Long-Term Prediction of the United States' Recession through Trend Decomposition of Interest Rate Term Spread

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This study analyzes whether the trend obtained by decomposing the expected portion of the interest rate term spread into risk premium shock and monetary policy shock is useful for long-term forecasts of the United States' recession. After the Beverage Nelson decomposition of the interest rate term spread from the co-integrated VAR model composed of short-term and long-term interest rates, the monetary policy and independent risk premium shocks' trends are estimated and used for the prediction. Using linear and probit prediction models, we test whether these trends are effective for the predictive power enhancement of output gap and recession. Based on the proposed process, United States data were analyzed through the probit model and FM-OLS estimation. We found that the trends of monetary policy shock and risk premium shock clearly have an edge for long-term forecast compared with conventional term spread forecasts.

Keywords: Economic forecast, risk premium, Term spread.

JEL Classification: M60

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I. Introduction

After a pioneering study of Estrella and Hardouvelis (1991) on the predictability of the economic downturn of the interest rate term spread (or short- and long-term interest rate difference, hereinafter abbreviated as term spread), a number of studies, including Estrella and Mishikin (1996, 1998), Kishor and Koenig (2010), have reported that the ability to predict economic recession up to one year of the term spread is superior to other financial variables. Wheelock and Wohar (2009) conducted a research survey related to this matter.

However, Mody and Taylor (2003) and Wright (2006) reported that the economic forecasting power of the term spread after 2000 is weakening. Hence, an analysis of the factors of predictive ability is necessary to determine the robustness of this approach.

An attempt to start from this point of view is to divide the term spread into the expected portion and the term premium to evaluate which portion of the economic recession forecasting ability it depends. In this regard, existing studies often conclude that the predictive ability exists in the expected part rather than the term premium. For example, Hamilton and Kim (2002) did not find a strong correlation between the term premium and the recession. In addition, Rosenberg and Maurer (2008) also showed through the probit model that the expected portion, excluding the term premium, was more superior to the prediction of the recession and that the expected portion contained the same information as the federal fund rate indicating monetary policy.

However, the long-term expected part of the term spread (expectation of short-term interest rates in the future) can be affected not only by short-term interest rate shocks but also by long-term interest rate shocks. In the long- and short-term loan market, if the long-term interest rate is high, borrowing each term is advantageous. In other words, if an endogenous effect involves long- and short-term interest rates that dynamically affect each other, the term premium shock could affect the expected portion of the term spread.

These two shocks to the long- and short-term interest rates could have contradictory signal effects for a future recession. To explain this notion, we first note that the short-term interest rate shock is mainly regarded as a monetary policy shock. In this regard, according to Estrella and Hardouvelis (1991), the current tightening monetary policy leads to an increase in real interest rates under the assumption of nominal price rigidity and flattens the yield curve with a relatively fixed long-term interest rate. This increase in real interest rates can lead to lower investments and lower output in the future.

However, the term spread can change not only through short-term rate fluctuations through monetary policy but also through long-term rate fluctuations. To explain this aspect in more detail, the current long-term interest rate shock is accounted to be composed of a term (or liquidity) premium that includes risk premiums, such as future default risk along with monetary policy shock. In other words, if the risk premium of long-term bonds increases due to the expected economic downturn, the term spread increases at a given short-term interest rate. Hence, the shock of rising risk premiums could lead to an increase in the term spread predicting an economic downturn, thus causing a negative economic downturn contrary to the shock of monetary policy. Therefore, the coexistence of the two effects seems to be able to explain the false signal of the term spread's economic downturn prediction effect either in the non-existent or opposite direction.

This study aims to examine the existence of contradictory signaling effects on the economic forecast of the monetary policy shock and the risk premium shock that may exist on the term spread of US interest rates according to the theory presented above using Kim's (2018, 2020) methodology. More specifically, after Beverage Nelson decomposition of the term spread in the cointegrating VAR model consisting of short- and long-term interest rates, we test and estimate whether risk premium shock trends exist (which are independent with monetary policy shock trends). Next, in the linear and probit prediction model, we test whether these decomposed trends of different signs have the economic prediction power as explanatory variables.

According to the empirical analysis using US data, in the probit model estimation of the recession dummy using the term spread, the long-term prediction showed statistically significant signs in the opposite direction to the conventional theoretical prediction, unlike the short-term prediction. However, the trend decomposition presented in this study was found to explain effectively the signal reversal of the long- and short-term economic forecasting using this term spread. In addition, when monetary policy trends are used in the long-term prediction of the output gap, it is found to be superior to the conventional term spread prediction.

The composition of this paper is as follows. Section 2 explains the trend decomposition and estimation method of the interest rate term spread. Next, Section 3 reports the results of the empirical analysis using Korean data. Lastly, Section 4 discusses the conclusions.

II. Trend decomposition of the interest rate term spread through the VAR model

In this section, we first break down the term spread into long-term trends and cyclical part. Then, we decompose the trend into parts where monetary policy shocks and risk premium shocks have contributions.

We first define $i_{n,t}$ as the long-term interest rate at maturity n and $i_{1,t}$ as the short-term interest rate at maturity 1. Long-term and short-term loans are substitutes for each other. Therefore, long- and short-term interest rates are dynamically linked to each other. Next, the vector $z_t \equiv (i_{1,t}, i_{n,t})'$ of the long- and short-term interest rates follows the reduced form VAR(k) process co-integrated, as shown in Equation (1).

$$\Delta z_t = \Phi z_{t-1} + \Pi_1 \Delta z_{t-1} + \cdots + \Pi_k \Delta z_{t-k} + \upsilon_t, \tag{1}$$

where Δ is the variable difference and δ_t is the error term of the reduced form model. On the other hand, Model (1) is assumed to have the following structure.

