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Research article

The impact of macroeconomic news on stock returns of energy firms—evidence from China

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Abstract: This paper identifies the change point of stock returns of energy firms, and examines the impact of macroeconomic news on stock returns of energy firms. Our analysis used China's A-share listed energy firms from January 2008 to December 2018. First, we use high-dimensional time series factor models to pick up most of the structural changes in the common components of stock returns of energy firms. And then based on the change-points, we use the TVP-VAR method to explore the complex relationship between the macroeconomic news and the common component of stock returns of energy firms in different periods. The results show that there are three change points in the common components of stock returns of energy firms, but the idiosyncratic components don't have change points. What's more, for different periods, macroeconomic news has a heterogeneous impact on stock returns of energy firms.

Keywords: macroeconomic news; energy firms; stock return; change point

JEL Codes: C32, C51, G11, G32

1. Introduction

In recent decades, the rapid development of global economic integration has made information transmission between macroeconomics and asset prices increasingly significant. On the one hand, the regular adjustment of macroeconomic indicators by the national statistical department has become a core factor affecting asset pricing. On the other hand, the volatility of financial asset prices directly affects the stability of the real economy. The frequent outbreak of the international financial crisis has highlighted the negative effects of macroeconomic and asset price dynamics in the procyclical relationship (Athanasoglou et al., 2014). This procyclical relationship between the financial system and the macro-economy has spawned and even exacerbated cyclical fluctuations in the economy and led to instability in the financial system. In this context, linkages between financial asset price and the macroeconomy news have become a popular topic (Brenner et al., 2009; Kishore et al., 2013; Cakan et al., 2015; Caruso, 2019).

The impact factors on stock returns have been a topic of great interest for researchers (Campbell and Shiller, 1988; Fama and French, 1988). Macroeconomic news has been identified as one of the drivers of stock returns and causes of financial market volatility (Chen et al., 1986; Fama, 1981). Chen et al. (2016) find that among five macroeconomic news (Consumer Price Index, the Producer Price Index, the Total Retail Sales of Consumer Goods, the Industrial Production, and the Investment in Fixed Assets) releases, only the Consumer Price Index announcement has substantial effects on the short-term return, realized volatility, and trading liquidity of the CSI 300 index futures market. Lee and Ryu (2019) suggest that the effect on stock returns of macroeconomic news are more pronounced in the crisis and postcrisis periods than in the precrisis period.

Macroeconomic information announcement will generally change the stock market returns, but the influence is heterogenous according to industry classifications (Kavussanos et al., 2002; Bahmani-Oskooee and Saha, 2019). Unbalanced development of the industry leads to differences in the degree of marketization, capital structure, and product market competitiveness between different industries. These differences are the main incentives for different industries to absorb and respond to macroeconomic information. Therefore, taking into account industry characteristics is critical to a deeper understanding of the relationship between macroeconomics and stock returns.

Energy is an essential input factor for various industries in the economic system. Since the first oil crisis in 1973 and the subsequent "stagflation" problem, the correlation between energy prices and the macroeconomy has increasingly become the focus of academic research. Most researchers believe that macroeconomic news can exert considerable impact, directly or indirectly, on energy prices (Belgacem et al., 2015; Bahloul and Gupta, 2018; Hailemariam et al., 2019). It is suggested that macroeconomic news announcements can affect energy prices directly, by the common response, or indirectly, by volatility transmission (Belgacem et al., 2015). More importantly, both macroeconomic news surprise and uncertainty are important in driving energy prices (Bahloul and Gupta, 2018), and the correlation between economic policy uncertainty and energy prices is time-varying (Hailemariam et al., 2019). Also, there exists a large literature that has proven that energy prices are closely related to energy stock prices (Broadstock et al., 2012; Ma et al., 2019). But the correlation between macroeconomic news announcements and the stock returns of energy firms are almost a gap to be studied. This topic is particularly important since energy stocks, as the key component of the energy finance market, is a thermometer of the country's energy economic development. We build on the existing literature but focus on the impact of macroeconomic news on the stock returns of energy firms.

There are different ways of news about macroeconomics could affect the stock returns of energy firms. First, macroeconomic news announcements could convey information on the fundamental economic variables, that are otherwise actually not completely observable. Also, the news could serve as an update of the macroeconomic variables. These factors may further affect expectations for future stock returns of energy firms, which may influence investors' decisions and the current stock returns of energy firms. (Kilian and Murphy, 2014；Huang, 2018; Michael and Lin, 2019). Secondly, macroeconomic news announcements could affect the sentiment of rational arbitrageurs, who change their Bayesian beliefs upon macroeconomic fundamentals. (Bahloul and Gupta, 2018; Michael and Lin, 2019). At last, macroeconomic news announcements could also affect the sentiment of noise traders, who update their random beliefs on noisy signals (Bahloul and Gupta, 2018). In general, the links between macroeconomic news and energy stock markets can be explained in terms of investor psychology.

Stock market responses to macroeconomic news vary over time. Huang (2018) show that the effect of macroeconomic news on the second-moment response is affected by the level of financial stress and monetary policy regime. In recent years, China is in the critical period of energy reform, which provides a valuable window for us to study the time-varying effects between macroeconomic news and energy stock market. Here, we use high-dimensional time series factor models with multiple change-points (Barigozzi et al., 2018) to pick up most of the structural changes in the common components of stock returns of energy firms. According to the change-points, we then use the TVP-VAR method (time-varying parameter structural vector autoregression, Nakajima, 2011) to study the complex relationship between the macro-information and the market-driven factors of energy stocks in different periods. This method can timely capture the structural changes in the relationship between variables.

We contribute to the existing literature at least in three aspects. First, to the best of our knowledge, this is the initial work to assess the linkage between the macroeconomic information and energy stock prices empirically and therefore, an important contribution to date. Second, we adopt a new change-point detection method, namely the high-dimensional time series factor models with multiple change-points, to improves the detectability of structural changes in the market-driven components of stock returns of energy firms. Last but not least, we take time variation into account and divide the sample time into different stages according to the change- points. This is particularly noteworthy since the relationship between macroeconomic news and stock returns of energy firms are time-varying. These contributions complement the extant literature and provide new insights into macroeconomic and stock returns of energy firms.

The remainder of the paper is organized as follows: Section 2 identify the change points, while Section 3 provides the definition and description of variables. Section 4 contains a discussion of the empirical results. Finally, Section 5 comprises our conclusion.

2. Identify the change points

2.1. High-dimensional time series factor model

According to the well-known Asset Pricing Theorem(APT) and the Capital Asset Pricing Model (CAPM), asset returns can be decomposed into common (or market-driven) components and idiosyncratic components. The stock returns of energy firms are composed of the macro market-driven component and the micro factors of the individual, idiosyncratic component. Essentially, the market-driven risks matter for asset prices, while the idiosyncratic one can be eliminated by appropriate portfolio diversification. To investigate the structural changes in stock returns of energy firms, we first followed the idea of Barigozzi and Hallin (2016) to decompose stock returns of energy firms into the common and idiosyncratic components.

Consider an n-dimensional vector of time series $X_t = (x_{1t}, ..., x_{nt})^T$, which following the factor model, such as:

$$x_{it} = \chi_{it} + \varepsilon_{it} = \lambda_i^T f_t + \varepsilon_{it}, \quad i = 1,...,n, \quad t = 1,...,T, \tag{1}$$

where the common component $\chi_t = \{\chi_{it}; i = 1,...,n; t = 1,...,T\}$ is driven by pervasive factors and the idiosyncratic component $\varepsilon_t = \{\varepsilon_{it}; i = 1,...,n; t = 1,...,T\}$ is stationary and mildly cross-correlated. r denotes the number of factors and χ_t is driven by $f_t = (f_{1t},..., f_{rt})^T$ with $E(f_t) = 0$. Bai and Ng(2002) proposed the information criterion to estimate the number of factors. Thus with the known r, the common and idiosyncratic components of x_{it} can be estimated using PCA:

$$\begin{aligned} \widehat{\chi}_{it} &= \sum\nolimits_{j=1}^{r} \widehat{w}_{\chi,ij} \widehat{W}_{\chi,j}^{T} X_t, \\ \hat{\varepsilon}_{it} &= x_{it} - \hat{\chi}_{it}, \end{aligned} \tag{2}$$

where $\widehat{W}_{\chi,j}$ is the normalised eigenvector of the sample covariate matrix with entries $\widehat{w}_{\chi,ij}$.

Many studies agree with the close connection among jumps in the returns process, large changes in market volatility, and the arrival of events (such as macroeconomic news) that might take the market by surprise (Maheu and McCurdy, 2004; Rangel, 2011). By decomposing the stock returns of energy firms, we can perform change point analysis on the common and idiosyncratic components separately. This will help us better analyze the impact of macroeconomic news on stock returns of energy firms.

To detect the change-points of the high-dimensional stock returns of energy firms, we need to transform the estimations of the common and idiosyncratic components into panels with piecewise constant signals by Wavelet Transformations(WT) $g_j(\hat{\chi}_{it}^k)$ and $h_j(\hat{\chi}_{it}^k)$ (see Barigozzi and Hallin(2018) for the detailed description of Wavelet Transformations):

$$\begin{aligned} g_j(\widehat{\chi}_{it}^k) &\equiv g_j(\widehat{\chi}_{it}^k,..., \widehat{\chi}_{i,t-\mathcal{L}_j+1}^k) = \left|\widehat{d}_{j,it}\right| = \left|\sum_{l=0}^{\mathcal{L}_j-1} \widehat{\chi}_{i,t-1}^k \Psi_{j,1}\right|, \ 1 \le i \le n, \\ h_j(\widehat{\chi}_{it}^k, \widehat{\chi}_{i't}^k) &\equiv h_j(\widehat{\chi}_{it}^k,..., \widehat{\chi}_{i,t-\mathcal{L}_j+1}^k, \widehat{\chi}_{i't}^k,..., \widehat{\chi}_{i',t-\mathcal{L}_j+1}^k) = \left|\widehat{d}_{j,it} + s_{ii'} \widehat{d}_{j,i't}\right| \\ &= \left|\sum_{l=0}^{\mathcal{L}_j-1} \widehat{\chi}_{i,t-l}^k \Psi_{j,1} + s_{ii'} \sum_{l'=0}^{\mathcal{L}_j-1} \widehat{\chi}_{i',t-l'}^k \Psi_{j,l'}\right|, \qquad 1 \le i < i' \le n, \end{aligned} \tag{3}$$

where $j = -1, -2,..., -J_T^*$, $s_{ii'} \in \{-1,1\}$. According to proposition 1 in Barigozzi and Hallin(2018), the corresponding decomposition is obtained:

$$y_{lt} = z_{lt} + \varepsilon_{it}, \quad \ell = 1,..., N, \quad t = 1,...,T. \tag{4}$$

z_{lt} are piecewise constant and are the elements of

$$\{\mathrm{E}\{\mathrm{g}_j(\chi_{it}^{\beta(t)})\}, 1 \le \mathrm{i} \le \mathrm{n}, \ \mathrm{E}\{\mathrm{h}_j(\chi_{it}^{\beta(t)}, \chi_{i't}^{\beta(t)})\}, 1 \le i < i' \le \mathrm{n}; \ \text{-}\mathrm{J}_T^* \le \mathrm{j} \le \text{-}1, 1 \le \mathrm{t} \le \mathrm{T}\} \tag{5}$$

$\max_{1\le\ell\le N}\max_{1\le s\le e\le T}(e-s+1)^{-1/2}\left|\sum_{t=s}^{e}\varepsilon_{\ell t}\right| = O_p(\log^{\theta+v}T)$.

Then by the Double Cumulative sum Binary Segmentation(DCBS) and the stationary bootstrap algorithm on panels $g_j(\cdot)$ and $h_j(\cdot)$, we get the set of change-points detected for the common and idiosyncratic components(see Barigozzi and Hallin(2018) for the detailed algorithmic process). We can define the location of the change-point as:

$$\hat{\eta} = \arg\max_{b\in[s,e)}\max_{1\le m\le n}\sqrt{\frac{m(2N-m)}{2N}}\left(\frac{1}{m}\sum_{\ell=1}^{m}\left|\mathcal{Y}_{s,b,e}^{(\ell)}\right| - \frac{1}{2N-m}\sum_{\ell=m+1}^{N}\left|\mathcal{Y}_{s,b,e}^{(\ell)}\right|\right) \quad (6)$$

where $\mathcal{Y}_{s,b,e}^{\ell} = \frac{1}{\sigma_\ell}\sqrt{\frac{(b-s+1)(e-b)}{e-s+1}}\left(\frac{1}{b-s+1}\sum_{t=s}^{b}y_{lt} - \frac{1}{e-b}\sum_{t=b+1}^{e}y_{\ell t}\right)$. With the set of factor number candidates $R = \{\underline{r}, \underline{r}+1, ..., \bar{r}\}$, we repeat the factor decomposition and change-points analysis for all $k \in R$.

2.2. Change point analysis

To explore the change points of stock returns of energy firms. This studies employs all of the energy-related firms listed on the A-share from China Security Market from January 2008 to December 2018. Because some important energy firms were listed on the A-share from China Security Market started in 2008. Finally, We are left with a sample of 49 energy firms. When calculating the stock returns, the logarithmic transformation of the closing data subtracted from each other to get the stock returns data. We collected complete data from China Stock Market & Accounting Research (CSMAR) database.

Figure 1 shows the change points of stock returns of energy firms. The left side of Figure 1 shows that the common components of stock returns of energy firms present one change point in September 2009. Combined with the characteristics of China Security Market and 2008 global financial risks, from January 2008 to September 2009, China Security Market experienced a cliff-like decline and then has been in a relatively stable state. However, in 2015, the China Security Market has once again appeared similar to 2008. To test whether there are still change points after September 2009 (T = 20), we excluded the data before September 2009 for analyzing. The right side of Figure 1 shows that the common components of stock returns of energy firms present two change point at April 2015 (T = 66) and July 2016 (T = 81), which is exactly in line with the abnormal situation in the China Security Market in 2015. We observe that more eigenvalues are required to calculate the same proportion of variance during the low volatility period, and fewer factors drive the majority of the cross-sectional correlations during the high volatility period.

These three change points have all be found in the common components of stock returns of energy firms, and there is no change point in the idiosyncratic components of stock returns of energy firms. This indicates that the change points of stock returns of energy firms are mainly driven by the market information; the idiosyncratic information of energy firms is not enough to cause change points in stock returns. The common components of stock returns of energy firms are driven by macroeconomic factors and the market situation. Macroeconomic news will affect the common components of stock returns of energy firms. Therefore, the impact of macroeconomic news on stock returns of energy firms is heterogeneous before and after the change point.

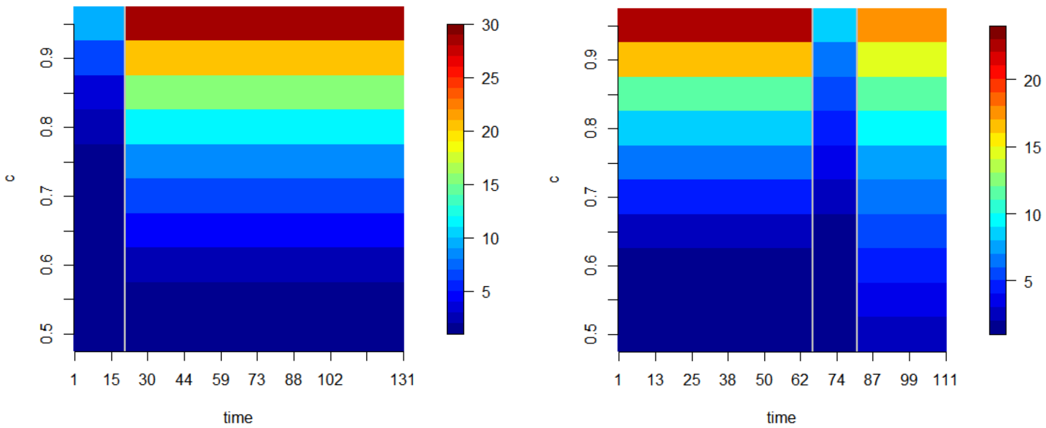

Figure 1. Stock returns data: $k_b(c)$ for each $[\hat{\eta}_b^x+1, \hat{\eta}_{b+1}^x], b=1,\ldots,\hat{B}_x$ according to the color legend in the right; x-axis denotes the time, and y-axis denotes $c \in \{0.5, 0.55, \ldots, 0.95\}$.

3. Definition and description of variables

3.1. Common components of stock returns of energy firms

The stock returns of energy firms are caused by the macro market-driven common component and the micro factors of the individual, idiosyncratic component. Since macroeconomic news is the same for every energy firms, the impact of the market on the common components of stock returns of energy firms is the same. However, the idiosyncratic information of each energy firms is different, so the stock returns of energy firms are different. We decompose stock returns of energy firms into market-driven common stock returns and individual-driven idiosyncratic stock returns. In section 2, we find all change points occurred in the common components of stock returns of energy firms, so this paper focuses on the common components of stock returns of energy firms.

3.2. Macroeconomic news

For the selection of macroeconomic news, this paper selects five macroeconomic news indicators based on the availability of data and the characteristics that are mainly issued during securities market transactions. Monetary policy is closely related to security market volatility. Changes in monetary policy affect the security market at all times, causing changes in the stock prices of energy firms. This paper selects the money supply (M2) and the weighted average 7-day interbank offered rate to represent the monetary policy (IR). Consumer price index (CPI) is an important macroeconomic variable that is closely related to the consumption and life of investors. Purchasing managers' index (PMI) involves micro-data of firms and industries, reflecting the internal operating conditions of the firm and reflecting the intrinsic value of the stock price. The relationship between energy prices and the securities market has always been a hot issue for scholars. Energy firms closely related to energy price are more vulnerable to energy price volatility. Since coal, oil, and natural gas is the most widely used in the energy structure, this paper selects the index of comprehensive conversion of commodity fuels (P) to reflect the changes in crude oil, natural gas and coal prices (International Monetary Fund 2016 = 100).

3.3. Description of variables

Based on the change points, we divided our sample into four sub-samples. The common components of stock returns of energy firms driven by market shock (MS) display different characteristics for a diverse period. Due to the elimination of data from the first two periods during data processing, our data will eventually start in March 2008. The descriptive statistics of all variables in its original form are represented in Table 1. Combined with the characteristics of China Security Market from 2008 to 2018, we can find that the securities market declines significantly during the period 1 (2008.03–2009.10) and period 3 (2015.05–2016.07) and has high volatility. Period 2 (2009.11–2015.04) and Period 4 (2016.08–2018.12) have been in a relatively stable state. Both the maximum (2.3917) and minimum values (−2.9970) of MS appear in period 1, and the volatility is the largest (1.5391). The highest mean of MS is 0.1369 in period 2, and period 3 shows the lowest mean is −0.2199. The mean of MS is only positive in period 3, which indicates that the common components of stock returns of energy firms are only positive in period 3, and the rest of the period has been in a loss state.

