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Abstract

This paper analyses the relationship between the China Containerized Freight Index (CCFI), Containership Earnings, Fleet Development, bunker price and Global Economic Activity. The Markov-switching Vector Autoregressive model has been applied by assuming the existence of two regimes. The first one is characterized by low and volatile freight rates, while the second one is more stable with high earnings and high freight rates. Three major cycles in the liner shipping industry have been identified. Moreover, by applying the Impulse Reponses Function, we have estimated the reaction of the freight rates following an increase of 1% of the other variables in the model.

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Key words: Freight rates, Container trade, Shipping, Vector Autoregressive Model

1. Introduction

Maritime transport is of major importance for the world's economy as over 80% of the world's trade is carried by sea (UNCTAD, 2017). It is the cheapest and most efficient way to transport goods in large quantity. Since the 1960s, containerization has greatly reduced the expense of international trade and increased its speed, especially in consumer goods and commodities. It has also dramatically changed the ports' infrastructures and shipbuilding industry. Even though in 2016, containerized cargo accounted for only 16.7%¹ of the total volume of transported goods, its value is more than 60%². According to data of Clarkson Research, since 1990, the containerized trade has increased by more than 600%.

However, the industry can be characterized by a high level of vulnerability and cyclic pattern. Following the Subprime crisis, in 2009 container prices fell by 14% (UNCTAD, 2009) which was caused by the dramatic decrease of 10.8% of the cargo transported in containers. It was the first time since the invention of the containers that the World GDP grew faster than the World Seaborne Container Trade. Since then, the industry has been in an unstable state. In the last years, freight rates have been very low, ship values have plummeted and competition on the various trade routes has intensified (Rex et al., 2016). In February 2017, the 7th biggest shipping company Hanjin Shipping declared bankruptcy. It is a clear sign that even the big players in the industry are threatened by the current situation.

¹ Estimated by the authors based on the data collected from Clarkson Research Shipping Intelligence and UNCATD official websites.

² <http://www.worldshipping.org/about-the-industry/global-trade>

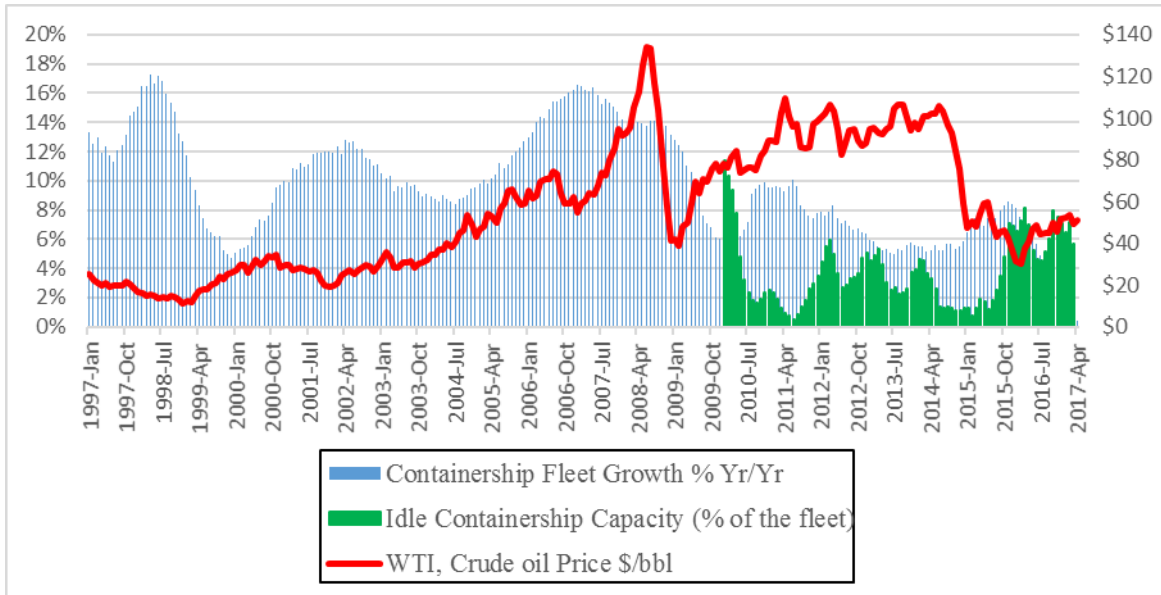


Figure 1 Containership Fleet Growth and Idle Capacity: Source: Clarkson Research

Prior to the subprime crisis, the price of oil was steadily increasing (Figure 1). On some major routes, shipping lines undertook different strategies with regard to the commercial speed of the fleet and the scale of the vessels (Notteboom and Vernimmen, 2009). Notteboom and Cariou (2009) estimated that by increasing the speed by two knots on average the fuel cost increases by around 40%. The high fuel prices gave incentives to shipping companies to invest in bigger ships and increase the time of travelling by reducing the speed and deploying more ships on some maritime routes. After the world crisis and the slowdown of the world economy, the excessive capacity seemed to have been a major concern for the industry. As shown in Figure 1, global idle container ship capacity represented 11.4% in January, 2010 and despite the decreasing trend of the fleet growth, it has remained relatively high (5.64% in March, 2017).

Freight Rates in the containerized industry have a direct impact on the shipping lines decisions and world trade. They can be defined as the price for transporting a standard 20-foot container from one port of origin to a destination port. However, analyzing on a macro level the

factors behind the freight rates is not an easy task. The complexity arises from the fact that a large number of parties, each one with different objectives, is involved in container shipping (that is consignor, a consignee, an ocean carrier, freight forwarders, inland carriers, banks, legal experts, insurance brokers, customs, port/terminal operators, and inland depot operators). Lee and Song (2017) classified them into service users and service providers. In addition, Container rates are quoted as the price per box, “Freight all Kinds”. This makes it even more complex to generalize how rates are structured spatially, because the tariffication is not related to the product being transported as in some other trades (Slack and Gouveral, 2011).

Container freight rates can be broken down into three main components: Basic Ocean Freight (BAS), Mandatory surcharges and Value Added Services (VAS). BAS is mainly determined by the origin and destination of the cargo. Mandatory surcharges include a variety of charges that are added to BAS. For instance Bunker Adjustment Factor take into account the variation of the cost spent on fuel while Terminal Handling Charges are based on the cost of handling a container. Finally, VAS is related to the requirements of any particular client. Examples of such services are container cleaning and cold treatment. According to Maersk Line, BAS accounts for 50%, Mandatory surcharges for 25% and VAS for 25%³. Slack and Gouveral (2011) found out that surcharges account for more than 50% in the total freight charged to customers.

The objective of this paper is to analyze the relationship between key variables in the liner shipping industry by taking into account its cyclical and nonlinear patterns. Firstly, we depict some key findings and gaps in the literature regarding the ocean freight rates. Secondly, the methodology of Markov-Switching Vector Autoregressive (MS-VAR) models and the

³ Freight shipping rates and container costs, Official Website of Maersk Line
<https://www.maerskline.com/news/2017/08/03/rates-and-pricing>

Impulse Response function are presented along with detailed description of each one of the selected variables. Thirdly, a detailed explanation of the different regimes as well as their switching probability are explained. This section of the paper also describes the six economic cycles that have been identified and the impulse responses of China Containerized Freight Index (CCFI) following a shock of another variable in the model. Finally, a summary of the main findings and possibility of future research are provided.