Assumption 2.1

(i) Structural shock $(\delta_t, \varepsilon_t)'$ for z_t is an i.i.d. normal process, with an expected value of 0 and the following diagonal variance matrix.

$$E[(\delta_t, \varepsilon_t)', (\delta_t, \varepsilon_t)] \equiv \begin{pmatrix} \sigma_\delta^2 & 0 \\ 0 & \sigma_\varepsilon^2 \end{pmatrix}.$$

(ii) The shock vector for the reduced model is given by the linear transformation for the structural model shock.

$$\upsilon_t \equiv \begin{pmatrix} \delta_t \\ \xi_t \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \mu & 1 \end{pmatrix} \begin{pmatrix} \delta_t \\ \varepsilon_t \end{pmatrix}.$$

(iii) Model (1) is a co-integrated one in which the co-integration vector is $\beta = (1, -\gamma')'$, where the long-term impact matrix of Model (1) has the decomposition of $\Phi = \alpha\beta$.[1]

The shock on long-term interest rates caused by factors specific to the long run can have a unique effect on long-term interest rates without affecting short-term interest rates. This effect is shown in the diagonal variance matrix of Assumption 2.2(i). Of the structural shock terms defined by Model (1) and Assumption 2.1(ii), δ_t reflects the monetary policy shock to the short-term interest rates, and ε_t reflects the term premium shock to the long-term interest rates, respectively. Meanwhile, according to Assumption 2.1(ii), the error term of the reduced form VAR model (1) for the long-term interest rate is composed of $\mu\delta_t$, which is a linear function of the monetary policy shock term, and may reflect the inflation risk shock caused by the monetary policy shock and ε_t, which is the term premium shock to the long-term interest rates. In addition, Assumption 2.1(ii) indicates that the causality ordering for the identification of the structural VAR model is in the order of short-term interest rate → long-term interest rate, thus reflecting the transmission mechanism of monetary policy.

According to the hypothesis of liquidity preference and preferred habitat, the term premium is caused by a liquidity that reflects transaction costs required for cash, debt structure of creditors, hedging tendency, and the possibility of future interest rate volatility. Among these term premium shock factors, this study focuses on the risk premium in ε_t, including the default risk of long-term bonds and the resulting interest rate fluctuations.

Accordingly, under Assumption 2.1(iii), the term spread can be written as follows.[2]

$$ts_t = i_{n,t} - i_{1,t} = (\gamma - 1)i_{1,t} + u_t. \tag{2}$$

Using the following cointegration between the short- and long-term

[1] In this case, Model (1) is an error correction model where α denotes the adjustment speed toward a co-integration equilibrium.

[2] We assume that the short-term and long-term interest rates are all I(1). In this case, the term spread is I(1). See Kang (2002) for the issue when a term spread is I(1).

interest rates:

$$i_{n,t} = \gamma i_{1,t} + u_t, \tag{3}$$

where γ denotes the cointegration coefficient and u_t denotes the cointegration error of I(0).

Finally, the decomposition of the long-term expectation of the following term spread is given from Equations (2) and (3) as;

$$\begin{aligned}\lim_{j\to\infty} E_t ts_{t+j} &= (\gamma-1)\lim_{j\to\infty} E_t i_{1,t+j} \\ &= (\gamma-1)\left[\left(\theta_{11}(1)+\Lambda\right)\sum_{s=1}^{t}\delta_s + \theta_{12}(1)\sum_{s=1}^{t}\varepsilon_s\right].\end{aligned} \tag{4}$$

This equation applies Kim (2018), where $\Lambda \equiv (E\delta_t\delta_t')^{-1}[E\delta_t(\xi_t - \gamma\delta_t)]$. $\theta_{11}(1)$ and $\theta_{12}(1)$ are long-term multipliers in an infinite order vector moving average form of the VAR model[3] of $(\Delta i_{1,t}, u_t)$. Notably, the risk premium shock term ε_t is independent with the monetary policy shock term δ_t by the Assumption of 2.1(i).

The second equality of Equation (4) reflects that a trend composed of long-term interest rate shocks can exist in short-term interest rates when short-term interest rates change to reduce the (cointegration) disequilibrium error caused by long-term interest rate shocks. The following example illustrates this possibility well.

Example 2.2 Following Kim (2018, Example 2.2), we may write a cointegrated VAR(1) model as:

$$u_t = \rho u_{t-1} + (\mu - \gamma)\delta_t + \varepsilon_t, \tag{5}$$

$$\Delta i_{1,t} = \psi u_{t-1} + \delta_t. \tag{6}$$

Equation (5) represents a disequilibrium adjustment process that is stationary if $|\rho|<1$; Equation (6) represents an error-correcting mechanism for short-term interest rate change.

Now, assuming $\rho = 0$ for simplicity, we write (2.12) as:

[3] It may be derived from VAR model (1). See Kim (2018).

$$\begin{aligned} i_{1,t} &= i_{1,0} + \sum\nolimits_{s=0}^{t} \Delta i_{1,t} = i_{1,0} + \sum\nolimits_{s=0}^{t} (\psi u_{s-1} + \delta_s) \\ &= i_{1,0} + \sum\nolimits_{s=0}^{t} (\psi \xi_{s-1} + (\mu - \gamma)\delta_{s-1} + \delta_s) \end{aligned} \tag{7}$$

from $u_{s-1} = (\mu - \gamma)\delta_{s-1} + \varepsilon_{s-1}$,
which is a trend decomposition of long-term interest rate.

The interpretation of Equation (7) is as follows. First, if $\psi > 0$ and $\gamma > 0$, when an increase in ε_{t-1} (that is, an increase in $i_{n,t}$) occurs in period t-1, the cointegration error u_{t-1} increases in Equation (5). This increase leads to an increase in $\Delta i_{1,t}$ in Equation (6), which in turn leads to an increase in $\Delta i_{1,t}$ in Equation (6). Then, this increase consequently decreases u_t. If such an error adjustment process exists, that is, $\psi \neq 0$, then a trend composed of a long-term interest rate shock exists within the short-term interest rate $i_{1,t}$.

In the second equation of Equation (4) above, each component has the following statistical and economic meaning.

