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Asymmetric risk spillovers between oil and agricultural commodities

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A B S T R A C T

Increase in agricultural commodities' prices not only increases economic and social costs, it may also affect health, education and family ties. The dependence and risk transmission between oil prices and the price of agricultural commodities is subject to possible symmetric or asymmetric changes due to legislation in the farm sector in recent times. The objective of this study is to understand the extent to which oil as a global economic factor influences the price behavior of agricultural commodities such as wheat, maize, soybeans, and rice under adverse and prosperous market scenarios. We find evidence of symmetry in the tail dependence between variables, and of asymmetry in the spillovers from oil to agricultural commodities that intensify during financial turmoil. Policymakers and traders of agricultural commodities may benefit by considering the identified asymmetries in co-movements and risk spillovers.

1. Introduction

In recent decades, world agricultural commodity prices experienced a decline of around fifty-three per cent in real terms (as measured in Euros). From 1976–2001 a steady downward trend in prices raised concerns about the welfare of agricultural producers in the Eurozone (as well as producers around the world), with France, followed by Germany, Poland, Italy and the Czech Republic, becoming the largest producers of wheat and maize.[1] Given this market scenario, consumers from emerging economies, which viewed agricultural production as a cornerstone for their food baskets have grown skeptical about the quality and safety of grain and crop production (Grunert, 2005; Harper and Makatouni, 2002) and have shifted their attention to agricultural producers from developed countries in Europe and the Americas, among others, who maintain responsible and safety-informed crop production procedures. Observations over the long term indicate that agricultural commodity prices have not shifted in a linear fashion; rather they have been strongly influenced by global business cycles (e.g. economic booms and busts), and by increases in demand from consumers in countries such as China and India, which have experienced rapid demographic and economic growth.[2] On the flip-side, escalation in agricultural commodity prices has increased economic costs and aggravated related social costs for consumers, with potential negative effects on health, education and family ties. They have also caused changes in the price index of an average 'food basket' in net importing countries (as well as exporting countries) and have negatively impacted household budgets particularly in developing net food importing economies – this is especially the case for urban populations. Agricultural commodity price increases could also be directly and indirectly linked to causative factors of social unrest, with the potential to cause political instability at national, regional or even global levels (Bellemare, 2014). Further, higher prices are forcing people in many economies to purchase food that is inappropriate in both quantity and quality (Kristoufek et al., 2012; Nazlioglu et al., 2013; Saucedo et al.,

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[1] According to Eurozone statistics between 2010 and 2015, significant increases in production of green maize were also observed in Estonia (+ 105.2% above the 2010–14 average) and Latvia (+ 54.1% above the 2010–14 average). See, http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_production_-_crops.

[2] Prices of agricultural commodities increased by 120% from 2005 to 2008 and 100% from 2007 to 2008. The boom reached its peak in July 2008 as crude oil prices averaged US$ 133/barrel, a 94 percent increase over that in 2007. For example, rice prices doubled within the first five months of 2008, rising from US$375/ton in January to $757/ton in June. A sharp reduction in commodity prices was noted after the global financial crisis and after 2009, along with an upward trend until 2011. However, from 2013 to 2014, prices seem to move horizontally, subsequently dropping and surging (IMF, 2016).

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2015). On the other side of the spectrum, observed fluctuations in agricultural commodity prices has led policy makers, researchers and academics, pondering the probable causes fueling rises and declines in prices, to look at the role of oil –as a global economic factor– in driving the prices of agricultural commodities, and to explore risk management strategies that consider macroeconomic, microeconomic, industry and business factors.

Global oil prices correlate to economic growth, which is a driver of demand for agricultural commodities. Hikes in oil prices increase the cost of essential agricultural inputs such as fertilizer, which in turn increases the production costs of agricultural commodities. This dynamic relationship between oil and agricultural commodities also influences the cost of oil substitutes, such as biofuels (e.g., Ethanol, Biodiesel) derived from agricultural outputs, and could, therefore, have implications for policy makers. Specifically, it may provide reasons to justify financial support and subsidy packages to that subsector within the Agroindustry that has established, or is attempting to establish, linkages with the biotechnology sector that focuses on biofuel (e.g., ethanol, biodiesel) production. Additionally, it may justify the allocation of financial resources to further develop the competitiveness of biofuel markets and biofuel technologies to reduce costs incurred by agricultural producers and the costs incurred by consumers of those commodities. Thus, a regulatory approach in this direction fits the perspective that sees agricultural commodity substitutes of fossil fuel as clean and sustainable sources of energy generation, and as a path to reduction of crude oil dependency. Accordingly, we could expect the usage of biofuel in the future to depend on the sustainability of the Agroindustry and on the financial incentives provided to more strongly link it with the biotechnology sector. Food security issues will also play a determining role, as the demand for agricultural commodities used for biofuel production is expected to grow along with increases in world population. Further, the future of the biofuel industry and its demand will most likely depend on the development and growth of the renewable energy sector, and on the changes in the supply (price) of substitute fossil fuel, shale oil and natural gas commodities.

