https://doi.org/10.17221/55/2017-AGRICECON

Drivers of grain price volatility: a cursory critical review

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Santeramo F.G., Lamonaca E., Contò F., Nardone G., Stasi A. (2018): **Drivers of grain price volatility: a cursory critical review**. Agric. Econ. – Czech., 64: 347–356.

Abstract: Understanding the determinants of price volatility is a key step to prevent the potential negative consequences of the uncertainty faced by farmers. The presented critical review provides a novel categorization of grain price volatility drivers. The authors distinguish the endogenous and exogenous causes and conclude on the potential effects that each of the identified factors may generate on the price dynamics. In particular, there is deepened the contribution of endogenous factors, such as the spatial and temporal arbitrage, as well as the drivers of shocks of demand and supply.

Keywords: arbitrage, commodity, risk, storage, trade, uncertainty

During the last decades, commodity price volatility has become a relevant issue with the international resonance because of the consequences on food security (Santeramo 2015a), land use, and development (Bobenrieth et al. 2013; Cai et al. 2013; Brümmer et al. 2015; Wolf 2015). Understanding the determinants of price volatility is a key step to ground the academic and political debate on solid bases, as well as to predict the negative impacts related to uncertainty faced by farmers when forecasting weather conditions and yield (Moschini and Hennessy 2001; Bussay et al. 2015; Kusunose and Mahmood 2016).

After a period of moderate global food price stability, agricultural systems started to show an exceptional turmoil. Since the food price crisis of 2007–2008, the level and volatility of staple food prices have increased by more than 50% (Tadesse et al. 2014; Brümmer et al. 2015; Götz et al. 2015). This trend is particularly evident for grain, which provides a large share of the world's food energy consumption (Díaz-Bonilla and Ron 2010; Wright 2011; Serra and Gil 2012; Tadesse et al. 2014). Over time, sudden changes in the global food price have been largely transmitted to domestic markets, where their magnitude has been amplified. Local instability of commodities price is a serious problem, which calls the attention of national and international institutions: notably, although the magnitude of volatility seems to be unaltered by the presence of price crises, its nature tends to be different over time and thus it merits a deep investigation (Tadesse et al. 2014). A number of studies have identified several drivers of price volatility, but a consensus among scholars is far from being reached (Ott 2014; Tadesse et al. 2014; Baffes and Haniotis 2016).

Our critical provides a novel categorization of grain price volatility drivers. We distinguish the endogenous and exogenous causes and conclude on the potential effects that each of identified factors may generate on the price dynamics. In particular, we deepen the contribution of endogenous factors, such as the spatial and temporal arbitrage, as well as the drivers of shocks of demand and supply. We try to clarify how the storage levels, trade flows, consumption, and yield fluctuations affect price volatility and how the price dynamics at the regional and national level interact with the global price volatility. Understanding these dynamics is of a great relevance to evaluate the potential impacts of price changes on different commodity markets, and it is crucial for forecasting and planning purposes.

COMMODITY PRICE VOLATILITY: AN OVERVIEW

Price volatility, measured in terms of price dispersion around a central trend, is an indicator of how much and how quickly prices change over time. Volatility describes price movements in the medium-

https://doi.org/10.17221/55/2017-AGRICECON

long term and reflects the potential risks related to price variability (Prakash 2011; Tadesse et al. 2014; Rude and An 2015). Volatility consists in asymmetric fluctuations, where intervals with sharp jumps in price are followed by steep falls back to the trend (Bobenrieth et al. 2013).

From a macroeconomic point of view, price volatility of staple food may cause several adverse effects (Tadesse et al. 2014). In the short-run, price instability may contribute to foster the potential food emergency and political crisis (Anderson 2012; Rude and An 2015) and to generate price uncertainty, which adversely affects decision making processes of risk-adverse producers (Tadesse et al. 2014; Haile et al. 2015; Santeramo et al. 2016). In the medium-run, price volatility may have diverse negative impacts on the growth and poverty levels (Anderson 2012; Rude and An 2015); price volatility may create unbalanced conditions in terms of economic welfare, both in exporting and importing countries (Anderson 2012); price volatility may cause food insecurity for poorer households (Wright 2011; Serra and Gil 2012; Ivanic and Martin 2014).

