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COMBINED EFFECT OF MACROECONOMIC VARIABLES ON TERM PREMIUMS

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КОМБІНОВАНИЙ ВПЛИВ МАКРОЕКОНОМІЧНИХ ПОКАЗНИКІВ НА ТЕРМІНОВІ ПРЕМІЇ

Purpose. Economists have found that macroeconomic variables influence the term structure of interest rates. In this paper we will investigate the combined effect of macroeconomic variables.

Methodology. This paper applies partial least square method to extract a macroeconomic factor from 23 macroeconomic variables, and explore the predictive effect of the macroeconomic factor on term premiums. To explore the persistence of the effect, the impulse response analysis of the macroeconomic factor on term premiums is carried out.

Findings. It has been found that the macroeconomic factor extracted by the partial least squares method can predict the changes of the term premiums efficiently. Furthermore, the impact of the macroeconomic factor on term premiums will disappear after three to four years.

Originality. To study the relationship between macro economy and the term structure of interest rates, this paper first applies the partial least square method to extract the macroeconomic factor. A series of research on macro economy and term premiums can be carried out. The research on this aspect has not been found at present.

Practical value. The results in this paper are helpful to understand the combined impact of the macro economy on the interest rate term structure. On the one hand, it can help investors to understand how the Treasury yield curve is affected by macro economy. On the other hand, it provides a good reference for policy makers to understand the current economic status and the reflex of market on policy.

Keywords: *bonds, term structure of interest rates, term premiums, macro economy, partial least squares method, impulse response analysis*

Introduction. Economic theory shows that the interest rate term structure is closely related to macroeconomic variables (such as economic growth, inflation and interest rate), on which scholars have also carried out various research studies. However, they tend to focus on the relationship between specific economic variables and the interest rate term structure. Since there is a strong correlation between macroeconomic variables, the exploration on the impact of individual economic variables on the interest rate term structure cannot present the combined action of multiple economic variables. At the same time, the investigation on the effect of multiple economic variables will lead to the problem of multicollinearity. Therefore, based on the previous studies, this paper selects 23 representative macroeconomic variables and utilizes partial least square method to extract the macro-economic factor to further study the relation between the macroeconomic factor and interest rate term structure. Specifically, this paper mainly examines the predictive effect of macroeconomic variables on the term premiums in the interest rate term structure. The impulse response analysis is carried out so as to explore the impact of macroeconomic factor on the term structure of interest rates.

The no-arbitrage model and an information set composed of 162 economic variables are applied to predict the interest rate term structure of the United States [1]. It is found that there are no absolute advantages or disadvantages of the two methods in predicting the interest rate term structure. The no-arbitrage model has better predictive power on the yields of short-term bonds. The information set composed of numerous variables does better at predicting long-term performance of long-term bonds. They also carried out the principal component analysis on the information set consisting of 162 economic variables, and found that the first five factors contain 72.21 % of the information. The industrial growth rate and CPI inflation rate were highly correlated with the first two factors.

Scholars have also invested the relation between interest rate term structure and macroeconomic variables from different aspects. For example, the term structure of interest rates should fully reflect the expectation of market participants for the macroeconomic situation and the economic structural transformation at any time [2]. The impact of macroeconomic variables on the term structure of interest rates is time-varying under different inflation rates [3]. The interest rate term structure model including macroeconomic variables has greater predictive power than the one which does not include macroeconomic variables [4].

On the whole, most of the previous studies focus on the relationship between single or multiple macro-

economic variables and the interest rate term structure. However, there is always a common change trend among different macroeconomic variables in the real economy. Therefore, the study of the influence of macro economy on the interest rate term structure through multiple macroeconomic variables often causes the problem of spurious regression or the multicollinearity. This paper uses the partial least squares method to extract the macroeconomic factor from multiple macroeconomic variables, and studies the impact of macroeconomic factor on the interest rate term structure. It can be proved that the information contents of term premiums and yield curve are the same [5]. This paper focuses on the impact of macroeconomic variables on the term premiums.

Factor extraction method. This paper will use Partial Least Squares (PLS) to extract the macroeconomic factor. PLS was put forward in 1966, and improved by [6] and [7]. This paper only introduces the improved PLS method. Since the PLS method can effectively remove the irrelevant information from the variables, retaining only the effective information to predict the bond, it could be applied in the situation where the quantity of variables is greater than the observations; thus, to solve the problem of variable multicollinearity effectively, it is used by more and more financial experts.

