Investor sentiment and bond market

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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. However, we conduct analysis with two constructed sentiment indices because the effects of two sentiment indices on bond market risk are 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. The result is in line with previous study. 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

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). In economics and finance, generally investor sentiment (also called market sentiment) is the expectations of market participants (Brown and Cliff, 2004). 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 used in finance 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 construct investor sentiment index of Korean market using indirect method and examine the effect of sentiment on 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 week (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, there are relatively less studies on sentiment and bond market than studies on stock market. Research results, however, 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 lead to 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 KRX (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 variable definition

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 .he 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).

Insert Table 2 Summary statistics

Table 2 presents the descriptive statistics of variables. I 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, I calculated correlation between first component and each variable. Then I 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 (1991) made coincidence index using kalman filter. Brown and Cliff (2004) used kalman filter to extract investor sentiment. In order to use kalman filter, I 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 St is Sentiment

Insert Figure 1 Kalman vs. PCA
Insert Figure 2 Kalman – PCA

Figure 1 shows the investor sentiment from 2003 to May 2015. Both sentiment_pca and sentiment_kalman shows similar trend. During the Korean credit card crisis from 2003 to 2004 and global financial crisis in 2008, 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 analyses. 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 Sentiment index and proxies

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, I use sentiment index, term premium (TERM), default premium (DEF) and convexity (CONV). Therefore, I set three VAR model. The vector of first VAR analysis is $Y_t = [\Delta sentiment, TERM_t, DEF_t]^{T.}$ The vector of second VAR analysis is $Y_t = [\Delta sentiment, TERM.RET_t, DEF.RET_t]^T$. The vector of third VAR analysis is $Y_t = [\Delta sentiment, CONV_t]^T$. Term premium is yield of KIS treasury bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS treasury 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 I convert daily data to weekly data using weekly average. The equation for our VAR analysis is followed. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \beta_5 Y_{t-5} + \beta_6 Y_{t-6} + \beta_7 Y_{t-7} + \beta_8 Y_{t-8} + \varepsilon_t,,$$

where $Y_t = [\Delta sentiment, TERM_t, DEF_t]^T$

Insert Table 3 Sentiment and bond market (VAR: level)

Table 3 contains the result of first VAR model. The result suggests sentiment has no significant predictive power about term premium. However, recent sentiment is positively correlated to default premium except lag 6 of sentiment measured by PCA is negatively correlated to default premium. 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.

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

Insert Table 4 Sentiment and bond market (VAR: return)

Table 4 presents the result of second VAR model. This VAR result shows recent past sentiment is negatively related to term premium return and remote past sentiment is positively related to term premium return. In case of sentiment measured by PCA, coefficients of recent past are insignificant. However, coefficients of remote past are significantly and positively related to term premium return. Remote past sentiment change is positively related to default premium return.

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

Insert Table 5 Sentiment and bond market (VAR: convexity)

Table 5 shows the result of third model. Sentiment change is positively related to convexity except lag 4. Convexity is the second derivative of the bond price, thus high sentiment lead to high risk of bond price. In general, investor sentiment is positively related to the bond market risk. This result is consistent with Nayak (2010) and Baker and Wurgler (2006) which show risky securities tend to be overvalued under high sentiment.

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 KRX, 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 have explanatory power for 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).

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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. I 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. I convert daily data to weekly data weekly average. I construct sentiment index based on principal component analysis and kalman filter. Each of the index components has been adjusted to have 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: level)

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 $Y_t = [\Delta\text{sentiment}, TERM_t, DEF_t]^T$. Term premium is yield of KIS treasury bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS treasury bond 3Y – 5Y. Bond yield data is provided daily, thus I convert daily data to weekly data using weekly average. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard deviations are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

		Dependent variable						Dependent variable			
Indep variable	lag	TERM		DEF		Indep variable	lag	TERM		DEF	
KAL	1	0.0002		0.0001		PCA	1	0.0000		0.0000	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	2	-0.0001		0.0003	***		2	-0.0001		0.0001	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	3	0.0001		-0.0001			3	-0.0001		0.0000	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	4	0.0000		0.0000			4	-0.0002		0.0001	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	5	-0.0003		0.0004	***		5	-0.0001		0.0002	***
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	6	-0.0003		0.0002	**		6	0.0000		-0.0001	**
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	7	0.0001		0.0000			7	0.0000		0.0000	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
	8	-0.0002		0.0001			8	-0.0003	*	0.0000	
		(0.0002)		(0.0001)				(0.0001)		(0.0001)	
TERM	1	1.3020	***	0.0045		TERM	1	1.2860	***	0.0135	
		(0.0419)		(0.0180)				(0.0419)		(0.0187)	
	2	-0.4192	***	0.0513			2	-0.4069	***	0.0390	
		(0.0687)		(0.0296)				(0.0684)		(0.0305)	
	3	0.2037	**	-0.0732			3	0.2034	**	-0.0705	
		(0.0703)		(0.0303)				(0.0701)		(0.0312)	
	4	-0.0396		0.0093			4	-0.0494		0.0171	
		(0.0705)		(0.0303)				(0.0703)		(0.0313)	
	5	-0.1280		0.0320			5	-0.1201		0.0232	
		(0.0703)		(0.0302)				(0.0700)		(0.0312)	
	6	0.0657		-0.0135			6	0.0760		-0.0308	
		(0.0697)		(0.0300)				(0.0696)		(0.0310)	

	7	-0.0195		-0.0362			7	-0.0334		-0.0228	
		(0.0672)		(0.0289)				(0.0676)		(0.0301)	
	8	0.0217		0.0250			8	0.0314		0.0304	
		(0.0405)		(0.0174)				(0.0405)		(0.0181)	
DEF	1	-0.5666	***	1.7140	***	DEF	1	-0.5748	***	1.7630	***
		(0.0967)		(0.0416)				(0.0921)		(0.0410)	
	2	0.9644	***	-0.7777	***		2	0.9621	***	-0.8383	***
		(0.1900)		(0.0818)				(0.1830)		(0.0815)	
	3	-0.3984		-0.0275			3	-0.3583		-0.0149	
		(0.2076)		(0.0893)				(0.1977)		(0.0881)	
	4	0.2238		0.1877			4	0.1745		0.2431	**
		(0.2088)		(0.0899)				(0.1958)		(0.0873)	
	5	-0.4199	*	-0.0186			5	-0.4016	*	-0.0744	
		(0.2062)		(0.0888)				(0.1958)		(0.0872)	
	6	0.5848	**	-0.2256	*		6	0.5692	**	-0.2645	**
		(0.2058)		(0.0886)				(0.1958)		(0.0872)	
	7	-0.4261	*	0.3289	***		7	-0.4022	*	0.3606	***
		(0.1897)		(0.0817)				(0.1825)		(0.0813)	
	8	0.0429		-0.1830	***		8	0.0358		-0.1767	***
		(0.0964)		(0.0415)				(0.0939)		(0.0418)	
Adj R-squared		0.9863		0.9993		Adj R-squared		0.9863		0.9993	

Table 4
Sentiment and bond market (VAR: return)

Table 4 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 return of term premium and DEF.RET means return of default premium. Term premium is yield of KIS treasury bond 7Y – 10Y minus CD rate. Default premium is yield of KIS corporate bond BBB 3Y – 5Y minus yield of KIS treasury bond 3Y – 5Y. Bond yield data is provided daily, thus I convert daily data to weekly data using weekly average. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard deviations are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

		Dependent variable						Dependent variable			
Indep variable	lag	TERM		DEF		Indep variable	lag	TERM		DEF	
KAL	1	0.4505		0.0010		PCA	1	0.0045		-0.0004	
		(0.2443)		(0.0016)				(0.1755)		(0.0011)	
	2	0.1087		0.0053			2	-0.0526		0.0018	
		(0.2440)		(0.0016)				(0.1774)		(0.0011)	
	3	-0.5840	*	0.0002			3	0.0357		-0.0010	
		(0.2463)		(0.0016)				(0.1777)		(0.0011)	
	4	0.1622		0.0005			4	0.0652		0.0006	
		(0.2467)		(0.0016)				(0.1776)		(0.0011)	
	5	-0.2263		0.0063			5	0.1244		0.0042	***
		(0.2465)		(0.0016)				(0.1766)		(0.0011)	
	6	0.5846	*	0.0034	*		6	-0.0449		-0.0021	
		(0.2460)		(0.0016)				(0.1785)		(0.0011)	
	7	0.3436		0.0004			7	0.5087	**	0.0005	
		(0.2465)		(0.0016)				(0.1785)		(0.0011)	
	8	0.2105		0.0000			8	0.0016		-0.0007	
		(0.2340)		(0.0015)				(0.1767)		(0.0011)	
TERM	1	0.0147		0.0001		TERM	1	0.0139		0.0002	
		(0.0404)		(0.0003)				(0.0405)		(0.0003)	
	2	-0.0918	*	-0.0001			2	-0.1031	*	-0.0002	
		(0.0405)		(0.0003)				(0.0403)		(0.0003)	
	3	0.0058		0.0000			3	-0.0041		0.0000	
		(0.0405)		(0.0003)				(0.0405)		(0.0003)	
	4	-0.0188		0.0004			4	-0.0272		0.0004	
		(0.0395)		(0.0003)				(0.0395)		(0.0003)	
	5	0.2412	***	0.0002			5	0.2455	***	0.0001	
		(0.0395)		(0.0003)				(0.0398)		(0.0003)	
	6	-0.0095		-0.0001			6	0.0100		-0.0002	
		(0.0406)		(0.0003)				(0.0410)		(0.0003)	

	7	0.0157		-0.0002			7	0.0150		-0.0003	
		(0.0405)		(0.0003)				(0.0408)		(0.0003)	
	8	-0.0140		0.0000			8	-0.0058		0.0000	
		(0.0405)		(0.0003)				(0.0408)		(0.0003)	
DEF	1	-16.1699	*	0.7287	***	DEF	1	-12.3576	*	0.7649	***
		(6.3676)		(0.0407)				(6.2776)		(0.0404)	
	2	5.0902		-0.0650	***		2	1.7600		-0.0741	
		(7.9193)		(0.0506)				(7.8512)		(0.0505)	
	3	5.8498		-0.0253			3	4.8421		-0.0332	
		(8.0049)		(0.0511)				(7.7848)		(0.0501)	
	4	-6.7896		0.0552			4	-1.5411		0.0992	*
		(7.9648)		(0.0508)				(7.7084)		(0.0496)	
	5	10.3023		0.0306	***		5	4.6958		0.0330	
		(7.8778)		(0.0503)				(7.7017)		(0.0495)	
	6	-6.3535		-0.1226	*		6	-1.7843		-0.1548	**
		(7.8842)		(0.0503)				(7.6628)		(0.0493)	
	7	0.6843		0.1277	*		7	-3.3634		0.1481	**
		(7.8331)		(0.0500)				(7.6894)		(0.0495)	
	8	-2.5913		0.0914	*		8	0.1511		0.0733	
		(6.2377)		(0.0398)				(6.1712)		(0.0397)	
Adj R-squared		0.0693		0.6224		Adj R-squared		0.0568		0.6109	

Table 5
Sentiment and bond market (VAR: convexity)

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 $Y_t = [\Delta\text{sentiment}, CONV_t]^T$. 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 I convert daily data to weekly data using weekly average. Lag is set to 8 to observe the pattern of the relationship between sentiment and bond market. Standard deviations are in parentheses. ∗indicates significance at 10%; ∗∗significance at 5%; ∗∗∗significance at 1%, respectively.

		Dependent variable				Dependent variable	
Indep variable	lag	CONV		Indep variable	lag	CONV	
KAL	1	0.0145	*	PCA	1	-0.0003	
		(0.0064)				(0.0047)	
	2	0.0119			2	-0.0010	
		(0.0064)				(0.0048)	
	3	0.0192	**		3	0.0078	
		(0.0064)				(0.0048)	
	4	-0.0238	***		4	-0.0053	
		(0.0065)				(0.0048)	
	5	0.0074			5	0.0126	**
		(0.0065)				(0.0048)	
	6	0.0127	*		6	0.0039	
		(0.0065)				(0.0048)	
	7	0.0104			7	-0.0018	
		(0.0065)				(0.0048)	
	8	-0.0007			8	0.0062	
		(0.0061)				(0.0047)	
CONV	1	1.1160	***	CONV	1	1.1370	***
		(0.0406)				(0.0402)	
	2	-0.2951	***		2	-0.3211	***
		(0.0609)				(0.0608)	
	3	0.0997			3	0.1188	
		(0.0627)				(0.0623)	
	4	-0.0035			4	-0.0138	
		(0.0631)				(0.0624)	
	5	0.0423			5	0.0793	
		(0.0626)				(0.0622)	
	6	0.0036			6	-0.0602	
		(0.0614)				(0.0621)	
	7	-0.0969			7	-0.0542	