A broad debate among scholars is being held on factors that affect the grain price volatility (Wright 2014; Baffes and Haniotis 2016): it is unlikely that a single driver may cause market instability, whereas the joint effect of a plethora of drivers is more likely to exist (Balcombe 2011; Serra and Gil 2012; Tadesse et al. 2014; Wright 2014; Brümmer et al. 2015) (Table 1). These drivers may be classified into exogenous or endogenous: the former trigger prices volatility and are independent to price fluctuations; the latter are generated by price dynamics

Table 1. A synthetic outline of the literature on commodity price volatility

Category		Driver		Effect on price volatility	References
Endogenous	arbitrage side	spatial arbitrage	trade	negative correlation	Anderson (2012); Anderson and Nelgen (2012); Serra and Gil (2012); Baffes and Dennis (2013); Gouel (2013); Ivanic and Martin (2014); Wright (2014); Rude and An (2015)
		temporal arbitrage	storage	negative correlation	Cafiero et al. (2011); Stigler and Prakash (2011); Mitra and Boussard (2012); Thompson et al. (2012); Bobenrieth et al. (2013); Ott (2014); Cafiero et al. (2015); Gouel and Legrand (2015); Guerra et al. (2015); Baffess and Haniotis (2016); Brümmer et al. (2016)
	supply side	production level		negative correlation	Goodwin et al. (2012); Haile et al. (2014); Bussay et al. (2015); Haile et al. (2015); Haile et al. (2016)
		acreage allocation		negative correlation	
		yield response		negative correlation	
	Demand side	consumption		positive correlation	Thompson et al. (2012); Ott (2014); Guerra et al. (2015)
Exogenous		wheather shocks		positive correlation	Wright (2014)
		natural/technological disasters		positive correlation	Wright (2014)
		energy markets	oil	positive correlation	Serra and Gil (2012); Baffes and Dennis (2013); Ott (2014); Tadesse et al. (2014); Wright (2014); Baffes and Haniotis (2016); Brümmer et al. (2016)
			biofuel	positive correlation	Baffes and Haniotis (2016); Brümmer et al. (2016)
		exchange/Interest rates		positive correlation	Serra and Gil (2012); Baffes and Dennis (2013); Ott (2014); Wright (2014); Baffes and Haniotis (2016); Brümmer et al. (2016)
		speculation in commodity futures markets		positive correlation	Tadesse et al. (2014); Wright (2014); Baffes and Haniotis (2016); Brümmer et al. (2016)

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and contribute to the amplification of price volatility (Tadesse et al. 2014; Wright 2014; Brümmer et al. 2015). Among the exogenous drivers, weather shocks (e.g. droughts, extreme temperatures, intense precipitation) influence outputs and thus price levels (Tadesse et al. 2014; Wright 2014; Brümmer et al. 2015); the consequences of natural and technological disasters may also be relevant (Goodwin et al. 2012; Haile et al. 2014; Ott 2014); price dynamics in energy and petroleum markets tend to be reflected on agricultural markets (Serra and Gil 2012; Bobenrieth et al. 2013; Tadesse et al. 2014; Brümmer et al. 2015; Ohashi and Okimoto 2016); exchange and interest rates dynamics contribute in explaining price levels and fluctuations in commodities market (Balcombe 2011; Serra and Gil 2012; Wright 2014; Brümmer et al. 2015). Among the endogenous drivers, political interventions may generate relevant impacts on the global consumption and production, on storage levels, as well as on the traded volumes and export concentration (Miranda and Helmberger 1988; Rude and An 2015): changes in stock levels are by far one of the main contributors to staple food price volatility (Cafiero et al. 2011; Wright 2011; Bobenrieth et al. 2013); the domestic price insulation increases world price volatility and does not reduce the domestic price instability (Cioffi et al. 2011; Santeramo and Cioffi 2012; Ivanic and Martin 2014), as well