Let us set $X_t = [x_{1,t}, ..., x_{N,t}]'$ as the $N \times 1$ vector composed of a single predictive index at time t, where $t = 1, ..., T$. According to [6] and [7], let us suppose $x_{i,t}$ to possess the following forms

$$x_{i,t} = \lambda_{i,0} + \lambda_{i,1} F_t + \lambda_{i,2} E_t + \varepsilon_{i,t}, \quad i = 1, ..., N,$$

where F_t is the factor containing information on bond returns, E_t is a common error term irrelevant with the proceeds of the bond, ε_{it} is the error term relevant with predictive factor i, $\lambda_{i,1}$ reflects the factor loading of $x_{i,t}$ to F_t. $\lambda_{i,2}$ reflects the factor loading of $x_{i,t}$ to E_t. The basic principle of the partial least square method is to extract the potential information factor F_t which cannot be observed from a large number of measurable indicators, and eliminate common error component E_t and idiosyncratic noise $\varepsilon_{i,t}$ irrelevant with the yield of the bond.

According to [8], the partial least squares method is mainly divided into two steps.

Firstly, we carry out time series regression (N regressions) for each observable variable, that is to say, make regression between $x_{i,t-1}$ and the realized bond yield,

$$x_{i,t} - 1 = \beta_{i,0} + \beta_{i,1} R_t + u_{i,t-1}, \quad t = 1, ..., T.$$

Bond yield R_t is the tool variable of the macroeconomic factor, and the sensitivity of variables $x_{i,t-1}$ to the macroeconomic factor can be obtained by the load $\beta_{i,1}$. Since the expected value of R_t is driven by the macroeconomic factor, the agency variable $x_{i,t-1}$ of the macroeconomic factor is only related to the expected return rate of bonds, rather than the factor that cannot predict the bond yield. Therefore, $\beta_{i,1}$ is considered to depict approximately the degree of each variable depending on the macroeconomic factor.

Secondly, we carry out cross sectional regressions for each time point, that is to say, we carry out cross sectional regression between $x_{i,t}$ and the loading coefficient $\hat{\beta}_{i,1}$ obtained in the first step.

$$x_{i,t} = c_t + M_t^{PLS} \hat{\beta}_{i,1} + v_{i,t}, \quad i = 1, \cdots, N,$$

where M_t^{PLS} is a proxy variable of macroeconomic index (It is called investors' sentiment indicator [8]). Intuitively, if $\beta_{i,1}$ is known, the macroeconomic factor could be conformably estimated through the regression of $x_{i,t}$ to $\beta_{i,1}$. However, $\beta_{i,1}$ is unknown, the first step of the partial least squares method provides the estimation method of determining $\beta_{i,1}$ with $x_{i,t}$.

If all sample information is used in the time series regression of the first step, the macroeconomic factor extracted through the partial least square method can be expressed as a linear combination of $x_{i,t}$, namely

$$M^{PLS} = XJ_N X' J_T R (R' J_T X J_N X' J_T R)^{-1} R' J_T R,$$

where $X = (X_1', ..., X_T')$ represents the $T \times N$ matrix composed of observable macroeconomic variables, R represents the bond excess return of $T \times 1$. $J_T = I_T - \frac{1}{T} l_T l_T'$, $J_N = I_N - \frac{1}{T} l_N l_N'$, where I_T and I_N are the unit matrixes of T order and N order respectively. l_T and l_N are the column vectors of T dimension and N dimension whose identity element is 1. For convenience, the factor extracted through the partial least squares method is denoted as PLS_t. The weight of each variable in PLS_t depends on the covariance between the variable and the bond excess return.

One of the important features of PLS_t is the data independence. The same indexes set will produce different PLS_t values due to the different bond yields to be predicted. This method will present what kind of combination of individual indexes can best predict the yield of a particular type of bond. For example, in predicting the yield of junk bonds, it will make the weight of the stock index greater.

In short, the partial least squares method is an effective method to extract useful information by separating noise. It has been applied to the financial field [6–7], and it was found that the partial least squares method is more effective than the principal component analysis method in the bond market. Compared to the partial least squares method, the factor analysis method was proposed earlier, and its application scope is wider. The mathematical basis of the partial least squares method is the principal component analysis, but it is more advanced than the principal component analysis, and it is suitable in the situation where the quantity of independent variables outnumbers the samples.

