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UNDERSTANDING RISK DISSEMINATION: AN OVERVIEW IN SOYBEAN AND CORN MARKETS

ABSTRACT

This paper provides an overview of the research literature on risk transmission for the corn and soybean markets. The systematic review includes research, structure and synthesis of empirical studies using terms such as contagion, transmission and spillover to assess the spread of risk across markets. The featured topics include the review of the main analytical perspectives of agricultural market interaction with other markets and theoretical developments in price risk analyses. Exogenous changes to the agricultural market, such as the financial crisis, rise of biofuels and financialization of commodities, are pointed out in the literature as vectors of risk transmission to the corn and soybean markets. The results show the increase of studies that evaluate spillover, with the predominant use of the multivariate GARCH approach, focused mainly on interrelations between the food and energy markets.

Keywords: Contagion; Transmission; Spillover; Agricultural Market.

RESUMO

Este artigo fornece uma visão geral da literatura de pesquisa sobre a disseminação de riscos para os mercados de milho e de soja. A revisão sistemática abarca a pesquisa, estruturação e sintetização dos estudos empíricos que utilizaram termos como contágio, transmissão e transbordamento para avaliar a propagação de riscos entre mercados. Os tópicos de destaque incluem a revisão sobre as principais óticas de análise da interação do mercado agrícola com outros mercados e os avanços teóricos na análise do risco de preços. Mudanças exógenas ao mercado agrícola como a crise financeira, ascensão dos biocombustíveis e financeirização das *commodities* são apontadas pela literatura como vetores de transmissão de risco para os mercados de milho e de soja. Dentre os resultados de pesquisa, cabe destacar a disseminação de artigos que avaliam a temática transbordamento, com a utilização predominante da abordagem GARCH multivariada, focada principalmente na interrelação entre os mercados de alimentos e energia.

Palavras-chave: Contágio; Transmissão; Transbordamento; Mercado Agrícola.

JEL Code: D80; G11; Q02.

INTRODUCTION

The concern with the identification, evaluation or mitigation of risks is a routine action, indispensable to the good governance of any productive activity. The study of risk management was disseminated to evaluate the stochastic elements in the decision-making, which can be evaluated in terms of objective probability (MOSCHINI, HENNESSI, 2001). The distinction between risk and uncertainty dates back to the seminal work of Knight (1921)¹. Risk is an unfavorable contingency that can be identified and measured considering the probabilities of possible outcomes, while uncertainty is every event derived from the unknown.

Price or production risks, climate, credit or technological risks are the main risks that agriculture faces. Historically, price risk occupies a prominent position. In an environment of greater interconnection between markets, risk mitigation involves both the risk recognition and measurement in the market study, such as identification of contagion channels between different markets.

Changes in the market environment have driven empirical research on risk spread in different markets. In this context, global financial crisis, climate change, food supply shocks, incentives to biofuels, oil price shocks, and financialization of agricultural markets are the main recent transformations (MENSI et al., 2014, HAN; ZHOU; YIN, 2015, AL-MAADID et al., 2017).

Moreover, technical, production and market changes influence the internal dynamics of corn and soybean markets. The search for greater production efficiency, link with other productive sectors, development of agricultural derivatives markets, and recurrences of supply shocks, due to climatic adversities, are factors that may affect the interdependence between these markets and destabilize the behavior of prices.

Understanding how risks spread from other markets to the agricultural market or between the products that comprise the agricultural market is useful for agents to improve the management of their portfolios, adjusting their strategies to include both direct and indirect risks. Given the advances in the literature on interdependence of the agricultural markets (GARDEBROEK; HERNANDEZ; ROBLES, 2016), this literature review aims to identify, evaluate and synthesize, systematically, the main results of empirical studies undertaken by the literature from 2010 to 2018, on spread of risk to the agricultural market, especially to the corn and soybean markets.

As an analytical strategy, we opted to evaluate the papers that use contemporary terminologies, such as contagion, transmission, and risk spillover. As a result of the criteria adopted, such as thematic, linguistic and temporal approach along with the underlying criteria of the periodicals to be analyzed, the literature review comprise 34 papers published in 12 different periodicals, from 2010 to 2018.

¹ Knight, F., 1921, Risk, Uncertainty and Profit (Houghton Mifflin, Boston).

To achieve the research objectives, the paper is structured in six sections. Section two describes the literature about the interaction between markets, highlighting different analyses of risk. Section three comprises the literature review on theoretical advances in the analysis of price behavior, with emphasis on the Law of One Price, the hypothesis of excess co-movements and the hypothesis of financialization of the commodities market. Section four describes the methodological approach used to evaluate and classify papers. Section five summarizes the main results, starting from an overview of the spread of risks in markets for a specific analysis of the physical and future markets of corn and soybean. Finally, section six summarizes the most important findings.

