Investor Sentiment and Bond Market in Korea

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Abstract

We construct sentiment index with eight economic variables reflecting investor sentiment. We use kalman filter and principal component analysis to extract common factor of those variables. Two sentiment indices are similar in broad trend, but different in detailed scale. We conduct analysis with two constructed sentiment indices to investigate the relationship with two sentiment indices and the bond market risk is similar. In order to assess the relationship between investor sentiment and risk premium of bond, we conduct VAR analysis with sentiment, term premium, default premium and convexity. VAR results suggest there are significant relationships with sentiment and risk premium of bond.

Keywords: Investor sentiment, term premium, default premium, convexity, Korea bond market

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I. Introduction

Market has sentiment, because it is driven by the market participants who have sentiment. Market, thus, responds to innumerable news from political, economic events to natural disasters, and sometimes moves irrationally. In this way, market acts like one big organism which has sentiment. There is no need to address the importance of sentiment. Since there have been many fluctuation and anomalies which are not explained by classical finance theory, other social science focused on actual human behaviour has been studied in finance field. Research on sentiment is one of the most crucial parts of behavioural finance. Many sentiment indices have been made and used in academic area and financial market as well. It is still controversial, but sentiment can be a useful tool to examine financial market.

In psychology, sentiment is an organised system of emotional dispositions centred about the idea of some object (McDougall, 2003). While investor sentiment (also called market sentiment) is the expectations of market participants (Brown and Cliff, 2004) in economics and finance. However, specific definition is varied from person to person. Sentiment can be a propensity to speculative assets (Baker and Wurgler, 2007). Sentiment can also simply represent the optimism and pessimism or confidence of investor.

Meanwhile, sentiment indices could be divided into two categories depending on the methodology: Direct and Indirect approach (Baker and Wurgler (2007) use the term bottom-up and top-down approach instead of direct and indirect approach). Direct approach surveys actual market participants. Indirect approach, on the other hand, uses economic variables which are considered to reflect sentiment. Sentiment index is made by extracting common factors of those variables. Both methods have their own strengths and weaknesses. Direct

approach can suggest actual feeling or expectation of market participants. However, there is a possibility that survey data do not always contain true feeling or expectation of market participant such as respondents lie in the survey. Indirect approach can measure the reduced-form, but it cannot provide microfoundations for the variation in investor sentiment (Baker and Wurgler, 2007). Despite the advantage and disadvantage, sentiment indices based on both approaches make significant process in academics and industry.

The goal of this paper is constructing investor sentiment index of Korean market using indirect method and studying the relationship with sentiment and bond market. The key of indirect method is the technique for extracting common factor among the proxies. There are two techniques to extract common factor: Principal component analysis and kalman filter. After measuring investor sentiment, we perform vector autoregression analysis to investigate the pattern of the relationship using two constructed sentiment indices.

Section 2 contains literature review on investor sentiment. In section 3, we measure investor sentiment in Korea market using kalman filter and principal component analysis. Section 4 presents the result of vector autoregression analysis and investigates the relationship between investor sentiment and bond market. Finally, section 5 concludes.

II. Literature review

Direct (Bottom-up) approach focuses on investors' feeling or emotion on future. Sentiment index constructed by direct approach can contain actual sentiment of investor but this approach can have sample selection biases. Moreover, it is hard to make survey questions which contain sophisticated investors and market behaviour completely. Because of availability to contact investors, industries use direct method more than academic area. In academic area, Shiller (2000) constructs confidence index, which is similar to sentiment index, using survey. In industry, American Association of Individual Investor (AAII) and

Investors Intelligence (II) measure sentiment using survey. The index of consumer sentiment (The university of Michigan Survey Research center), The index of consumer confidence (the conference board), Investor Confidence Index (JP Morgan), Investor Optimism Index (UBS/Gallup), UK Logistics confidence index (Barclays) and Tankan Sentiment Index (Bank of Japan) are also sentiment indices measured by direct method.

The key of indirect (Top-down) approach is extract common factor among economic variables which considered as containing investor sentiment information. Through this approach, one can easily construct time series sentiment data. However, there can be a controversy whether economic variables used in research really contain sentiment information. Principal component analysis and kalman filter is most common methods to extract common factors. In 1990s, research on investor sentiment uses single economic variable as a proxy of sentiment. Most commonly used proxy is the discounts of closed-end mutual fund. The closed-end mutual funds are mostly held by individual investors like small stocks. The performance of small stock is good, the discount of closed-end mutual fund is decreased (Lee, Shleifer and Thaler, 1991). Thus, the discounts of closed-end mutual funds can be a useful index to analyse overvaluation of stock market and the degree of overvaluation (De Long and Shleifer, 1991). In addition to the discounts of closed-end mutual funds, the ratio of odd-lot sales to purchase, net mutual fund redemptions (Neal and Wheatley, 1998) and put-call ratio (Wang et al, 2006) are used for sentiment study. Other researchers apply principal component analysis (Baker and Wurgler, 2006; Finter and Ruenzi, 2012) and kalman filter (Brown and Cliff, 2004) to consider the effect of multiple proxies. In industry, Fear & Greed Index (CNN Money), EFA ETF Volatility Index (CBOE), Panic/Euphoria Model (Citigroup) and Love-panic index (BNP Paribas) are constructed by multiple economic variables.

There has been much research on the relationship between investor sentiment and stock market. Empirical study shows sentiment and the return on risky stocks are negatively correlated (Baker and Wurgler, 2006). Some empirical results show

the predictive power of sentiment on near-term stock return is very weak (Brown and Cliff, 2004). However, other studies present sentiment can predict the size premium (Neal and Wheatley, 1998), and recent study by Kim and Kang (2014) suggest sentiment has the predictive power both on the time series and cross sectional variation of stock returns. Meanwhile, investor sentiment in bond market is recently studied. Expectation hypothesis suggests long term interest rate is the sum of current and future expected short term interest rates and the term premium. However, many empirical evidence violate the expectation hypothesis. Under expectation hypothesis, risk premia should be consistent. However, bond risk premia is time-varying and affects bond market fluctuation (Cochrane and Piazzesi, 2005). Macroeconomic factors, especially real activity and inflation, also have predictive power for excess bond return and yield risk premia (Ludvigson and Ng, 2009). Recently, investor sentiment has been pointed as significant factor in bond return and risk premium, because bond market is also related to investor sentiment. When investor sentiment is high and investors expect the performance of bond-like stocks is better and speculative stocks, bond return also increases (Baker and Wurgler, 2012). Investor sentiment has predictive power on bond market premia (Laborda and Olma, 2014). Research results show the relationship between sentiment and spreads. Empirical test suggest sentiment and credit spreads are negatively correlated (Tang and Yan, 2010). They argue that low sentiment makes investors more risk averse, so risk premium is increased. Other empirical study shows low sentiment leads overpricing of corporate bonds with low yield spreads (Nayak, 2010).