The characteristics of macroeconomic news are different when the sample periods are different. First, We can see that M2 has been in a state of decline, and the volatility is getting smaller and smaller. The highest mean of M2 is 21.2250 in period 1, and period 4 shows the lowest mean is 9.2517. P shows the highest volatility (67.7884) in period 1, significantly higher than in other periods. The highest mean of P is 210.1967 in period 1, and period 4 shows the lowest mean is 104.2347. Energy prices have been at high volatility. The highest mean (3.5198) and volatility (1.0827) of IR appear in period 2. Period 1 shows the lowest mean of IR is 2.0825. Period 3 shows the lowest volatility (0.0912) of IR. The highest mean of CPI is 3.2900 in period 1, and period 3 shows the lowest mean is 1.6919. The mean of PMI only under period 3 is less than 50 with minimum volatility (0.3357). The highest mean of PMI is 51.5152 in period 2, and period 1 shows the highest volatility (5.2535).

4. Impacts of macroeconomic news on stock returns of energy firms

4.1. TVP-VAR model

Based on the above results of the change-points analysis, we can divide the full sample period into different sample periods. Market response to macroeconomic news varies over time (Huang, 2018). Thus, for different sub-periods, we adopt the TVP-VAR (Nakajima, 2011) model, which allows for time variation in the coefficients to analyze the relationship between macroeconomic news variables and stock returns of energy firms. The TVP-VAR model defined as:

$$y_t = c_t + B_{1,t} y_{t-1} + \ldots + B_{s,t} y_{t-s} + A_t^{-1} \sum_t \varepsilon_t \tag{7}$$

where y_t is a $k \times 1$ vector of observed variables, $B_{i,t}$ are the coefficient matrix, ε_t is i.i.d$(0, I_k)$,

$$A_t = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21,t} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1,t} & \cdots & a_{kk-1,t} & 1 \end{pmatrix}, \quad \Sigma_t = \begin{pmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{k,t} \end{pmatrix} \tag{8}$$

The model can be written in the following way

$$y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t, \ \ t = s+1, \ldots, n \tag{9}$$

where β_t, A_t and Σ_t are time-varying. Let $h_t = (h_{1t,}, \ldots, h_{kt})' = (\log \sigma_{1t}^2, \ldots, \log \sigma_{kt}^2)'$, $t = s+1, \ldots, n.$ Assume that the parameters follow the random walk process:

$$\begin{cases} \beta_{t+1} = \beta_t + \mu_{\beta t} \\ a_{t+1} = a_t + \mu_{at} \\ h_{t+1} = h_t + \mu_{ht} \\ \beta_{t+1} \sim N(\mu_{\beta_0}, \sum \beta_0) \\ a_{t+1} \sim N(\mu_{a_0}, \sum a_0) \\ h_{t+1} \sim N(\mu_{h_0}, \sum h_0) \end{cases} \tag{10}$$

The variance-covariance matrix of the above model's innovations is a block diagonal:

$$\begin{pmatrix} \varepsilon_t \\ \mu_{\beta t} \\ \mu_{at} \\ \mu_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix}\right) \tag{11}$$

4.2. Unite root test

Before testing the TVP-VAR model, we should test for stationarity of all variables used. Table 2 provides the results of four sub-sample unit root tests. The procedures of TVP-VAR model relies on the assumption that all variables are stationary. To test for stationarity, we used the ADF test. Table 2 provides the results of four sub-sample unit root tests. The results show that MS is stationary in all periods, but all macroeconomic news variables are failed the unit root tests. So, we took the difference to maintain the macroeconomic news variables stationary in all the sub-sample. The results indicate that at the ADF tests reject the null hypothesis at the 1% significance level for all differential macroeconomic news variables used in this study. From these results, we can conclude that all data are I(1) process.

Table 1. Summary statistics.

Variable	N	Mean	Std. Dev.	Min	Max
		Period 1 (2008.03–2009.10)			
MS	20	−0.1408	1.5391	−2.9970	2.3917
M2	20	21.2250	5.6298	14.8000	29.4200
P	20	188.6170	67.7884	119.3300	312.4100
IR	20	2.0825	0.9720	0.9900	3.4400
CPI	20	3.2900	4.1874	−1.2000	8.2000
PMI	20	50.9400	5.2535	38.8000	59.2000
		Period 2 (2009.11–2015.04)			
MS	66	0.1369	0.8560	−1.4889	1.9858
M2	66	15.5249	3.9537	10.1000	29.7400
P	66	210.1967	32.3903	122.6800	253.3300
IR	66	3.5198	1.0827	1.4600	6.9800
CPI	66	2.9270	1.4145	−0.9000	5.7000
PMI	66	51.5152	1.7580	49.0000	56.6000
		Period 3 (2015.05–2016.07)			
MS	15	−0.2199	1.0639	−2.2714	0.9268
M2	15	12.6733	1.1247	10.2000	14.0000
P	15	104.2347	18.1737	77.5300	138.4500
IR	15	2.5060	0.0912	2.3500	2.7600
CPI	15	1.6919	0.3625	1.2622	2.1670
PMI	15	49.8467	0.3357	49.0000	50.2000
		Period 4 (2016.08–2018.12)			
MS	29	−0.1007	0.4454	−1.0482	0.6669
M2	29	9.2517	1.2351	8.0000	11.6000
P	29	135.6624	22.1684	103.7700	174.0900
IR	29	3.1593	0.3225	2.4700	3.5700
CPI	29	1.8254	0.3230	1.3547	2.5491
PMI	29	51.2138	0.6583	49.4000	52.4000