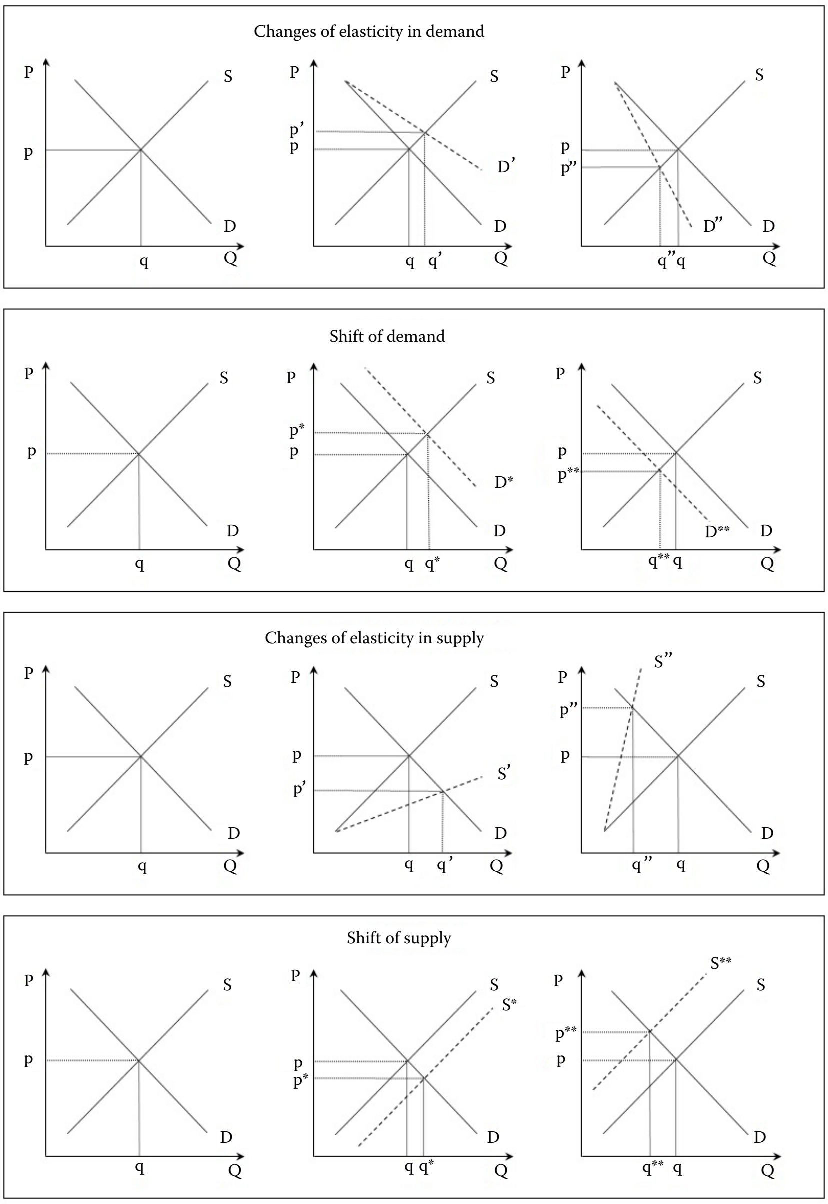

Figure 1. Dynamics of demand and supply: changes of elasticities and shift

D, S – demand and supply: D’, S’ – demand and supply after a rightward change in elasticity; D”, S” – demand and supply after a leftward change in elasticity; D*, S* – demand and supply after a rightward shift; D**, S** – demand and supply after a leftward shift. Q, P – price and quantity: q, p – equilibrium quantity and price; q’, p’ – equilibrium quantity and price after a rightward change in elasticity of demand or supply; q”, p” – equilibrium quantity and price after a leftward change in elasticity of demand or supply; q*, p* – equilibrium quantity and price after a rightward shift of demand or supply; q**, p** – equilibrium quantity and price after a leftward shift of demand or supply.

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https://doi.org/10.17221/55/2017-AGRICECON

as the out-of-season trade influence global prices (Anderson 2012); yields volatility tends to amplify the effects of weather shocks (Stigler and Prakash 2011; Wright 2014; Cafiero et al. 2015); production shocks, spill-overs from other agricultural commodities and the resulting consumer substitutability also influence the commodities price behaviour (Fisher et al. 2012; Baffes and Dennis 2013; Brümmer et al. 2015); speculation in the commodity futures markets are the potential drivers of price volatility (Tadesse et al. 2014; Haase et al. 2016; Lübbers and Posch 2016; Ohashi and Okimoto 2016).

According to Gilbert and Morgan (2010), changes in price volatility may be attributable either to the changes in demand and supply elasticities or to the changes in the variability of demand and supply shocks (Figure 1). These changes, in turn, may depend on the exogenous or endogenous factors. For instance, the biofuel mandates may reduce demand elasticity (D’ in Figure 1), increasing prices level; similarly, low stock levels may reduce demand elasticity (D’ in Figure 1), increasing prices level; the growing share of the Black Sea basin in the world grain production, where weather conditions are more erratic than in the traditional growing areas, as well as climate changes may increase the supply variability (e.g. by shifting supply to S^{**} in Figure 1), boosting prices level. In general, changes in slope of demand and supply, and the shifts in supply and demand alter the price dynamics and increase price volatility (Figure 1).

Internal drivers of price volatility play a significant role: arbitrage practices, such as storage levels and trade flows, and market fundamentals, through consumption, acreage and yield response, may generate problems of price instability in the agricultural commodities market (Ivanic and Martin 2014; Cafiero et al. 2015; Haile et al. 2016). All in all, because the domestic and global prices are generally closely linked and price volatility is the resultant of several drivers, the interaction between the endogenous and exogenous factors cannot be neglected.

ENDOGENOUS DETERMINANTS OF GRAIN PRICE VOLATILITY

Markets of agricultural commodities, in particular grain, tend to form long-term patterns of steady prices spaced out by tiny and severe upward peaks. The price instability causes distress to consumers, while farmers may or may not take advantage of such instability exploiting high prices when selling the product, and benefitting from low prices when buying inputs or storing the excess of production (Murphy 2009).

During the last fifty years, the global nominal prices of major grain worldwide (i.e. wheat, rice, corn, and barley) had a stable growing trend, with few sharp peaks: among grain rice exhibited emphasized swings (Figure 2) (World Bank 2016).

Since several drivers contribute to explain price volatility, a simple graphical analysis of the trends of grain market fundamentals contributes to improve the understanding of the global dynamics of commodity prices.

Trends of the market fundamentals are quite similar for each commodity (USDA FAS PSDO 2016). Domestic consumption concerns a large part of the domestic production: both production and consumption are steadily growing over time, probably due to the upward demand for staple food, depending on the growing population, that puts a high pressure on the inputs production (Figure 3). Trade flows rise gradually with sporadic peaks of low intensity and

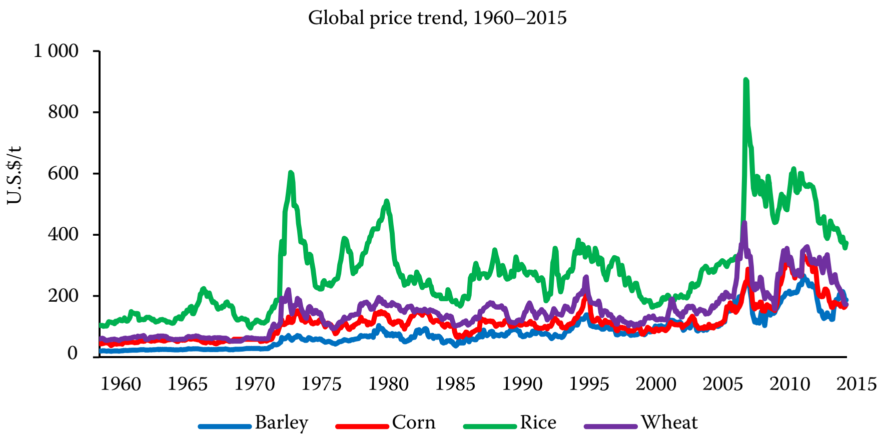

Figure 2. Global price trend of the major grain during the period 1960–2015

Source: Elaboration on World Bank (2016)

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frequency; storage levels swing dramatically with a slow upward trend, reaching minimum levels around 2007–2008, exactly when the grain prices started to show a great instability (Figures 2 and 3). Both stocks and trade highlight a remarkable variability during the last decade, probably due to the unfavourable weather conditions that caused the contraction in grain yields and consequently the reduction in production levels (Figure 2) (OECD 2008). Price volatility is not due to long-run trends, but to sudden shocks (Wright 2014; Tadesse et al. 2014; Ott 2014). Rephrasing the discussion on the drivers of grain price volatility, we propose a schematic representation of drivers, by distinguishing three main groups: arbitrage, supply and demand sides determinants (Figure 4).

