Drivers of grain price volatility: a cursory critical review

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Abstract

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

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1. Introduction

During last decades, commodity price volatility has become a relevant issue with international resonance because of the consequences on food security, food access, 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 negative impacts related to uncertainty faced by farmers when forecasting weather conditions, yield, etc. (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, 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 provide a large share of world's food energy consumption (Diaz-Bonilla and Ron, 2010; Wright, 2011; Serra and Gil, 2012; Tadesse *et al.*, 2014). Over time, sudden changes in 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 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 (e.g. Ott, 2014; Tadesse *et al.*, 2014; Baffes and Haniotis, 2016).

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

2. 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-long term and reflects 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 potential food emergency and political crisis (Anderson, 2012; Rude and An, 2015) and to generate price uncertainty, that adversely affects decision making processes of risk-adverse producers (Tadesse *et al.*, 2014; Haile *et al.*, 2015). In the medium-run, price volatility may have diverse negative impacts on 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 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 and contribute to the amplification of price volatility (Tadesse *et al.*, 2014; Wright, 2014; Brümmer *et al.*, 2015). Among exogenous drivers, weather shocks (e.g. droughts, extreme temperatures, intense precipitation, etc.) influence outputs and thus price levels (Tadesse *et al.*, 2014; Wright, 2014; Brümmer *et al.*, 2015); 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 global consumption and production, on storage levels, as well as on 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); domestic price insulation increases world price volatility and does not reduce domestic price instability (Cioffi *et al.*, 2011; Ivanic and Martin, 2014), as well as 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, spillovers from other agricultural commodities and the resulting consumer substitutability also influence commodities price behavior (Fisher *et al.*, 2012; Baffes and Dennis, 2013; Brümmer *et al.*, 2015); speculation in commodity futures markets are potential drivers of price volatility (Tadesse *et al.*, 2014; Haase *et al.*, 2016; Lübbers and Posch, 2016; Ohashi and Okimoto, 2016).

TABLE 1 ABOUT HERE

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

FIGURE 1 ABOUT HERE

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 agricultural commodities market (Ivanic and Martin, 2014; Cafiero *et al.*, 2015; Haile *et al.*, 2016). All in all, because domestic and global prices are generally tightly linked and price volatility is the resultant of several drivers, the interaction between endogenous and exogenous factors cannot be neglected.

3. 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 excess of production (Murphy, 2009).

During the last fifty years, 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[1], 2016).

FIGURE 2 ABOUT HERE

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

FIGURE 3 ABOUT HERE

Trends of market fundamentals are quite similar for each commodity (USDA FAS PSDO[2], 2016). Domestic consumption concerns a large part of 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 high pressure on inputs production (Figure 3). Trade flows rise gradually with sporadic peaks of low intensity and frequency; storage levels swing dramatically with a slow upward trend, reaching minimum levels around 2007/2008, exactly when grain prices started to show great instability (Figures 2 and 3). Both stocks and trade highlight a remarkable variability during the last decade, probably due to unfavorable weather conditions that caused contraction in grain yields and a consequently reduction in production levels (Figure 2) (OECD, 2008). Price volatility is not due to long-run trends, but to sudden shocks (Wright, 2014;

1 World Bank, Pink Sheet. Available at: www.worldbank.org/en/research/commodity-markets, accessed in February 2016.

2 United State Department of Agriculture, Foreign Agricultural Service, Production, Supply, and Distribution Online. Available at: apps.fas.usda.gov/psdonline/app/index.html#/app/home

Tadesse *et al.*, 2014; Ott, 2014). Rephrasing the discussion on 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).

FIGURE 4 ABOUT HERE

Arbitrage influences price volatility via trade (spatial arbitrage) and storage (temporal arbitrage); which are both useful mechanisms of 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.