In all these cases, the optimal lag length for the TVP-VAR model estimation was determined based on the minimum Akaike Information Criterion (AIC) information criterion through the VAR estimation. Results suggest retaining a lag equal to 1. Because the maximum number of the lag length in the model was set to be 1, the first monthly observations are used to compute the lagged determinants changes for each the sub-sample.

Table 2. Unite root test.

Variables	ADF			
	Period 1	Period 2	Period 3	Period 4
MS	−3.998***	−8.312***	−3.287***	−4.089***
M2	0.052	−3.500***	−1.445	−0.802
D.M2	−3.402***	−8.221***	−3.243**	−9.573***
P	−0.853	−0.428	−1.397	−1.549
D.P	−1.957**	−5.720***	−2.043**	−3.817***
IR	−0.802	−3.685***	−9.549***	−1.861
D.IR	−3.176***	−9.303***	−5.754***	−6.305***
CPI	−0.634	−2.571***	−0.566	−2.110**
D.CPI	−3.234***	−6.551***	−2.127**	−6.533***
PMI	−1.628	−2.823***	−2.423**	−1.818**
D.PMI	−2.954	−7.963***	−4.681***	−6.088***

4.3. Heterogeneity impacts of macroeconomic news on stock returns of energy firms

Figure 2 presents the time-varying movements of the M2 coefficient in all the sub-sample. The impact of M2 on stock returns of energy firms have been positive, because the increase of M2 will increase the liquidity in the market, thus stimulating the investment enthusiasm of investors to bring MS up. There is a significant change point in the impact of M2 on MS. Due to the impact of the global financial crisis in 2008, to stimulate economic recovery, China has implemented a 4 trillion economic stimulus plan, trying to prevent economic recession and maintain China's economic growth. This led to M2 being significantly higher in period 1 than in other periods, and also led to the positive impact of M2 on MS significantly higher than other periods.

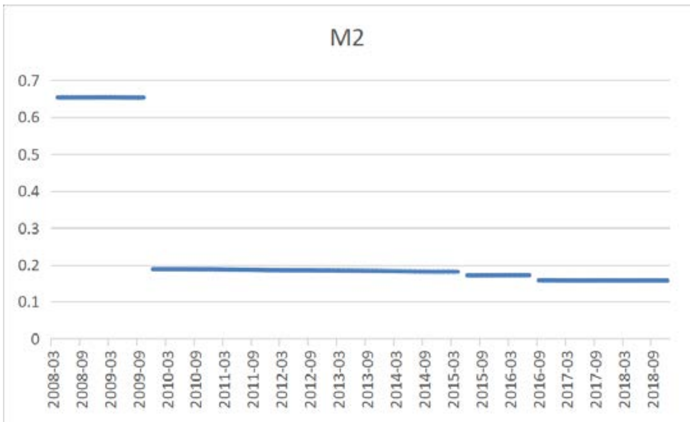

Figure 2. The coefficient of M2 in TVP-VAR model.

Figure 3 presents the time-varying movements of the energy price coefficient in all the sub-sample. In different periods, the impact of energy prices on the stock returns of energy firms is heterogeneous. In period 1 and 2, energy prices have a positive impact on stock returns of energy firms.

Because the increase in energy prices will increase the ability of energy firms to benefit in the future, resulting in rising stock returns of energy firms. Hamilton (2009) argues that, before the GFC, rising oil prices reflected growth in developing markets and high levels of business confidence. In period 3, energy prices have a negative impact on stock returns of energy firms. Because higher energy prices can lead to an overestimation of expected inflation and higher nominal interest rates. Interest rates are used to discount expected future cash flows; this will depress stock returns of energy firms. The negative impact of rising energy prices on macroeconomic is significantly stronger than the positive impact of declining energy prices on the macro economy. Higher energy prices associated with worsening macroeconomic conditions might result in a worse investment climate for energy firms in the long-run. In period 4, we found that the impacts of energy prices on stock returns of energy firms have strong volatility.