2. Literature Review

Since the Subprime Crisis, freight rates in the liner shipping industry have been very volatile and many empirical studies have been conducted to understand its behavior. De Oliveira (2014) applied different methods of regressions, such as the random effects (RE) and fixed effects (FE), and the Hausman–Taylor (HT) estimator to analyze the freight rates. His study included 1,128 quotations for transporting a standard 20-foot container between six European countries and 47 partners. The independent variables in his model were the port-to-port distance, number of transshipments, economies of scale and Liner Shipping Connectivity Index. The results show that inward freight rates are on average, 23% higher than for outward ones, with the competition having a strong effect on the freight rates and surcharges appearing to be one of the main revenue-makers.

Slack and Gouvernal (2011) analyzed the factors behind the freight rates in the case of 35 port destinations from Northern Europe. Their study shows that that distance is not a factor in explaining freight rates and the regional and temporal differences do not have any significant impact on the price of shipments. They also found that there is no correlation between the distance and BAF and no significant relationship between freight rates, imports and size of the large vessels.

Behrens and Picard (2011) suggested that the impact of globalization as well as regional disparities on freight rates are overstated. The main reason for asymmetric freight rates is the presence of empty containers. Lun et al. (2013) used Path analysis in Structural Equation Modeling (SEM) to analyze the causality between the following variables: container trade, total fleet, freight rate, new building vessel price, second-hand vessel price, and demolition vessel price. The data is weekly for a period of twelve years, collected from Clarkson Research. Results suggest that there is significant relationship between total Fleet size and seaborne trade and no link between freight rate and seaborne trade. Tran and Haasis (2015) applied multiple regression to analyze the costs and revenues of the top 25 Container Operators. They found that market freight rate has an effect on revenue and the capacity has an impact on the total cost of the operators. Ordinary Least Square method was used by Duru and Yoshida (2011) to investigate the factors behind the Long term composite Freight Index (LFI), created by them and the seaborne trade. Their study shows that life expectancy is significant for both the models while the effect of fleet size is very weak.

Considering the nonlinear relations between the different factors influencing freight rates and their interdependence, some authors have applied different autoregressive models. Veenstra and Franses (1997) used the Multivariate Cointegration approach to analyze the relationship of six bulk freight rates related to different commodities and routes. A cointegration between five of the variables in the model was found and a VEC model was formulated. The stochastic trend of all variables show that an important part of the pattern of the freight rates cannot be predicted. Veenstra (1999) used the VAR model to examine the relation between spot and period freight rates for the ocean dry bulk shipping market. The research show the evidence of a term structure in the industry and all deviations from the present value relation are of a transitory nature. Chi

(2016) applied the ARDL approach to build export and import models regarding the trade between China and US. Results reveal that gross domestic product is the key determinant of bilateral freight flows, while the real income is closely related to the bilateral freight flows. They also found that transport costs can be an important factor affecting the inflows of Chinese commodities to the US.

However the cyclic nature of the freight rates should also be considered. An appropriate approach is Markov Switching Vector Autoregressive model (MS-VAR) which allows us to analyze the relationship between the variables according to different states of the market. There are very few studies that have applied such a methodology in the context of ocean freight rates. Bildirici et al. (2015) analyzed the relation between GDP growth in US and the Baltic Dry Index (BDI) by assuming the existence of three regimes. The first one is associated with the crisis, the second one is the moderate growth regime and the third one is the high growth regime. They found that under the high growth regime, BDI improvement effects economic growth positively.

As seen from the literature review, most of the authors have focused on the ocean bulk freight rates. We have not found any study applying VAR methods to investigate the freight rates in the container trade. VAR modeling is widely applied in macroeconomics because it does not require as much knowledge about the forces influencing a variable as structural models with simultaneous equations. Its main advantage is that all variables are treated as endogenous and each one is explained by its lagged values, the lagged values of the other variables in the model and error terms. Thus, we can analyze the linear interdependence among multiple time series by avoiding the problem of endogeneity (an explanatory variable is correlated with the error term). A standard approach of VAR modelling is the estimation of the impulse responses function of each of the variables to one unit increase in the current value of one of the VAR errors (Stock

and Watson, 2001). Considering the current volatile freight rates and the oversupply in the industry, it is also important to investigate the potential structural changes in the containerized trade market.

Our paper aims to fill in this gap in the literature and to provide empirical application of MS-VAR and impulse responses function in the context of containerized trade market. The objective of the research is to identify the different business cycles that have occurred in the liner shipping industry in the last 13 years and to analyze their nature as well as to evaluate the effects on the container freight rates following a surprising increase in the oil price, earnings, Fleet Development or Global Economic Activity.

MS-VAR provides accurate estimates regarding the duration of each regime as well as the switching probabilities. Moreover, it allows one to distinguish different business cycles occurring during the observed period. For each regime we have computed the impulse responses of CCFI following a positive shock of another variable in the model.

3. Methodology

3.1. MS-VAR model

Following the pioneer work of Sims (1980), VAR modeling has become a useful tool in macroeconomics. Contrary to the structural models with simultaneous equations, VAR avoids the problems of over-identification (differentiating between correlation and causation by imposing restrictions). In VAR models, variables are endogenous. VAR provides a coherent and credible approach to data description, forecasting, structural inference, and policy analysis. In order to take into account the structural breaks in the time series and the different states that the

containerized market operates, we combine the VAR approach with the Markov Chain process in the so-called Markov-switching Vector Autoregressive (MS-VAR) modelling.

Following Hamilton (1989), the general MS-VAR is depicted by equations (1) where it is assumed that a change in regime corresponds to an immediate one-time jump in the process mean. The description of MS-VAR in the current paper follows (Ehrmann et al., 2003). In our model, we consider that the mean would smoothly approach a new level after the transition from one regime to another. We do it in an extension of Hamilton's approach to a regime-switching VAR system (Krolzig, 2013).

$$Z_t = \begin{cases} v_1 + B_{11}Z_{t-1} + \dots + B_{p1}Z_{t-p} + A_1u_t & \text{if } s_t = 1 \\ \vdots \\ v_m + B_{1m}Z_{t-1} + \dots + B_{pm}Z_{t-p} + A_mu_t & \text{if } s_t = m \end{cases} \quad (1)$$

$$u \sim N(0; I_K)$$

where $Z_t = [Y_t F_t^1 F_t^2 F_t^3 F_t^4]^T$ refers to China Containerized Freight Composite Index (CCFI), West Texas Intermediate oil price, Clarksons Average Containership Earnings, Total Containership Fleet Development and Index of Global Economic Activity. These exogenous variables are explained by an intercept v_t , autoregressive terms of order p and a residual A_iu_t . The number of regimes in the model is two, $s_t = 2$, and all parameters are allowed to switch between the regimes. Therefore, each of the two regimes is defined by an intercept v_1 , autoregressive term B_{1i}, \dots, B_{pi} and matrix A_i .

