The food price crisis of 2007/08, and the subsequent episodes of boom and bust in prices on agricultural markets, have raised substantial interest among policymakers and other stakeholders in agricultural policy on the issue of food price volatility. Both causes and consequences of volatile prices have been on the agenda of national and international discussions. While concerns about the impacts of increased food price volatility, in particular for the poorest and most vulnerable people in the world, are largely agreed upon, there is much more dissent about its drivers and the required responses in terms of agricultural and trade policy as well as in terms of regulatory oversight.

Science has responded to the concerns voiced in the policy debate, and has tried to unravel the nexus between agricultural price levels, price volatility, fundamental causes, and artificial bubbles. A detailed literature review shows that the literature up to now has been able to clarify the role of some - but not all - drivers which have often been held responsible for increased volatility.

Solutions require an adequate scientific basis

The political discussion in, e.g., the G20, the UN, or the EU, was accompanied by intensive attention in the public discourse. Many NGOs quickly took a stance in the discussion, initiating new campaigns for tighter financial regulation and for globally coordinated management of agricultural markets and stocks.
Much of this public discussion was more based on prior beliefs rather than on sound economic analysis. Five years after the food price crisis, we can take a more balanced perspective on the drivers of food price developments, since a substantial stock of scientific knowledge has emerged by now.

Lots of published studies offer many insights ...

In order to gain a comprehensive understanding of the insights offered by the literature on food price volatility, we proceed in two steps. In a first step, the existing literature is screened in order to identify which drivers have received most attention. In a second step, the results for the grain market are analysed in more detail, focussing primarily on the empirical significance of the impact of potential volatility drivers.

Figure 1

Drivers of food price volatility - key aspects in the literature. The figure shows simple counts of the number of studies which devote major attention to the specific drivers. We distinguish conceptual and empirical studies. The former discuss the drivers in conceptual or theoretical terms, while the latter use statistical methods to estimate the role of the driver in question for food price volatility on various important agricultural and food.

Note: The last category "Others" include, e.g., fertiliser and other input prices, or general stock prices.

1 We reviewed 72 papers from which 17 are working papers and the rest are from peer reviewed journals. This papers are selected by searching for key words on food and agricultural price volatility topics in both scientific and general search engines. The found articles were initially screened, and only those which are of highest relevance are finally selected for the literature review. For reasons of quality assurance, we deliberately concentrated on peer reviewed journals although being aware that there exists a substantial body of ‘gray’ literature which could potentially be relevant.
Recent developments on agricultural futures markets triggered a lot of research on the role of financialisation and speculation for price volatility.

There is a clear winner as far as attention in the literature is concerned. Studies investigating the impact of financialisation and speculation are dominating the field, both in conceptual and in empirical analyses. The leading position is more marked in the conceptual studies, which is probably due to the fact that empirical studies require an operational measure of financialisation and/or speculation. A more detailed look at the empirical literature reveals that financialisation papers often address the role of index funds. In this context, figures from the US Commodity Futures Trading Commission are typically used to construct some measure of financialisation. This data issue implies that most papers are on US futures markets. Other geographical areas, agricultural commodities without a liquid US futures market, and spot markets receive much less attention.

For studies focussing on speculation, measurement is even more difficult. The theoretically clear distinction between hedgers, speculators, and arbitrageurs as stylized groups of futures markets participants is of limited help when it comes to practical measurement. The inherent difficulty is that virtually every market participant is driven by mixed objectives. Even the farmer, whom we classically classify as a hedger, often wants to hedge only downside risks while still participating in price upswings. Thus, both hedging and speculation motives are prevalent. Faced with this difficulty, the literature is still lacking a universally accepted measure of speculation.

At the second overall position, the impact of oil prices on volatility is found. In particular in the empirical literature, we see a strong focus on the dependence of agricultural prices on oil prices. A major subset of these studies address the growing volatility spillovers from the - notoriously volatile - fossil fuel markets to those agricultural products which are used as raw materials in biofuel production (sugar, corn for bioethanol, vegetable oils for biodiesel). Additional reasons for these volatility spillovers to agricultural price volatility are macroeconomic interlinkages and the importance of fossil fuels as an input in crop production.

Positions 3 and 4 are almost on equal footing, both in overall numbers and in the relatively high importance of empirical studies: The role of low stocks and exchange rate volatilities. For both factors, theory suggests a clear impact on price volatility. The buffer function of stocks can only function as long as stocks are sufficiently filled, and, since most of the international trade in agricultural and food products is done in US dollars,

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2 Financialisation refers to the increasing amount of liquid funds which have become engaged in agricultural commodity markets over the past years. Often, the role of hedge and index funds is emphasised in particular for price formation on futures markets. Speculation is an even less clearly defined term. Major notions in the literature are speculative bubbles, when asset prices deviate systematically from their fundamental values, speculative hoarding, when stocks are built in the expectation of ever higher prices, and market manipulation, where price movements on less liquid markets are deliberately triggered by some market participants. The economic concept of speculation is yet defined differently; speculators in this meaning are market participants who are willing to take over price risks from hedgers at a premium (and thus fulfil an economically desirable function).

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fluctuating exchange rates of domestic currencies against the dollar will generally lead to price fluctuations, too. In empirical studies, both variables are readily available, although stock information is of notoriously low quality and usually available only at much lower frequencies than prices.

For the next two positions, the overall numbers are again virtually the same. However, for consumption increases and biofuel mandates, the empirical literature is surprisingly silent. Conceptually, both factors could lead to a tighter market balance between supply and demand through an increase in traditional demand (consumption increases) or new types of demand (biofuel mandates). In the latter category, the impact on volatility might be exacerbated by the low price responsiveness of biofuel mandates to price increases for the raw materials.

Weather shocks figure next in our literature appraisal. Here, the share of empirical studies is close to 50 per cent. By definition, weather shocks can only exert a short-run impact on price volatility, but as the experience of 2010 and 2012 has shown, the impact can be quite substantial, and might be magnified by policy reactions.

Finally, the two remaining categories are only discussed at the conceptual level: Underinvestment in agriculture and ad-hoc policy interventions. For the former, theory suggests that lack of technical progress, e.g., stagnation in yield improvements, could play a substantial role for thinning agricultural markets. Obviously, empirical analyses are difficult because of the decade-long time lag of spendings on research, before the investments pay off through technological progress. For the latter, it seems surprising that the very clearly expected impact of, say, sudden export policy interventions, on price volatility is rarely analysed in the empirical models used in this literature.

We now explore for the case of cereal prices to which extent the existing literature is already able to deliver a clear message on the drivers of volatility. Cereals are chosen for two reasons. