:1
2019: Vol 1: Iss 1: 1

Original Research Article

The Impacts of Macroeconomic factors on Chinese Short-term Treasury Yield-An Application of a Vector Error Correction Model

CAO Yiran[1*], SHEN Jiehui[2], WANG Dong[2], ZHAO Yanling[2]

[1]Department of Management Sciences, City University of Hong Kong, Hong Kong

[2]Department of Economics, Lingnan University, Hong Kong

Received: 24 February 2019

Accepted: 07 March 2019

[*]Correspondence:

CAO Yirany

E-mail: yirancao@cityu.edu.hk

ABSTRACT

In this research, we find that the short-term Chinese treasury yield is cointergrated with a group of six macroeconomic variables by employing the vector error correction model (VECM) in the system of seven equations. The signs of the long-term elasticity coefficient of four of the selected variables on treasury yield support the hypothesized relations and are robust to different combinations of macroeconomic variables in four-dimension systems. The money supply and shanghai inter-bank offered rate have positive impacts on Chinese short-term treasury yield, while the stock market performance and trade balance are negatively correlated to the treasury yield. However, the effects of economic growth and inflation are not robust in our empirical analysis.

Keywords: Treasury yield, VECM, Cointegration, Macroeconomic variables

JEL Codes: E4, G1

INTRODUCTION

In the context of Chinese interest rate marketization, the performance of bond market has more and more closely correlated with macroeconomic factors such as economic situation, inflation level, and monetary policy. As the basic risk-free rate for a nation, Chinese treasury yield can not only reflect the expectation on future economic growth but also the expansion or contraction of monetary market. Thus, research on the effects of macroeconomic factors on Chinese treasury yield has the important theoretical and practical significance in the process of marketization of interest rates in China.

From the theoretical point of view, the study on Chinese treasury yield curve was relatively later compared with developed countries. Previous research on Chinese treasury yield focus more on the basic theoretical perspective and are lack of the comprehensive empirical analysis on the macroeconomic determinants that make great difference on the performance of Chinese short term treasury yield. So in this research, we collect time series data and employ the vector error correction model to achieve the goal that mentioned above.

From the practical point of view, evidence from developed countries shows that the interest rate policy and the bond market are complementary and mutual. Without the well-developed bond market, it will be difficult to realize interest rate marketization. Strengthening the research on treasury bond yield curves and macroeconomic relations will promote the process of interest rate liberalization in China and further assist bond issuers, investors and policy makers to make timely and appropriate adjustment according to treasury yield curve.

LITERATURE REVIEW

Domestic

Chen & Shen [1] employed the Nelson-Siegel model to construct Chinese treasury yield curve. The model includes three parameters: horizontal factor, slope factor and curvature factor, which estimated by auto regressive model. They made comparison between random walk model, Nelson-Siegel model and Multi-step prediction in predicting treasury yield curve. The result showed that the random walk model was better than the Nelson-Siegel model in forecast at a whole, and the accuracy of 90-day Multi-step prediction was much better.

Yang [2] analysed treasury yield curve by using Nelson-Siegel Svensson method and the data of bond transactions among banks. At the same time, this paper analysed the multiple factors which affected bond yield curve. It considered that money supply, 7-day repo rate of bank and the change of Shanghai Composite Index yield had a greater impact on short-term treasury bonds while medium and long-term bonds were more sensitive to the change of deposit reserve ratio, and changes in inflation rate had a greater impact on treasury bonds yield in all maturities.

Li et al. [3] studied the level of inflation rate in forecasting Chinese treasury yield curve. Taking the 3-year and 5-year treasury yield as a sample, this research found that the yield curve of medium and long-term treasury bonds contains more Information in term of future inflation changes. Therefore, the yield curve of medium-term treasury bonds can be used as an indicator of inflation rate. It also indicated that because the nominal interest rate term structure contains important information about the real interest rate since Chinese real interest rate is not stable.

Cai et al. [4] selected the yield data of treasury bonds from 2004 to 2010, and adopted the macro-control and inflation indicators as the macroeconomic indicators that affect the yield of government bonds. They constructed the multiple regression models by using principal component analysis. The results showed that the bond yields and inflation rate were positively correlated, indicating that Chinese bond yields and inflation have a significant correlation.

Foreign

The theory of term structure of interest rate in foreign countries developed earlier. Evan Fisher proposed the Expected Assumptions Theory in 1896, which formed the earlier term structure theory of interest rates together with market segmentation theory and liquidity preference theory. The later theory treated the term structure of interest rates as a stochastic process, which stated that the term structure of interest rates is a time-dependent stochastic functional relationship model.

Mishkin [5] examined the relationship between interest rates and inflation. Results showed that the term structure of interest rates less than 6 months contained such limit inflation information that it could not predict the future inflation effectively. In the mean-while, this research found that the term structure of interest rate for 9-12 months included more information that could be better used to predict future inflation. However, it contained more information on future inflation, but did not further reflect real interest rates.

Litterman & Scheinkman [6] proposed a factorial model, believing that the changes in the bond yield curve could be explained by three factors: horizontal, slope and curvature. It is found that the horizontal factors affected the parallel movement of the yield curve, which reflected the role of the parallel movement factors in the change of the yield curve. The influence of the slope factor on interest rates varied according to different periods, demonstrating the effects of different degrees of short-term and long-term yields factors. Curvature factors accounted for effects other than horizontal and slope factors.

Ang et al. [7] constructed a dynamic model of GDP growth and treasury yields, which was not a non-arbitrage model but a better predictor of GDP growth. The study found that short-term interest rates were more predictive in GDP growth than any other terms. The study also suggested using the lagged GDP and the yield of the longest deadline in measuring the slope of the yield curve. Efficient yield curve model is better than the least squares regression when predicts GDP growth rates.

Diebold et al. [8] constructed a model that incorporates the underlying factors used in the yield curve (notably the horizontal factor, slope factor and curvature factor) and macroeconomic variables (investment, Inflation rates, and monetary policy tools). The purpose of constructing this model is to depict the direct dynamic relationship between the macro economy and the yield curve. The study found that the future change of the yield curve was closely related to macroeconomic variables, and the reversal of inflation also had highly correlation with macroeconomic factors.

HYPOTHESIZED EQUILIBRIUM RELATIONS

We select six macroeconomic variables based on their hypothesized effect on performance of treasury yield in the basic valuation model. These variables are: economic growth (IP), inflation (CPI), money supply (M), Shanghai inter-bank offered rate (SBR), stock market performance (CSI), and trade balance (TB). The definition of the variables used to proxy the Chinese treasury yield and the six macroeconomic factors are provided in Table 1. Economic interpretation of the first difference in the logarithm of each variable is shown in the lower panel of **Table 1**.

Variables	Proxy Indicator	Data Sources
Treasury Yield (YTM)	One-year treasury yield	Investing
Economic Growth (IP)	Industrial Production Index	National Bureau of Statistics of China
Inflation (CPI)	Consumer Price Index	National Bureau of Statistics of China
Money Supply (M2)	M2	National Bureau of Statistics of China
Inter Bank Offered Rate (SBR)	Shanghai Interbank Offered Rate	SHIBOR
Stock Market Performance (CSI)	Shanghai Shenzhen CSI 300	Bloomberg
Trade Balance(TB)	Total value of exports-total value of imports	National Bureau of Statistics of China
Time-Series Transformation*		
$\Delta YTM_t = In[YTM_t / YTM_{t-1}]$	Growth rate of treasury yield	
$\Delta IP_t = In[IP_t / IP_{t-1}]$	Growth rate of industrial production	
$\Delta CPI_t = In[CPI_t / CPI_{t-1}]$	Realized inflation rate	
$\Delta M2_t = In[M2_t / M2_{t-1}]$	Growth rate of money supply	
$\Delta SBR_t = In[SBR_t / SBR_{t-1}]$	Changes in Shanghai Interbank Offered Rate	
$\Delta CSI_t = In[CSI_t / CSI_{t-1}]$	Changes in CSI 300	
$\Delta TB_t = In[TB_t / TB_{t-1}]$	Changes in trade balance	

Table 1: Definitions of Variables.

We hypothesize a positive relation between the economic growth and treasury yield. First, the process of economic growth is usually accompanied by inflation. Therefore, on one hand, the yield of medium and long-term treasury bonds will be correspondingly higher; on the other hand, when economy of a country is experiencing prosperity, the stock market is more sensitive to economic growth. A great amount of money will flow into the stock market, so that bond market will be relatively deserted. In response, bond issuers will raise the yield to attract investors. Thus, we hypothesize that the long-term treasury yields and economic growth are usually positively correlated.

