TAIL-BASED RISK NETWORK IN ENERGY SECTORS

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Overview

Understanding and management of systemic uncertainty and contagion has become a high priority for various market participants particularly after the global financial crisis of 2008 and the recent outbreak of COVID-19. An idiosyncratic uncertainty becomes 'systemic 'when there is a potential that the distress condition of one institution or a group of institutions can exert negative externality on the entire system or economy as a whole.

Despite significant literature examining the systemic risk in financial and commodity markets, the nature and extent of systemic dependence and spillover among energy companies 'stock prices has received considerably less attention. Previous literature primarily revolves around estimating the dependence dynamics between energy companies 'stock prices with overall financial and commodity market indexes (Kocaarslan and Soytas, 2019). This is primarily attributed to conventional belief that energy companies do not pose a significant systemic risk to the entire energy system or for their peer companies (Zhu et al., 2020). We, however, argue that the idiosyncratic uncertainty or distress in large energy companies may significantly impact other energy companies or the sector due to counterparty relationship. Therefore, it is of significant importance to examine the systemic risk in the energy sector (Antonakakis et al., 2018). To this end, the aim of this paper is to analyse the risk spillover and network dependence across energy market participants to determine how they are affected by global economic conditions and financial uncertainty.

Our paper contributes to different strands of the existing literature. First, we extend the previous literature by evaluating firm-level network connectedness and volatility spillover among the firms operating across the four main energy market sectors (oil & gas, oil & gas related equipment and services, multiline utilities, and renewable energy). Undertaking the heterogeneity of the firms operating across the four subsectors is important as the oil & gas producing companies are only a segment of the entire energy sector.

We contend that aggregate analysis cannot capture heterogeneity in firm-level risk spillover and concentrating solely on the oil and gas producing companies provide only a partial overview of risk spillover in the aggregate energy sector. Furthermore, over the recent years, several oil & gas producers are increasingly diverting their investments to the clean energy and renewable sector (Mäkitie et al., 2019). Therefore, it is important to consider network connectedness and risk spillover dynamics by utilizing firms spanning across the four energy subsectors. Second, we utilize a novel approach to estimate network connectedness and risk spillover between the energy companies. More specifically, we combine the conditional variance-at-risk (CoVaR) approach by Adrian and Brunnermeier (2016) with the Tail-Event driven NETwork approach by Härdle et al. (2016) to provide a comprehensive overview of the systemic risk contributors in the energy sector. Finally, we have segregated the incoming and outgoing links to identify the companies and sub-sectors with positive and negative systemic risk contribution.

Methods

The goal of this paper is to evaluate the network connectedness and uncertainty spillover of 100 of the worlds' leading energy companies in four different sectors: oil and gas companies (OGC), oil and gas related equipment and services (OGS), multiline utilities (MLU), and renewable energy (REC) for the period 2006 to 2020 and determine how they are affected by global economic conditions and financial uncertainty. Consequently, our models explore non-linear and semi-parametric quantile-based risk events, by looking at the network-based specifications that allow for asymmetric contemporaneous and dynamic risk interconnectedness across major energy markets.

We estimate the TENET among the underlying assets in three-steps. The first step comprises of estimation of VaR. Thus, we measure the Adrian and Brunnermeier (2016) conditional variance-at-risk (CoVaR) in a network setting. CoVaR is derived from Value-at-Risk (VaR) for a specific financial institution j conditional on another event in separate financial institutions i. $\{X_{i,t}, X_{j,t}\} : t = 1, 2, \dots, T$, is the returns of financial institutions i and j, respectively. Then $VaR^{i}_{\tau,t}$ can be described with the quantile distribution at the τ-th quantile of returns of i:

$$\Pr\left(X_{i,t} \leq VaR^{i}_{\tau,t}\right) = \tau, \qquad (1)$$

and with a CoVaR of j conditional on $X_{i,t}$ at a quantile $\tau \in (0,1)$ is then

$$\Pr\left(X_{j,t} \leq \mathrm{CoVaR}_{\tau,t}^{j|i} \middle| R_{i,t}\right) = \tau, \tag{2}$$

where $R_{i,t}$ is the information set including the event $X_{i,t} = \mathrm{VaR}_{\tau,t}^{i}$ and M_{t-1} that is a vector of relevant macroeconomic variables that depict the macro state of the economy.

Whereas, in the second and third step, we estimate the network analysis and identify the key contributors and receivers of systemic risk. By utilizing the following equation, we estimate the total network connectedness among the top leading energy sectors.

$$TC_T = \sum_t^T \sum_j \widehat{D}_{j \to -j,t} \tag{3}$$

Results

Our empirical results show that there is growing interconnectedness during the extreme periods, and a network-based measure reflecting the connectivity. Furthermore, we document the asymmetric connectedness among the firms in the energy sector. Specifically, the total energy sectors, in general, are highly sensitive to the global market conditions, and the risk tends to spillover across the firms in these sectors.

In addition, we document that the firms operating in the same sub-sector are more prone to risk spillover. This is expected as the operations and services of the companies within each sub-sector are somewhat interconnected. Therefore, a key decision by a large organization may influence the operations and services of other key players within that sector.

Moreover, we find that the firms operating in the oil & gas sub-sector are more sensitive to economic downturn as compared to other sub-sectors in our sample. This may be attributed to the increased reliance of the economic activities on the oil & gas sector. Fourth, the renewable energy sector is largely unaffected by the financial crisis and only show slightly higher risk incoming and outgoing risk than in normal market conditions.

Conclusions

Understanding the systemic uncertainty and contagion has become the central concern for various market participants, particularly after the global financial crisis and due to the outbreak of COVID-19. The latter has especially given rise to the necessity to understand the connectedness dynamics more comprehensively among the markets. More specifically, the measures to mitigate the spread of COVID-19 globally have significantly altered the demand and supply equilibrium in the energy sector. Therefore, in this paper, we evaluate the risk spillover and network connectedness across energy market participants to determine the role of global economic conditions and financial uncertainty on the energy sector.

This study draws an important policy implication based on both the largest systemic risk receivers and the largest systemic risk emitters within the leading energy companies and sectoral groups as well. The findings of our analysis have important implications on diversification benefits and network risk management as well as policy implications for global sustainable energy markets.

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