		(0.0597)				(0.0608)	
	8	0.0914	*		8	0.0741	
		(0.0398)				(0.0403)	
Adj R-squared		0.9181		Adj R-squared		0.9146	

Figure 1
Sentiment index (2003 - 2015)

Sentiment indices are constructed by two methods: principal component analysis and kalman filter. First, I performed principal component analysis with 16 variables: Nlist, Vol, Mom, Fore, KKR, ETF, Ab, Turn and their lagged variables. After first PCA, I calculated correlation between first component and each variable. Then I 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, I perform principal component analysis with selected 8 variables to extract investor sentiment. In order to use kalman filter, I 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 have mean zero and variance one.

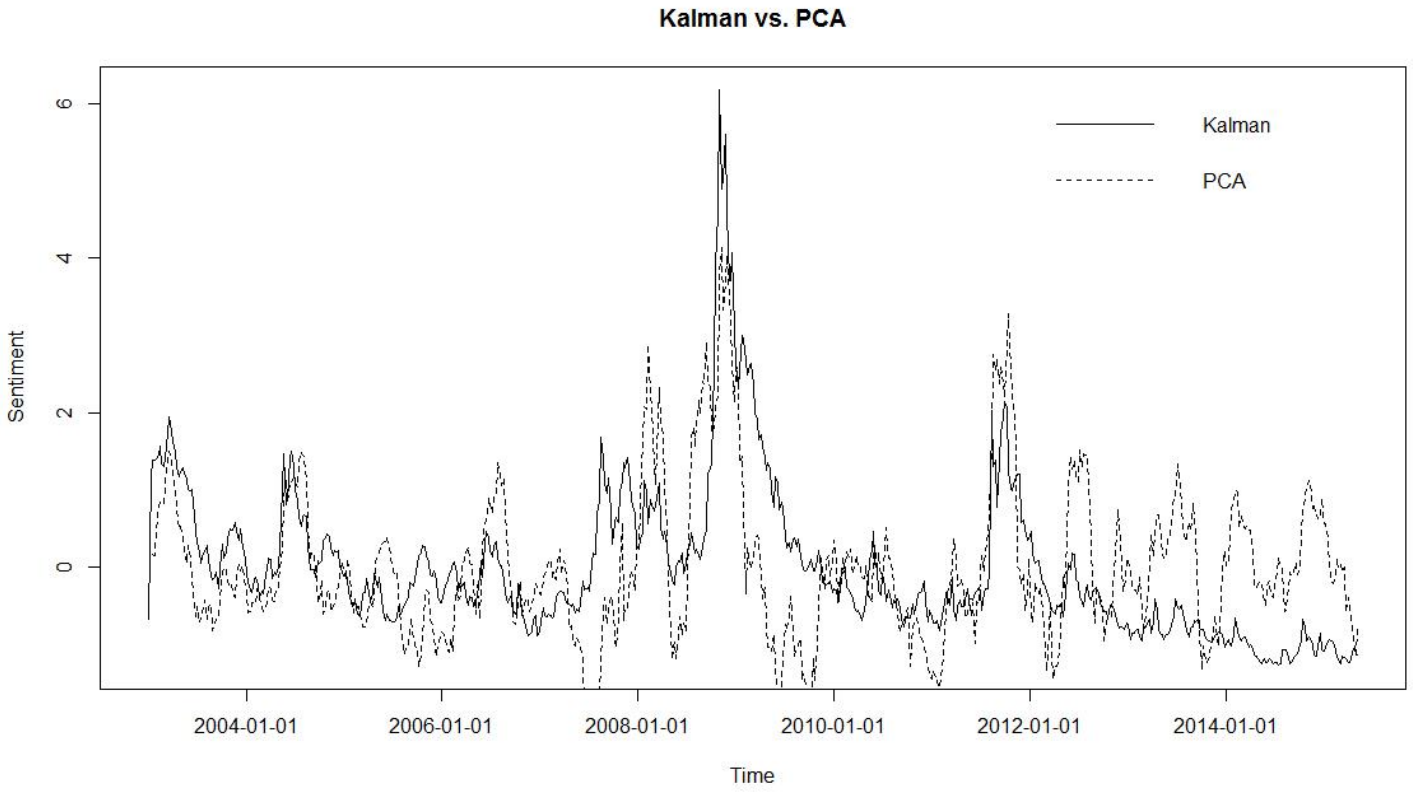


Figure 2
The difference between kalman filter and principal component analysis
This plot presents the difference between sentiment indices constructed by kalman filter and principal component analysis

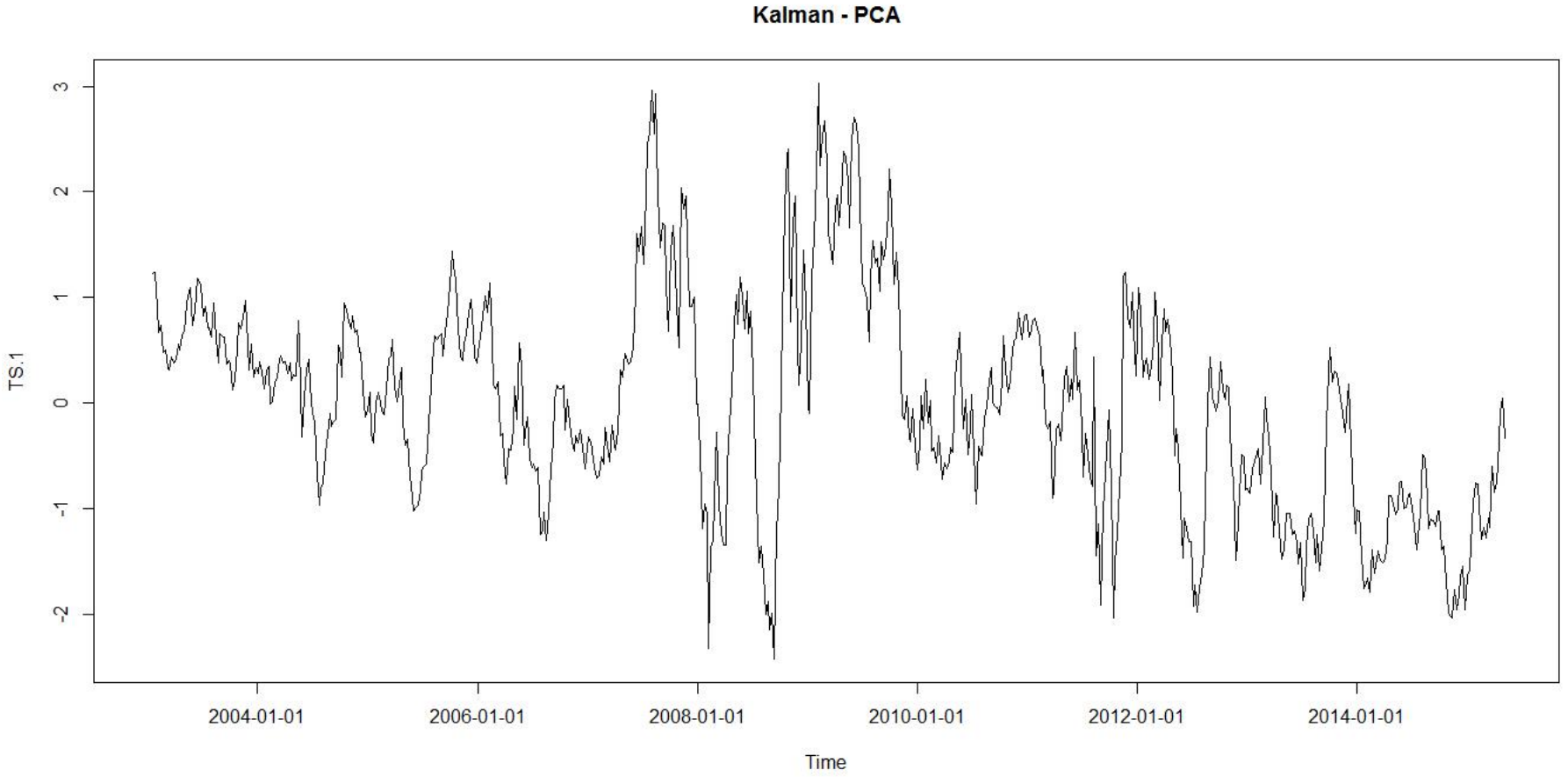
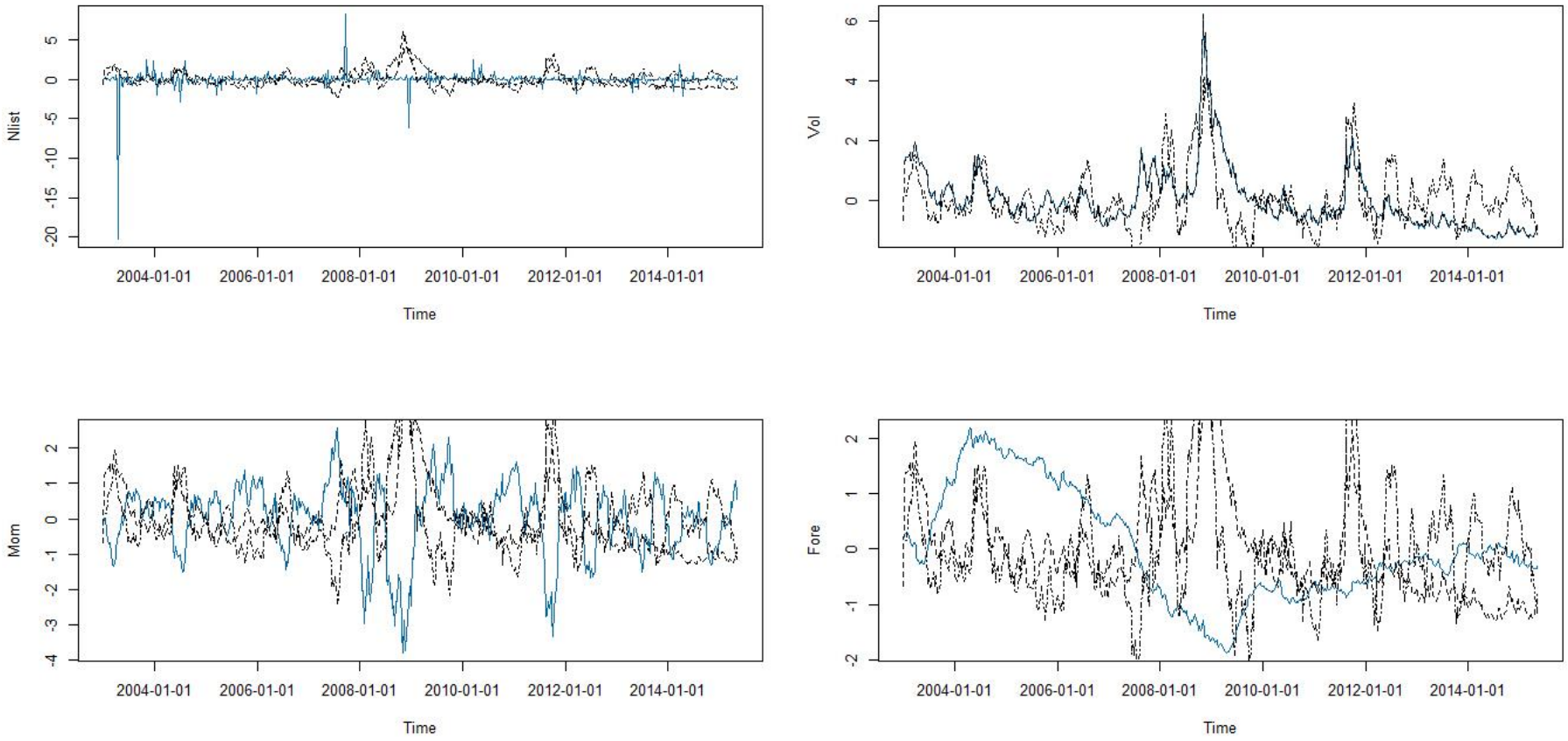
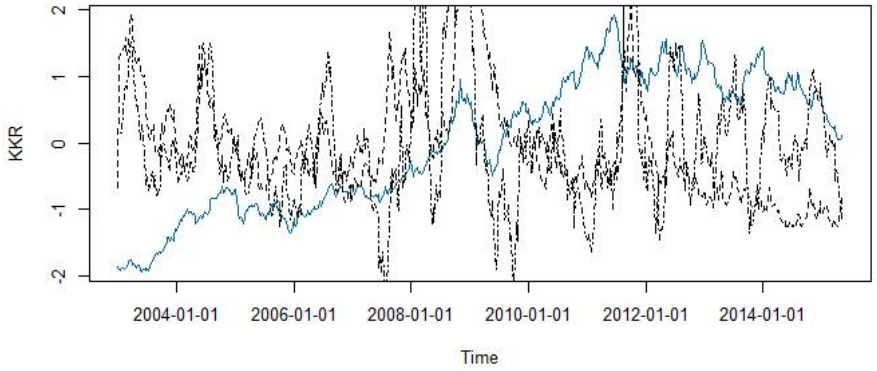


