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Assessing contagion risk from energy and non-energy commodity markets

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ABSTRACT

The aim of this study is to investigate contagion risk from commodity markets towards the whole economy and across sectors. Indeed, the financialization and integration of commodity markets expose the economy to potential contagion risks i.e., adverse shocks hitting one or more commodity markets spread to the entire economic system. To this purpose, we use the delta Conditional Value-at-Risk ($\Delta CoVaR$) approach based on quantile regression to identify a measure of contagion risk for energy, food and metals commodity markets. This novel methodology allows us to detect whether the risk contribution for a given market is significant, while distinguishing between tail events driven by financial factors, economic fundamentals or both. Furthermore, it permits us to assess whether the contagion risk of one market is significantly larger than the one of another market. The results show that commodity markets generate contagion risks which are mainly triggered by financial factors for energy and metal markets and by financial and economic fundamentals for food markets. Oil market contributes more to contagion than metal and food markets. Moreover, it emerges that there are spillovers from energy to food markets and oil is also more important than biofuel in affecting food markets.

1. Introduction

Following the stock market crash in 2002, commodity futures have emerged as a popular asset class within investment portfolios for several financial institutions and the general investment community. Recognition of the potential diversification benefits of investing in commodity markets stimulated, in fact, the rapid growth of commodity index investments and triggered a process of financialization among commodity markets (Tang and Xiong, 2012). In particular, the levels of financial activity measured by open interest in commodity futures increased from $103 billion at the end of 2003 to $509 billion in July 2008 (Hong and Yogo, 2010) and the total value of commodity index-related instruments purchased by institutional investors raised from about $15 billion to $200 billion during the same period (CFTC, 2008). Concurrently, a broad set of commodities across the energy and agricultural sector experienced synchronized sequences of large price swings, drawing renewed attention from policymakers and academics on the risks that increased co-movements could cause price distortions adversely affecting the broader economy. A highly debated question is whether fundamental factors related to supply and demand or new financial drivers dominate price formation and volatility in financialized commodity markets (Irwin and Sanders, 2012; Cheng and Xiong, 2014).

Starting from this background, the present study aims to assess the potential contagion risks arising from tail events occurring in energy, food and metal markets and to explore how commodity markets interact. This involves investigating whether the financialization and integration of commodity markets expose the whole economy to contagion risk, whether a shock from one market spreads to the others, and whether a commodity market has a significant influence on the others. In doing this, we explore whether there is evidence of "financial contagion", "fundamentals-based contagion" or a mix of the two.

We define contagion risk as the risk that a distress in one commodity market transmits across markets and to the whole economy. The risk of distress in commodity markets is caused by extreme price shocks (i.e., abnormal price rises and price falls located on the far tails of the return distribution) of a given commodity that can spill over across sectors and affect negatively the rest of the economy. Technically, the risk of extreme commodity prices and their impact on the economy are identified by a measure of risk proposed in the systemic

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risk literature, i.e., the Δ*CoVaR* measure developed by Adrian and Brunnermeier (2016), where the prefix "Co" stands for Conditional, Contagion or Co-movement. Thus, Δ*CoVaR* captures the potential for the transmission of specific market distress across the economy by gauging the increase in tail co-movements of commodity prices.

The rationale for examining the contribution to contagion risk coming from energy, food and metals markets is driven by the fact that commodity trading could cause an analogous degree of risk as the systemic risk caused by financial markets through the use of derivatives.

This study provides several contributions to the literature. It explicitly examines the extent to which a tail event in one commodity market can propagate and generate or worsen a tail event in another market and in the rest of the economy. This research aspect differs from the extant literature, that has extensively investigated the transmission of risks from one financial institution (bank or financial company) to another within the same sector. A further novelty is that we try to establish which of the commodity market contributes the most to contagion risk and which factors drive it. An additional novelty of the study relates to the use of the Δ*CoVaR* systemic risk measures based on economic fundamentals, financial factors or a combination of the two, to examine tail dependence during extreme market events generated by financial, fundamentals-based or mixed contagion, and to detect impacts and interactions between energy and food markets. The Δ*CoVaR* methodology has been recently proposed in the systemic risk literature, but applied only to financial institutions or to the financial sector (Bernal et al., 2014). We extend it to commodity markets with some differences to account for their specificity. Studying the contagion risk associated to commodity markets is particularly relevant since, quoting Serra and Gil (2012), commodity "price increases are the most likely to have relevant negative economic impacts."