We hypothesize a positive relation between the inflation and treasury yield. It is known that the treasury yields in mature markets represent the nominal interest rate and

macroeconomic data. The sample period spans September 2012 to August 2017, consisting of 60 monthly observations for each variable. We choose 2012 as the starting year because the data for all the variables in this research become more completed and accessible around this period. Also, we consider the period around 2008 is more likely affected by the US financial crisis, and this impact was gradually got rid of by 2012.

Testing for Cointegration

While Engle & Granger provide methods of testing for cointegration in a single-equation framework, the method introduced by Johansen [11] allows testing for cointegration in a system of equations. The latter method does not require specific variables to be normalized and gives more efficient estimators of cointegrating vectors (Phillips [12]).

The VECM takes the following form:

$$\Delta Y_t = \sum_{j=1}^{k-1} \Gamma_j \Delta Y_{t-j} + \alpha\beta Y_{t-k} + \mu + \varepsilon_t \qquad (1)$$

Where Δ is the first difference notation, Y_t is a p × 1 vector integrated of order one, μ is a p × 1 constant vector representing a linear trend in a system, k is a lag structure, and ε_t is a p × 1 Gaussian white noise residual vector. j is a p p matrix and indicates short-term adjustments among variables across p equations at the j^{th} lag. The two matrices α and β are of dimension p × r, where denotes the speed of adjustment and represents the cointegrating vectors. If variables are cointergrated, there will be a linear combination of βY_t (a long-term equilibrium relation), although Y_t itself is non-stationary. As shown in equation (1), in the presence of cointegration a VAR in first differences is misspecified, as it omits the error correction term ($\alpha\beta Y_{t-k}$) and thus overlooks the long-term equilibrium relation. Johansen's [11] VECM employs the full information maximum likelihood method, and it is implemented in the following steps:

- Test whether all variables are integrated of order one by applying a unit root test;
- Find the truncated lag(k) such that residuals from each equation of the VECM are uncorrelated;
- Regress ΔY_t against the lagged differences of ΔY_t and Y_{t-k}, and estimate the Eigen-vectors (cointegrating vectors) from the Canonical correlations of the set if residuals from these regression equations;
- Determine the order of cointegration.

The order of cointegration (r) indicates the dimension of the cointegrating space and is determined by constructing the following test statistics:

$$Trace = -T \sum_{i=r+1}^{p} In(1-\hat{\gamma}_i)$$

$$\gamma_{\max} = -T\, In(1-\hat{\gamma}_{r+1})$$

Where γ are the estimated Eigen-values. These statistics do not represent the regular chi-square distributions, but as Johansen shows, they weekly converge to a function of (p - r) dimensional Brownian motion. Johansen & Juselius [13] compute the critical values of this function, and Osterwald-Lenum [14] recalculates and extends the critical values for higher dimensions. The presence of a linear trend in the VECM alters the asymptotic distributions, consequently changing these critical values. Therefore, we apply the likelihood ratio (LR) test to determine if a linear trend exists.

Testing for a Linear Restriction on the Cointegrating Vector:

Since we aim to examine the relation between the Chinese treasury yield and macroeconomics variables, it is necessary to test whether stock prices contribute to the cointegrating relation. We employ the LR tests developed by Johansen [11] by imposing linear restrictions on the matrices of cointergrated vectors. The hypothesis for a linear restriction in the matrix of cointegrating vectors can be written as:

$$H_0 : \beta = H_\varphi$$

Where is a (p + 1) r cointegrating matrix, H is a (p + 1) s matrix with (p + 1 s) restrictions, and ' is a s r matrix for a case without a linear trend. The test statistic is

$$LR = T\sum_{i=1}^{r} In(1-\hat{\gamma}_{H,i})/(1-\hat{\gamma}_i)$$

Where LR is distributed as a Chi-square with r(p + 1-s) degrees of freedom, $\gamma_{H,i}$ and γ_i are the eigenvalues based on restricted and unrestricted eigenvectors respectively.

RESULTS

In this section we present the result of the impacts of these six determinants on the monthly performance of treasury yield by adopting the Vector Error Correction Model (VECM).

Stationary Test

We employ the augment Dickey and Fuller (1981) test to determine the presence of a unit root. Table 2 reports the results of the ADF test for lnfY T M; IP; CP I; M2; SBR; CSI; T Bg and the first difference of these series respectively. The main reason for taking the logarithm form for our variables is to alleviate the collinearity and heteroscedasticity within the model constructed in this research. As the results shown, only the time series for and pass the ADF test under the significance of 5%, indicating the unit root exist in the logarithm time series for the remaining ve macroeconomic variables under the criteria of ADF test. However, the results are robust for the first difference series, demonstrating that all-time series variables are integrated of order one.