III. Measuring Investor Sentiment

1. Data

Sentiment index is constructed from following data (January 2003 to April 2015, Weekly, from FnGuide): Growth rate of listed companies in the Korean Stock Exchange (Nlist), Implied volatility index in Korean Stock Exchange (Vol),

Three-month momentum of KOSPI 200 (Mom), Percentage of shares owned by foreign investors in the Korean market (Fore), Ratio between the KOSPI 200 and KOSDAQ index (KKR), Discount rate of exchange trade funds (ETF), Percentage of stocks above 20-day moving average (Ab) and Turnover ratio (Turn).

[Insert Table 1]

Table 1 contains the definition of variables used to construct sentiment index. First variable is the growth rate of listed companies in KRX (Nlist). The number of IPOs data is not available in Korean market, thus the growth rate of listed companies is used as the proxy of the number of IPOs data (Kim and Kang, 2014). Second variable is the implied volatility index in KRX (Vol). The three-month momentum of KOSPI 200 (Mom) is also included because asset management firms in Korea consider momentum reflects investor sentiment (Kim and Kang, 2014). The percentage of shares owned by foreign investors (Fore) is calculated as follows: 100*(the number of shares owned by foreigners)/(the number of shares outstanding). Foreign investors are considered as well- informed investor in the Korean market. The percentage of shares owned by foreign investors might reflect the informed investors' behaviour (Kim and Kang, 2014). The ratio between the KOSPI 200 and KOSDAQ index (KKR) also reflect investors' risk preference (Kim and Kang, 2014). The ratio of ETF market price and ETF Net Asset Value minus one (ETF) is used as proxy for the average discount on closed-end mutual fund which Baker and Wurgler (2006) used (Kim and Kang, 2014). The percentage of stocks above 20-day moving average (Ab) is also used to measure investor sentiment. The percentage of stocks above 20-day moving average can contain cross sectional upward sentiment (Kim and Kang, 2014). Turnover ratio (Turn) is included following Baker and Wurgler (2006). The premium for dividend-paying stocks, which is also used in Baker and Wurgler (2006), is not used in the paper because of the limitation in data.

[Insert Table 2]

Table 2 presents the descriptive statistics of variables. We construct two sentiment indices based on principal component analysis and kalman filter using weekly data. Correlation column shows all variable, except Nlist, are significantly correlated to the sentiment.

2. Methodology

We construct sentiment index using two methods: principal component analysis and kalman filter. Both principal component analysis and kalman filter are useful method for extracting common factors from time series. Especially principal component analysis is widely used to constructing investor sentiment index. Baker and Wurgler (2006) set sentiment index with six economic variables using principal component analysis. Kim and Kang (2014) conduct principal component analysis with nine variables. First, we performed principal component analysis with 16 variables: Nlist, Vol, Mom, Fore, KKR, ETF, Ab, Turn and their lagged variables. After PCA, we calculated correlation between first component and each variable. Then we chose variables with high correlation among original variable and lagged variable: $Nlist_t$, Vol_t, Mom_{t-1}, $Fore_t$, KKR_{t-1}, ETF_t, Ab_{t-1}, $Turn_{t-1}$. Finally, we perform principal component analysis with selected 8 variables to extract investor sentiment. Correlation between first component of first principal component analysis and that of second principal component analysis is 0.9879672, thus information loss is not that significant.

Kalman filter, also, has been used by many researchers to find unknown factors and common factors. Stock and Watson (1989) made coincidence index using kalman filter. Brown and Cliff (2004) used kalman filter to extract investor

sentiment. In order to use kalman filter, we set measurement equation and transition equation as follows.

Measurement equation

$Y_t = F \cdot S_t + V_t$, $V_t \sim N(0, V_t)$

$Y_t = (Nlist_t, Vol_t, Mom_t, Fore_t, KKR_t, ETF_t, Ab_t, Turn_t)'$

Transition equation

$S_t = G \cdot S_{t-1} + W_t$, $W_t \sim N(0, W_t)$ where S_t is Sentiment

[Insert Figure 1]

[Insert Figure 2]

Investor sentiment (S_t) is following AR(1) process. Maximum likelihood estimation is used for estimate unknown parameter G and F. Macro-economic factors are not provided in weekly frequency in Korea, thus orthogonalization would be meaningless in this paper. Figure 1 shows the investor sentiment from January 2003 to April 2015. Both sentiment_pca and sentiment_kalman show similar trend. During the Korean credit card crisis from 2003 to 2004, global financial crisis in 2008 and Eurozone crisis in 2011/2012, sentiment is fallen. However, detailed trend is quite different because of the difference in methodology. Figure 2 plots the difference between sentiment_kalman and sentiment_pca. PCA is eigenvector-based analysis. On the other hand, kalman filter is statistical (stochastic) model, and it extracts time-varying commonality. The most distinct difference is the sensitivity to scalar factors. PCA is sensitive to scale of original variables while kalman filter method is insensitive. It is hard to compare two models, since two models are fundamentally different.

[Insert Figure 3]

The relationship between proxy variables used for constructing index and sentiment index is presented in Figure 3. Especially, the implied volatility index in KRX (Vol) and the discount rate of exchange trade funds (ETF) show similar pattern with sentiment index. Three-month momentum of KOSPI 200 (Mom) is negatively correlated to sentiment index.

IV. Result

In order to analyse the relationship with sentiment and bond market, we perform vector autoregression analysis. In addition to our sentiment index, we use sentiment index, term premium (TERM), default premium (DEF) and convexity (CONV).

[Insert Figure 4]

Figure 4 plot the term premium, default premium and convexity and their difference. In global financial crisis, both risk premium and convexity are quite volatile. Especially, risk premium are widen due to the recession followed by financial crisis.

We set four VAR model. The vectors of VAR analyses are as follows: $Y_t = [\Delta\text{sentiment}, \text{TERM.RET}_t, \text{DEF.RET}_t]^T$, $Y_t = [\Delta\text{sentiment}, \text{TERM}_t, \text{DEF}_t]^T$, $Y_t = [\Delta\text{sentiment}, \text{CONV.RET}_t]^T$ and $Y_t = [\Delta\text{sentiment}, \text{CONV}_t]^T$. Term premium is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Convexity is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. Bond yield data is provided daily, thus we

convert daily data to weekly data using weekly average. Log returns are used for VAR analysis for slope.