The influence of the macroeconomic factor on the term premiums. ***Selection and description of macro-economic variables.*** In the case of the constant money supply, the demand of the real economy for funds determines the level of interest rates. The high demand for funds will promote the overall up-

ward of yield curve. When the economic downturn leads to the low capital demand, the yield curve will be overall downward. At the same time, the long short spread also reflects the estimation of the market regarding the future economic trend. The steep yield curve shows the optimistic market expectation of the future economic, and vice versa. Therefore, to study the impact of macroeconomic variables on the term premiums, it is necessary to introduce economic variables that reflect the conditions of the real economy.

The Fisher effect shows that the nominal interest rate is equal to the sum of the real interest rate and the inflation rate. Therefore, when inflation rate rises, the nominal interest rate will also rise, and vice versa. Therefore, it is necessary to add the macroeconomic indexes that represent the relevance with the inflation rate in this paper.

The national debt policy is the link between the monetary policy and fiscal policy. On the one hand, the issue of bonds is part of the government's current fiscal revenue, which closely connects the government bonds with the government's fiscal policy (such as tax policy and fiscal investment policy). On the other hand, the central bank can adjust the money supply through the government bonds. For example, when the central bank implements tight monetary policy, the withdrawal of currency from circulation could be realized by underselling the government bonds to the financial markets. Therefore, the study of the relationship between the interest rate term structure and monetary policy has important significance not only for policy makers to make policy, but also for market participants to predict the future trend. The macro economic variables related to monetary policy will certainly have influence on the term structure of interest rates.

Finally, this paper selects 23 macroeconomic variables. The observation time of macroeconomic variables varies from March, 2006 to December, 2014, which are all monthly data. (1) Chinese Container Freight Index (CCFI); (2) Gross Domestic Product (GDP); (3) Industrial Added Value (IAV); (4) Fixed Assets Investment (Fix); (5) Total Retail Sales of Consumer Goods (TRSCG); (6) OECD Composite Leading Indicators(OECD); (7) Macro-economic Climate Index (macroeconomic); (8) Corporate Goods Price Index (CGPI); (9) Producer Price Index (PPI); (10) Consumer Price Index (CPI); (11) Retail Price Index (RPI); (12) Currency in circulation (M0); (13) Narrow money supply (M1); (14) Broad money supply (M2); (15) Shanghai Securities Composite Index (SSCI); (16) Deposit Rate (Deposit); (17) Short Term Yield (STY); (18) Short and Medium Term Yield (SMTY); (19) Medium and Long Term Yield (MLTY); (20) Long-Term Yield (LTY); (21) Spread10: the yield spread between Treasuries whose time to maturity is ten years and one year respectively; (22) Spread30: the yield spread between Treasuries whose time to maturity is thirty years and one year respectively; (23) CP5: [9] it has been found that the single factor of long-term interest rate term structure has much predictive power on the excess return of bonds, R^2 within the sample can reach 44 %. The CP factor is constructed by the following methods

$$\frac{1}{K-1}\sum_{n=2}^{K} ry_{t+1}^{(n)} = \rho_0 + \rho_1 y_t^{(1)} + \rho_2 f_t^{(2)} + \cdots + \rho_K f_t^{(K)} + \overline{\varepsilon}_{t+1}$$

or

$$\overline{ry}_{t+1} = \rho^T f_t + \overline{\varepsilon}_{t+1},$$

where $ry_{t+1}^{(n)}$ is the excess return rate. The calculation method is that the holding period yield obtained by purchasing n-year bonds at the moment of t and selling the bond whose maturity term is $n - 1$ year at the moment of $t + 1$ minus the one-year maturity yield at the moment of t. $f_t^{(n)}$ is the forward interest rate of moment t from moment $t + n - 1$ to $t + n$. The coefficient ρ can be used to construct CP factor to predict the bond yield. CP regression is carried out with the forward interest rates within 5 years, which will become the CP5 factor.

In order to depict the time trend of macroeconomics, we will use the year-on-year growth rate in this paper except OECD, macroeconomic, CGPI and yields. For OECD, macroeconomic and CGPI, we will use the difference between the value of variable and 100.