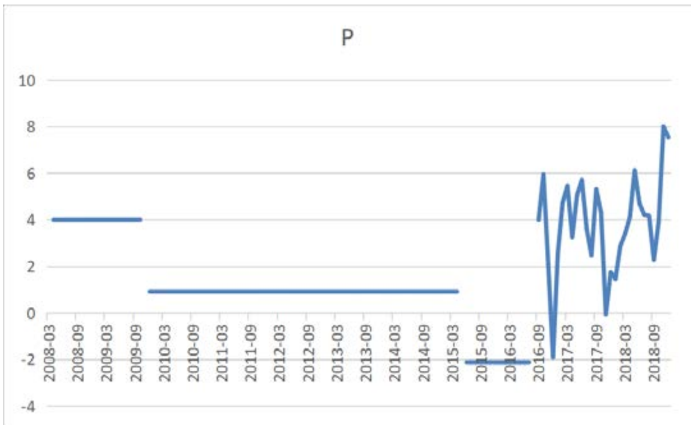

Figure 3. The coefficient of P in TVP-VAR model.

Figure 4 presents the time-varying movements of the IR coefficient in all the sub-sample. The impact of IR on stock returns of energy firms have been negative. The rise in interest rates increases the opportunity cost of investors. It will also affect the operating conditions of energy firms, increase financing costs, reduce profits, and enable people to lower the valuation of energy firms' stocks. More importantly, interest rate adjustment represents the government's signal to macroeconomic regulation. When interest rates rise, it means that the government wants to prevent the economy from overheating. Investors will sell stocks in time to prevent stock market risks, causing energy firms to fall in stock prices. There are two significant change points in the impact of M2 on MS. In period 2, the negative impact of IR on MS is significantly greater than in other periods.

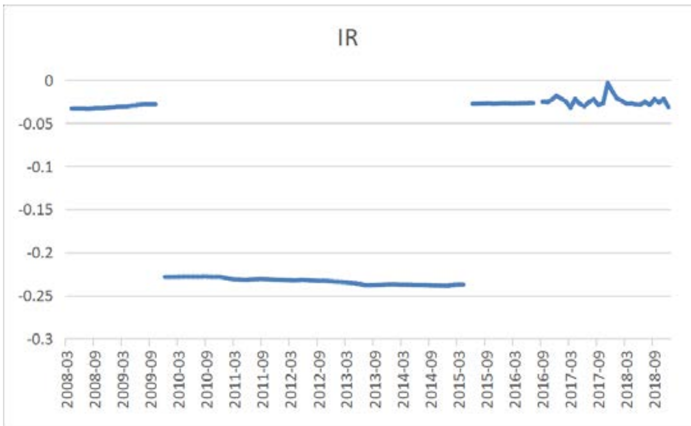

Figure 4. The coefficient of IR in TVP-VAR model.

Figure 5 presents the time-varying movements of the CPI coefficient in all the sub-sample. Usually, CPI has a negative impact on stock returns of energy firms. On the one hand, inflation will cause the government to reduce the money supply and money credit, increase interest rates, and thus adversely affect the stock market. On the other hand, the stock market is related to the real economy. When the economy developed strongly, the stock market performed well, and inflation was negatively correlated with the real economy, so it was negatively correlated with stock market returns. But in period 1, CPI has a positive impact on stock returns of energy firms. Because when the CPI is too high, investors will increase stock investment to offset the currency depreciation caused by inflation, thereby increasing stock returns. In other periods, the negative impact of CPI on MS is getting smaller and smaller. This shows that when the CPI is maintained at a low level, it can reduce the negative impact on stock returns of energy firms due to inflation.

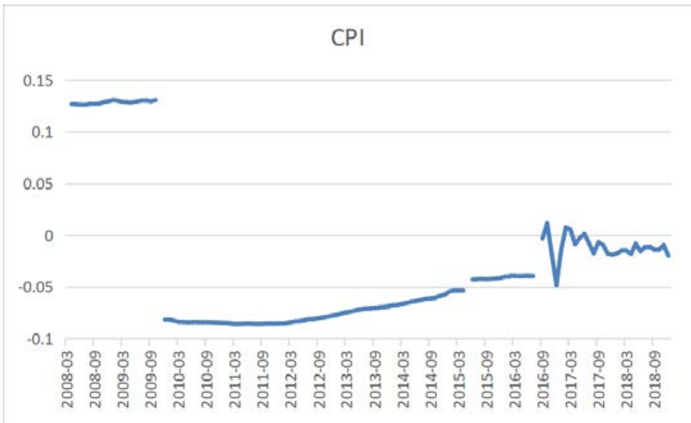

Figure 5. The coefficient of CPI in TVP-VAR model.