The equation of VAR analysis for investigating slope of risk premium is followed. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t,, \text{ where } Y_t = [\Delta\text{sentiment}, TERM.RET_t, DEF.RET_t]^T$$

[Insert Table 3]

[Insert Table 4]

Table 3 presents the result of VAR model. This VAR result shows sentiment is insignificantly related to the term premium, except sentiment of lag 7. On the other hand, sentiment of lag 1 is negatively related to the default premium. When sentiment is low, investors become risk averse. Thus, the demand for riskless asset (i.e., government-issued securities) is increased. This causes default premium to decrease. Sentiment of lag 3, 5, 6 are significantly but positively related to default premium. Cointegration test statistics in Table 4 suggest there is no cointegration among these variables.

The equation of VAR analysis for investigating level of risk premium is followed. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t,, \text{ where } Y_t = [\Delta\text{sentiment}, TERM_t, DEF_t]^T$$

[Insert Table 5]

[Insert Table 6]

[Insert Table 7]

Table 5 contains the result of VAR model. The result suggests sentiment is insignificantly related to the level term premium, except lag 8. However, sentiment of lag 3 is negatively correlated to default premium. This result is not that different from the VAR result of Table 3. Default premium is decreased under high sentiment, because corporate bond is overpriced with low yield (Nayak, 2010). When sentiment is high, investors tend to be more risk-taking, thus demand for risky asset (i.e. long-term bond, corporate bond etc.) increases. This causes overvaluation of market. VAR results of table 3 and table 4 suggest the patterns of the relationship with sentiment and term premium/default premium are not similar. Remote past sentiment is significantly related to term premium. Thus is consistent with previous research. However, not only remote past sentiment but recent past sentiment are significantly related to default premium. Cointegration test statistics in Table 6 reveal two cointegration relationships among these variables. VECM result is also tabulated in Table 7. The result suggests sentiment index constructed by kalman filter is somehow related to the default premium.

The equation of VAR analysis for investigating the relationship between sentiment and the slope of convexity is followed. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t,, \text{ where } Y_t = [\Delta\text{sentiment}, \text{CONV.RET}_t]^T$$

[Insert Table 8]

[Insert Table 9]

Table 7 shows the result of model. Sentiment change is negatively related to the slope of convexity. Convexity is the second derivative of the bond price, thus the result implies the sensitivity is increased when sentiment is low. When sentiment is low, investor tend to be more risk averse. Risk-averse investors are more sensitive to the change of bond price. Cointegration test statistics in Table 8 suggest there is no cointegration relationship among these variables.

The equation of VAR analysis for investigating the relationship between sentiment and the level of convexity is followed. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t,, \text{ where } Y_t = [\Delta\text{sentiment}, CONV_t]^T$$

[Insert Table 10]

[Insert Table 11]

Table 9 shows the result of last model. Cointegration test statistics in Table 10 suggest there is no cointegration relationship among these variables. Sentiment is insignificantly related to the level of convexity. VAR results suggest investor sentiment is related to the bond market.

V. Conclusion

As we mentioned in introduction section, investor sentiment is one of the most important factor to consider because market is consist of complicated investors. This paper examines the relationship between investor sentiment and bond market in Korea. In order to measure investor sentiment, we choose eight economic variables which considered reflecting sentiment: Growth rate of listed

companies in the Korean Stock Exchange, Implied volatility index in Korean Stock Exchange, Three-month momentum of KOSPI 200, Percentage of shares owned by foreign investors in the Korean market, Ratio between the KOSPI 200 and KOSDAQ index, Discount rate of exchange trade funds, Percentage of stocks above 20-day moving average and Turnover ratio. Then, we extract common factor of those variable using kalman filter and principal component analysis. Through VAR analysis, we investigate the relationship of sentiment and bond market. VAR results suggest sentiment is significantly related to the level of default premium, return of term and default premium and convexity. These results are in line with previous study of Nayak (2010) and Baker and Wurgler (2006).

Acknowledgement

We appreciate Professor Sung Won Seo of Ajou University for remarkable comments on the earlier draft

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Table 1
Variable definition

Table 1 presents explanation of the variables.

Variable	Definition
Nlist	Growth rate of number of listed companies in the Korea stock exchange
Vol	Implied volatility index (V-KOSPI 200)
Mom	Three month momentum of KOSPI 200
Fore	100*(number of shares owned by foreigners)/(number of shares outstanding)
KKR	KOSPI200 index/KOSDAQ index
ETF	(ETF market price/ ETF net asset value)-1
Ab	The percentage of stocks above 20-day moving average
Turn	Turnover ratio

Table 2
Descriptive statistics

Table 2 contains the descriptive statistics of all variables. We use weekly data from January 2003 to April 2015. We collect the data from the FnGuide (http://www.fnguide.com). Raw data is daily data collected from FnGuide. We convert daily data to weekly data weekly average. We construct sentiment index based on principal component analysis and kalman filter. Each of the index components has been adjusted to mean zero and variance one. ∗indicates significance at 5%; ∗∗significance at 10%; ∗∗∗significance at 1%, respectively.

Panel A: Sentiment_pca with proxy variables

	Mean	Median	Min.	Max.	Std.dev	Correlation with sentiment	$Nlist_t$	Vol_t	Mom_{t-1}	$Fore_t$	KKR_{t-1}	ETF_t	Ab_{t-1}	$Turn_{t-1}$
$Nlist_t$	0.00	0.00	-0.04	0.02	0.00	-0.06	1.00							
Vol_t	22.93	20.61	10.60	81.82	9.50	0.49***	-0.04	1.00						
Mom_{t-1}	3.54	6.25	-67.03	51.29	18.71	-0.99***	0.05	-0.39	1.00					
$Fore_t$	0.35	0.34	0.28	0.44	0.04	-0.18***	-0.01	-0.26	0.16	1.00				
KKR_{t-1}	0.38	0.39	0.17	0.59	0.11	0.10**	0.03	-0.24	-0.14	-0.59	1.00			
ETF_t	0.06	0.06	-0.31	0.82	0.18	0.49***	-0.05	0.56	-0.44	-0.59	0.36	1.00		
Ab_{t-1}	0.46	0.46	0.03	0.89	0.17	-0.30***	-0.03	-0.28	0.28	-0.09	0.17	-0.08	1.00	
$Turn_{t-1}$	0.01	0.01	0.01	0.04	0.01	-0.19***	-0.08	0.38	0.24	0.28	-0.62	-0.04	0.00	1.00