Remark 2.2

(i) $\gamma - 1$: Long-term premium (theoretically + sign expected);

(ii) $\dfrac{\partial \lim_{j\to\infty} E_t i_{1,t+j}}{\partial \delta_t} \equiv \theta_{11}(1) + \Lambda$:

Long-term expected short-term interest rate response to monetary policy shocks that raise short-term interest rates (theoretically + sign expected);

(iii) $\sum\nolimits_{s=1}^{t} \delta_s$: Long-term expectations of a stochastic trend driven by monetary policy shocks that fluctuate short-term interest rates;

(iv) $\theta_{12}(1) \equiv \dfrac{\partial \lim_{j\to\infty} E_t i_{1,t+j}}{\partial \varepsilon_t}$:

Long-term expected short-term interest rate response to the shock of rising risk premiums (theoretically + sign expected);

(v) $\sum\nolimits_{s=1}^{t} \varepsilon_s$: Long-term expectation of a stochastic trend resulting from a risk premium unit shock that causes short-term interest rates to fluctuate.

Accordingly, from Equation (7), the term spread can be decomposed into long-term expectations of I(1) monetary policy shock and risk premium shock trends and stationary series as follows.

$$ts_t = M_t + NM_t + S_t, \tag{8}$$

where $M_t \equiv (\gamma - 1)\left(\theta_{11}(1) + \Lambda\right)\sum_{s=1}^{t}\delta_s$, $NM_t \equiv (\gamma - 1)\theta_{12}(1)\sum_{s=1}^{t}\varepsilon_s$, and $S_t \equiv ts_t - M_t - NM_t$ are respectively defined. M_t represents the short-term interest rate or monetary policy shock trend, NM_t represents the risk premium shock trend independent of the monetary policy shock, and S_t represents the I(0) residual cyclical part in the term spread.

Meanwhile, according to Equation (8), both null hypotheses $H_{0A} : \gamma = 1$ and $H_{0B} : \theta_{12}(1) = 0$ must be rejected for the risk premium shock trend to exist within the term spread. These null hypotheses may be tested by Johansen's (1991) log-likelihood ratio test for the null hypothesis H_{0A} and by Kim's (2018) Wald test for the null hypothesis H_{0B}.

Then, a question emerges on how the sign of the effect of M_t, which represents the monetary policy shock, on the long-term forecast recession is determined. Two possibilities exist. First, the increase shock in M_t can reduce investment and thus increase the likelihood of future recession. In this case, a positive correlation exists between M_t and the possibility of future recession.[4] This relationship is a traditional interpretation of the monetary policy effect, which shows the direction of causal relations from the monetary policy to the future economy. We will call this notion the *active* monetary policy effect.

Next, if monetary policy is implemented in a manner that preemptively raises short-term interest rates due to concerns about future expected economic overheating, a negative correlation exists between M_t and the possibility of a recession. Unlike the first interpretation, this interpretation emphasizes the passive role of monetary policy that reduces the fluctuation of the economy. It reveals the direction of causal relations from the future economy to the monetary policy. We will call this notion the *passive* monetary policy response. Of course, which of the above two phenomena is observed for a certain period is a matter that must be determined through empirical analysis, not theory.

[4] If we replace the possibility of recession to an output gap alternatively, then we expect a negative correlation between them.

Meanwhile, we expect the sign of the impact of NM_t on the long-term recession to reflect a positive correlation between NM_t and the likelihood of a recession, as the increase shock of the risk premium is probably triggered by the possibility of a future recession. This trend is a passive response of the financial market to future economic conditions, and unlike monetary policy, which is the result of central bank decision-making, no active effect exists.

In the next section, we will conduct an empirical analysis to test whether the theoretical predictions presented in this section are valid using United States data.

III. Empirical analysis for the United States

In this section, we empirically analyzed the prediction performances of the recession of the United States through probit and FM-OLS estimation based on the methods presented above. Estrella and Hardouvelis's (1991) work was used as a reference to select the explanatory variables. However, inflation was added as an additional variable in consideration of the fact that the New Keynesian model consisted of interest rate, inflation and the output gap.[5]

The dependent variables used for the analyses were NBER recession indicators or output gap. The selected interest rates were for 3-month, 5-year, 10-year maturity treasury bill/notes and federal fund rates. For the computation of inflation, the consumer price index (all items in United States city average, seasonally adjusted) was multiplied by 100 after the logarithmic difference of the previous year's value. The output gap was estimated as the residual of the OLS regression for the constant and time trend using the log-transformed (seasonally adjusted) industrial production index.[6]

The data source was the FRED of Saint Louis FRB, where the analysis frequency and period were monthly from July 1954 to July 2020, respectively.

[5] Please refer to Kim (2020) for the study results of estimating the probability of recession in the Korean economy by applying the same method.

[6] Please refer to De Brower (1998) for a discussion on the estimation of the output gap. The Hodrick-Prescott filter was also used to estimate the output gap. However, one criticism is that the selection of smoothing weights is arbitrary and the output gap varies accordingly.

Table 1

UNIT ROOT TEST RESULT[1)]

		Interest Rates and Economic Variables					
		Federal fund	Treasury Bill 3 month	Treasury Note 5 year	Treasury Note 10 year	Output gap	Inflation
ADF	Level	0.132	0.207	0.595	0.702	0.435	0.064
	Difference	0.000	0.000	0.000	0.000	0.000	0.000
ERS[2)]	Level	3.392	4.396	10.996	13.97	21.21	3.813
	Difference	0.169	0.250	0.045	0.049	0.496	0.032

Note: 1) It is based on a p-value where the null hypothesis is "H_0: unit root exists."
2) Tested with the constant term.
3) In the Elliot-Rothenberg-Stock test, the 5% level rejection value is 3.177, and the 1% level rejection value is 1.946.
If it exceeds this value, the existence of the unit root cannot be rejected.