	Z(t)	p		Z(t)	P
lnYTM	-1.023	0.155	D_lnYTM	-5.473	0.000***
lnIP	-1.201	0.911	D_lnIP	-7.71	0.000***
lnCPI	-0.879	0.958	D_lnCPI	-2.76	0.064*
lnM2	-2.276	0.447	D_lnM2	-9.428	0.000***
lnSBR	-3.845	0.014**	D_lnSBR	-7.889	0.000***
lnCSI	-2.145	0.521	D_lnCSI	-8.867	0.000***
lnTB	-3.73	0.021**	D_lnTB	-10.71	0.000***
*Significant at the 10% level					
**Significant at the 5% level					
***Significant at the 1% level					

Table 2: Augment Dickey and Fuller (ADF) Test for Presence of Unit Root.

Equilibrium Relations

We report the results of the T race tests in **Table 3** based on k = 1. The result indicates there is more than one cointegrating relation. The T race test rejects the null hypothesis of the r 3 in favour of r = 4. We conclude that there are four cointegrating relation existing in our model. In the presence of more than one cointegrating vector, Johansen and Juselius [13] consider the first eigenvector to be the most useful. Accordingly, we base our analysis on the cointegrating vector by the largest eigenvalue. The cointegrating vector is given by

$$\beta = \{1, -0.0547, 0.0513, -1.2669, -0.0034, 0.7166, 0.0012, -0.0035\}$$

These values represent the coefficients for YTM (normalized to one), IP, CPI, M2, SBR, CSI, TB, and a linear trend, and are long-term elasticity measures due to logarithmic trans-formation. The **Table 4** shows the estimated coefficients for cointegrating equations, thus the above vector can be expressed as:

The test shows that YTM contributes to this cointegrating relation and is significant at the 1% level. It is shown in **Table 3** that the t-test statistic for M2 is 3.00 and is significant at 1% level. Thus, as we hypothesize the relation between the YTM and the money supply (M2) is positive, namely, YTM increases as the more expansionary monetary policy imposed by central bank. Table 3 also reports the positive relation between the Shanghai Inter-bank Offered Rate and Chinese treasury yield, with the t-statistic of 5.28 and significant at 1% level, which is also in line with our hypothesis. Similarly, as hypothesized the stock market performance, representing by CSI 300 Index, are negatively correlated with the treasury yield with a t-statistic test of -3.42 and robust at the 1% significance level, indicating the Seesaw Effect existing between the stock market and bond market. Also, as we hypothesize, the relation between Chinese trade balance and treasury yield is negative. The t-test for the trade balance (TB) is -2.56 and significant at 1% level, implying a stable foreign exchange policy imposed by Chinese government.

However, the relation between the Industrial Production Index (IP) and the treasury yield (YTM) is not significant from our empirical results.

Maximum Rank	Trace	CV(Trace)
0	170.226	124.24
1	121.555	94.15
2	84.092	68.52
3	48.439	47.21
4	26.051*	29.68
5	6.188	15.41
6	0.148	3.76
* fails to rejected and in favour of the null hypothesis that the maximum rank is 4.		

Table 3: Test Statistics for the Number of Cointergrated Vectors

	Coefficient	Z(t)	p
IP	0.0547	0.29	0.773
CPI	-0.0513	-1.11	0.267
M2	1.2669	3	0.003***
SBR	0.0034	5.28	0.000***
CSI	-0.7166	-3.42	0.001***
TB	-0.0012	-2.56	0.010***
***Significant at the 1% level.			

Table 4: The Results for Cointegrating Equations

We can analyse the reason behind from the point of view of the interaction between capital supply and demand. The reduction of social capital supply but constant capital demand raises the capital cost, along with the decreasing growth rate in economic growth, the yield of government bonds deviates from economic growth. On the one hand, in the context of low savings and capital out flows, the capital supply has decreased; on the other hand, once an expansionary fiscal policy and moderately positive monetary policy after the US financial crisis allow the financial sectors and physical sectors add leverage, but the de-leverage policy forces these sectors to contract their liabilities, and thus the capital demand is di cult to be lowered. Thus, there is a chance for the treasury yield deviating from the economic growth because it is also derived by the monetary policy imposed by Chinese government.