Panel B: Sentiment_kalman with proxy variables

	Mean	Median	Min.	Max.	Std.dev	Correlation with sentiment	$Nlist_t$	Vol_t	Mom_t	$Fore_t$	KKR_t	ETF_t	Ab_t	$Turn_t$
$Nlist_t$	0.00	0.00	-0.04	0.02	0.00	-0.04	1.00							
Vol_t	22.93	20.61	10.60	81.82	9.50	1.00***	-0.04	1.00						
Mom_t	3.54	6.25	-67.03	51.29	18.71	-0.40***	0.04	-0.40	1.00					
$Fore_t$	0.35	0.34	0.28	0.44	0.04	-0.27***	-0.01	-0.26	0.16	1.00				
KKR_t	0.38	0.39	0.17	0.59	0.11	-0.22***	0.03	-0.24	-0.14	-0.59	1.00			
ETF_t	0.06	0.06	-0.31	0.82	0.18	0.57***	-0.05	0.56	-0.44	-0.59	0.36	1.00		
Ab_t	0.46	0.46	0.03	0.89	0.17	-0.26***	-0.05	-0.27	0.28	-0.09	0.17	-0.06	1.00	
$Turn_t$	0.01	0.01	0.01	0.04	0.01	0.37***	-0.13	0.38	0.24	0.28	-0.62	-0.04	0.02	1.00

Table 3

Sentiment and bond market (VAR: slope of risk premium)

Table 3 presents the result of vector autoregressive VAR model is $Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t$,, where $Y_t = [\Delta\text{sentiment}, \text{TERM.RET}_t, \text{DEF.RET}_t]^T$. TERM.RET means log return of term premium and DEF.RET means log return of default premium. Term premium is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard errors are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

		term premium		**default premium**				**term premium**	**default premium**	
	Lag	Estimate		Estimate			Lag	Estimate	Estimate	
sentiment_kalman	1	0.1046		-0.0040	**	**sentiment_pca**	1	-0.0001	0.0000	
		(0.0709)		(0.0016)				(0.0001)	(0.0001)	
	2	0.0340		-0.0008			2	0.0002	0.0000	
		(0.0713)		(0.0016)				(0.0001)	(0.0001)	
	3	-0.1056		0.0040	*		3	0.0001	0.0001	
		(0.0713)		(0.0016)				(0.0001)	(0.0001)	
	4	-0.1303	.	-0.0002			4	-0.0002	0.0001	.
		(0.0720)		(0.0016)				(0.0001)	(0.0001)	
	5	-0.0116		0.0041	*		5	-0.0001	0.0000	
		(0.0720)		(0.0016)				(0.0001)	(0.0001)	
	6	-0.0678		0.0053	***		6	0.0002	0.0000	
		(0.0721)		(0.0016)				(0.0001)	(0.0001)	

	7	-0.2050	**	-0.0019			7	-0.0001		0.0001	*
		(0.0728)		(0.0016)				(0.0001)		(0.0001)	
	8	0.0848		0.0021			8	-0.0002	.	0.0000	
		(0.0733)		(0.0016)				(0.0001)		(0.0001)	
term premium	1	-0.1616	***	0.0010		**term premium**	1	1.2930	***	0.0050	
		(0.0416)		(0.0009)				(0.0422)		(0.0192)	
	2	-0.2064	***	-0.0003			2	-0.3977	***	0.0476	
		(0.0415)		(0.0009)				(0.0691)		(0.0314)	
	3	0.0005		-0.0012			3	0.1817	*	-0.0684	*
		(0.0423)		(0.0009)				(0.0705)		(0.0320)	
	4	0.0786	.	0.0001			4	-0.0472		0.0114	
		(0.0421)		(0.0009)				(0.0706)		(0.0321)	
	5	-0.0317		-0.0002			5	-0.0989		0.0122	
		(0.0419)		(0.0009)				(0.0704)		(0.0320)	
	6	-0.0220		0.0000			6	0.0769		-0.0118	
		(0.0418)		(0.0009)				(0.0700)		(0.0318)	
	7	-0.0961	*	0.0019	*		7	-0.0467		-0.0255	
		(0.0410)		(0.0009)				(0.0679)		(0.0308)	
	8	-0.0382		-0.0015	.		8	0.0265		0.0286	
		(0.0408)		(0.0009)				(0.0407)		(0.0185)	
default premium	1	-1.3094		0.6869	***	**default premium**	1	-0.5622	***	1.7520	***
		(1.8792)		(0.0415)				(0.0910)		(0.0413)	
	2	3.9829	.	-0.0782			2	0.9454	***	-0.8231	***

		(2.2452)		(0.0496)				(0.1795)		(0.0815)	
	3	-6.8785	**	0.1223	*		3	-0.3713	.	-0.0072	
		(2.2315)		(0.0493)				(0.1950)		(0.0885)	
	4	0.6736		-0.0208			4	0.1704		0.2216	*
		(2.2559)		(0.0499)				(0.1961)		(0.0891)	
	5	2.6476		0.0434			5	-0.3815	.	-0.0561	
		(2.2457)		(0.0496)				(0.1961)		(0.0890)	
	6	-1.7203		-0.0179			6	0.5987	**	-0.2760	**
		(2.2311)		(0.0493)				(0.1966)		(0.0893)	
	7	4.1939	.	0.1332	**		7	-0.4547	*	0.3819	***
		(2.2172)		(0.0490)				(0.1842)		(0.0837)	
	8	1.2000		-0.0709	.		8	0.0599		-0.1948	***
		(1.8384)		(0.0406)				(0.0951)		(0.0432)	
const		-0.0084		0.0001		**const**		-0.0001		0.0001	.
		(0.0160)		(0.0004)				(0.0001)		(0.0001)	

Table 4
Johansen cointegration tests

This table contains the result of Johansen cointegration tests between Δsentiment, $TERM.RET_t$ and $DEF.RET_t$. TERM.RET means log return of term premium and DEF.RET means log return of default premium. Term premium is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis.

Panel A: Cointegration test for $Y_t = [\Delta sentiment\_kalman, TERM.RET_t, DEF.RET_t]^T$

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r <= 2	49.88	7.52	9.24	12.97	r <= 2	49.88	7.52	9.24	12.97
r <= 1	189.41	17.85	19.96	24.6	r <= 1	139.53	13.75	15.67	20.2
r = 0	419.16	32	34.91	41.07	r = 0	229.75	19.77	22	26.81

Panel B: Cointegration test for $Y_t = [\Delta sentiment\_pca, TERM.RET_t, DEF.RET_t]^T$

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r <= 2	49.58	7.52	9.24	12.97	r <= 2	49.58	7.52	9.24	12.97
r <= 1	200.44	17.85	19.96	24.6	r <= 1	150.87	13.75	15.67	20.2
r = 0	449.58	32	34.91	41.07	r = 0	249.13	19.77	22	26.81

Table 5

Sentiment and bond market (VAR: level of risk premium)