Figure 6 presents the time-varying movements of the PMI coefficient in all the sub-sample. The impact of PMI on stock returns of energy firms have been positive because PMI is typical representations of economic index news in China. If the PMI is above 50, then the manufacturing economy has the status of general expansion. If the PMI is under 50, then the manufacturing economy has the status of general recession. In this sense, the PMI serves as a timely indicator of economic forecasting and business analyses for the government, financial institutions, and firms. However, there are significant differences in the impact of PMI on stock returns of energy firms at different periods. The asymmetric effects of PMI on the stock returns of energy firms are observed: no market reaction is generated towards PMI under 50, while a positive reaction is generally generated for PMI above 50. In particular, PMI is not the bigger, the better. In period 1, PMI has the highest positive impact on stock returns of energy firms, which indicate that synergistic development of manufacturing and energy firms can better promote stock returns.

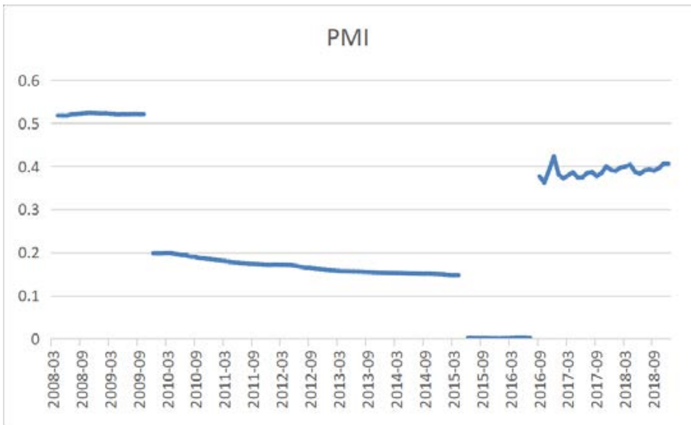

Figure 6. The coefficient of PMI in TVP-VAR model.

In order to better observe the impact of macroeconomic variables on stock returns of energy firms, we summary of estimated coefficients results in the four sub-samples are shown in Table 3. We can find that the change in the impact of macroeconomic variables on stock returns of energy firms occurs mainly at the first change point. Because period 1 happens to be the main period for China to cope with financial risks in 2008. Macroeconomic policies are quite different from other periods. The second and third breakpoints correspond exactly to the second abnormal period of the Chinese stock market. M2, IR and PMI do not change the fundamentals of their impact on stock returns of energy firms, but P and CPI have changed the fundamentals of their impact on stock returns of energy firms in different periods.

Table 3. Summary of the coefficient.

Variable	Period 1		Period 2		Period 3		Period 4	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
M2	0.6533	0.1982	0.1844	0.1516	0.1710	0.3638	0.1568	0.5894
P	3.9888	1.0082	0.8981	1.3173	−2.1433	0.9533	3.8191	9.6022
IR	−0.0309	0.2042	−0.2337	0.1296	−0.0270	0.3435	−0.0243	0.6487
CPI	0.1286	0.3315	−0.0759	0.0723	−0.0409	0.5777	−0.0113	0.9163
PMI	0.5211	0.6101	0.1673	0.1556	0.0016	0.9910	0.3887	1.2103

5. Conclusion

In this paper, we use the High-dimensional time series factor model to exam the change points of stock returns of energy firms over the period from January 2008 to December 2018. The data are subdivided into four periods (2008.03–2009.10; 2015.05–2016.07; 2009.11–2015.04; 2016.08–2018.12) to study the relationship between macroeconomic news and stock returns of energy firms. We use the TVP-VAR to conduct an empirical test. The main conclusions drawn from this analysis are as follows.

The change points only exist in the common components of stock returns of energy firms, but not in the idiosyncratic components of stock returns of energy firms. We conclude that macro information is key factor to driven the change points in stock returns of energy firms.

These change points have caused the relationship between some macroeconomic news and stock returns of energy firms to shift. Specifically, energy prices have a positive impact on stock returns of energy firms in period 1, 2, and 3. However, their interrelation is negative in period 3. CPI has a negative impact on stock returns of energy firms in period 2, 3, and 4. However, their interrelation is positive in period 1.

These change points have caused the different impact of macroeconomic news on stock returns of energy firms. Specifically, the impact of M2 on stock returns of energy firms have been positive, but M2 has the highest positive impact on stock returns of energy firms in period 1 and significantly higher than other periods. The impact of interest rate on stock returns of energy firms has been negative, but the negative impact of interest rate on stock returns of energy firms in period 2 is significantly higher than other periods. The impact of PMI on stock returns of energy firms have been positive, but the impact of PMI on stock returns of energy firms is almost zero in period 3.

Based on the above conclusions, the following policy implications are suggested. First, macroeconomic stability is the premise of the stability of the securities market; policy makers should be based on the stable operation of the economy and reduce uncertainty caused by changes in macroeconomic policies, thereby reducing stock market risks. Second, when investors deal with macroeconomic news, they should adopt different approaches at different times.

Conflict of interests

All Authors declare no conflict of interest.

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