Arbitrage influences price volatility via trade (spatial arbitrage) and storage (temporal arbitrage), which are both useful mechanisms of the price risk coping (Coleman 2009; Murphy 2009; Bobenrieth et al. 2013; Ivanic and Martin 2014). As for the supply side, production, harvested area, and yield, influencing price equilibria and movements, affect price volatility (Haile et al. 2014). As for the demand side, usually stable over time (Murphy 2009), shocks in consumption may generate sudden changes in price levels and thus in price volatility (Fisher et al. 2012). A detailed analysis of these macro-drivers will allow the conceptualization of how price volatility evolves.

Arbitrage and price volatility

Grain stockpiles are an ancient idea and a useful tool that allows achieving several scopes, such as food security, the compensation of production shortfalls, harvest failures at domestic level, local markets development. A close relationship exists between the storage and price volatility (Wright 2011; Serra and Gil

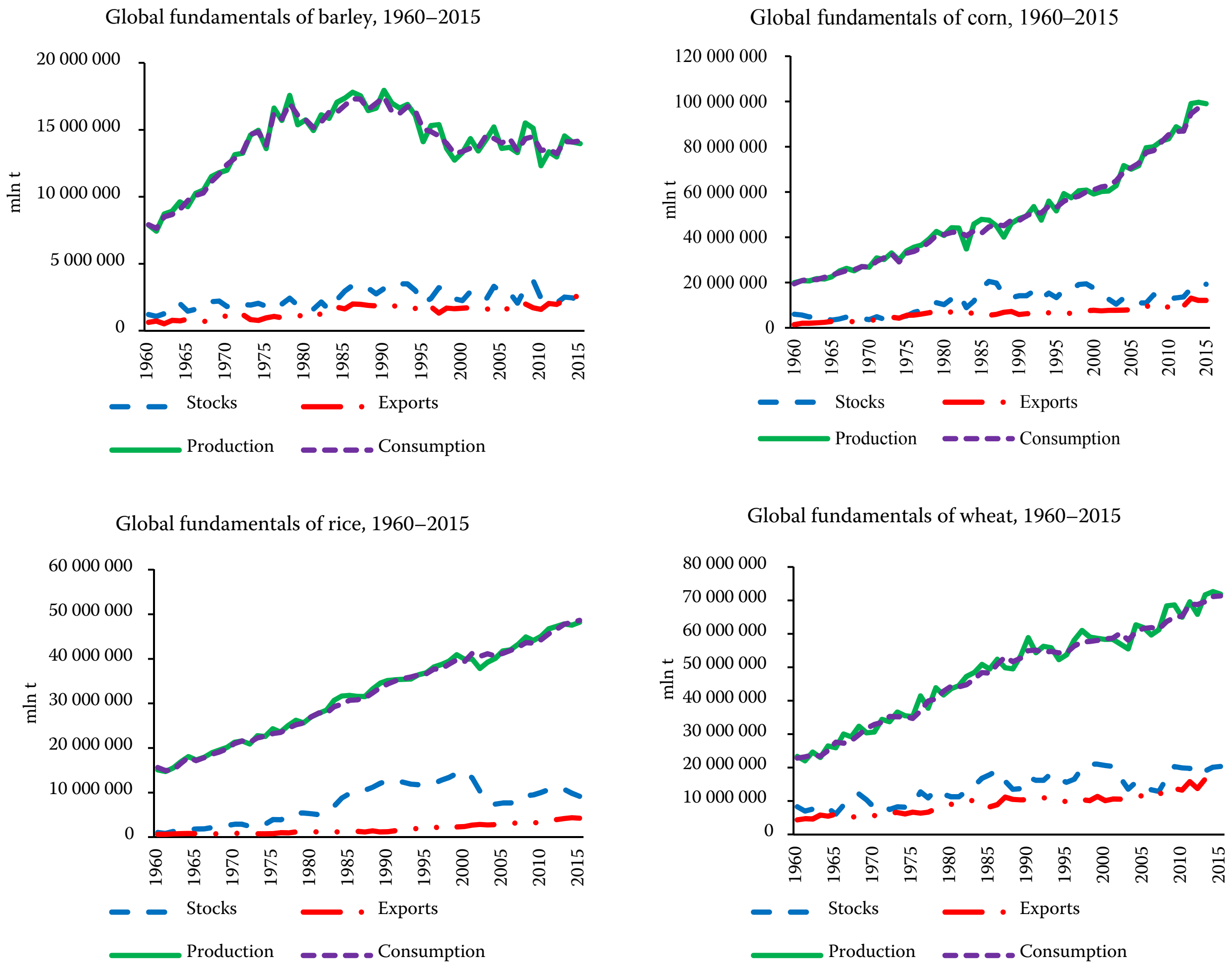

Figure 3. Global fundamentals of major grain during the period 1960–2015

Source: Elaboration on USDA FAS PSDO (2016)

https://doi.org/10.17221/55/2017-AGRICECON

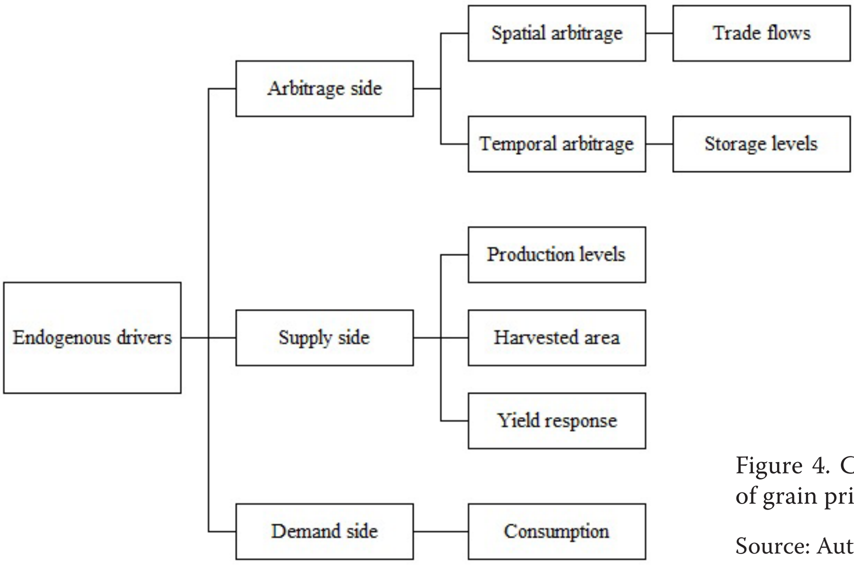

Figure 4. Classification of endogenous drivers of grain price volatility

Source: Authors' elaboration

2012): storage is an effective way to achieve price stabilization (Murphy 2009). Such a relationship finds its roots in the well-established theoretical framework of the competitive storage (Wright and Williams 1982, 1984; Williams and Wright 1991; Deaton and Laroque 1992; Bobenrieth et al. 2013). According to the theoretical models proposed