Table 5 presents the result of vector autoregressive VAR model is $Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t$,, where $Y_t = [\Delta\text{sentiment}, TERM_t, DEF_t]^T$. Term premium (TERM) is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium (DEF) is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard errors are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

		term premium		**default premium**				**term premium**	**default premium**	
	Lag	Estimate		Estimate			Lag	Estimate	Estimate	
sentiment_kalman	1	-0.0003	.	0.0002	*	**sentiment_pca**	1	-0.0001	0.0000	
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	2	0.0001		-0.0003	***		2	0.0002	0.0000	
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	3	0.0000		-0.0001			3	0.0001	0.0001	
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	4	-0.0002		0.0001	.		4	-0.0002	0.0001	.
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	5	0.0000		0.0000			5	-0.0001	0.0000	
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	6	-0.0001		0.0003	***		6	0.0002	0.0000	
		(0.0002)		(0.0001)				(0.0001)	(0.0001)	
	7	-0.0001		-0.0001			7	-0.0001	0.0001	*

		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	8	-0.0005	**	0.0003	***		8	-0.0002	.	0.0000	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
term premium	1	1.2850	***	0.0095		**term premium**	1	1.2930	***	0.0050	
		(0.0420)		(0.0183)				(0.0422)		(0.0192)	
	2	-0.3961	***	0.0407			2	-0.3977	***	0.0476	
		(0.0686)		(0.0300)				(0.0691)		(0.0314)	
	3	0.1969	**	-0.0662	*		3	0.1817	*	-0.0684	*
		(0.0701)		(0.0306)				(0.0705)		(0.0320)	
	4	-0.0522		0.0232			4	-0.0472		0.0114	
		(0.0703)		(0.0307)				(0.0706)		(0.0321)	
	5	-0.1076		0.0019			5	-0.0989		0.0122	
		(0.0701)		(0.0306)				(0.0704)		(0.0320)	
	6	0.0652		-0.0125			6	0.0769		-0.0118	
		(0.0694)		(0.0304)				(0.0700)		(0.0318)	
	7	-0.0315		-0.0298			7	-0.0467		-0.0255	
		(0.0672)		(0.0294)				(0.0679)		(0.0308)	
	8	0.0276		0.0328	.		8	0.0265		0.0286	
		(0.0402)		(0.0176)				(0.0407)		(0.0185)	
default premium	1	-0.5953	***	1.7670	***	**default premium**	1	-0.5622	***	1.7520	***
		(0.0931)		(0.0407)				(0.0910)		(0.0413)	
	2	1.0240	***	-0.8634	***		2	0.9454	***	-0.8231	***
		(0.1847)		(0.0807)				(0.1795)		(0.0815)	

	3	-0.4331	*	0.0324			3	-0.3713	.	-0.0072	
		(0.1988)		(0.0869)				(0.1950)		(0.0885)	
	4	0.1832		0.2229	*		4	0.1704		0.2216	*
		(0.1980)		(0.0866)				(0.1961)		(0.0891)	
	5	-0.3666	.	-0.1053			5	-0.3815	.	-0.0561	
		(0.1983)		(0.0867)				(0.1961)		(0.0890)	
	6	0.5312	**	-0.2049	*		6	0.5987	**	-0.2760	**
		(0.1990)		(0.0870)				(0.1966)		(0.0893)	
	7	-0.3546	.	0.3156	***		7	-0.4547	*	0.3819	***
		(0.1857)		(0.0812)				(0.1842)		(0.0837)	
	8	0.0157		-0.1658	***		8	0.0599		-0.1948	***
		(0.0949)		(0.0415)				(0.0951)		(0.0432)	
const		-0.0001		0.0001		**const**		-0.0001		0.0001	
		(0.0001)		(0.0000)				(0.0001)		(0.0001)	

Table 6

Johansen cointegration tests

This table contains the result of Johansen cointegration tests between Δsentiment, $TERM_t$ and DEF_t. Term premium (TERM) is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium (DEF) is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis.

Panel A: Cointegration test for Yt = [Δsentiment_kalman, TERMt, DEFt]T

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r<= 2	4.31	7.52	9.24	12.97	r<= 2	4.31	7.52	9.24	12.97
r<= 1	14.77	13.75	15.67	20.2	r<= 1	14.77	13.75	15.67	20.2
r = 0	161.75	19.77	22	26.81	r = 0	161.75	19.77	22	26.81

Panel B: Cointegration test for Yt = [Δsentiment_pca, TERMt, DEFt]T

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r<= 2	4.3	7.52	9.24	12.97	r<= 2	4.3	7.52	9.24	12.97
r<= 1	19.52	17.85	19.96	24.6	r<= 1	15.22	13.75	15.67	20.2
r = 0	174.64	32	34.91	41.07	r = 0	155.12	19.77	22	26.81

Table 7
VECM result

Term premium (TERM) is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium (DEF) is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis.

	Term premium		**Default premium**			**Term premium**		**Default premium**	
ect1	-0.0178	**	-0.0037		ect1	-0.0180	**	-0.0039	
	(0.0057)		(0.0026)			(0.0057)		(0.0026)	
ect2	0.0044	**	0.0007		ect2	0.0047	**	0.0011	
	(0.0015)		(0.0007)			(0.0015)		(0.0007)	
ΔTERM$_{t-1}$	0.3267	***	0.0363	*	ΔTERM$_{t-1}$	0.3286	***	0.0394	*
	(0.0397)		(0.0179)			(0.0397)		(0.0182)	
ΔDEF$_{t-1}$	-0.5336	***	0.7776	***	ΔDEF$_{t-1}$	-0.5311	***	0.7708	***
	(0.0906)		(0.0409)			(0.0892)		(0.0410)	
ΔKAL$_{t-1}$	0.0000		0.0004	***	ΔPCA$_{t-1}$	-0.0002		0.0000	
	(0.0002)		(0.0001)			(0.0002)		(0.0001)	
ΔTERM$_{t-2}$	-0.0263		0.0567	**	ΔTERM$_{t-2}$	-0.0248		0.0580	**
	(0.0400)		(0.0181)			(0.0400)		(0.0184)	
ΔDEF$_{t-2}$	0.5052	***	-0.0430		ΔDEF$_{t-2}$	0.5103	***	-0.0346	
	(0.0911)		(0.0412)			(0.0904)		(0.0416)	
ΔKAL$_{t-2}$	0.0001		0.0000		ΔPCA$_{t-2}$	0.0000		-0.0001	
	(0.0002)		(0.0001)			(0.0001)		(0.0001)	

Table 8

Sentiment and bond market (VAR: slope of convexity)