Also, the result is not robust for the relation between and the Consumer Price Index (CPI) and the treasury yield. Theoretically, Inflation erodes the purchasing power of a bond's future cash flows. Put simply, the higher the current rate of inflation and the higher the (expected) future rates of inflation, the higher the yields will raise across the yield curve, as investors will demand this higher yield to compensate for inflation risk. However, an empirical evidence shown by Mishkin [15] that the term structure of nominal interest rate provides almost no information about the future path of inflation but does provide information about the term structure about the real interest rate. But as maturities lengthen to nice and twelve months, the nominal interest term structure does contain the expected inflation information. This can be interpreted by the differences in the relative variability of expected future inflation changes and real term structure slopes at different points in the term structure. From this point of view, treasury yield with different maturities may have different response to the expected inflation rate. Moreover, in practical, the effect of expected inflation on treasury yield usually has time-lag and vice versa.

CONCLUSION

Diebold et al. [8] demonstrate that macroeconomic variables affect treasury yield through several determinants such as investment, inflation rates and monetary policy tools. Based on the previous theory, we expect to find empirical evidence to test the equilibrium relation among these variables. The cointegration framework provides an appropriate vehicle to test for the relation. The advantage of cointegration analysis stems from its ability to directly examine co-movements of variables implicit in equilibrium models, even in the presence of non-stationary data.

In this research we use Johansen's [11] vector error correction model (VECM) to investigate whether cointegration exists between the Chinese treasury yield and six Chinese macroeconomic variables, namely the economic growth, inflation, money supply, interbank rate, stock market performance, and trade balance. We find that a cointegrating relation indeed exists and the treasury yield contributes to this relation. The signs of the long-term elasticity coefficients of the macroeconomic variables on the treasury yield are consistent with our hypothesis apart from the economic growth and inflation.

REFERENCES

1. Chen F and Shen C. (2006) Nelson-siegel moxing yu guozhai shouyil quxian de yuce. Statistics & Decision 4: 133-135.
2. Yang Y. (2011) Woguo yinhang jian guozhai shouyilv quxian zhuyao yingxiang yinsu yanjiu. Market Economy & Price 6: 33-36.
3. Li H, et al. (2010) Lil•u qixian jiegou, tonghuo pengzhang yuce yu shiji lil•u.The journal of World Economy 10: 120-138.
4. Cai J, et al. (2011) Hongguan jingji yinsu dui guozhai shouyi de yingxiang fenxi. Contemporary Economy & Management 33: 84-87.
5. Mishkin FS. (1990) What does the term structure tells us about future inflation? Journal of monetary economics 25: 77-95.
6. Litterman R and Scheinkman J. (1991) Common factors a ecting bond returns. Journal of xed income 1: 54-61.
7. Ang A, et al. (2006) What does the yield curve tell us about gdp growth? Journal of econometrics 131: 359-403.
8. Diebold FX, et al. (2006) The macroeconomy and the yield curve: a dynamic latent factor approach. Journal of econometrics 131: 309-338.
9. Cornell B. (1982) Money supply announcements, interest rates, and foreign exchange. Journal of International Money and Finance 1: 201-208.
10. Engle RF and Granger CW. (1987) Co-integration and error correction: representation, estimation, and testing. Econometrica: journal of the Econometric Society pp: 251-276.
11. Johansen S. (1991) Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. Econometrica: Journal of the Econometric Society pp: 1551-1580.
12. Phillips PC. (1991) Optimal inference in cointegrated systems. Econometrica: Journal of the Econometric Society pp: 283-306.
13. Johansen S and Juselius K. (1990) Maximum likelihood estimation and inference on cointegrationwith applications to the demand for money. Oxford Bulletin of Economics and statistics 52: 169-210.
14. Osterwald-Lenum M. (1992) A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics 1. Oxford Bulletin of Economics and statistics 54: 461-472.
15. Mukherjee TK and Naka A. (1995) Dynamic relations between macroeconomic variables and the japanese stock market: an application of a vector error correction model. Journal of Financial Research 18: 223-237.

Cite this article as: CAO Yirany, et al. The Impacts of Macroeconomic factors on Chinese Short-term Treasury Yield-An Application of a Vector Error Correction Model. Gen Soc. Sci. Cur. Tr. 2019: 1: 1.