in Williams and Wright (1991) and Deaton and Laroque (1992), market fundamentals jointly determine stock levels and prices: the stock levels influence the price behaviour through their buffer effect of supply shocks, as well as price dynamics endogenously determine decisions on the stock levels. Under the assumption of rational expectations, the competitive storage model postulates that when the current price is below (above) the expected price, it is convenient to store the product (to sell the stockpiles) and to sell it (to store the product) in the future, when price is expected to be higher (lower). Put differently, the price stabilizing function of a grain reserve operates through the incentives to arbitrage and speculate on price dynamics: when the prices are low, producers (or speculators) have an incentive to store and to resell in the future, so that, by taking out production from the market, the reduced supply (being equal the demand) stimulates an increase in prices, restoring the incentive to produce; and *vice versa*, when prices are high, the incentive is to sell the stored product until stock-outs, so that the increased supply (being equal the demand) lowers prices (Murphy 2009; Bobenrieth et al. 2013). Several empirical researches demonstrated that price variability increases when the stocks decline (Symeonidis et al. 2012); and *vice versa*, the possibility to store limits the effects of positive supply shocks as well as the high levels of storage buffer positive (negative) shocks of demand (supply), thus reducing price volatility (Serra and Gil 2012; Thompson et al. 2012; Bobenrieth et al. 2013; Ott 2014). Due to the high storability of grain, such a mechanism is very relevant.