The results indicate that while positive or negative shocks to economic fundamentals do not generally lead to contagion risk, financial stress in commodity markets spills over to the whole economy. This confirms that the economic system fragility is conditioned by what happens in commodity markets. In addition, oil market has a more significant influence in terms of contagion risk than metal and food commodity markets. This holds true when both positive and negative extreme price shocks materialize. It finally emerges that there are spillovers from energy to food markets and oil is more important than biofuel in affecting food market.

The remainder of the study is organized as follows: Section 2 reviews the existing literature on the measures of systemic risk, Section 3 depicts the adopted methodology, Section 4 describes the data used in the study and sketches their descriptive statistics, Section 5 presents the empirical analysis and discusses the results, and Section 6 concludes.

2. Literature review

Extreme price events can trigger contagion effects across markets and shocks can rapidly spread from the increasingly financialized commodity sectors to rest of the economy.

In order to capture contagion tail effects and assess whether financial determinants, economic fundamentals or both factors drive contagion, we draw from the literature on systemic risk[1] measures. Indeed, different systemic risk measures have been proposed in literature to analyze the tail-risk interdependence. Well-know examples of risk measures[2] include: 1. the Systemic Risk (*SRISK*) Index (Acharya et al., 2010, 2012; Brownlees and Engle, 2017), 2. the Game theoretic "Shapley Value" (Drehmann and Tarashev, 2013; Tarashev et al., 2016), 3. the Δ*CoVaR* measure (Adrian and Brunnermeier, 2016).

The *SRISK* index of an individual firm is determined by the expected capital shortage a financial firm would experience in case of a systemic event, defined as a significant market decline over a given time horizon. The shortage depends on the firm's degree of leverage, its size and its equity loss conditional on a market decline, which is also known as Marginal Expected Shortfall (*MES*). This risk measure can be considered as a "top-down measure" given that it tries to assess the impact of distress occurring at the level of the financial system on an individual financial institution.

The Shapley value (*SV*) is a very general methodology to quantify the contribution of individual institutions to systemic risk. The methodology was developed in the context of cooperative games, in which the collective effort of a group of players produces a shared "value" (e.g., wealth, costs) for the group as a whole. The methodology decomposes this value and allocates it across players according to their individual contributions. The share of the aggregate value attributed to a particular player is the *SV* of this player. Applied to the financial system, the *SV* methodology allocates the total risk of the aggregated financial system (the shared value) to individual institutions (the players). The allocations are based on each institution's marginal contribution to the overall risk. The systemic importance of each institution is hence its Shapley value. Institutions with higher systemic importance will have a higher *SV* than others.

A rather different approach underpins the Δ*CoVaR* measure, which has been suggested by Adrian and Brunnermeier (2016) as a way to measure the systemic importance of institutions. Δ*CoVaR* gauges the severity of distress in the system, conditional on distress in a given institution or in a group of institutions. In this sense, it can be considered as a "bottom-up measure" of systemic risk.

There is no perfect methodology that precisely allow us to measure the contributions of individual commodity markets to contagion risk. However, we adopt the Δ*CoVaR* methodology since it would permit us to nicely appraise tail dependence and to identify tail dependence driven by financial contagion, economic fundamentals or both factors. In addition, the Δ*CoVaR* approach offers great flexibility for evaluating the ranking of the riskiest commodity markets,[3] the interconnectedness and risk spillovers across markets. Besides, given that Δ*CoVaR* relies on high-frequency data, it is a highly reactive systemic risk measure in form of contagion.[4]

In what follows, we will first describe the use of Δ*CoVaR* in the context of financial systemic risk (Section 3) and then adapt it to commodity markets and to the case of biofuel/crude oil-related price transmission (Appendix A).

3. Δ*CoVaR* methodology

Let $\left\{R_t^{system}\right\}_t$ and $\left\{R_t^i\right\}_t$ denote the time-series of log-price returns[5] of the financial *system* (measured by the stock market returns) and the log-returns of a financial institution *i*, respectively.

[1] Systemic risk in financial systems arises if the crisis in one or group of financial institutions threatens the functioning of the entire financial system (Hellwig, 1998) Put differently, strong spillover and ripple effects operate during turbulent times so that the distress of a single institution transmits to the entire financial system and all financial institutions go down jointly.

[2] See Bisias et al. (2012) for a comprehensive survey.

[3] The Δ*CoVaR* methodology has also been applied to assess contributions to systemic risk by sectors (Bernal et al., 2014) and countries (Stolbov, 2015).

[4] Indeed, price and stock returns, used to compute the, Δ*CoVaR* reflect information more rapidly than non-trading-based measures such as accounting variables, especially considering that such information is mostly not available on a daily frequency.

[5] Price returns R_t are daily logarithm price differential, i.e., $R_t = lnS_t - lnS_{t-1}$ where S_t is the price of the stock at time *t*.