Next, as a result of the usual unit root tests,[7] *i.e.*, Augmented Dickey Fuller (ADF) and Elliot Rothenberg Stock Point Optimal (ERS) tests for model variables, the null hypothesis that unit root exists could not be rejected in all cases for model level variables at the 5% significance level, as shown in Table 1 below.

Then, we analyzed using the VAR model composed of short- and long-term interest rates. The appropriate orders in all VAR models conformable with the combinations of interest rates of four term

[7] Assume that the equation for the ADF unit root test of variable y_t is given as

$$\Delta y_t = \alpha y_{t-1} + x_t{}'\delta + \beta_1 \Delta y_{t-1} + \cdots + \beta_p \Delta y_{t-p} + \varepsilon_t,$$

where variable x_t represents a constant term and a time trend. Here, the null hypothesis is $\alpha = 1$ and the alternative hypothesis is $\alpha < 1$. Assume that the equation for the ERS unit root test of variable y_t is given as

$$d(y_t \mid a) = d(x_t \mid a)'\,\delta(a) + \eta_t,$$

where variable $d(y_t \mid a) = y_t - ay_{t-1}$ and $d(x_t \mid a) = x_t - ax_{t-1}$ represent a quasi-difference and a is a point alternative. The OLS regression residual of the above equation is defined as $\hat{\eta}_t = d(y_t \mid a) - d(x_t \mid a)'\hat{\delta}(a)$. $SSR(a) = \sum \hat{\eta}_t^2(a)$ is the sum-of-squared residual functions. Then, the ERS point optimal test statistic of the null that $\alpha = 1$ against the alternative that $a = \bar{a}$ is then defined as: $P_T = (\text{SSR}(\bar{a}) - \bar{a}\ \text{SSR}(1)) / f_0$, where f_0 is an estimator of the residual spectrum at frequency zero.

Table 2

Term Spread's Non-stationarity and Risk Trend Existence Test Results[1)]

Term spread	VAR model order[2)]	$H_{0A} : \gamma = 1$	$H_{0B} : \theta_{12}(1) = 0$
10-year treasury note-Federal fund	3	0.026*	0.000**
5-year treasury note-Federal fund rate	3	0.047*	0.000**
10-year treasury note-3-month treasury bill	3	0.000**	0.006**
5-year treasury note-3-month treasury bill	3	0.000**	0.009**

Note: 1) The p-value for the null hypothesis. ** and * indicate rejection at 1% and 5% levels, respectively.
2) Schwartz Criterion is used to select a VAR model order.

spreads were found to be all 3 by Schwartz Criterion, as shown in Table 2.

Next, we checked whether we could observe a trend of I(1) or integrated of order 1 in the term spread and whether the risk premium shock trend existed within the term spread. Both null hypotheses $H_{0A} : \gamma = 1$ and $H_{0B} : \theta_{12}(1) = 0$ were tested, *i.e.*, the null hypothesis H_{0A} by Johansen's (1991) log-likelihood ratio test, and the null hypothesis H_{0B} by Kim's (2018) Wald test. Table 2 presents the test results.

In all the combinations of interest rates of four term spreads, the null hypotheses suggested above were rejected at the 5% significance level. The term spreads were all I(1), and the risk premium shock trend existed within the conformable term spread.

On the other hand, the estimation results using decomposed trends of four term spreads are in Table 3 below. The estimated value $\hat{\gamma}$ of the cointegration coefficient γ is a positive number greater than 1, while it increases as the maturity difference of term spread increases. This trend indicates that the term premium increases as the maturity of the bond increases in the long run, which is consistent with the theoretical prediction. In addition, the signs of other coefficients were found to be all positive as theoretically predicted.

The estimated value $\hat{\gamma}$ of the cointegration coefficient γ is similar to 1, and it suggests that the term spread has information similar to

Table 3

Estimates of Term Spread Decomposition Parameters

Term Spread	Parameter Estimates			
	$\hat{\gamma}$	$\hat{\Lambda}$	$(\gamma-1)(\theta_{11}(1)+\Lambda)$	$(\gamma-1)\theta_{12}(1)$
10-year treasury note-Federal fund	1.138	0.164	0.1869	0.0027
5-year treasury note-Federal fund rate	1.090	0.248	0.1212	0.0016
10-year treasury note-3-month treasury bill	1.258	0.372	0.3246	0.0004
5-year treasury note-3-month treasury bill	1.205	0.493	0.2595	0.0003

the cointegration error. In the case of γ = 1, the term spread is the cointegration error itself between the long- and short-term interest rates. These facts imply the possibility that information on long-term economic forecasts included in the trend of short- and long-term interest rates is missing from the term spread. From this point of view, testing the difference between term spread and the trend decomposition in the recession prediction is meaningful. The results of this work are described below.

Next, the results of probit model estimation using the term spread of 10-year (or 5-year treasury) bonds minus the federal fund rate to predict the NBER recession indicator are shown in Table 4 (a), (b). In the short term, the term spread showed significant negative sign in the recession prediction conformable with the traditional theory. More specifically, in the short-term forecast up to two years (24 months), the estimated sign was negative and was found to be significant at the 1% level. However, when the predicted lead is extended to over 36 months, the estimated coefficient of the term spread was found to be insignificant at the 5% level, where it shows a positive sign.

Then, the probit model was estimated using the decomposed trends in the term spread of the monetary policy shock trend and the risk premium shock trend as explanatory variables. We found that the decomposed trends of term spread were significant at the 5% level in the prediction of the long-term lag over 36 months. The monetary policy shock trend indicated a negative sign, and the risk premium shock trend showed a positive sign.[8]

Hence, a negative correlation exists between the monetary policy shock trend and the possibility of a recession. This result implies that the monetary policy has been implemented in a manner that preemptively raises short-term interest rates due to concerns about future economic overheating (*i.e.*, *passive* monetary policy response as mentioned in Section 3).[9]

This passive monetary policy seems to trigger an active monetary policy effect in the short term as the short-term prediction result of recession through term spread. In other words, tightening monetary policy, which is concerned about long-term economic overheating, slows the economy in the short term. Meanwhile, the prediction through trend decomposition showed a MacFaden R^2 higher than the term spread.