Extraction of the macroeconomic factor. This paper selects Chinese macroeconomic data from March 2006 to December 2014, and then uses the partial least square method to extract the macroeconomic factor. Table 1 is the descriptive statistics of various macroeconomic variables, which shows the different dimension of various macroeconomic variables. Therefore, in order to facilitate the analysis, the macroeconomic variables will be standardized before the utilization of partial least squares method, namely standardized data = (oiginal data-mean value)/standard deviation.

The definition and calculation method of term premiums. Actually, the term premiums is the premium required by the investors for the risk that the future real short-term interest rate does not equal to the current expected interest rate. However, there are several different forms of the expected hypothesis itself, and the expression forms of interest rates are also diverse (spot interest rate, forward interest rate, holding period interest rate, etc.). Therefore, the interest rate term premiums will naturally be different. The most common three kinds of calculation methods will be introduced respectively.

Term premiums for spot interest rates $\pi_{n,t}^r$**.** Term premiums for spot interest rates originate from the rational expectation hypothesis. It is the spot interest rate of zero coupon bonds minus the average value of a collection of short-term interest rates expectation.

$$\pi_{t,T}^r = r_t^T - \frac{1}{T}\sum_{i=0}^{T-1} \mathrm{E}_t\left(r_{t+i}^1\right),$$

where r_t^T is the spot interest rate of T term at moment t, $E_t\left(r_{t+i}^1\right)$ is the expectation at moment t of spot

Table 1

Descriptive statistics of macroeconomic variables

Stats	Mean	Sd	Min	p25	Median	p75	Max	Skewness	Kurtosis	*N*
CCFI	1.18	18.23	–32.88	–12.58	–1.39	11.48	53.48	0.58	2.93	106
CGPI	2.15	5.05	–8.00	–1.90	2.30	6.50	10.30	–0.12	1.89	106
CPI	3.08	2.31	–1.80	1.80	2.69	4.60	8.70	0.22	2.95	106
GDP	9.79	2.42	6.60	7.50	9.50	11.90	14.90	0.6	2.15	106
M0	11.86	5.74	–4.64	9.50	11.95	14.54	42.50	1.47	10.90	106
M1	14.63	8.45	1.20	7.90	13.35	20.87	38.96	0.65	2.83	106
M2	17.27	4.37	12.1	13.90	16.48	18.50	29.74	1.36	4.28	106
OECD	–0.03	1.22	–3.94	–0.31	0.31	0.76	1.47	–1.64	5.53	106
PPI	1.49	4.50	–8.20	–2.00	2.42	5.39	10.06	–0.12	2.15	106
RPI	2.47	2.39	–2.50	0.90	1.90	4.10	8.10	0.32	2.78	106
Deposit	2.95	0.59	2.25	2.25	3.00	3.33	4.14	0.50	2.35	107
IAV	12.85	3.79	5.40	9.50	13.15	16.00	21.30	0.09	1.96	106
Fix	24.47	4.40	15.7	20.60	25.00	26.80	33.60	–0.04	2.49	106
macroeconomic	1.43	1.90	–2.60	–0.10	1.45	2.60	5.90	0.32	2.55	106
SSCI	0.10	1.10	–3.39	–0.53	0.15	0.74	2.91	–0.62	4.20	106
TRSCG	15.93	3.10	11.52	13.50	15.20	18.10	23.30	0.64	2.58	106
STY	2.55	0.84	0.90	1.92	2.72	3.20	4.17	–0.28	2.11	106
SMTY	2.65	0.83	0.96	2.01	2.80	3.36	4.22	–0.32	2.12	106
MLTY	3.68	0.47	2.75	3.32	3.59	4.06	4.55	0.21	2.01	106
LTY	4.24	0.38	3.50	4.01	4.18	4.53	5.11	0.28	2.56	106
Spread10	1.03	0.55	0.03	0.65	0.93	1.31	2.26	0.60	2.55	106
Spread30	1.59	0.60	0.61	1.18	1.45	1.88	3.03	0.76	2.85	106
CP5	–0.63	0.65	–2.33	–0.99	–0.55	–0.29	0.85	–0.49	3.16	105

Remark: This table reports the descriptive statistics of the macroeconomic variables used in this paper. p25 and p75 are quantile of 25 % and 75 % respectively. Sample section is from March 2006 to December 2014

interest rate with *1*-term at moment $t+i$. Although this definition is intuitive, it involves the expectations of a series of short-term interest rates. Therefore, it implies great difficulty in empirical research.