After the change in regime there is thus an immediate one-time jump in the variance of errors. This model is based on the assumption of varying processes according to the economic cycle in the liner shipping industry controlled by the unobserved variable s_t . Recall that in our

model $s_t = \{1,2\}$ is assumed to follow the discrete time and discrete state stochastic process of a hidden Markov chain and governed by transition probabilities $p_{ij} = \Pr(s_{t+1} = j | s_t = i)$, and $\sum_{j=1}^2 p_{ij} = 1 \forall i, j \in (1,2)$. The conditional probabilities are collected into a transition matrix P as follows:

$$P = \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix} \quad (2)$$

For a given parametric specification of the model, probabilities are assigned to the unobserved regimes conditional on the available information set which constitutes an optimal inference on the latent state of the market (Girardin and Moussa, 2011). We thus obtain the probability of staying in a given regime when starting from that regime, as well as the probability of shifting to another regime. The classification of regimes and the dating algorithm used imply that every observation in the sample is assigned to one of the two regimes. We assign an observation to a specific regime when the smoothed probability of being in that regime is higher than 50%. The smoothed probability of being in a given regime is computed by using all the observations in the sample.

3.2. Impulse Response Function

In a MS-VAR model, with regime-dependence in the mean, variance and autoregressive parameters, a large number of parameters can switch between regimes. Ehrmann et al. (2003) suggest the use of regime-dependent impulse response functions which allow the investigation of how fundamental disturbances affect the variables in the model. For each regime, there is a set of impulse response functions. Each response function depends on the prevailing regime at the time of the shock. They facilitate the interpretation of switching parameters by providing a convenient way to summarize the information contained in the autoregressive parameters, variances and

covariances of each regime (Girardin and Moussa, 2011). We follow the method of identification and estimation of impulse response proposed by Ehrmann et al. (2003).

There are mK^2 regime-dependent impulse response functions which correspond to the reaction of K variable to K disturbances in regime m .

$$\frac{\partial E_t Z_{t+h}}{\partial u_{k,t}} \Big|_{s_t=\dots=s_{t+h}} = i = \theta_{ki,h} \text{ for } h \geq 0 \quad (3)$$

Equation 3 shows the mathematical representation of the impulse response function for regime s . It reveals the expected changes in endogenous variables at time $t + h$ to one standard deviation shock to the k -th fundamental disturbance at time t in regime s . A series of K dimensional response vectors $\theta_{ki,1}, \dots, \theta_{ki,h}$ predict the response of the endogenous variables.

In order to make the precision of the impulse responses function more accurate, the bootstrapping technique was applied. This technique is used to create artificial observations for the variables and use them for the same estimation procedures as the original dataset. The artificial histories are created by replacing the parameters in the model with their estimated variance-covariance matrix, and then calculating the endogenous variables (Ehrmann et al., 2003). However, in MS-VAR, applying the bootstrapping technique is complicated due to the existence of a hidden Markov-chain process which determines the regimes. Therefore, we first create a history for the regimes, and then we use it to continue for the endogenous variables. Ehrmann et al. (2003) proposed the following five steps to apply bootstrapping technique in the context of MS-VAR. Firstly, a history for the hidden regime s_t is created by replacing the exogenous transition matrix with its estimated value \hat{P} . At each time t , a random number is drawn from a uniform [0,1] distribution and compared with the conditional transition probabilities to determine whether there is a switch of the regime. Secondly, a history for the

endogenous variables is generated. All parameters in Equation 1 are replaced by their estimated values and new residuals are computed. Thirdly, we use the data of the artificial history to compute bootstrapped parameters $\{\tilde{\nu}; \tilde{B}_1, \dots, \tilde{B}_p; \tilde{\Sigma}_i\}$ for $i = 1, \dots, m$, the transition matrix \tilde{P} , and the smooth probabilities $\tilde{\xi} = \Pr(\tilde{s}_t = i)$ for $i = 1, \dots, m$ and $t = 1, \dots, T$. Fourthly, a set of restrictions are imposed which provide bootstrapped estimates of the matrices $\tilde{A}_1, \dots, \tilde{A}_m$. Finally, the bootstrapped estimates of the response vectors are computed.

3.3. Data

The following data have been selected: China Containerized Freight Composite Index (CCFI), Clarksons Average Containership Earnings (\$/Day), Total Containership Fleet Development (thousand TEUs), West Texas Intermediate oil price (\$/bbl) and the updated version of the index of global real economic activity. In total, there are 168 observations. The first three variables were collected from Clarksons Shipping Intelligence Network. Statistics regarding the price of crude oil were provided by the Energy and Information Administration of US (<https://www.eia.gov/>). The Global Real Economic Activity index was computed by (Kilian, 2009).

- China Containerized Freight Composite Index - CCFI (Index)

China (Export) Containerized Freight Index (CCFI) is sponsored by the Ministry of Communications of China and formulated by the Shanghai Shipping Exchange. The index serves as a barometer of the liner shipping industry and it is computed based on data collected from 22 major international and domestic shipping companies for 11 major ports of departure in China. The reliability of the data is ensured by a freight rate formulation committee composed by

representatives of major domestic and foreign shipping companies. This is the key variable in the research and it is denoted as CCFI in our analyses.

- Clarksons Average Containership Earnings (\$/Day)

Clarksons Average Containership Earnings is based on information provided by Clarksons brokers on a daily and weekly basis. This information is used to calculate the earnings in the liner shipping industry by taking into account the number of the fully cellular containerships. Clarkson Research compute earnings based on a single freight rate. This indicator is a proxy for the profitability in the container shipping industry. In our research, this variable is denoted as “Earnings”. In broad terms, earnings for each route are calculated by taking the total revenue, deducting current bunker costs based on prices at representative regional bunker ports, estimated port costs (after currency adjustments) and total commission and then dividing the result by the number of voyage days (Clarkson Research, 2015).

- Total Containership Fleet Development (Thousand TEUs)

The size of all containerships is estimated in TEUs. This variable refers to the supply of the Liner Shipping. In the current paper we refer to this variable as “Fleet”.

- West Texas Intermediate oil price (\$/bbl)

West Texas Intermediate, also known as Texas light sweet, is a grade of crude oil used as a benchmark in oil pricing. The bunker cost accounts for 70% of the operational cost of carriers and thus WTI could be used as a proxy for the operational costs of the carriers.

- Global Real Economic Activity (index)

The index of global real economic activity is computed from data collected from the monthly report on "Ship and Economics" published by Drewry Shipping Consultants Ltd. It is based on a global index of dry cargo single voyage freight rates of various bulk dry cargos such as grain, oilseeds, coal, iron ore, fertilizer, and scrap metal. The index can be traced back to 1968 and it is a direct measure of global economic activity which does not require exchange-rate weighting. It automatically aggregates real economic activity in all countries and incorporates shifting country weights, changes in the composition of real output, and changes in the propensity to import industrial commodities for a given unit of real output (Kilian, 2009).