Further, all interest rate combinations, the size and statistical significance of the estimation coefficient of the variable S representing the remainder of the term spread except for the trend part are very similar to those of the term spread in the prediction using the term spread. This observation indicates that the forecast using the trend portion of the term spread provides additional information toward the long-term forecasting of a recession in a different aspect from the short-term forecast using the term spread.

Finally, inflation was found to be a significant predictor of recession at the 1% level in the prediction of a longer term of 36 months or more. The inflation reflecting rising oil prices and wages hinders the corporate investment, thus causing a long-term recession.

These results were largely maintained even if the interest rates constituting the term spread were changed differently. See Appendix for

[8] Contrary to the theoretical prediction, the risk premium shock trend showed a negative sign in the short-term recession prediction within one year. The risk premium factor included in the interest rate of long-term bonds used for long-term investment does not work, while the current short-term money supply and demand situation appears to be insufficient due to the current economic boom. This view is also supported by the fact that the variable S representing the cyclical part of the interest rate also shows significant negative coefficient values in the same short-term forecast.

[9] In the case of using the term spread of 10-year treasury bonds and federal fund rate, the coefficient of the positive sign for MTREND is observed. However, it is insignificant in the prediction of recession within 12 months, which may be related to the *offensive* monetary policy effect.

TABLE 4
PROBIT MODEL ESTIMATION

(a) Term Spread: 5-year Treasury Note-Federal Fund Spread

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-1.322	-0.290	8.687	-0.892	0.743	-128.450	-0.270	8.171
	0.000**	0.000**	0.000**	0.000**	0.234	0.024*	0.000**	0.004**
	0.168			**0.180**				
6	-1.121	-0.440	4.344	-0.780	0.539	-113.705	-0.424	3.570
	0.000**	0.000**	0.097	0.000**	0.402	0.048*	0.000**	0.237
	0.227			**0.235**				
9	-0.932	-0.580	0.188	-0.668	0.338	-100.278	-0.569	-0.772
	0.000**	0.000**	0.945	0.002**	0.613	0.092	0.000**	0.807
	0.273			**0.279**				
12	-0.839	-0.563	-2.045	-0.689	-0.213	-44.630	-0.554	-2.115
	0.000**	0.000**	0.448	0.001**	0.748	0.439	0.000**	0.490
	0.239			**0.241**				
24	-1.168	-0.126	4.259	-1.090	-1.670	103.497	-0.137	7.894
	0.000**	0.010*	0.074	0.000**	0.007**	0.051	0.007**	0.004**
	0.035			**0.049**				
36	-1.462	0.029	8.345	-1.542	-2.812	217.355	0.012	14.074
	0.000**	0.557	0.001**	0.000**	0.000**	0.000**	0.823	0.000**
	0.023			**0.059**				
48	-1.309	0.075	3.867	-1.243	-2.220	161.395	0.075	8.907
	0.000**	0.151	0.121	0.000**	0.001**	0.007**	0.178	0.001**
	0.005			**0.033**				
60	-1.211	0.067	1.257	-1.019	-1.788	111.608	0.087	6.415
	0.000**	0.184	0.614	0.000**	0.012*	0.084	0.113	0.025*
	0.003			**0.029**				

Note: 1) The number in bold is MacFaden R^2.
2) * and ** denote 5% and 1% significance, respectively.

the other estimation results.

Figure 1 below compares the fitted ones of the NBER recession indicator in the prediction by the term spread and its decomposed trends, where the term spread is given by the rates of 5-year Treasury Note and Federal Fund.