Figure 3
Sentiment proxies and sentiment index (2003 - 2015)

Sentiment indices and sentiment proxies adjusted to have 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
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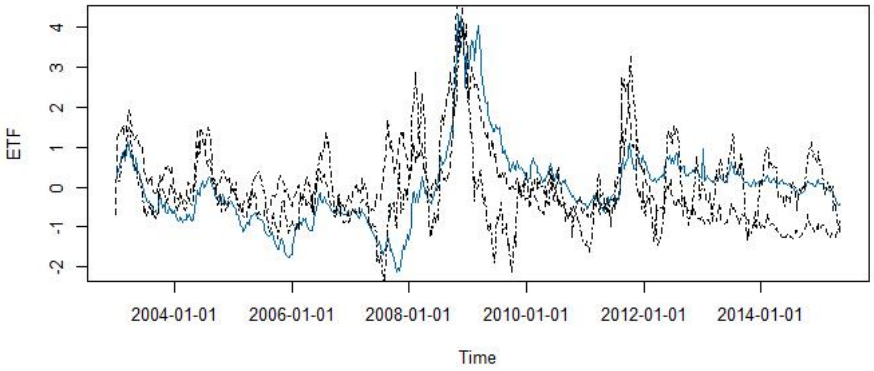
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time


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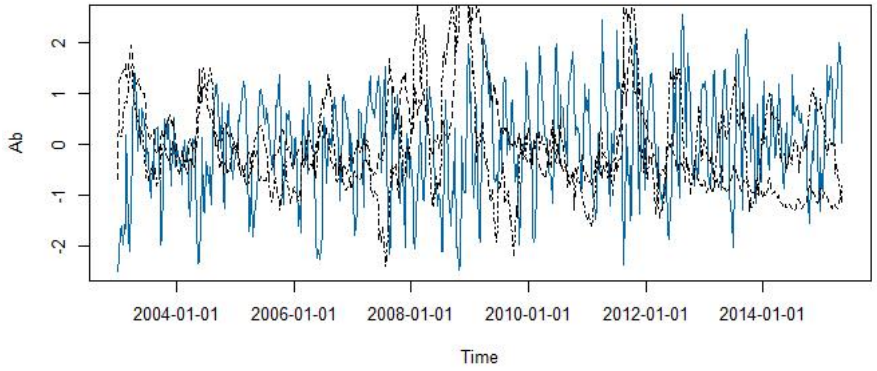
-1
-2
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time


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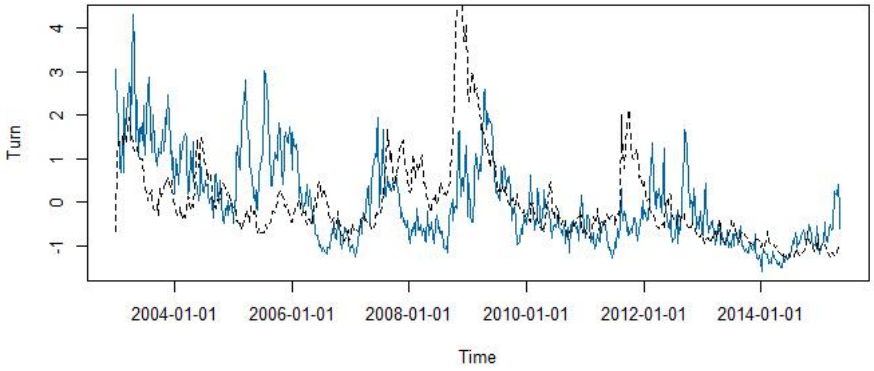
0
-1
-2
2004-01-01
2006-01-01
2008-01-01
2010-01-01
2012-01-01
2014-01-01
Time


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