LITERATURE REVIEW

Optics of Analysis on Interaction between Markets

The interaction between markets can be assessed by the optics of interdependence, equilibrium or contagion. Interdependence is commonly assessed based on the concept of causality, in which the temporal precedence is useful to predict time series (GRANGER, 1969, 1980). The temporal precedence is also evaluated with the lead-lag concept, which follows the same approach of Granger (1969), but it focuses on the stochastic ordering of the variables. In analyzing whether two prices move in sequence, the lead-lag effect is equivalent to a causality tested a step forward (GARCIA; LEUTHOLD; ZAPATA, 1986). The analysis of precedence or directionality between variables can capture the exogenous signals from the behavior of prices or volatility of related commodities.

In turn, the balance between markets is evaluated in terms of a statistical link in the long-run between two variables. Because persistent economic variables move together and share common long-term trends, contributions of Engle and Granger (1987) and Johansen (1995) promote the cointegration concept (STOCK; WATSON, 2017). The concepts of causality and cointegration are used in a complementary way by the literature to evaluate the interaction between prices of different commodities.

The static approach has gradually been replaced by the dynamic approach. In this context, the dynamic regressions as vector autoregression models (VAR) and vector error correction (VEC) have become dominant in empirical studies on the transfer of agricultural prices. (FISZERD; ORZESKO, 2018). The concept of causality is influenced by methodological innovations over the past decades, among which we highlight causality in the variance developed by Cheung and Ng (1996), nonlinear causality implemented in the tests of Hiemstra and Jones (1994) and Diks and Panchenko (2006) and causality in volatility, as described by Chang and McAleer (2017).

Studies of Cruz Junior, Capitani and Silveira (2018) that applied the concept of causality in the variance are examples of empirical applications. The

results indicate more integrated corn and soybean futures markets and increased price transmission between the Brazilian and the United States markets, as in 2007. In turn, Firzerd and Orzesko (2018) use the concept of non-linear causality to demonstrate the existence of non-linear two-way causality between the grain and meat markets.

In addition to the interaction between prices of commodities, the analysis of equilibrium and interdependence between the vertical links of a productive chain was diffused. Since the 1970s, seminal contributions of Wolfram (1971) and Houck (1977) have contributed to the diffusion of an analysis strand to diagnose and evaluate the effects of asymmetry on price co-movements. The asymmetric approach to transmission pricing (ATP) summarizes literature efforts to understand dynamics, adjustment speed and the presence of asymmetry in the transmission of a commodity prices, or between different regions or links between a production string (spatial and vertical approaches). As an example of empirical application, the study of Goodwin and Piggott (2001) identified asymmetric relations between soybean and corn prices in North Carolina, the United States.

In turn, Engle, Ito and Lin (1990) surpass the concept of price transmission, with its application in terms of volatility transmission. For these authors, information on a specific market could be classified into two distinct types: a) disturbances in volatility are concentrated in this market, and b) a disturbance in a particular market could affect the conditional variations in subsequent markets, generating volatility transmission between these markets.

Two important changes are highlighted in the literature. First, the focus of analysis. The emergence of empirical approaches, such as causality in volatility or the transmission of volatility, denotes a growing concern with the analysis volatility to the detriment of price or return analyses. For Ceballos et al. (2017), the increase in volatility in the agricultural market distorts the allocation of resources, inhibits investment, hinder growth potential in agricultural productivity, especially in the absence of efficient mechanisms for risk sharing. Second, studies on long-term equilibrium relationships are gradually replaced by studies of short-term imbalance relations. This has contributed to the popularization of studies on contagion or spillover risk.

These new thematic studies usually arise in times of crisis. By studying the effects of the financial crisis in 1987, King and Wadwani (1990) used the term "contagion" to define the errors incurred (in terms of inferences about the behavior of prices) by rational agents in a given market, which are transmitted to other markets. Similarly, given the uncertain environment created in the global financial crisis of 2008, risk assessment and mitigation have gained new impetus. However, in this case, the terminology that became popular in the literature was spillover.

The contagion analysis focuses on the diagnosis of abnormal increases and the intensity of linkages between markets. Contagion is quantified in terms of changes in prices or financial flows after the occurrence of a specific shock in a market or country (DORNBUSCH; PARK; CLAESSENS, 2000).

Moreover, the contagion mechanism could also be translated as the transmission of information from a specific market to another. In this context, negative information, may have different effects depending on the market evaluated, with potential damages to the process of price discovery, increase of risk premium or reduction of liquidity (HAB; KOZIOL; SCHWEIZER, 2014).