Term premiums of forward interest rates $\pi_{t,T}^{f}$**.** The term premium defined by the forward rate is the difference between the forward rate and the expected short-term interest rate.

$$\pi_{t,T}^{f} = f_t^{T-1\to T} - E_t\left(r_{t+T-1}^{1}\right),$$

where $f_t^{T-1\to T}$ is the forward interest rate from time $T-1$ to time T at moment t. This term premium is more common because it only needs the expectation of short-term interest rate. It is used by the Federal Reserve to study the relationship between interest rate changes and monetary policy in a relatively short period of time.

Term premiums for holding period yield $\pi_{n,t}^{h}$. The term premium for holding period refers to the difference between the yield of T term zero coupon bond within one term and the current spot short-term interest.

$$\pi_{t,T}^{h} = \mathrm{E}_t\left(h_{t+1,T}\right) - r_t^1,$$

where $h_{t+1,\,T}$ is the return within one term of T term zero coupon bond.

$$E_t\left(h_{t+1,T}\right) = Tr_t^T - (T-1)E_t\left(r_{t+1}^{T-1}\right).$$

The terms of the three methods are different in terms of values, but they basically change in the same direction and possess similar policy implications. Therefore, they could be converted into each other.

In empirical research, the scholars generally use $\pi_{t,T}^{h}$ and $\pi_{t,T}^{f}$. $\pi_{t,T}^{h}$ is used as the term premium in this paper. In the following discussion, the term premium is the term premium divided by the term to maturity, namely $\pi_{t,T}/T$, which will not affect the actual result.

To study the effect of the macroeconomic factor on the term structure of interest rates, the maturity yields from 1-year to 10-year are selected to investigate the influence of macro economy on the term premiums.

Table 2 presents the descriptive statistics of the term premiums, including the mean value, standard

Table 2

Descriptive statistics of the term premiums

Stats	T_10	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2
mean	0.24	0.32	0.51	0.38	0.69	0.43	0.51	0.36	0.24
sd	6.58	6.01	5.45	4.94	4.28	3.72	2.96	2.14	1.12
min	–12.43	–11.06	–9.55	–8.27	–7.22	–5.87	–4.35	–2.96	–1.50
p25	–4.56	–3.96	–3.80	–3.55	–2.53	–2.67	–1.75	–1.07	–0.47
p50	0.37	0.37	0.45	0.07	0.27	–0.20	–0.11	–0.16	0.00
p75	4.53	3.95	3.93	3.36	3.45	2.60	2.10	1.25	0.63
max	17.55	17.19	16.37	14.91	13.16	11.25	8.79	5.96	3.16
skewness	0.34	0.39	0.44	0.53	0.51	0.74	0.87	1.04	1.087
kurtosis	2.68	2.75	2.78	2.86	2.84	3.08	3.25	3.51	3.66
N	94	94	94	94	94	94	94	94	94

Remark: This table provides the descriptive statistics results of the term premiums, where T_10, T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2 present the term premiums of 10-year, 9-year, 8-year, 7-year, 6-year, 5-year, 4-year, 3-year, 2-year with respect to 1-year. p25, p50 and p75 present the quantile of 25, 50 and 75. The sample interval is from March 2006 to December 2014

deviation, minimum value, maximum value, skewness and kurtosis.

It is noted that the term premiums discussed in this paper are $\pi_{t,T}/T$. That is to say the term premiums are all obtained by term premiums divided by term to maturity. Table 2 shows that, firstly, the mean value of term premiums does not change with the term. This proves that the actual term premium increases with the term. Theoretically, the shorter the term is, the lower the interest rates will be. The bonds with longer term will require higher term premiums, which is consistent with the descriptive statistics results of term premiums. Secondly, the standard deviation of the term premiums has an obvious trend of changing with the term. The longer term yields possess larger term premiums standard deviation compared to the 1 year bond. This proves that the term premiums with longer term to maturity have a greater fluctuation, which is consistent with our intuition. Thirdly, the skewness of term premiums is greater than 0, which indicates that the distributions of all term premiums are right skewed. Fourthly, the kurtosis shows that the short end distribution of the term premiums presents steeper peak features than normal distribution, while the long end of the term premiums presents flat feature.

Prediction of the macroeconomic factor influence on the term premiums. In order to predict bond excess return, the following standard prediction regression model is used.

$$\pi_{t+1,i} = \alpha + \beta \cdot PLS_t + \varepsilon_{t+1}, \quad i = 1, ..., T,$$

where, $\pi_{t+1,i}$ is the bond term premiums, PLS_t is macroeconomic factor, and ε_{t+1} is an error term.