4. Empirical Results

4.1. Descriptive statistics and specifications of MS-VAR

We use monthly time series from March 2003 to February 2017. Table 1 provides a summary of the descriptive statistics for all variables. The average values of all indicators are positive. Standard Deviation is very high for the Crude oil, Earnings, and Global activity. According to the results of Skewness and Kurtosis, most of the variables are symmetrically distributed except CCFI and Global Activity. In addition, the Jarque–Bera test confirms these results and accepts the normality hypothesis. In order to check whether each variable follows a unit-root process, we applied the Dickey–Fuller test. The unit root test of Augmented Dickey Fuller test clearly rejects the null hypothesis of the stationarity of all variables except Global Activity. It means that all variables except Global Activity have a unit root and are generated by a stochastic process.

	Min	Max	Mean	S. dev.	Med.	Kurtosis	Skewness	JB test *	ADF test**
CCFI	641.5040	1315.8740	1.0309e+03	140.7295	1060.5850	3.3858	-0.9034	23.8936 (1.7019e-03)	0.0000 (4.7803e-01)
EARNINGS	4395.7770	28650.8608	1.2237e+04	6866.1563	10142.5182	2.2824	0.6766	16.4238 (4.6844e-03)	0.0000 (3.6586e-01)
FLEET	6163.6750	20043.4390	1.3140e+04	4410.1717	13097.9290	1.7259	-0.0394	11.4069 (1.1359e-02)	0.0000 (9.9900e-01)
CRUDE OIL	28.1100	133.8800	7.0221e+01	25.0233	69.5400	2.0869	0.1636	6.5850 (3.6691e-02)	0.0000 (5.1096e-01)
Global Activity	-133.1265	66.7783	1.0220e+01	35.9535	18.1813	3.7078	-0.7674	19.9951 (2.7876e-03)	1.0000 (3.8479e-02)

* In brackets, critical values for the tests. ** Augmented Dickey-Fuller test.

Table 1 Descriptive statistics

Correlation coefficients for the whole sample are presented in Table 1. It shows that all variables in the model have a positive correlation with CCFI except the Fleet. However the correlation coefficients are less than 50%. The strong and negative correlation between Earning and Fleet (-0.80) suggests a possible negative effect of the growing capacity in the shipping industry on the Earnings. There is also a negative correlation of 75% between Fleet and Global Activity.

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
CCFI	1				
Earnings	0.4369	1			
Fleet	-0.4613	-0.7975	1		
Crude Oil	0.3906	-0.2051	0.2811	1	
Global Activity	0.4553	0.6475	-0.7538	0.0962	1

Table 2 Correlation Matrix

In the MS-VAR model and impulse response functions, all variables were transformed into log and we use their growth rates for our analysis. Following the results of the Augmented Dickey–Fuller test, we also transform all variables into first difference, except Global Activity. In the current paper we estimate an unrestricted MS-VAR model with intercept and without trend. We choose 2 lags based on the AIC, HQ and SC criteria. We also assume the existence of two regimes.

4.2. Business Cycles in the Liner shipping industry

As we have already emphasized, the MS-VAR model allows us to identify the different business cycles that have occurred from May 2003 to February 2017 (we have included two lags in the model). Figure 2 shows the transitional switching probabilities of regime 1 (the blue line) as well as the value of the CCFI (the red line).

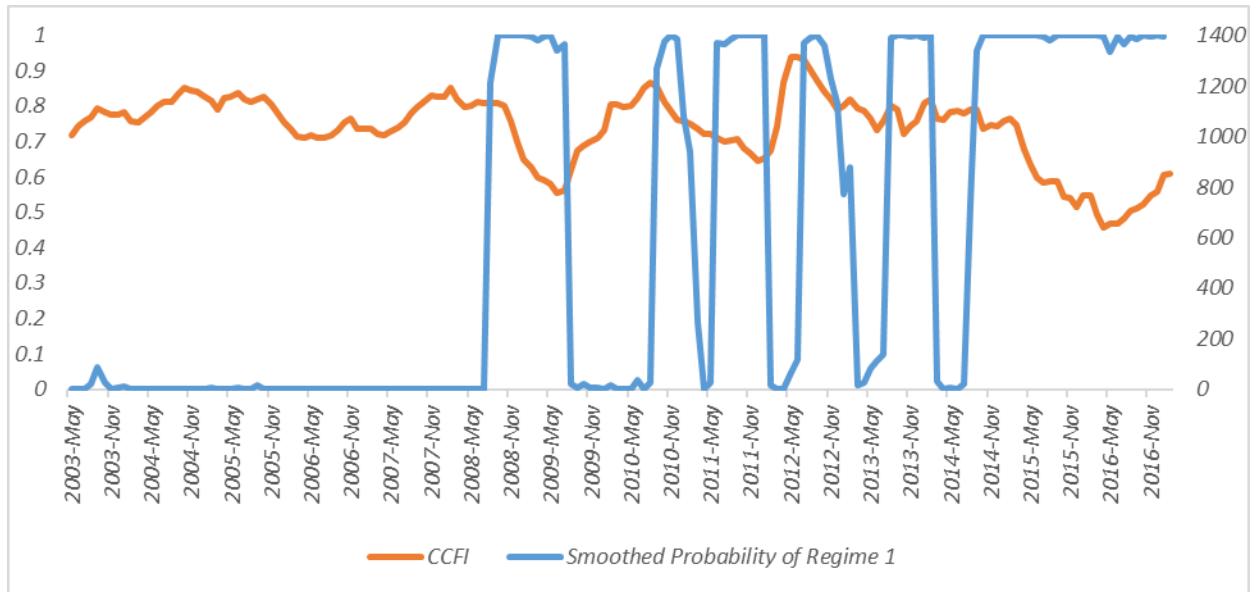


Figure 2 Smoothed probability of Regime 1 (volatile and decreasing freight Rates) and CCFI index. Source: Author's drawing

In the MS-VAR model, all variables were transformed into log and we use their monthly growth rates. The blue line shows the switching probability of the more volatile Regime 1. The red line depicts CCFI.

Both regimes are very persistent as shown in the matrix below. The regime switching probabilities for Regime 1 and Regime 2 are 18% and 17%, respectively. A major event that marks the switch of the regime 2 to regime 1 is the Subprime Crisis. The switch occurs in September 2008 and has a major impact on the variables in the model.

$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \quad \text{with } P = \begin{pmatrix} 0.8151 & 0.1849 \\ 0.1697 & 0.8307 \end{pmatrix}$$

Throughout the observed period, Regime 1 and Regime 2 last 71 and 95 months, respectively. Table 3 and Table 4 show the descriptive statistics of the variables under each of the identified regimes. Regime 1 is characterized by lower average container freight rates and considerably higher volatility (Standard Deviation). Moreover, under the second regime the average Global Activity is negative (-15.2), while in regime one, its mean value is 29.32. Earnings are also considerably higher under the second regime (15,908). On the other hand, the mean and the standard deviation of the Fleet are higher in the first regime. It suggests, that Regime 1 is characterized by a low level of economic activity, a high level of volatility of freight rates, a low level of earnings and a high growth rate of the containership capacity. The second regime is slightly more persistent than the first one and can be defined as a regime of a high level of economic activity, high and stable container freight rates, a high level of earnings and a low level of fleet capacity.

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
Min	641.50	4,619.34	11,926.45	30.32	-133.13
Max	1,263.72	1,5740.16	20,043.44	106.29	44.45
Average	943.04	7,310.74	16,677.73	69.88	-15.42
Std. Dev.	161.10	2,344.44	2,679.00	23.65	32.54
Med	956.77	6,461.60	17,084.64	69.64	-15.28
Kurtosis	-1.12	1.85	-1.18	-1.62	1.66
Skewness	0.15	-1.47	0.32	-0.01	0.84

Table 3 Descriptive Statistics of Regime 1

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
Min	946.37	4,395.78	6,257.82	28.11	-29.43
Max	1,315.87	28,650.86	17,872.49	133.88	66.78
Average	1,097.40	15,908.95	10,642.82	71.30	29.32
Std. Dev.	74.32	6,906.49	3,524.77	25.72	25.35
Med	1,097.94	16,205.72	6,501.78	30.34	42.01
Kurtosis	0.50	-0.86	-0.92	-0.55	-0.22
Skewness	0.48	-0.16	0.57	0.24	-0.80

Table 4 Descriptive Statistics of Regime 2

By looking at Figure 2 we can distinguish three economic cycles. The first one is from May 2003 to August 2008 which falls under Regime 2. This period can be characterized by steady growth, very low volatility of CCFI, a high level of earnings, a low price of crude oil and a very high level of Global Activity (Table 5). This is the longest period which falls uniquely under the second regime (64 months).

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
Min	995.21	14,315.05	6,257.82	28.11	17.80
Max	1,194.93	28,650.86	11,824.90	133.88	66.78
Average	1,094.43	20,011.35	8,506.10	62.41	41.45
Std Dev.	59.38	3,879.29	1,682.30	25.75	14.42
Median	1,098.37	18,893.90	8,169.19	59.35	42.99

Table 5 : Business Cycle 1: Steady Growth

Descriptive statistics (May 2003 - August 2008)

The effect of the Subprime Crisis on Containerized trade started in September 2008, when we have a switch from Regime 2 to Regime 1. This marks the beginning of the second business cycle, which is characterized by a high level of uncertainty. This cycle continues until August 2014 (72 months in total). Throughout this period we have frequent switches between the two regimes. Even though the average CCFI has decreased by only 3% compared to the previous cycle, its volatility has increased by 102%. Earnings and Global Activity also had a dramatic decrease of 62% and 95%, respectively (Table 6). This period could be characterized as a post-crisis period where government took considerable measures to support the industry and to maintain economic growth. This business cycle lasts 72 months.

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
Min	777.04	4,395.78	11,926.45	39.09	-41.27
Max	1,315.87	15,740.16	17,872.49	109.53	44.45
Average	1,057.41	7,504.49	14,884.93	86.40	2.19
Std. Dev.	119.77	2,725.36	1,776.50	16.82	24.20
Median	1,066.60	6,537.33	15,066.53	89.33	2.69

Table 6: Business Cycle 2: Uncertainty, Descriptive statistics (September 2008 - August 2014)

From September 2014 to February 2017, we observe a business cycle which falls entirely under Regime 1 and we have named it “The New Normal” which lasts 30 months. During this period, the average Global Activity decreased by 39.52 points (Table 7). The average CCFI is 21% lower than the second business cycle and its volatility is 20% higher. Earnings became less volatile and decreased by 7% compare to the previous cycle. The Fleet has increased by 30% and its volatility is 58% lower. In April 2016, CCFI registered its lowest monthly value ever recorded, 641.50 points, and in August 2016 the Hanjin Shipping, the seventh biggest shipping company, declared bankruptcy.

	CCFI	Earnings	Fleet	Crude Oil	Global Activity
Min	641.50	5,357.11	17,926.47	30.32	-133.13
Max	1,107.11	10,935.99	20,043.44	93.21	2.18
Average	834.42	6,978.76	19,302.69	50.69	-37.33
Std Dev.	143.40	1,729.89	743.40	13.65	30.08
Median	799.92	6,156.18	19,657.97	47.52	-33.49

Table 7: Business Cycle 3: The new Normal

Descriptive statistics (September 2008 - August 2014)

The proposed MS-VAR model tracks well different cycles that have occurred in the liner shipping industry. Both regimes are very persistent, which allows us to assume that the last business cycle, “The New Normal” might continue for at least a few more years. The growing number of conferences between carriers is a clear sign that shipping companies are trying to minimize their costs in order to deal with the low world demand and high level of containership capacity. We also observe a monopolization of the shipping market. According to Alphaliner, in 2008 Maersk had a share of around 6% of the world fleet, while in April 2017, it was more than 16%.

4.3. Impulse Reponses Functions

We use impulse response functions to show how the endogenous variables react to shocks of one standard deviation of the residuals of each equation (Crude Oil, Earnings, Fleet or Global Activity). The Impulse response functions are conditional on a given regime prevailing at the time of the disturbance and throughout the duration of the response (Ehrmann et al., 2003). In order to increase the precision of our estimation, we have applied the standard bootstrapping techniques. This method consists of increasing the number of observations by creating artificial histories for the variables. We have made 1000 bootstrap replications. Similarly to Uhlig (2005) and considering the findings of Inoue and Kilian (2016), we use a confidence interval of 68%.

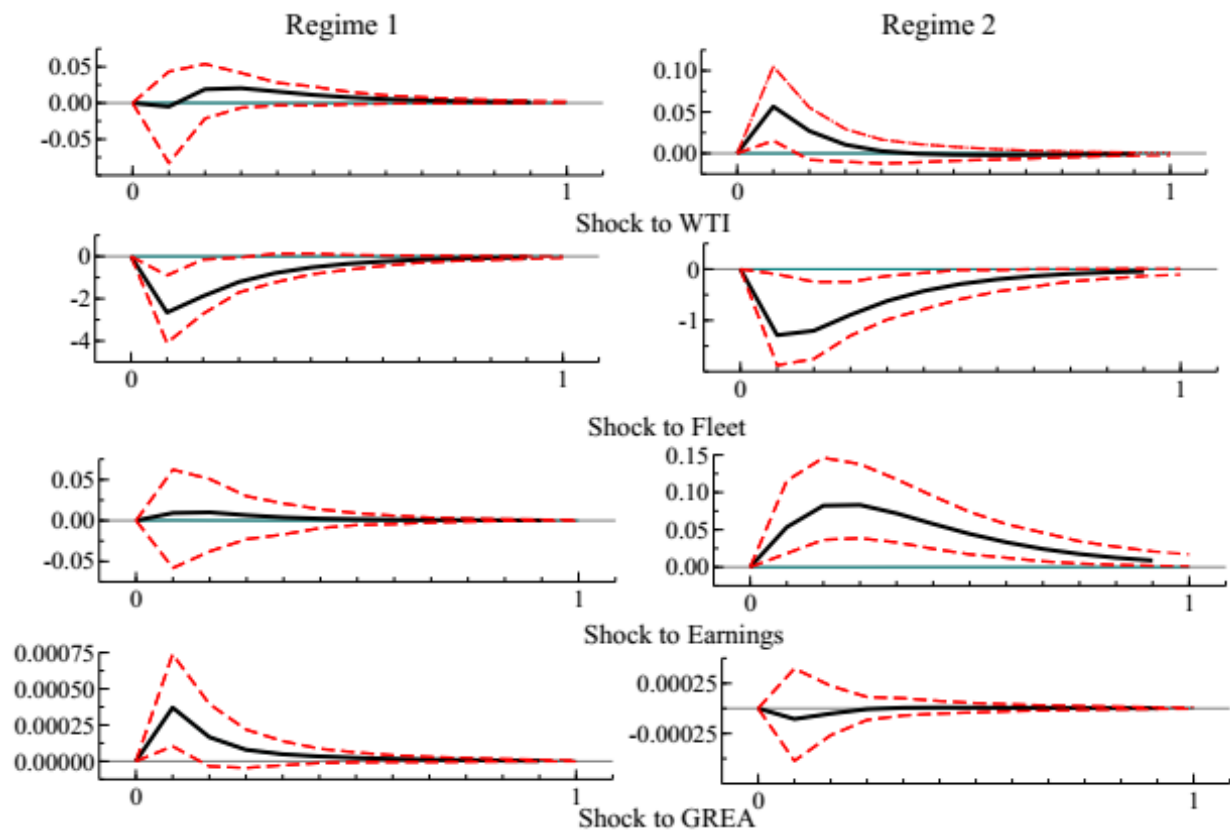


Figure 3: Response of CCFI reacting to shock to the other variables in the MS-VAR model according to the two regimes.

Note: The variables were transformed in log and we use their growth rate for the analysis. Impulse response functions of CCFI are conditioned to the prevailing regime. The figure depicts responses of CCFI to a positive shock of 1% to the other variables in the model. The impulse reaction period is chosen to be 12 months. Solid black lines

depict impulse responses of CCFI, while dashed lines depict 68% confidence intervals. The upper dashed and lower dashed lines represent 84% quantile and the 16% quantile of the posterior distribution, respectively. Impulse responses are computed on the basis of 1000 bootstrap replications. GREA refers to Global Real Economic Activity Index while WTI refers to the price of Crude Oil.

The response of CCFI to a one standard deviation shock to the other variables in the model are shown in Figure 3. Responses are regime dependent: the left-hand diagrams correspond to Regime 1 (high volatility and decreasing freight rates) whereas the right-hand figures refer to Regime 2 (low volatility and high container freight rates).

A positive shock of 1% of the crude oil has a significant effect on CCFI only in the second regime. This could be explained by the fact that most of the observations which fall under the second regime (stable growth) are before September 2008. During that time, the oil price had an increasing trend (see Figure 1) and thus the freight rates were strongly associated with the bunker price. On the other hand, throughout Regime 1 which is post crisis regime, the price of crude oil is quite low and has a decreasing trend.

The size of the world Fleet has substantial impact in both regimes. It is more pronounced in Regime 1, where a 1% increase of the size of the fleet leads to an immediate 3% decrease of the container freight rates. Then it takes around 7 months for CCFI to go to its equilibrium level. In the second regime, the shock of the Fleet is also significant and CCFI decreases by approximately 1.4%. These results suggest that the supply in the shipping industry plays a major role in the container freight rate price formation. During a period of growth and low volatility, companies are able to better plan their strategies in terms of fleet development, while during a period of crisis, we have a substantial decrease in the demand for container transport which drives the freight rates down. Shipping companies are trying to optimize their fleet by renewing their fleets. According to the data of Clarkson research, between March 2003 and August 2008,

the monthly average of scrapped vessels were 3,257 TEUs, while from September 2009 to March 2017, the monthly average was 16,138 TEUs, which is the equivalent of one Triple E containership. In January 2014, the equivalent of demolished ships was 84,740 TEUs, the highest level ever recorded. We should emphasize that many environmental and safety regulations also play a role in the increase of scrapping activities.

Earnings in the shipping industry are significant only under the regime of growth and low volatility. A change in 1% in the level of earnings would lead to a 0.08% increase of CCFI. Even though the impact on the container freight rates is not very great, it lasts for 12 months.

The last variable in the model, Index of Global Economic Activity (GRE), is significant only in the First Regime of the impulse response function of CCFI. However, the effect of this variable is not substantial and its duration is only 2 months. It is interesting to highlight the fact that under the second regime, the function has a decreasing trend.

In appendices 1, 2, and 4 are presented the impulse response functions of Earnings, Fleet, Global Activity and Crude Oil respectively. It is interesting to observe that CCFI has a very substantial negative effect on Earnings in the case of both regimes. To a lesser extent, CCFI has a positive impact on Global Activity and the price of crude oil.

5. Conclusion

This paper contributes to the existing literature by exploring the relationship between the China Containerized Freight Index (CCFI), Clarksons Average Containership Earnings, Fleet Development, the price of Crude Oil and Global Real Economic Activity by applying MS-VAR and Impulse response function approaches. We have applied the MS-VAR model without trend

and intercept by assuming the existence of two regimes. The first one can be characterized as a regime of crisis, low freight rates and high volatility occurring after the Subprime crisis, while the second one is a state of steady growth and low volatility in the shipping industry. The identified regimes are very persistent and track well the trends and business cycles in the shipping industry between May 2003 and February 2017. We have identified 3 major business cycles. The first one is characterized by a period of long and steady growth which lasts until August 2008. The following cycle is a transitional one which lasts 6 years. The third cycle is characterized by very low freight rates, low earnings and substantial size of the world fleet.

The impulse responses methodology allows us to pin down the consistent and efficient estimates of the reaction of CCFI to different factors according to the two states of the industry (Regime 1 and Regime 2). The variable which has a profound negative impact on the container freight rates is the growth of the world fleet. Its effect is more pronounced under the regime of crisis. Earnings in the shipping market and the crude oil price are only significant in the second regime and both have a positive impact on CCFI. The Global Economic activity has a minor effect on CCFI in the regime of crisis.

Potential future research could include the use of another indicator as a proxy for freight rates instead of CCFI. In this way we could double check our findings. Moreover, a variable which depicts the market concentration in the liner shipping industry (for example, the share of the top 10 companies in terms of transported TEUs) could also be included in the model. Other variables which reflect the Economic activity worldwide such as the industrial production of OECD member states could be also be considered.

The last identified economic cycle (“The New Normal”) is characterized by low container freight rates, low earnings, high fleet capacity and relatively low crude oil prices.