3.1. Arbitrage and price volatility

Grain stockpiles are an ancient idea and a useful tool that allow to achieve several scopes, such as food security, compensation of production shortfalls, harvest failures at domestic level, local markets development, etc. A close relationship exists between storage and price volatility (Wright, 2011; Serra and Gil, 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 determined stock levels and prices: stock levels influence price behavior through their buffer effect of supply shocks, as well as price dynamics endogenously determine decisions on 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 prices are low, producers (or speculators) have 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; *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 stocks decline (Symeonidis *et al.*, 2012); *vice versa*, the possibility to store limits the effects of positive supply shocks as well as 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 international trade flows tend to influence price dynamics and volatility and, in this respect, 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 grain markets (2007/2008 and 2010/2011), restrictive trade policies have been implemented to protect domestic markets from 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). But restrictive trade policy, reducing 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, price of a commodity has to be the same in two different geographical areas (Fackler and Goodwin, 2001; Listorti and Esposti, 2012; Santeramo, 2015). Trade restrictions tend to cause supply shocks which result in prices surge and 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 (Rude and An, 2015; Anderson and Nelgen, 2012). In grain markets, export restrictions contribute to price volatility more than import measures, due to the higher concentration of export side with respect to import side (Rude and An, 2015; Gouel, 2013). 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 open the path to strategic behavior, advantaging net exporters and importers: the gain in terms of reduced volatility of domestic market comes at expenses of an increase in volatility of international market; the larger the trading country interested by the intervention, the larger the impact (Anderson and Nelgen, 2011; Ivanic and Martin, 2014; Tadesse *et al.*, 2014). When countercyclical trade policies become widespread, the result is a thinner and less reliable world market (Rude and An, 2015; Gouel, 2013). National trade policies, while contribute to insulate domestic markets from international price fluctuations, tend to thin both 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 imposes restrictive trade measures (Cioffi *et al.*, 2011). 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 price behavior by neglecting the influence of the existing insulating policies, that tend to influence price dynamics at global level.

3.2. Demand and supply dynamics and price volatility

The dynamics of agricultural commodities price and the exceptional surge in price volatility of grain call for more attention on the role of demand and supply dynamics: domestic consumption are expression of demand (Roberts and Schlenker, 2009; Fisher *et al.*, 2012), as well as acreage allocation and yield, which jointly determine 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 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 jointly interaction between 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 price level: being equal the supply, increase (decrease) in consumption may determine the expectation of upward (downward) prices in future. Price level determines supply (via levels of production), influencing consumers and producers behavior: being equal the demand, increase (decrease) in prices may lead producers to achieve greater (lower) yields in future, through current decisions about 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 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 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, storage or exports may alternatively cope with the remaining overproduction, on the basis of current affordability (Roberts and Schlenker, 2009; Fisher *et al.*, 2012); at domestic level, if 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, expectations about production influence prices and tend to cause temporary price spikes: at global level, if yield responds to price dynamics within year and between years, in the short term harvest deficiencies in one part of the world can be absorbed by increased production somewhere else; at domestic level, 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 yield shocks and resulting in prices instability. The empirical literature reveals that supply yield shocks propagate into higher volatility between crop years but have no effect within the crop year; global crop acreage responds to crop prices, but price volatility tends to reduce acreage and to have a negative correlation with crop supply: farmers shift land and other inputs and invest in 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 commodity price volatility, policymakers could improve producers flexibility in response to price changes by supporting contract farming and price insurance mechanisms (Tadesse *et al.*, 2014).

4. Conclusions

Several factors determined the volatility that has characterized grain market during the last decades. Understanding determinants of price instability is a first step towards the regulation of its negative consequences. Because the complexity of commodities market makes difficult to disentangle drivers of volatility, it should be useful distinguishing exogenous from endogenous factors, and operating on the latter, which are more relevant and deserve particular attention. This is because endogenous drivers are affected by volatility and tend to amplify 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 grain price volatility (Bobenrieth *et al.*, 2013), on the potential impact of trade policies on price instability both at local and global scale (Ivanic and Martin, 2014), on the effect of progressive adjustment mechanism between demand and supply on price dynamics (Fisher *et al.*, 2012). It is evident that all market fundamentals should be carefully taken into consideration in analyzing 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 spatial and temporal arbitrage; by reallocating land and inputs; by insisting in 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 the significant implications that these choices, made at domestic level, may have at global scale, especially for major producers or exporters.