Hence, the spillover interaction between oil prices and those of agricultural commodities can take several shapes ranging from unidirectional to bidirectional. Accordingly, the need to examine the dynamic relationship between oil prices and those of agricultural commodities presents a real concern to stakeholders and policy makers, who are responsible for designing and implementing regulatory reform and frameworks to improve the performance of the agricultural commodity sector, the competitiveness of the biotechnology industry oriented to biofuel production, and the linkages between Agro and Biotechnology industries. In broader terms, our research study compliments and updates analyses of energy markets and commodities, such as those undertaken by Arreola-Hernandez (2014). In that study, vine copula models such as c-vines and d-vines were implemented to examine the symmetric and asymmetric dependence structure and risk profile of oil, with natural gas, coal and uranium. Reboredo (2012) estimated bivariate copulas (Gaussian, Student-t, Clayton, Gumbel, symmetrized Joe-Clayton) to measure the dependence between energy and agricultural commodities (crude oil, corn, soybean, wheat). The insignificance of upper tail dependence between oil and agricultural commodities led the author to conclude that extreme oil price increases do not cause food price increases. Nazlioglu et al. (2013) examined the causality-in-variance between agricultural commodities (i.e., wheat, corn, soybeans and sugar and oil). They showed that in the pre-food crisis period (2006–2008) there is no causality-in-variance from oil to the agricultural commodities. However, unidirectional and bidirectional causality-in-variance was present between oil and some agricultural commodities. To the best of our knowledge, Nazlioglu et al. (2013) is the most recent study addressing the relationship between oil and agricultural commodities; however, no prior study examined the tail dependence-based upside and downside spillover risk from oil to agricultural commodities.

We contribute to the relevant literature by thoroughly examining, under-market downturns and upturns, the symmetry and asymmetry of spillover risks between oil and agricultural commodities. We opted to model the energy and agricultural commodities in this study knowing that oil, in its role as a major global economic factor, impacts the production, processing, manufacturing and distribution chains of maize, soybeans, rice and wheat, while also having a determining effect on those commodities' price behavior. Moreover, given that maize, soybeans, rice and wheat are major agricultural commodities produced, traded, processed, distributed and consumed worldwide, it is of interest to unveil the extent to which changes in the international price of those agricultural commodities influence the international price of oil, and vice versa.

This research paper concentrates on the tail dependence and nonlinear, symmetric and asymmetric downside and upside spillover risks between oil and agricultural commodities. We draw our empirical results and conclusions by implementing a modeling framework consisting of static and dynamic bivariate elliptical and Archimedean copula functions for nonlinear dependence estimation; a standard Value-at-Risk (VaR), a conditional Value-at-Risk (CoVaR) and delta conditional Value-at-Risk (ΔCoVaR), to measure the bilateral spillover effects between oil, wheat, maize, soybeans and rice. The specific advantage of our modeling framework derives from the marginal model specification that has a skewed characteristic; thus, permitting measurement of short-term trends in the downside of the commodities' return distributions. Also, the skewed shape of the student-t distribution is appropriate to examine highly kurtotic behavior in both, market downturns and upturns, as the shape of the student-t distribution is fat-tailed. The bivariate copula approach adopted to measure and understand the dynamic symmetric and asymmetric tail dependence between the commodity markets is flexible, as selected bivariate copula functions estimate dependence at various locations (e.g. negative tail, center and positive tail) of the pairs of commodities' joint distributions.

Our findings indicate that the tail dependence between oil and most agricultural commodities is governed by symmetry, except for the pair oil-rice, which appears to co-move asymmetrically.[3] The upside and downside spillover impacts are observed to be asymmetric, with a tendency to strengthen in market downturns, as opposed to market upturns. Similarly, significant bidirectional spillover effects are found between oil agricultural commodities, except for rice. A noticeable increase in the spillovers is detected during periods of financial turmoil or uncertainty rather than in periods of economic prosperity. The largest asymmetric spillover effects occur between the oil markets and those of rice and soybeans.[4] These findings are supported by the ΔCoVaR estimates. Higher spillover transmissions during crisis periods lead us to believe a possible contagion effect exists between oil and agricultural commodities and this could result in significant losses to investors, agricultural commodity producers and traders. The presence of a heavy lower tail in the dependence between the returns of oil and some of the agricultural commodities calls for market participants to assess both upside and downside dependence and spillover risks, and to engage in dynamic hedging strategies and broader risk diversification, particularly in periods of financial distress. Policymakers, oil producers and retailers, as well as food producers, traders and processing firms of agricultural commodities may benefit from a clearer picture of the dynamics of risk transmission between agricultural commodities and oil markets.

The remainder of the paper is organized as follows. Section 2

[3] When measuring the static and dynamic dependence between the energy and agricultural commodities, we find that the Student-t (mainly) and the rotated Gumbel copulas for the modeling of symmetry in both tails, and asymmetry in the negative tail more adequately account for the dependence of the pairs of commodities studied.

[4] Asymmetric tail dependence refers to the stronger correlation financial and economic variables tend to have in the positive tail during market upturns and in the negative tail during market downturns.