Shipping companies are dealing with this unstable prospect of the market by limiting their operational costs (that is slow steaming strategies and economies of scale) and sharing capacity (creation of alliances). As UNCTAD pointed out, the market has become more monopolized and small players are vulnerable. In addition, even the big companies, such as Hanjin Shipping, could face bankruptcy. When we take into account the regionalization of the trade (for example, ASEAN Economic Community, Trade agreement between the EU and Canada, etc.) and the slowdown of the Chinese economy, it is obvious that the current unstable situation of “New Normal” might last a few more years.

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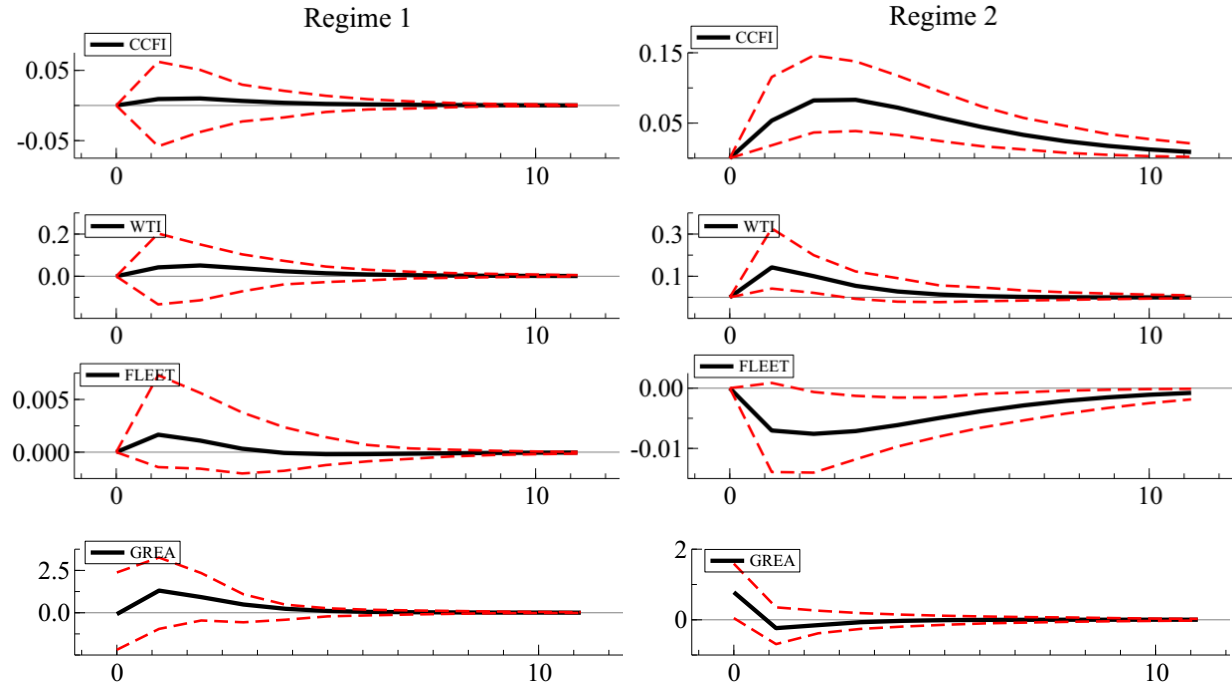
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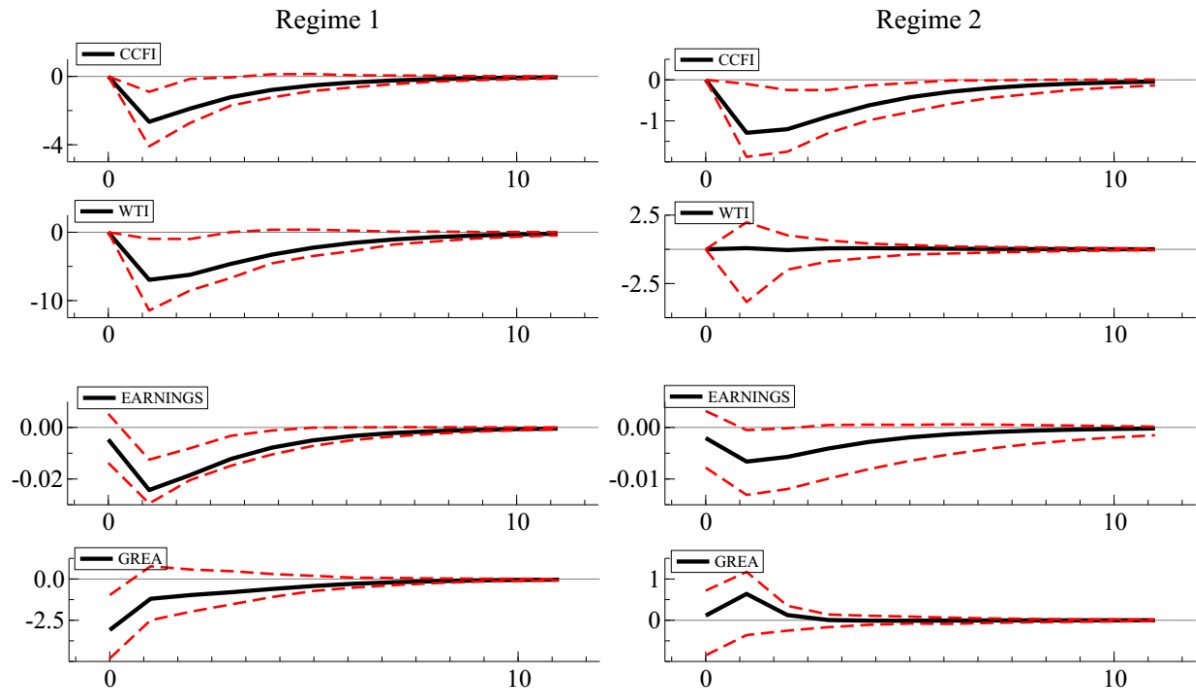
Appendices

Appendix 1: Response of Earnings reacting to shock to the other variables in the MS-VAR model according to the two regimes