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TABLE AND FIGURES

Table . 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	Stigler and Prakash (2011); Cafiero *et al.* (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)		

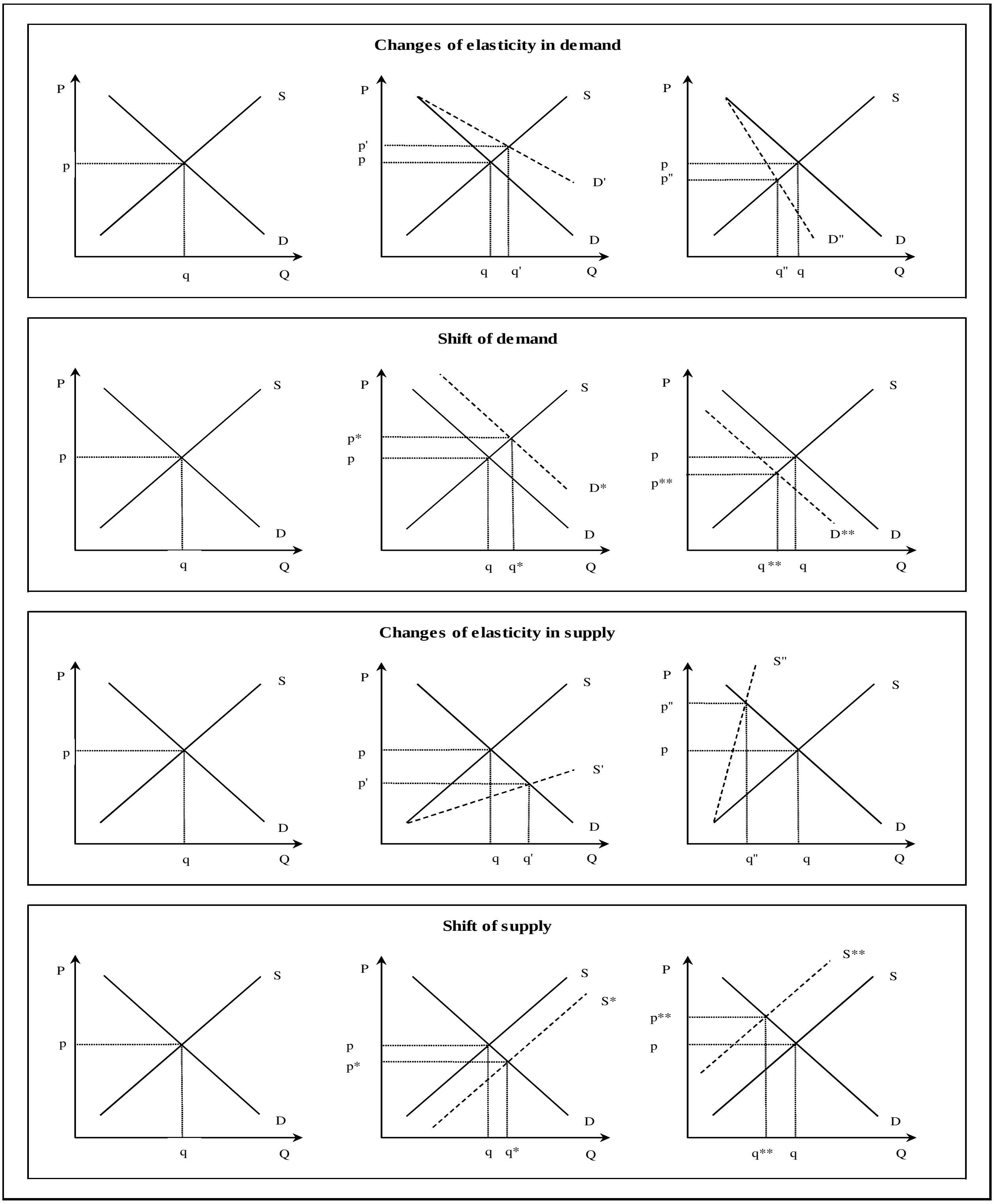

Figure . Dynamics of demand and supply: changes of elasticities and shift.