Despite recent popularization, the term spillover, applied to the study on agricultural markets, could be found in Havlicek and White (1983), in which the authors were concerned with the spillover or diffusion of benefits of agricultural research in the United States. Currently, the concept of spillover illustrates the distribution of risk between markets. Finally, the joint study of contemporary issues, such as transmission, spillover or contagion, could help to identify factors that influence the interdependence between prices or volatility of different markets, which are not evidenced in traditional models.

Theoretical Advances in Price Risk Analyses

In traditional literature, to assess the behavior of prices in the grain market and identify the causes of volatility changes required the understanding of the relationship between prices and inventories (WRIGHT, 2011). The theoretical framework on the stock-price relationship has provided a coherent framework for implementing price stabilization policies and understanding the dynamic nature of equilibrium in agricultural markets (MYERS; SEXTON; TOMEK, 2010). In many cases, factors that destabilized the behavior of agricultural commodity prices were associated to the speculative behavior of agents.

The Law of One Price (LOP) was created to illustrate the equilibrium relationships in the agricultural commodities market. Thus, in a situation without intervention, a commodity price in a local market is expected to follow the fluctuating of prices in foreign markets (regions or countries) (RICHARDSON, 1978). Moreover, when the price difference exceeds the transaction costs between these two markets, an arbitration process is initiated that reestablishes the equilibrium relation (ESPOSTI; LISTORTI, 2013). The LOP premise refers to long-run equilibrium relationships, as costs could be high for short periods arbitrage (ARDENI, 1989). In short, LOP theorizes a case of price co-movements, as the case of a product in different locations (spatial price transmission).

The natural interdependence between agricultural markets is also associated with the sharing of common information to these markets (GARDEBROEK; HERNANDEZ; ROBELS, 2016). However, there are situations where commodity prices move together beyond what fundamentals may explain, due to herd behavior or liquidity constraints (FERNANDEZ, 2015). Fluctuations in prices could also be attributed to noise caused by overreaction of speculators to new information, driving futures prices beyond expectations based on market fundamentals (BOSCH; PRADKHAN, 2017).

For these situations, Pyndick and Rotemberg (1990) formulated the excess of co-movements hypothesis (ECH). The authors regressed the price changes of commodities (wheat, cotton, copper, gold, crude oil, wood and cocoa) with macroeconomic indicators and found regression residues highly correlated. The authors questioned the rationality of commodity markets, identifying situations in which agents alternately buy or sell different commodities with little economic justification. In subsequent decades, several studies refute the hypothesis of excess co-movement (AI; CHATRATH; SONG, 2006), but there also other that corroborate it (OHASHI; OKIMOTO, 2016).

Although there was no consensus in the literature, the efforts undertaken to evaluate co-movements of prices contributed to a subsequent hypothesis of financialization of commodity markets. Financialization of the commodity markets occurred over the last decade, with a growing interest of investors in commodity markets for portfolio diversification purposes (HAMADI; BASSIL; NEHME, 2017). This investors' behavior turns these markets more susceptible to exogenous shocks.

To illustrate this phenomenon, Du, Cindy and Hayes (2011) pointed out that in July 2008, during the financial crisis, corn prices in Chicago physical market increased by more than US \$ 3.00/bushel to reach US \$ 7.20/bushel. Subsequently, in December 2008, the price fell to US\$ 3.60/bushel, without significant changes in market fundamentals. In general, the financialization process is derived from a conjunction of factors, among which we highlight: the development of information technology, economy deregulation, financial market liberalization, increased speed of transactions, increase in speculative trading, among others (LAGOARDE-SEGOT, 2017).

The increase in the share of non-usual investors in the agricultural commodities market (institutional investors, investment funds, etc.) is one effect of the financialization process. Thus, interconnections between the prices of economically unrelated products are created, increasing the potential for external shocks to the commodity market (ADAMS; GLUCK, 2018).

In this context, quantifying the financialization effects in the market of commodities has gained the attention of researchers. Thus, many researchers have made efforts to evaluate the effects of financialization on mechanisms that underlie the functioning of these markets: storage, risk sharing and price discovery (CHENG; XIONG, 2014). Tang and Xiong (2012) showed the highest correlation between oil and non-energy products from 2004. Silvennoinen and Thorp (2016) identified an increase in the correlation of commodity prices, around the year 2000 (dot.com bubble).

Finally, given the magnitude and effects of the 2008 financial crisis, equilibrium approaches and price relationships, as illustrated by LOP, contribute to the dissemination of theoretical approaches that recognize the presence of imbalances, such as the ECH. This new approach also evaluates the market environment in which the agricultural commodities market is inserted, such as the hypothesis of financialization postulates.