The trend of the international trade flows tend to influence the price dynamics and volatility and, in this respect, the agricultural trade policies play a key role (Martin and Anderson 2011; Anderson 2012; Ivanic and Martin 2014). During the recent periods of price instability in the grain markets (2007–2008 and 2010–2011), restrictive trade policies have been implemented to protect domestic markets from the world price surge and stabilize internal prices (Götz et al. 2015): intervening on the restrictiveness of domestic trade policies is an increasingly common strategy, that seeks to stabilize price fluctuations and avoid price spikes (Anderson and Nelgen 2012; Rude and An 2015). However, the restrictive trade policy, reducing the integration of domestic markets, may limit the stabilizing function of spatial arbitrage. According to the Low of One Price (LOP), spatial arbitrage ensures that, excluding transaction costs, the price of a commodity has to be the same in two different geographical areas (Fackler and Goodwin 2001; Listorti and Esposti 2012; Santeramo 2015b). Trade restrictions tend to cause supply shocks which result in the prices surge and the amplification of price volatility (Martin and Anderson 2011; Ivanic and Martin 2014; Götz et al. 2015). The contribution of protectionist policies is heterogeneous: domestic price of tradable commodities may be altered through export taxes or import subsidies (Anderson and

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Nelgen 2012; Rude and An 2015). In the grain markets, export restrictions contribute to price volatility more than the import measures, due to the higher concentration of the export side with respect to the import side (Gouel 2013; Rude and An 2015). Strategies to limit price spikes and volatility are different for exporters and importers: exporters may reduce export controls, whereas importers may decrease import restrictions. Whatever the protectionist measure be, its effect on domestic and international markets is asymmetric and depends on the size of the market on which the intervention is imposed (Esposti and Listorti 2013). Such an asymmetry opens the path to strategic behaviour, advantaging net exporters and importers: the gain in terms of reduced volatility of the domestic market comes at the expenses of an increase in volatility of the international market; the larger the trading country interested by the intervention, the larger the impact (Anderson and Nelgen 2012; Ivanic and Martin 2014; Tadesse et al. 2014). When the countercyclical trade policies become widespread, the result is a thinner and less reliable world market (Gouel 2013; Rude and An 2015). National trade policies, while contributing to insulate the domestic markets from the international price fluctuations, tend to thin both the domestic and international markets, making them more vulnerable to exogenous shocks to the detriment of those countries who are open to trade and have not imposed the restrictive trade measures (Cioffi et al. 2011; Santeramo and Cioffi 2012). The risk of a war of imposing restrictive measures is concrete and would result in unstable international prices that generate an increasing pressure on domestic prices, nullifying the efficacy of trade policies (Anderson 2012; Ivanic and Martin 2014). In this scenario, it seems impossible to examine the price behaviour by neglecting the influence of the existing insulating policies, which tend to influence price dynamics at global level.

Demand and supply dynamics and price volatility

The dynamics of agricultural commodities price and the exceptional surge in price volatility of grain call for a more attention on the role of demand and supply dynamics: domestic consumption is the expression of demand (Roberts and Schlenker 2009; Fisher et al. 2012), as well as the acreage allocation and yield, which jointly determine the levels of production, may influence supply (Roberts and Schlenker 2009; Goodwin et al. 2012; Haile et al. 2014, 2015, 2016). In particular, planting decisions and acreage allocation are endogenous drivers, whereas crop yields are the result of noneconomic exogenous drivers such as the weather conditions, pest infestations, environmental conditions, and technological changes (Schlenker and Roberts 2006; Roberts and Schlenker 2009; Goodwin et al. 2012; Fisher et al. 2012; Haile et al. 2014; Baldos and Hertel 2016). All these factors influence prices variability, but the joint interaction between the dynamics of demand and supply may operate as a buffer of price volatility, calling off price fluctuation throughout a progressive adjustment mechanism over time (Fisher et al. 2012). Demand (via domestic consumption) moves up the creation of the price level: being equal the supply, increase (decrease) in consumption may determine the expectation of upward (downward) prices in future. The price level determines supply (via levels of production), influencing the consumers and producers behaviour: being equal to the demand, the increase (decrease) in prices may lead producers to achieve greater (lower) yields in future, through the current decisions about the acreage reallocation or input use.