Table 3 is the prediction regression analysis results of macroeconomic factor influence on the term premiums. Table 3 shows that almost all regressions R2 are above 0.25.

The single factor macroeconomic variables extracted through the partial least squares are almost above 0.25. The regression coefficient is still significant under the significant level of 0.01. This proves that the macroeconomic factor extracted through the partial least squares method can predict the term premiums changes better.

Impulse response analysis. To study how the changes of the macroeconomic factor influence the term premiums, the following vector autoregressive (VAR) model is established.

$$\begin{pmatrix} T\_10_t \\ \vdots \\ T\_2_t \\ PLS_t \end{pmatrix} = \beta_0 + \beta_1 \begin{pmatrix} T\_10_{t-1} \\ \vdots \\ T\_2_{t-1} \\ PLS_{t-1} \end{pmatrix} + \cdots + \beta_p \begin{pmatrix} T\_10_{t-p} \\ \vdots \\ T\_2_{t-p} \\ PLS_{t-p} \end{pmatrix} + \varepsilon_t,$$

where p is the lagged order. The vector autoregression model requires each variable to possess the same stability. Both the term premiums and the macroeconomic factor are examined to be first-order integration. Therefore, the vector autoregression analysis could be carried out. There is always correlation in the random error items of vector autoregression, namely the relevant interference among the variables. Therefore, the cross interference source is decomposed into independent interference sources by using the Cholesky decomposition method.

In the vector autoregression model, the more the lagged order is, the more the explanatory variables included in the model will be, so the fitting effect of the model will be better. However, excessive explanatory variables will also increase the parameters to be estimated of the model. Therefore, the optimal lagged order should be the balanced results of the model complexity and model fitting degree. This paper applies the sequential modified LR test statistic (LR), Akaike information criterion (AIC), Final prediction error (FPE), Hannan-Quinn information criterion (HQ) and Schwarz information criterion (SC) respectively

Table 3

The prediction of term premiums by PLS

	T_10	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2
L_pls	0.295***	0.303***	0.319***	0.334***	0.373***	0.395***	0.447***	0.527***	0.614***
	(5.63)	(5.62)	(5.73)	(5.68)	(6.24)	(6.01)	(6.61)	(7.49)	(9.05)
_cons	0.023	0.036	0.069	0.059	0.134*	0.104	0.164*	0.172*	0.227***
	(0.35)	(0.54)	(1.00)	(0.80)	(1.80)	(1.27)	(1.94)	(1.96)	(2.69)
N	94	94	94	94	94	94	94	94	94
adj. R2	0.248	0.247	0.255	0.252	0.29	0.274	0.315	0.372	0.465

Remark: T_10, T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2 present the term premiums of 10-year, 9-year, 8-year, 7-year, 6-year, 5-year, 4-year, 3-year, 2-year with respect to 1-year. L_pls represents the lagged item of PLS. The data in the table is the regression coefficients corresponding to variables, data in the brackets are the value of *t*, *, ** and *** represent the significance under significant level of 1 %, 5 % and 10 %

Table 4

Order selection of a vector autoregressive model

Lag	LogL	LR	AIC	FPE	HQ	SC
0	568.907	NA	–12.560	1.66E–18	–12.447	–12.280
1	1007.423	768.635	–20.167*	8.36e–22*	–18.927*	–17.091*
2	1101.961	144.463*	–20.044	1.02E–21	–17.677	–14.172
3	1181.062	103.097	–19.574	2.02E–21	–16.080	–10.906
4	1262.174	87.492	–19.150	4.83E–21	–14.529	–7.685
5	1387.609	107.113	–19.722	6.26E–21	–13.973	–5.461

Remark: * represents the optimal order under corresponding criterion

to select the optimal lagged order of the model. Table 4 presents the order results selected through the vector autoregressive model, which shows that different criteria will lead to inconsistent results. All the methods except LR select VAR(2). Therefore, the VAR (2) model will be used for the term premiums modelling.