METHODOLOGY

The concern with identification, measurement and mitigation of price risk is a frequent theme in the literature. In order to evaluate the propagation or dissemination of risks between markets, several terminologies are used, such as contagion, transmission or spillover. This study is exploratory. It fits as bibliographic and documentary research, undertaken systematically to identify, evaluate, and synthesize the results of empirical studies on the issue of interest. The literature review was operationalized through the advanced search capabilities of Science Direct and Web of Science.

The selection of papers followed four main criteria: a) scientific papers published between 2010 and 2018; b) scientific papers containing in their titles, keywords or abstract, the terms: contagion, transmission and spillover, c) scientific papers including in their results, analyses of corn or soybean markets, or both, and d) scientific papers published in scientific journals ranked in the quarters Q1 and Q2 of SCImago Journal Rank (SJR) classified in the category of Economics, Econometrics and Finance.

The period of analysis was chosen to evaluate the scientific production subsequent to the global financial crisis of 2008 and the price rise cycle that became known as the commodity boom. In relation to the adopted terminology, three groups of terms were defined: a) contagion, price contagion, volatility contagion; b) transmission, price transmission, volatility transmission; and c) spillover, price spillover, volatility spillover. The use of combinations defined a priori by words “price” or “volatility” leads the analysis directly to the variables widely studied in literature in the field of economic sciences, since the term “contagion” is widely used in the fields of biological sciences and health.

The adoption of SJR ranking to delineate the literature review was also performed by Haase, Selier-Zimmermann and Zimmermann (2016). The choice for papers classified in Q1 and Q2 categories of the Economics, Econometrics and Finance category is aprioristic and allows to consider mainly papers with a high impact factor. The following table presents the characteristics of the journals selected and the number of papers evaluated.

Table 1. Characteristics of journals selected and number of papers evaluated journals in the literature review from 2010 to 2018

Journals	Quartil SJR	H index	Total Docs.	Total Ref.	Ref. / Doc.	Papers
Agricultural Economics	Q1	63	72	3046	42,31	5
Economic Modelling	Q2	50	285	11165	39,18	2
Energy Economics	Q1	109	363	16918	46,61	9
Energy Policy	Q1	159	713	38575	54,10	4
International Economics	Q2	6	45	1310	29,11	1
Journal of Agricultural and Resource Economics	Q2	40	24	1098	45,75	2
Journal of Agricultural Economics	Q1	50	59	2120	35,93	2
Journal of Empirical Finance	Q1	63	66	3032	45,94	1
Journal of Futures Markets	Q2	45	58	1939	33,43	3
Journal of International Financial Markets, Institutions & Money	Q1	42	88	4300	48,86	1
Journal of International Money and Finance	Q1	77	142	5543	39,04	1
Research in International Business and Finance	Q2	27	347	12435	35,84	3

Source: Research results.

Note: 1. Information on journals, such as the number of Documents (Docs.) published number of references (Ref.) of the number of papers published in each journal, were obtained from the SCImago Journal Ranking and refer to the 2017 classification.

Based on the criteria adopted, the bibliographic review comprises 34 papers published in 12 different journals. In order to achieve the research objectives, we used the systematic bibliographic review manager StArt® developed by the Software Engineering Research Laboratory of the Federal University of São Carlos (UFScar).

AN OVERVIEW OF THE SELECTED LITERATURE

The majority share of the research findings of this literature review points to the transmission of risks from crude oil to the cereal market. Cereals and oil markets are characterized by high volatility (MENSI et al., 2014) and great interconnection between them, which makes risk management a more complex task. Thus, the debate on risk spread in the energy market for agricultural commodities has gained notoriety in the literature. The adoption of the Renewable Fuel Standard (RFS) in 2005 in the United States, global financial crisis of 2008, shocks on food supply and on oil prices affect the dynamic interactions between energy and food prices (AL-MAADID et al., 2017).

The increase in oil prices boosts both the substitution effect between biofuels and fossil fuels (Lucotte, 2016) and may raise costs of agricultural production, due to the effects on prices of fertilizers and transportation costs (BELLINGHINI, 2012). Moreover, adverse effects of global warming or speculative capital flows have also been responsible for spikes in food prices and energy (MENSI et al., 2014). In addition, the new rules of the European Union for biofuels, could also represent a structural break in the relationship between the food and energy markets. Thereby, On October 17, 2012, the EU launched new rules indicating that crop-based biofuels would not be subsidized in the future. These developments will reduce the use of

agricultural commodities for energy and in turn lead to weaker correlations between the energy and agriculture markets. (HAN; ZHOU; YIN, 2015).