Demand shocks have a lesser impact on price dynamics with respect to supply shocks, because of the rigidity of demand with respect to supply (Fisher et al. 2012). Supply shocks may be yield shocks (and the consequent production shocks) due to the unpredictable conditions, arising after planting: their impacts essentially influence price volatility within year, but it is also likely that the impacts are spanned across different crop years for storable commodities such as grain (Goodwin et al. 2012; Haile et al. 2014; Ott 2014). At the global level, when an upward shock occurs in supply and prices consequently decline, *in primis* consumption absorb excess of production and, when demand is saturated, the storage or exports may alternatively cope with the remaining overproduction, on the basis of the current affordability (Roberts and Schlenker 2009; Fisher et al. 2012); at domestic level, if the market is not integrated, the progressive adjustment mechanism between demand and supply fails, generating price instability. *Vice versa*, when a downward shock occurs in supply, the expectations about production influence prices and tend to cause the temporary price spikes: at the global level, if the yield responds to the price dynamics within the year and between years, in the short term, harvest deficiencies in one part of the world can be absorbed by the increased

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production somewhere else; at the domestic level, the expansion and reallocation of the cropland area are the only way to increase productivity (Tadesse et al. 2014; Haile et al. 2014, 2015), making not easily to absorb the yield shocks and resulting in prices instability. The empirical literature reveals that the supply yield shocks propagate into higher volatility between the crop years but have no effect within the crop year; the global crop acreage responds to crop prices, but price volatility tends to reduce the acreage and to have a negative correlation with the crop supply: the farmers shift land and other inputs and invest in the yield-improving investments to crops with less volatile prices (Goodwin et al. 2012; Ott 2014; Haile et al. 2014, 2015, 2016). Aside policies to reduce the commodity price volatility, policymakers could improve the producers' flexibility in response to price changes by supporting contract farming and price insurance mechanisms (Tadesse et al. 2014).

CONCLUSIONS

Several factors determined the volatility that has characterized the grain market during the last decades. Understanding the determinants of price instability is a first step towards the regulation of its negative consequences. Because the complexity of commodities market makes it difficult to disentangle the drivers of volatility, it should be useful distinguishing the exogenous from endogenous factors, and operating on the latter, which are more relevant and deserve a particular attention. This is because the endogenous drivers are affected by volatility and tend to amplify the existing price instability. Among them, the most important are storage, trade, and dynamics of demand and supply. We discussed on the role of storage in buffering the grain price volatility (Bobenrieth et al. 2013), on the potential impact of trade policies on price instability both at the local and global scale (Ivanic and Martin 2014), on the effect of the progressive adjustment mechanism between demand and supply on the price dynamics (Fisher et al. 2012). It is evident that all market fundamentals should be carefully taken into consideration in analysing price volatility. In particular, for storable and tradable commodities such as grain, smoothing out price volatility is an objective that can be achieved in several ways: through the spatial and temporal arbitrage; by reallocating land and inputs; by insisting on technological innovations that foster and stabilize yield; by promoting consumption; by implementing policies that promote environmental stability and sustainable development. It should not be neglected what significant implications these choices, made at the domestic level, may have at the global scale, especially for major producers or exporters.

In an era of price instability and globalized markets, understanding price dynamics is important to form and forecast economic scenarios. Our review presents the state of art in the term of determinants of price volatility, and deepens the understanding of the unresolved issues, what is undoubtedly a promising area of a further research.

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Received Feb 19, 2017
Accepted Aug 24, 2017
Published online July 31, 2018