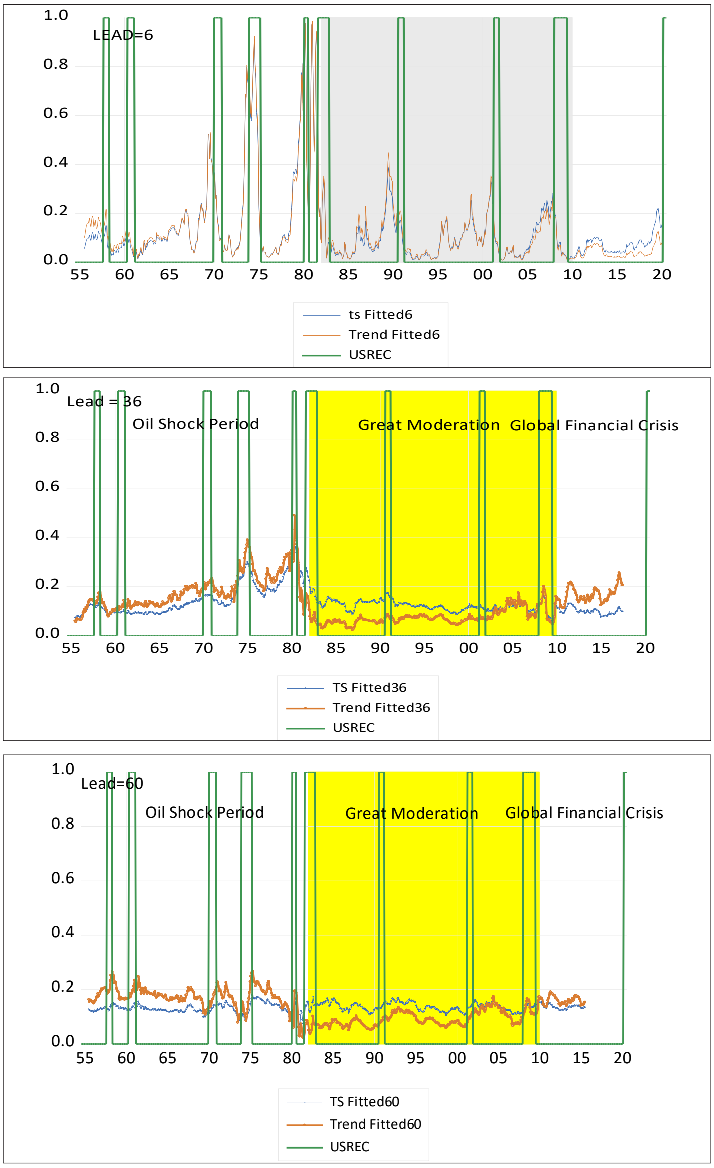
Table 4
Probit Model Estimation

(b) Term Spread : 10-year Treasury Note-Federal Fund Spread

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-1.290	-0.239	8.761	-0.951	-0.007	-52.100	-0.216	11.456
	0.000**	0.000**	0.000**	0.000**	0.990	0.255	0.000**	0.000**
	0.164			**0.175**				
6	-1.057	-0.380	4.196	-0.837	0.351	-75.979	-0.362	4.799
	0.000**	0.000**	0.108	0.000**	0.546	0.104	0.000**	0.121
	0.229			**0.235**				
9	-0.846	-0.513	-0.235	-0.708	0.310	-74.469	-0.497	-0.492
	0.000**	0.000**	0.932	0.000	0.608	0.124	0.000**	0.881
	0.283			**0.287**				
12	-0.734	-0.512	-2.970	-0.673	0.159	-55.458	-0.502	-3.657
	0.000**	0.000**	0.276	0.000**	0.790	0.241	0.000**	0.261
	0.257			**0.259**				
24	-1.061	-0.153	2.763	-0.948	-0.982	47.775	-0.152	5.431
	0.000**	0.000**	0.249	0.000**	0.070	0.259	0.001**	0.052
	0.046			**0.052**				
36	-1.389	-0.011	7.240	-1.197	-1.795	108.452	-0.007	12.264
	0.000**	0.804	0.003**	0.000**	0.002**	0.019*	0.877	0.000**
	0.023			**0.047**				
48	-1.249	0.029	2.989	-1.042	-1.588	94.785	0.044	7.954
	0.000**	0.500	0.236	0.000**	0.007**	0.047*	0.353	0.006**
	0.002			**0.025**				
60	-1.232	0.061	1.454	-1.002	-1.430	82.321	0.086	6.747
	0.000**	0.146	0.562	0.000**	0.023*	0.109	0.067	0.023**
	0.004			**0.026**				

Note: 1) The number in bold is MacFaden R^2.
2) * and ** denote 5% and 1% significance, respectively.

We can see that the predicted performance of the recession period window that is longer than the NBER recession indicator may be differently identified through Figure 1. The extended period was classified into three categories: before the 1980s (period 1), from the 1980s to the 2009 global financial crisis (period 2), and after the 2009



Note: USREC: NBER Recession Dummy, TS FittedX: Forecasting using 10-year Treasury Note-Federal Fund Spread for X month lead recession, Trend FittedX: Forecasting using trend decomposition of 10-year Treasury Note-Federal Fund Spread for X month lead recession.

Figure 1

Comparison of predictability of term spread and trend decomposition global financial crisis (period 3). Here, period 2 includes the boom period often referred to as the Great Moderation, and periods 1 and 3 include the period of depression caused by oil price shock and financial instability, respectively.

Among these periods, in the short-term prediction up to six months, the prediction through the term spread trend and the prediction through the term spread itself do not have a significant difference in predictive performance. However, in the long-term predictions of 36 and 60 months, the prediction using the decomposed trends of term spread shows a lower probability of recession compared with the prediction using the term spread for period 2 and a higher probability of recession to the prediction using the term spread for periods 1 and 3.

This result indicates that prediction through the decomposed trends of term spread is more efficient in predicting a longer window recession period than prediction through the term spread itself.

Next, we attempted to compare the prediction performances of the term spread and its trend decomposition after changing the dependent variable by the output gap leaving the explanatory variable of the probit model estimation. Now, the estimation method is the FM-OLS.

The estimation results are in Table 5. We found that the estimation coefficient had little statistical significance regardless of the lead order of the output gap in the case of term spread used prediction. However, inflation shows a positive sign coefficient estimator with a high statistical significance.

Meanwhile, in the case of forecasting using trend decomposition, the monetary policy shock trend showed positive estimated coefficient signs, and the risk shock trend showed negative estimated coefficient signs. Their statistical significances of the estimation coefficients were high in both the short and long term.

These signs of two trends were opposite to those observed in the previous probit model coefficient estimation results. These results are not contradictory because the NBER-based recession indicators and the output gap have a negative correlation with each other by definition. Meanwhile, the prediction through the trend decomposition showed adjusted R^2 higher than the term spread. However, the sign of the estimation coefficient of inflation showed little statistical significance and had a different result with the case of term spread used prediction. Monetary policy shock and risk shock trends bring information of inflation to predict the output gap.

TABLE 5
FM-OLS MODEL ESTIMATION

(a) Term Spread: 5-year Treasury Note-Federal Fund Spread

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-0.073	0.003	2.142	-0.078	0.443	-30.390	-0.002	0.730
	0.000	0.746	0.000	0.006**	0.000**	0.000**	0.749	0.069
	0.199			**0.364**				
6	-0.072	0.005	2.054	-0.073	0.443	-30.817	0.002	0.692
	0.000	0.475	0.000	0.013*	0.000**	0.000**	0.773	0.098
	0.165			**0.317**				
9	-0.073	0.010	2.002	-0.070	0.431	-30.102	0.006	0.707
	0.001**	0.255	0.000**	0.021*	0.000**	0.000**	0.397	0.103
	0.139			**0.282**				
12	-0.072	0.012	1.937	-0.064	0.420	-29.825	0.010	0.729
	0.001**	0.156	0.000**	0.041*	0.000**	0.000**	0.207	0.103
	0.121			**0.256**				
24	-0.073	0.018	1.899	-0.055	0.367	-27.181	0.019	1.006
	0.001**	0.035*	0.000*	0.097	0.000**	0.001**	0.025*	0.031*
	0.118			**0.225**				
36	-0.062	0.016	1.754	-0.026	0.377	-30.643	0.017	0.964
	0.004**	0.064	0.000**	0.428	0.000**	0.000**	0.037*	0.033*
	0.110			**0.220**				
48	-0.047	0.009	1.540	0.007	0.393	-34.788	0.012	0.829
	0.027*	0.266	0.000**	0.838	0.000**	0.000**	0.125	0.064
	0.102			**0.214**				
60	-0.031	0.004	1.242	0.042	0.417	-39.830	0.010	0.675
	0.159	0.616	0.004**	0.207	0.000**	0.000**	0.212	0.129
	0.074			**0.196**				

Note: 1) The number in bold is Adjusted R^2.
2) * and ** denote 5% and 1% significance, respectively.