Therefore, a literature branch based on diverse econometric methods to evaluate the transmission of shocks or risk spillover (price or volatility) between the energy market and agricultural commodities has been spread. Table 2 presents a summary of these studies conducted in the period from 1995 to 2015.

In risk management the dynamic approach is prevalent among the methodologies adopted in the studies analyzed. All of the studies that evaluate the relationship between energy and grain markets have two common characteristics: a) the analysis is done for the period between 2007 and 2008, and b) evaluate the corn market. Greater attention is also given to the financial crisis of 2008 and biofuels (especially ethanol produced from corn), which are configured as risk transmission channels between the respective these markets.

Table 2. Summary of literature review on risk dissemination between agricultural and energy markets between 1985 and 2015

Studies carried out	Analyzed Period							Product		Analyzed Methodology
	1985	1990	1995	2000	2005	2010	2015	Corn	Soybean	
Algieri e Leccadito (2017)								X	X	Value-at-Risk, Δ CoVaR
Al-Maadid et al. (2017)								X	X	VAR-Garch- BEKK
Du, Yu, Hayes (2011)								X		SV
Fernandez-Diaz e Morley (2019)								X	X	cDCC
Gardebroek e Hernandez (2013)								X		Garch-DCC, T-BEKK
Mensi et al. (2014)								X		Garch-BEKK, Garch-DCC
Natanelov et al. (2011)								X	X	TVECM
Nazlioglu, Erdem e Soytaş (2013)								X	X	Garch
Reboredo (2012)								X	X	Copula
Saghaian et al. (2018)								X		Garch-BEKK
Terterin, Brooks e Enders (2016)								X		Garch
Trujillo-Barrera et al. (2012)								X		GJR-Garch, Garch-BEKK
Wu e Li (2013)								X		Garch-BEKK
Wu, Guan e Myers (2011)								X		Garch-BEKK

Source: Research results.

For Han, Zhou and Yin (2015), when analyzing the period from January 2000 to January 2014, the main events that contributed to the spread of risks were: a) food crisis; b) financial crisis of 2008; c) biofuel policy; and d) financialization of commodities. For these authors, the financial crisis was the event with the greatest impact on the food-energy relationship. For Du, Cindy and Hayes (2011), the spillover volatility of crude oil and corn

observed after the fall of 2006 was induced by the production of corn ethanol in the United States.

Among the studies that refuted the hypothesis that the movements in prices of agricultural commodities are driven by oil price fluctuations, we highlight Reboledo (2012), which studied co-movements between oil and cereal prices (corn, soybeans and wheat) from January 1998 to April 2011 and found no causal relationship between oil peak prices and agricultural price peaks in any of the different specifications of the copula model (variants or time invariant).

In another stream of analysis, risk transmission is evaluated in markets of futures. In that scope, Trujillo-Barrera, Mallory and Garcia (2012) did not show a spillover price risk of ethanol to corn in the period between July 2006 and November 2011. In turn, Beckman and Czudaj (2014) showed that the volatility spillover in agricultural markets of futures is observed only in the short-term, suggesting the presence of speculation and limited effect of direct political actions *ex post*. Finally, Terterin, Brooks and Enders (2016), showed an accelerated growth in volatility in the corn market after 2006 and before the financial crisis of 2008, given the greater interrelationship with the oil market.

Identifying risk spillovers between crude oil and corn markets helps corn futures performing their function in terms of risk mitigation. In addition, Wu, Guan and Myers (2011), argued that risk spillovers between these markets lead participants to consider both traditional hedging strategies and cross-hedging strategies. On the other hand, situations of high volatility could affect the interpretation of informational content in the spot and future price series. Ganneval (2016), reported in his study on corn and canola producers in the United States that the price of futures is probably the reference price for economic agents. However, in a situation of high volatility, without the presence of liquid markets of futures, price information at producer level becomes more important for investors.

Nazlioglu, Erdem and Soytas (2013) applied causality tests on the variance in the period between January 1986 to March 2011 to assess the effects of the global financial crisis of 2008, and they did not identified risk transmission between oil and food markets before the financial crisis of 2008. However, these authors reported risk transmission after the financial crisis. Baldi, Peri and Vandone (2016), compared the two crises experienced at the beginning (crisis dot.com) and the end of the last decade (subprime crisis in 2008). They observed that the volatility spillover increased after the financial crisis of 2008, signaling a growing interconnection between financial and agricultural markets.

In the early of last decade, studies have been focused on the direct relationship between crude oil and food commodities. However, over time the connections between fossil fuels, biofuels and food gained notoriety. Many researchers have analyzed how new links between corn and ethanol markets could increase risk transmission between food-energy binomials. In this context, Algieri and Leccadito (2017) showed greater risk spillovers between oil and food than between biofuels and food markets.

In turn, Gardebroek and Hernandez (2013) found spillover volatility from corn and ethanol markets, but not vice versa. This was mainly observed after 2006, when ethanol becomes the main additive to gasoline authorized in the United States. Research findings led the authors to argue for diversification of raw materials in the biofuel production. The unidirectional relationship of risk transmission from corn market to ethanol market was also found in Trujillo-Barrera, Mallory and Garcia (2012) for the United States market and in Wu and Li (2013) for the Chinese market.

Ethanol and corn markets respond differently to the positive and negative changes in crude oil prices (Saghaian et al., 2018). Thus, in addition to the spillover risk, asymmetries in this process were detected. In turn, Ji et al. (2018) applied the copula approach with switching regime and found asymmetries in the co-movements of prices. The interaction between commodity and energy markets (based on smoothed correlation coefficients) becomes larger in periods of decline than at rising prices. De Nicola et al. (2016), also demonstrated that the price increase co-movement occurs between both oil and corn markets, and between oil and soybean oil markets.

In addition to assessing which markets are most likely to transmit risk, some studies have assessed how risk transmission occurs between different countries or regions. In this context, Esposti and Listorti (2013) evaluated the relationship between grain markets in Italy and in the United States. The authors found that the predominant exogenous shocks on the international corn market are transmitted to a national market pivot, followed by satellite markets.

Two possible fields of analysis are risk transmission between spatially separated markets (cross-markets) or between different commodities markets (cross-commodity). Volatility transmission seems to be more common in countries with a higher rate of production allocated to trade (imports and exports), compared to the rate allocated to domestic demands (Ceballos et al., 2017). Hao et al. (2017), showed that the change in corn supply and demand in the United States affected corn markets in developing countries.

Jiang et al. (2016) applied the cross-quantilogram test and identified a bidirectional relationship between the return series of soybean and corn in China and those in the United States. However, the spillover risk is more intense from the United States to China than in the opposite direction in all commodities analyzed. Abidoye and Labuschagne (2013) and Pierre and Kamiski (2018) identified risk spillovers from the international corn market to the markets in South Africa and sub-Saharan Africa, respectively.

Another debate that has been established in the literature deals with the financialization of commodities market. According to Fernandez-Dias e Morley (2019), the interrelationship between series of oil price returns to the agricultural price index supports the hypothesis of financialization. However, despite the larger volume of future contracts traded at major stock exchanges, there is little evidence that this has contributed to

stimulating co-movement in returns and conditional volatilities between agricultural commodities (Gardebroek, Hernandez and Robles, 2016).

Nevertheless, Hamadi, Bassil and Nehme (2017) emphasized that the financialization process creates an environment of greater speculation and volatility in commodity markets, which has negative effects on the use of assets for portfolio diversification in these markets. Kang, McIver and Yoon (2017) highlight that the intensity of spillovers during periods of turbulence diminishes the diversification of benefits. However, Shahzada et al. (2018) point out that with the greater interconnection between oil and grain markets, OPEC announcements or Strategic Petroleum Reserve (SPR) announcements in the United States may induce a speculative behavior in commodity markets.

Kang, McIver and Yoon (2017) related the markets of rice, corn and wheat to the metal market (gold and silver), and found that in periods of turbulence the investors prefer safe assets, searching for a reserve of value. These authors identified that gold and silver are sources of information transmission to the agricultural sector. De Nicola et al. (2016), assessed the relationship between agricultural products and other economic variables, and they did not find statistically significant relationships between changes in interest rates or in exchange rates and commodity price returns.

Sanjuán-Lopez and Dawson (2017) assessed the interrelationship between grain markets and evidenced a risk of spillover from soybean to corn market, which could be explained by several factors, such as: the high degree of complementarity between these products, the increased demand for corn due to ethanol production, and the competition for natural resources, as for instances the disputes for arable lands in the United States.

Figure 1 presents an overview of the selected studies in this research that have been undertaken to identify risk spread to the grain markets. Among the analyzed terminologies, the term “spillover” is the most popular in the literature, especially in the studies published between 2016 and 2018. The term “transmission” comes in second. The approach to price transmission is very popular in the literature and most studies are designed to evaluate the transmission of prices between the links of a production chain (not included in the scope of this literature review).