Figure reflects the impact of the macroeconomic factor on the term premiums. It shows that the impulse response function of the impact of the macroeconomic factor on term premiums is hump shaped. Most of the initial response values are negative, whereas most of the time response values are positive, which is consistent with the results of term premiums predicted with the macroeconomic factor. Almost all response functions reach the maximum value at moment $t + 12$. Before the moment $t + 12$, the increase of one standard deviation of the macroeconomic factor will lead to the gradual increase in extent of term premiums. After moment $t + 12$, the influence of the impact of the macroeconomic factor on the term premiums will be gradually decreased, and tends to 0 before moment $t + 48$. This proves that the impact of the macroeconomic factor on the term premiums peaked at the 12th month, and disappeared in 3 to 4 years.

Conclusion. The literature suggests that there is a close relationship between the term structure of interest rates and macroeconomic variables (such as economic growth and inflation). Previous research studies tend to focus on the relation between the specific economic variables and the term structure of interest rates. This paper selects 23 representative macroeconomic variables, and applies the partial least squares method to extract the macroeconomic factor on the basis of the previous research studies. Furthermore, the relationship between the macroeconomic factor and term premiums is studied. This paper finds that the macroeconomic factor extracted through the partial least squares method can predict the term premiums changes better.

The macroeconomic factor extracted by the partial least squares and term premiums are used to establish the vector autoregression model. And the persistence of the influence of the macro economy on term premiums is studied through the impulse response analysis on the basis of the Cholesky decomposition. It has been found that the impact of the macroeconomic factor on the term premiums will disappear in 3 to 4 years. The result of the impulse response analysis is consistent with the prediction on term premiums through the macroeconomic factor.

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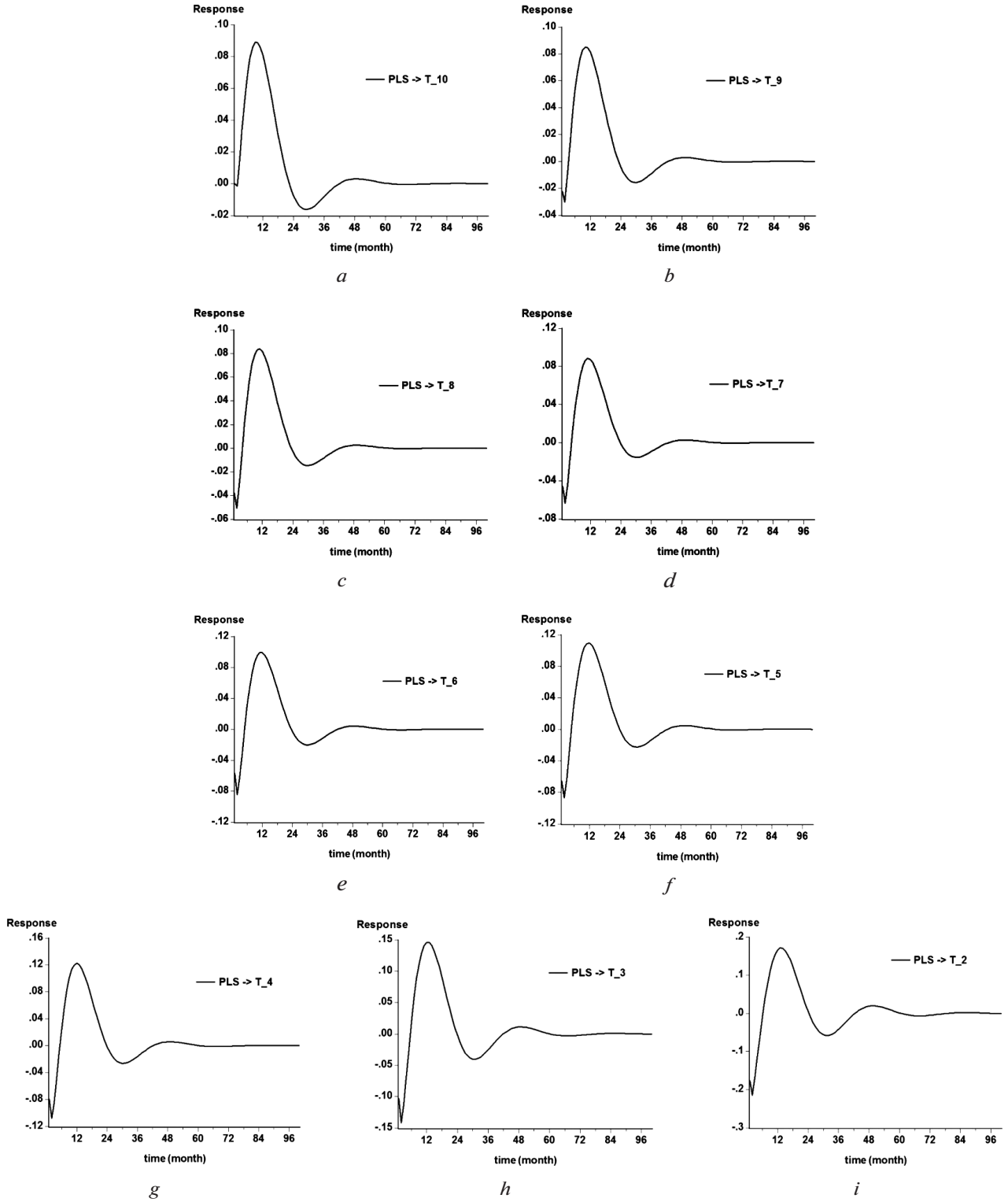