TABLE 5
FM-OLS MODEL ESTIMATION

(b) Term Spread : 10-year Treasury Note-Federal Fund Spread

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-0.069	0.000	2.079	-0.061	0.489	-34.264	0.000	0.593
	0.001**	0.983	0.000**	0.010**	0.000**	0.000**	0.978	0.118
	0.201			**0.450**				
6	-0.067	0.002	1.973	-0.057	0.493	-34.764	0.003	0.528
	0.002**	0.750	0.000**	0.021*	0.000**	0.000**	0.564	0.180
	0.166			**0.402**				
9	-0.067	0.005	1.904	-0.053	0.488	-34.715	0.007	0.553
	0.002**	0.510	0.000**	0.040*	0.000**	0.000**	0.263	0.178
	0.138			**0.364**				
12	-0.065	0.006	1.821	-0.047	0.481	-34.690	0.009	0.589
	0.004**	0.388	0.000**	0.078	0.000**	0.000**	0.147	0.168
	0.119			**0.336**				
24	-0.063	0.009	1.724	-0.033	0.435	-33.115	0.015	0.944
	0.006**	0.197	0.000**	0.244	0.000**	0.000**	0.026*	0.039*
	0.108			**0.291**				
36	-0.048	0.006	1.526	-0.009	0.428	-34.286	0.013	0.970
	0.032*	0.435	0.000**	0.742	0.000**	0.000**	0.056	0.030*
	0.099			**0.281**				
48	-0.031	0.000	1.286	0.015	0.431	-36.176	0.009	0.889
	0.166	0.975	0.003**	0.605	0.000**	0.000**	0.191	0.046*
	0.097			**0.269**				
60	-0.009	-0.007	0.914	0.046	0.447	-39.482	0.006	0.769
	0.701	0.352	0.032*	0.099	0.000**	0.000**	0.376	0.084
	0.080			**0.259**				

Note: 1) The number in bold is Adjusted R^2.
2) * and ** denote 5% and 1% significance, respectively.

IV. Conclusion

This study analyzed whether the trend obtained by decomposing the expected portion of the interest rate term spread into risk premium shock and monetary policy shock is useful for long-term forecasts of recession in the United States. After the Beverage Nelson decomposition of the interest rate term spread from the co-integrated VAR model composed of short-term and long-term interest rates, the trends in monetary policy and independent risk premium shocks were estimated and used for the prediction. Through the linear and probit prediction models, we tested whether these trends were effective for the predictive power enhancement of output gap and recession. On the basis of the proposed process, US data were analyzed through the probit model and FM-OLS estimation. We found that the trends of monetary policy shock and risk premium shock clearly have an edge in the long-term forecast when it is compared with conventional term spread forecasts.

These results reveal that the trend-based method is excellent in long-term economic forecasting. Hence, these findings will be very helpful in policy making.

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Appendix

Table 5
10-year Treasury Note-3Month Bill

Dependent variable: NBER based recession indicators

Estimation Method: Probit

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-1.433	-0.180	13.905	-1.261	-0.093	-287.660	-0.143	14.880
	0.000**	0.001**	0.000**	0.000**	0.565	0.134	0.013*	0.000**
	0.133			**0.140**				
6	-1.119	-0.385	11.355	-1.043	-0.175	-334.277	-0.362	10.736
	0.000**	0.000**	0.000**	0.000**	0.299	0.087	0.000**	0.000**
	0.191			**0.196**				
9	-0.819	-0.606	8.537	-0.828	-0.318	-338.999	-0.595	6.726
	0.000**	0.000**	0.000**	0.000**	0.079	0.098	0.000**	0.016*
	0.265			**0.270**				
12	-0.592	-0.694	4.629	-0.662	-0.441	-226.660	-0.695	2.465
	0.000**	0.000**	0.043*	0.000**	0.018*	0.258	0.000**	0.390
	0.269			**0.272**				
24	-0.850	-0.295	3.673	-0.752	-0.540	182.354	-0.291	6.021
	0.000**	0.000**	0.082	0.000**	0.001**	0.315	0.000**	0.019*
	0.074			**0.079**				
36	-1.156	-0.132	5.611	-0.975	-0.574	326.737	-0.110	9.969
	0.000**	0.013*	0.011*	0.000**	0.001**	0.097	0.068	0.000**
	0.034			**0.050**				
48	-1.134	-0.027	1.768	-0.935	-0.495	332.915	0.017	6.730
	0.000**	0.605	0.440	0.000**	0.004**	0.104	0.784	0.014*
	0.002			**0.022**				
60	-1.257	0.077	0.708	-0.975	-0.411	239.484	0.171	7.183
	0.000**	0.128	0.761	0.000**	0.021*	0.293	0.009**	0.011*
	0.004			**0.035**				

Note: 1) The number in bold is MacFaden R^2.
2) * and ** denote 5% and 1% significance, respectively.