Table 7 presents the result of vector autoregressive VAR model is $Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t$,, where $Y_t = [\Delta\text{sentiment}, \text{CONV.RET}_t]^T$. Convexity(CONV) is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. CONV.RET is log return of convexity. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard errors are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

	lag	convexity				convexity
sentiment_kalman	1	0.1597		**sentiment_pca**	1	-0.0580
		(0.1161)				(0.0850)
	2	-0.2792	*		2	-0.0881
		(0.1148)				(0.0857)
	3	-0.3270	**		3	-0.0702
		(0.1144)				(0.0858)
	4	-0.0529			4	0.0506
		(0.1157)				(0.0858)
	5	0.1292			5	0.1295
		(0.1154)				(0.0859)
	6	0.1644			6	0.0633
		(0.1149)				(0.0863)
	7	0.1571			7	-0.0568
		(0.1157)				(0.0862)

	8	0.1431			8	0.0775	
		(0.1169)				(0.0854)	
convexity	1	-0.2016	***	**convexity**	1	-0.1902	***
		(0.0421)				(0.0421)	
	2	-0.0672			2	-0.0691	
		(0.0427)				(0.0428)	
	3	-0.0179			3	-0.0250	
		(0.0428)				(0.0429)	
	4	0.0188			4	0.0194	
		(0.0426)				(0.0427)	
	5	0.0399			5	0.0378	
		(0.0427)				(0.0427)	
	6	-0.0552			6	-0.0496	
		(0.0424)				(0.0427)	
	7	-0.0329			7	-0.0265	
		(0.0421)				(0.0426)	
	8	-0.0190			8	-0.0209	
		(0.0415)				(0.0419)	
const		-0.0466	.	**const**		-0.0466	.
		(0.0266)				(0.0268)	

Table 9

Johansen cointegration tests

This table contains the result of Johansen cointegration tests between Δsentiment and $CONV.RET_t$. Convexity(CONV) is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. CONV.RET is log return of convexity. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis.

Panel A: Cointegration test for $Y_t = [\Delta sentiment\_kalman, CONV.RET_t]^T$

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r<= 1	222.1	7.52	9.24	12.97	r<= 1	222.1	7.52	9.24	12.97
r = 0	538.76	17.85	19.96	24.6	r = 0	316.67	13.75	15.67	20.2

Panel B: Cointegration test for $Y_t = [\Delta sentiment\_pca, CONV.RET_t]^T$

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r<= 1	201.45	7.52	9.24	12.97	r<= 1	201.45	7.52	9.24	12.97
r = 0	509.92	17.85	19.96	24.6	r = 0	308.46	13.75	15.67	20.2

Table 10

Sentiment and bond market (VAR: level of convexity)

Table 9 presents the result of vector autoregressive VAR model is $Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t$,, where $Y_t = [\Delta\text{sentiment}, CONV_t]^T$. Convexity(CONV) is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard errors are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

	lag	**convexity**			**lag**	**convexity**	
sentiment_kalman	1	0.0031		**sentiment_pca**	1	-0.0050	
		(0.0064)				(0.0047)	
	2	-0.0015			2	-0.0032	
		(0.0064)				(0.0048)	
	3	-0.0070			3	-0.0030	
		(0.0064)				(0.0048)	
	4	0.0015			4	0.0053	
		(0.0064)				(0.0048)	
	5	0.0016			5	0.0014	
		(0.0064)				(0.0048)	
	6	0.0195	**		6	-0.0106	*
		(0.0064)				(0.0048)	
	7	-0.0059			7	0.0114	*
		(0.0064)				(0.0048)	

	8	0.0276	***		8	0.0074	
		(0.0064)				(0.0048)	
convexity	1	1.1372	***	**convexity**	1	1.1305	***
		(0.0397)				(0.0404)	
	2	-0.3368	***		2	-0.3049	***
		(0.0601)				(0.0610)	
	3	0.1479	*		3	0.1109	.
		(0.0611)				(0.0619)	
	4	-0.0358			4	-0.0145	
		(0.0611)				(0.0618)	
	5	0.0942			5	0.0835	
		(0.0615)				(0.0618)	
	6	-0.0495			6	-0.0500	
		(0.0615)				(0.0617)	
	7	-0.0640			7	-0.0662	
		(0.0602)				(0.0606)	
	8	0.0684	.		8	0.0685	.
		(0.0398)				(0.0401)	
const		0.0012		**const**		0.0011	
		(0.0015)				(0.0015)	

Table 11

Johansen cointegration tests

This table contains the result of Johansen cointegration tests between Δsentiment and $CONV_t$. Convexity (CONV) is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Sentiment_kalman is the sentiment measured by kalman filter, and sentiment_pca is the sentiment measured by principal component analysis.

Panel A: Cointegration test for $Y_t = [\Delta sentiment\_kalman, CONV_t]^T$

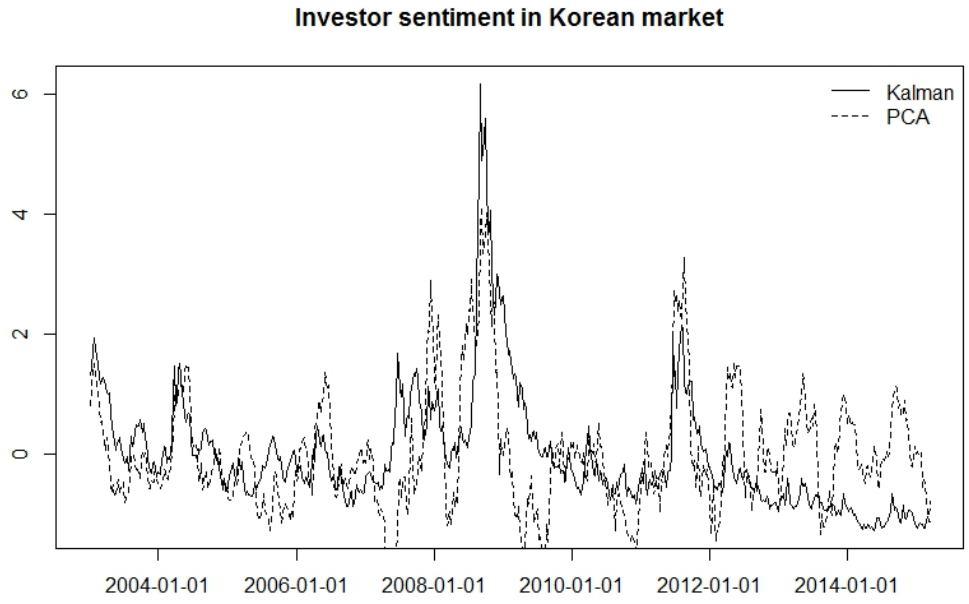
	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r <= 1	19.95	7.52	9.24	12.97	r <= 1	19.95	7.52	9.24	12.97
r = 0	278.78	17.85	19.96	24.6	r = 0	258.83	13.75	15.67	20.2