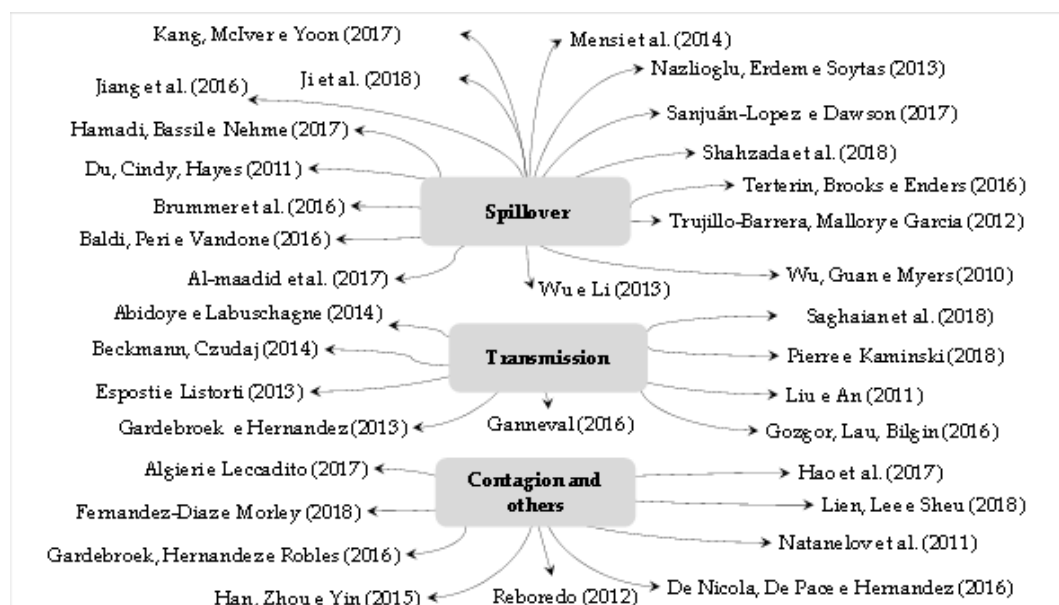


Figure 1. Terminology adopted in the studies on risk spread to soybean and corn markets

Source: Search results.

Regardless of the terminology adopted, studies on risk propagation are directed to evaluate factors responsible for imbalances between variables, such as recurrence of shocks, intensification of price variability or volatility and appearance of speculative bubbles. On the other hand, equilibrium relationships have received less attention in the literature.

A conventional step in the analysis of time series of agricultural products is the establishment of causal relations, which, were approached in approximately 20% of the studies reviewed in this research, and dominated the econometric studies between the 1980s and 1990s. In this sense, the studies of Natanelov et al. (2011), Trujillo-Barrera, Mallory and Garcia (2012), Wu and Li (2013) and Mensi et al. (2014) evaluated causal relationships in the sense of Granger (1980), while Gardebroek and Hernandez (2013) and Nazlioglu, Erdem and Soytas (2013) implemented the causality test in the variance.

CONCLUSION

In order to provide an overview of the main advances in research on risk dissemination in agricultural markets, this literature review evaluated 34 papers published in 12 different high ranked journals from 2010 to 2018. The triad of concepts selected *a priori* - contagion, transmission and spillover - is intended to capture recent developments of risk spillover to the agricultural markets. The literature review shows that changes in the interaction between markets and the consequent spread of risks are caused by three main factors: financial crisis of 2008; rise of biofuel markets; and financialization of commodities.

A chain of events fueled the scientific debate on the spread of risk across markets. Concomitant to the financial crisis of 2008, there was an increase in commodity prices, with a first cycle of studies giving prominence to higher oil prices, along with the debate on relations between food and energy markets. In response to rising oil prices, policies to encourage biofuel production were disseminated over the past decade. New research was conducted to understand how ethanol and other renewable fuels altered the interrelationship between various markets, such as the grain markets. Another consequence of the financial crisis was the intensification of strategies of portfolio diversification in the risk management process, which contributed to the debate on financialization of the commodity market.

Each of these research topics is extensively analyzed in a wide range of empirical studies. Literature reviews on some of these topics have already been conducted, such as the transmission of biofuel prices by Serra and Zilberman (2013) or the financialization concept evaluated by Lagoarde-Segot (2017). This literature review contributes to the analysis of risk spread in different grain markets, especially in corn and soybean markets. It also identifies the debate on the risk spread between energy and food markets and on financialization of commodity markets. Market financialization has a double effect on the grain market of futures. The increasing trade volume in soybean or corn markets of futures led to the debate on the role of these commodities in the strategies of portfolio diversification. On the other hand, the analysis of cross-risk management strategies gains new impetus with the evaluation of effectiveness of cross-hedge operations in this new context.

In methodological terms, the study on risk diffusion between different markets is based on the main econometric advances carried out in the last two decades. The predominance of multivariate GARCH approach demonstrates in literature the concern with information content in variance, especially in the serial dependence of the conditional variance. The application of dynamic conditional correlation models in recent period (GARDEBROEK; HERNANDEZ; ROBLES, 2016; FERNANDEZ-DIAZ; MORLEY, 2019) showed that, in addition to the volatility, the conditional correlation starts gaining the attention of researchers.