Fig. The impulse response analysis of term premiums: a, b, c, d, e, f, g, h and i in Figure give the impulse response analysis of PLS on T_10, T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2. PLS in Figure represents the macroeconomic factor extracted from macroeconomic variables by the partial least squares method. T_10, T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2 in Figure present the term premiums of 10-year, 9-year, 8-year, 7-year, 6-year, 5-year, 4-year, 3-year, 2-year with respect to 1-year

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Мета. Економісти встановили, що макроекономічні показники мають вплив на тимчасову структуру процентних ставок. У даній роботі ми досліджуємо сукупну дію макроекономічних змінних.

Методика. Ця робота використовує метод часткових найменших квадратів для витягання макроекономічного чинника з 23 макроекономічних показників і досліджує прогностичний вплив макроекономічного чинника на термінові премії. Для вивчення збереження впливу здійснюється аналіз імпульсної характеристики макроекономічного чинника на термінові премії.

Результати. Встановлено, що макроекономічний чинник, який витягується методом часткових найменших квадратів, дозволяє передбачити зміну термінових премій дуже добре. Крім того, вплив макроекономічного чинника на термінові премії зникає через три-чотири роки.

Наукова новизна. Для вивчення взаємозв'язку між макроекономікою та тимчасовою структурою процентних ставок, ця робота вперше використовує метод часткових найменших квадратів для витягання макроекономічного чинника.

Практична значимість. Результати, приведені в цій роботі, дозволяють зрозуміти сукупну дію макроекономіки на тимчасову структуру процентних ставок. З одного боку, це може допомогти інвесторам зрозуміти, як крива прибутковості казначейства залежить від макроекономіки. З іншого боку, результати забезпечують хороші рекомендації для політиків, аби зрозуміти нинішній економічний статус і рефлекс ринку з питань політики.

Ключові слова: *облігації, тимчасова структура процентних ставок, термінові премії, макроекономіка, метод часткових найменших квадратів, аналіз імпульсної перехідної функції*

Цель. Экономисты установили, что макроэкономические показатели имеют влияние на временную структуру процентных ставок. В данной работе мы исследуем совокупное воздействие макроэкономических переменных.

Методика. Эта работа использует метод частичных наименьших квадратов для извлечения макроэкономического фактора из 23 макроэкономических показателей и исследует прогностическое влияние макроэкономического фактора на срочные премии. Для изучения сохранения влияния осуществляется анализ импульсной характеристики макроэкономического фактора на срочные премии.

Результаты. Установлено, что макроэкономический фактор, извлекающийся методом частичных наименьших квадратов, позволяет предсказать изменение срочных премий очень хорошо. Кроме того, влияние макроэкономического фактора на срочные премии исчезает через три-четыре года.

Научная новизна. Для изучения взаимосвязи между макроэкономикой и временной структурой процентных ставок, эта работа впервые использует метод частичных наименьших квадратов для извлечения макроэкономического фактора.

Практическая значимость. Результаты, приведенные в этой работе, позволяют понять совокупное воздействие макроэкономики на временную структуру процентных ставок. С одной стороны, это может помочь инвесторам понять, как кривая доходности казначейства зависит от макроэкономики. С другой стороны, результаты обеспечивают хорошие рекомендации для политиков, чтобы понять нынешний экономический статус и рефлекс рынка по вопросам политики.

Ключевые слова: *облигации, временная структура процентных ставок, срочные премии, макроэкономика, метод частичных наименьших квадратов, анализ импульсной переходной функции*

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