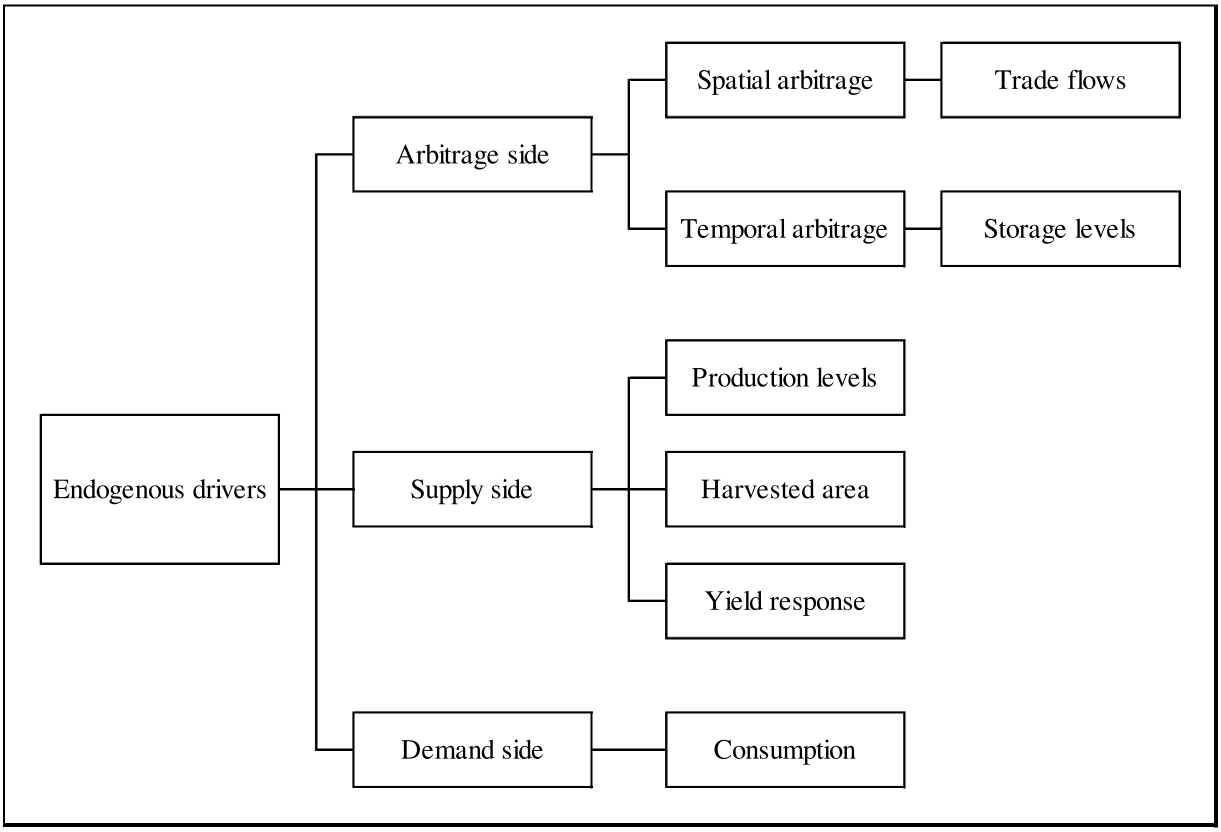

Figure . Classification of endogenous drivers of grain price volatility.