For future research on the subject, we highlight the need to evaluate the risk transmission between agricultural markets. Few studies evaluate the spillover risk between highly correlated markets, such as corn and soybean markets. The study of Sanjuán-Lopez and Dawson (2017), evidences the overflow risk from soybean market to corn market, there is a need for identifying the presence of structural breaks or regime changes in the dynamic relationships.

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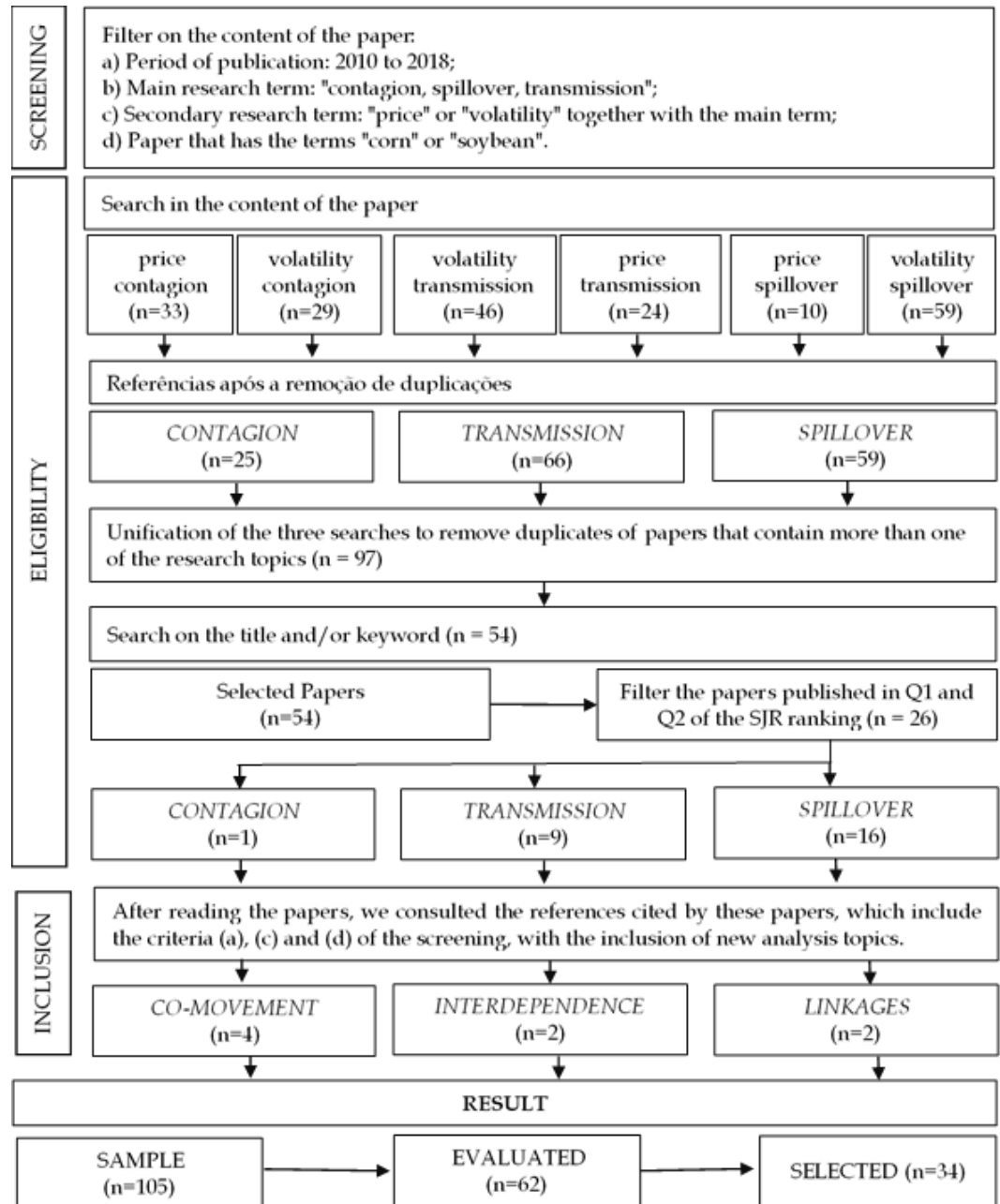
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APPENDIX A. Flowchart of the systematic review on risk spread in the soy and corn markets



Note: 1. The literature review was operationalized through the advanced search capabilities of Science Direct and Web of Science.