Panel B: Cointegration test for $Y_t = [\Delta sentiment\_pca, CONV_t]^T$

	Trace Statistic					Max Eigenvalue Statistic			
	test	10pct	5pct	1pct		test	10pct	5pct	1pct
r <= 1	20.04	7.52	9.24	12.97	r <= 1	20.04	7.52	9.24	12.97
r = 0	251.59	17.85	19.96	24.6	r = 0	231.55	13.75	15.67	20.2

Figure 1
Sentiment index (2003 - 2015)

Sentiment indices are constructed by two methods: principal component analysis and kalman filter. First, we performed principal component analysis with 16 variables: Nlist, Vol, Mom, Fore, KKR, ETF, Ab, Turn and their lagged variables. After first PCA, we calculated correlation between first component and each variable. Then we chose variables with high correlation among original variable and lagged variable: $Nlist_t$, Vol_t, Mom_{t-1}, $Fore_t$, KKR_{t-1}, ETF_t, Ab_{t-1}, $Turn_{t-1}$. Finally, we perform principal component analysis with selected 8 variables to extract investor sentiment. In order to use kalman filter, we set measurement equation and transition equation as follows. $Y_t = F \cdot S_t + V_t$, $V_t \sim N(0, V_t)$, where $Y_t = (Nlist_t, Vol_t, Mom_t, Fore_t, KKR_t, ETF_t, Ab_t, Turn_t)'$ and $S_t = G \cdot S_{t-1} + W_t$, $W_t \sim N(0, W_t)$, where S_t is Sentiment. Two sentiment indices are adjusted to mean zero and variance one. Change of sentiment is measured by $\ln\left(\frac{S_{t-1}}{S_t}\right)$, where ln means natural log.



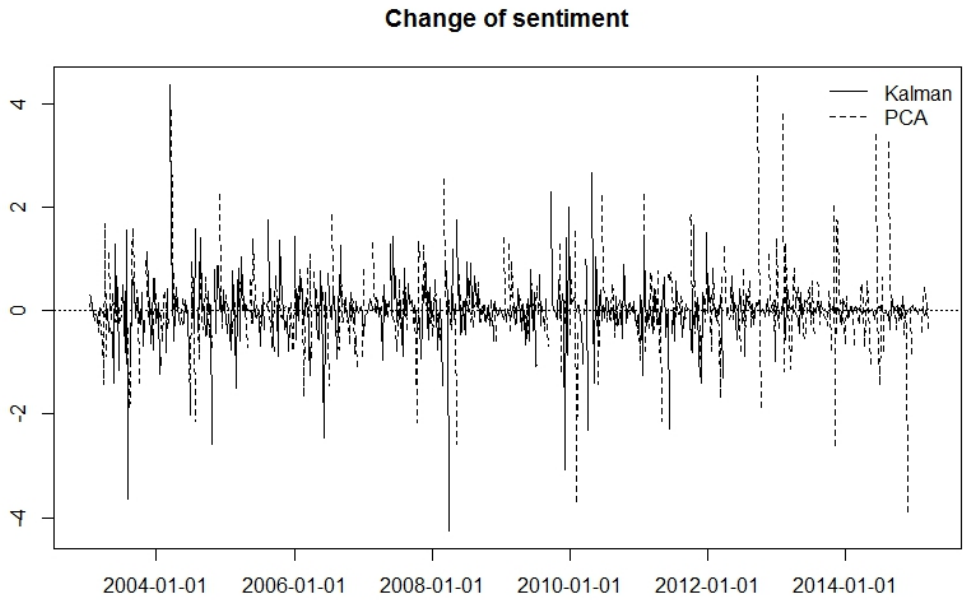

Change of sentiment
Kalman
PCA
4
2
0
-2
-4
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01

Figure 2

The difference between kalman filter and principal component analysis

This plot presents the difference between sentiment indices constructed by kalman filter and principal component analysis

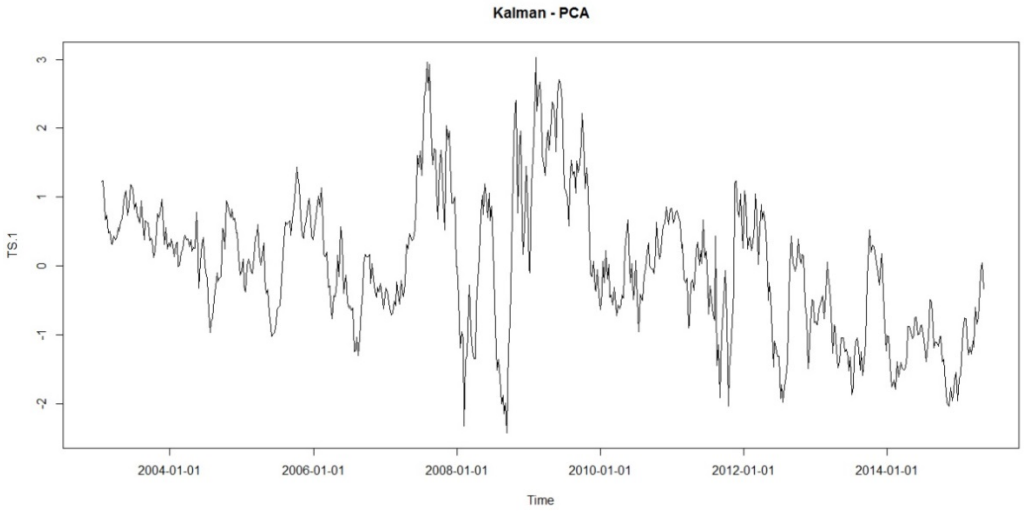
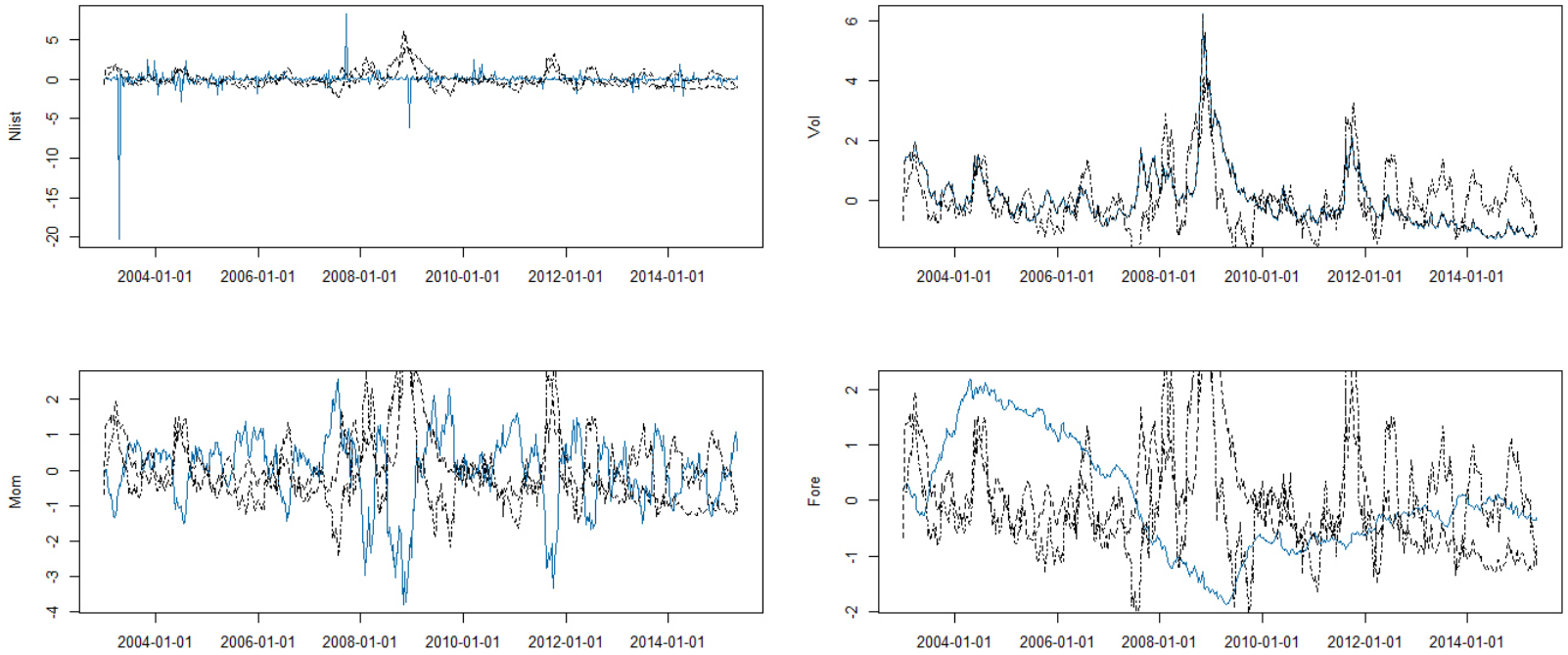
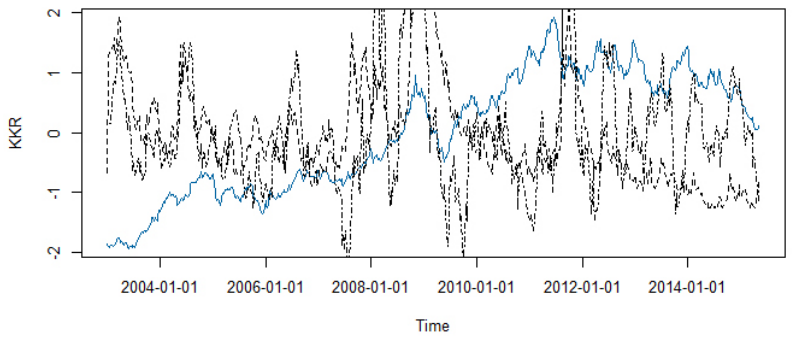
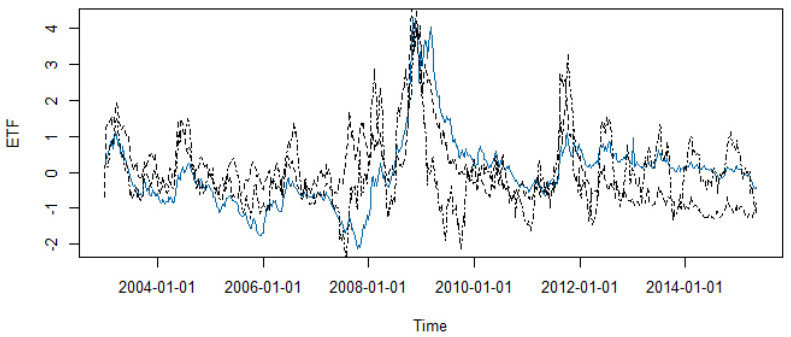


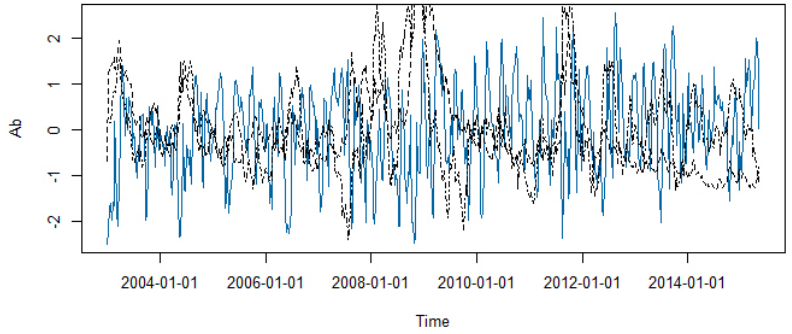
Figure 3
Sentiment proxies and sentiment index (Jan 2003 – Apr 2015)

Sentiment indices and sentiment proxies adjusted to mean zero and variance one. The black solid line is sentiment index using kalman filter, and the black dashed-line is sentiment index using principal component analysis. The blue solid line is sentiment proxies.




KKR
2
1
0
-1
-2
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time


ETF
4
3
2
1
0
-1
-2
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time


Ab
2
1
0
-1
-2
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time

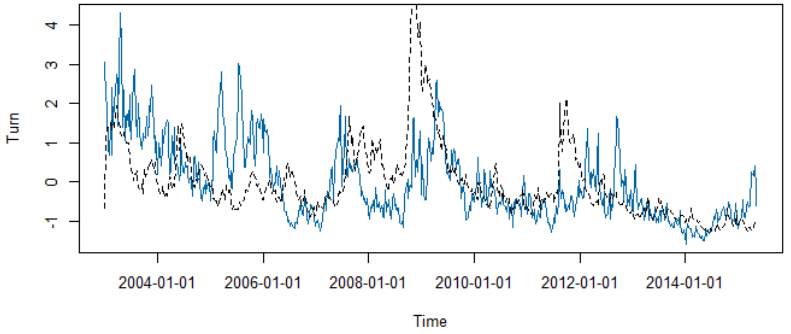

Turn
4
3
2
1
0
-1
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time

Figure 4
Bond risk premium and convexity (Jan 2003 – Apr 2015)

Figure 4 plot the bond risk premium, convexity and the change of each variable. Term premium (TERM) is yield of KIS government bond 7Y – 10Y minus CD rate. Default premium (DEF) is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS government bond 3Y – 5Y. Convexity (CONV) is calculates as follows: (Long-term bond yield + Short-term bond yield - 2*Middle-term bond yield)/2. Bond yield data is provided daily, thus we convert daily data to weekly data using weekly average. Change is measured by natural log return.