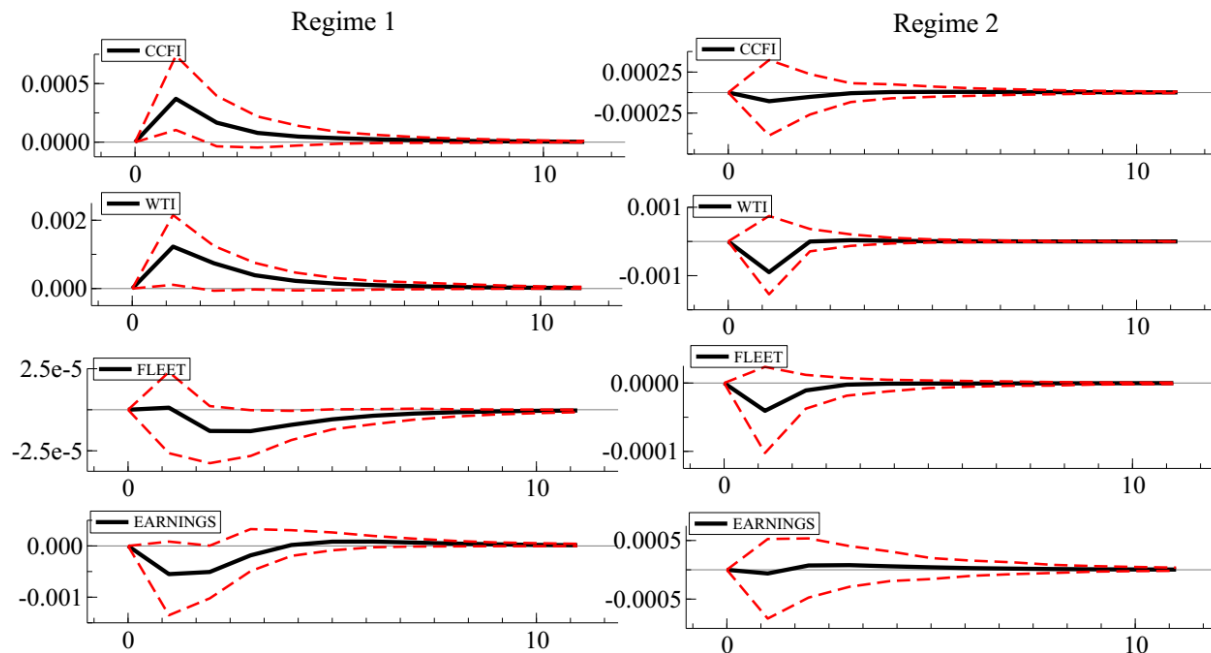
Note: The variables were transformed in log and we use their growth rate for the analysis. Impulse response functions of Earnings are conditioned to the prevailing regime. The figure depicts responses of the Earnings to a positive shock of 1% to the other variables in the model. The impulse reaction period is chosen to be 12 months. Solid black lines depict impulse responses of Earnings, while dashed lines depict 68% confidence intervals. The upper dashed and lower dashed lines represent 84% quantile and the 16% quantile of the posterior distribution, respectively. Impulse responses are computed on the basis of 1000 bootstrap replications. GREA refers to Global Real Economic Activity Index while WTI refers to the price of Crude Oil.

Appendix 2 Response of Fleet reacting to shock to the other variables in the MS-VAR model according to the two regimes



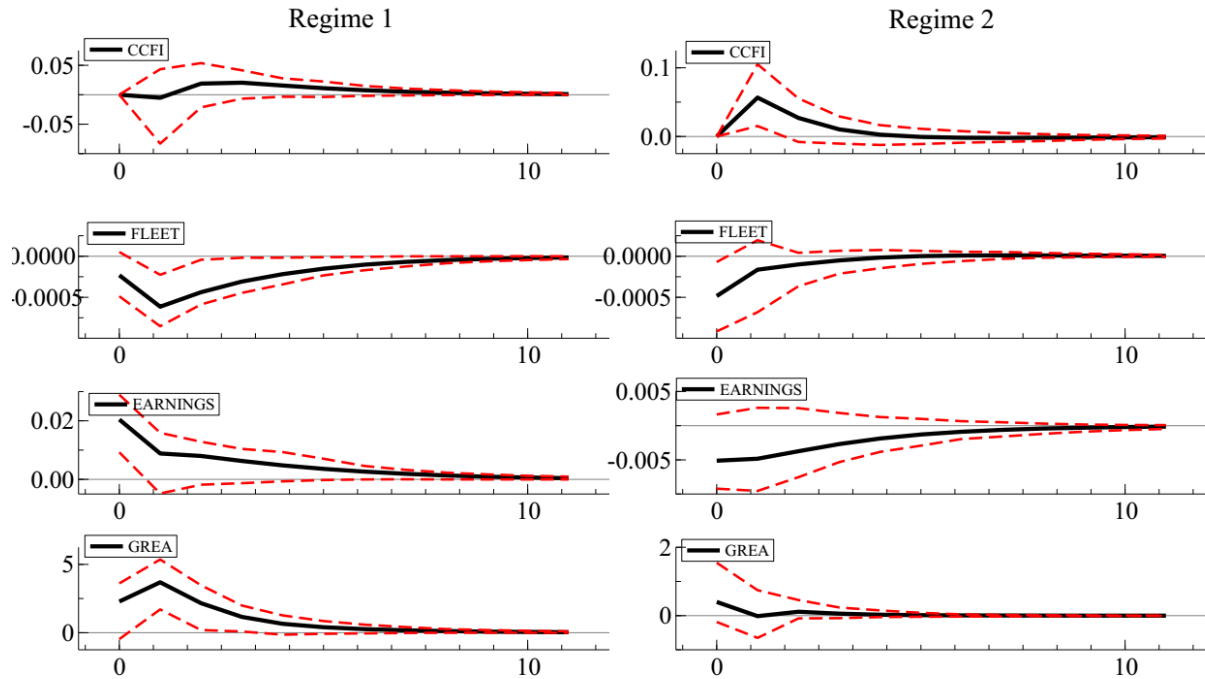
Note: The variables were transformed in log and we use their growth rate for the analysis. Impulse response functions of Fleet are conditioned to the prevailing regime. The figure depicts responses of the Fleet to a positive shock of 1% to the other variables in the model. The impulse reaction period is chosen to be 12 months. Solid black lines depict impulse responses of Fleet, while dashed lines depict 68% confidence intervals. The upper dashed and lower dashed lines represent 84% quantile and the 16% quantile of the posterior distribution, respectively. Impulse responses are computed on the basis of 1000 bootstrap replications. GREA refers to Global Real Economic Activity Index while WTI refers to the price of Crude Oil.

Appendix 3 Response of Global Real Economic Activity (GREA) reacting to shock to the other variables in the MS-VAR model according to the two regimes



Note: The variables were transformed in log and we use their growth rate for the analysis. Impulse response functions of Fleet are conditioned to the prevailing regime. The figure depicts responses of GREA to a positive shock of 1% to the other variables in the model. The impulse reaction period is chosen to be 12 months. Solid black lines depict impulse responses of GREA, while dashed lines depict 68% confidence intervals. The upper dashed and lower dashed lines represent 84% quantile and the 16% quantile of the posterior distribution, respectively. Impulse responses are computed on the basis of 1000 bootstrap replications. GREA refers to Global Real Economic Activity Index while WTI refers to the price of Crude Oil.

Appendix 4 Response of the price of Crude oil (WTI) reacting to shock to the other variables in the MS-VAR model according to the two regimes



Note: The variables were transformed in log and we use their growth rate for the analysis. Impulse response functions of WTI are conditioned to the prevailing regime. The figure depicts responses of WTI to a positive shock of 1% to the other variables in the model. The impulse reaction period is chosen to be 12 months. Solid black lines depict impulse responses of WTI, while dashed lines depict 68% confidence intervals. The upper dashed and lower dashed lines represent 84% quantile and the 16% quantile of the posterior distribution, respectively. Impulse responses are computed on the basis of 1000 bootstrap replications. GREA refers to Global Real Economic Activity Index while WTI refers to the price of Crude Oil.