TABLE 5
10-YEAR TREASURY NOTE-3MONTH BILL

Dependent variable: Output gap

Estimation Method: FM OLS

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-0.080	0.006	2.154	-0.072	0.154	-168.141	-0.002	0.641
	0.000**	0.446	0.000	0.000**	0.000**	0.000**	0.780	0.052
	0.199			**0.508**				
6	-0.077	0.007	2.005	-0.066	0.156	-171.657	0.002	0.556
	0.001**	0.371	0.000**	0.002**	0.000**	0.000**	0.744	0.108
	0.166			**0.469**				
9	-0.075	0.009	1.884	-0.061	0.154	-171.155	0.006	0.515
	0.001**	0.288	0.000**	0.005**	0.000**	0.000**	0.401	0.153
	0.140			**0.437**				
12	-0.071	0.010	1.768	-0.055	0.151	-171.022	0.010	0.513
	0.002**	0.248	0.000**	0.015*	0.000**	0.000**	0.192	0.169
	0.122			**0.414**				
24	-0.067	0.012	1.604	-0.045	0.138	-167.356	0.021	0.785
	0.006**	0.166	0.000**	0.063	0.000**	0.000**	0.012*	0.049*
	0.110			**0.379**				
36	-0.055	0.009	1.487	-0.029	0.133	-175.714	0.024	0.893
	0.021*	0.284	0.000**	0.223	0.000**	0.000**	0.004**	0.022*
	0.103			**0.370**				
48	-0.038	0.003	1.335	-0.009	0.131	-190.741	0.023	0.911
	0.109	0.711	0.001**	0.702	0.000**	0.000**	0.007**	0.019*
	0.098			**0.364**				
60	-0.011	-0.006	1.033	0.018	0.130	-211.564	0.020	0.852
	0.649	0.479	0.007**	0.432	0.000**	0.000**	0.022*	0.028*
	0.078			**0.353**				

Note: 1) The number in bold is Adjusted R^2.
2) * and ** denote 5% and 1% significance, respectively.

Table 6
5-year Treasury Note-3Month Bill

Dependent variable: NBER based recession indicators
Estimation Method: Probit

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-1.478	-0.208	14.636	-1.195	-0.067	-418.608	-0.187	13.716
	0.000**	0.002**	0.000**	0.000**	0.681	0.054	0.006**	0.000**
	0.131			**0.140**				
6	-1.187	-0.453	12.637	-0.975	-0.167	-523.316	-0.441	10.238
	0.000**	0.000**	0.000**	0.000**	0.332	0.018*	0.000**	0.000**
	0.184			**0.194**				
9	-0.900	-0.713	10.267	-0.743	-0.317	-605.042	-0.706	6.847
	0.000**	0.000**	0.000**	0.000**	0.088	0.010*	0.000**	0.012*
	0.252			**0.264**				
12	-0.681	-0.807	6.535	-0.586	-0.443	-506.734	-0.795	3.467
	0.000**	0.000**	0.003**	0.003**	0.022*	0.029*	0.000**	0.210
	0.251			**0.259**				
24	-0.957	-0.301	4.970	-0.838	-0.532	150.607	-0.291	7.333
	0.000**	0.000**	0.016*	0.000**	0.002**	0.455	0.000**	0.004**
	0.059			**0.064**				
36	-1.222	-0.128	6.341	-1.157	-0.662	547.265	-0.113	11.336
	0.000**	0.050	0.003**	0.000**	0.000**	0.012*	0.107	0.000**
	0.030			**0.049**				
48	-1.203	0.011	2.215	-1.072	-0.536	511.219	0.060	7.590
	0.000**	0.873	0.323	0.000**	0.002**	0.024*	0.419	0.004**
	0.002			**0.026**				
60	-1.236	0.091	0.349	-1.002	-1.430	82.321	0.086	6.747
	0.000**	0.165	0.879	0.000**	0.023*	0.109	0.067	0.023*
	0.003			**0.026**				

Note: 1) The number in bold is MacFaden R^2.
2) * and ** denote 5% and 1% significance, respectively.

Table 6
5-year Treasury Note-3Month Bill

Dependent variable: Outputgap

Estimation Method: FM OLS

	Term Spread Model			Decomposed Trends Model				
Lead	C	TS	INF	C	MTREND	NMTREND	S	INF
3	-0.088	0.014	2.174	-0.068	0.146	-162.511	-0.007	0.458
	0.000**	0.176	0.000**	0.004**	0.000**	0.000**	0.395	0.189
	0.200			**0.444**				
6	-0.086	0.016	2.027	-0.061	0.147	-165.741	-0.002	0.347
	0.000**	0.121	0.000**	0.013*	0.000**	0.000**	0.802	0.339
	0.168			**0.403**				
9	-0.084	0.019	1.906	-0.056	0.146	-163.912	0.003	0.296
	0.000**	0.076	0.000**	0.029*	0.000**	0.000**	0.778	0.433
	0.144			**0.370**				
12	-0.082	0.021	1.795	-0.050	0.143	-162.730	0.007	0.272
	0.000**	0.053	0.000**	0.062	0.000**	0.000**	0.447	0.485
	0.128			**0.345**				
24	-0.082	0.027	1.656	-0.039	0.131	-153.753	0.021	0.487
	0.000**	0.015*	0.000**	0.159	0.000**	0.000**	0.041*	0.236
	0.127			**0.312**				
36	-0.076	0.027	1.577	-0.019	0.129	-167.178	0.026	0.539
	0.001**	0.013*	0.000**	0.485	0.000**	0.000**	0.009**	0.173
	0.126			**0.320**				
48	-0.062	0.020	1.465	0.009	0.128	-190.308	0.025	0.495
	0.006**	0.058	0.000**	0.753	0.000**	0.000**	0.013*	0.203
	0.114			**0.326**				
60	-0.041	0.012	1.229	0.043	0.131	-221.907	0.022	0.354
	0.075	0.277	0.001**	0.111	0.000**	0.000**	0.028*	0.351
	0.078			**0.327**				

Note: 1) The number in bold is Adjusted R^2.
2) * and ** denote 5% and 1% significance, respectively.

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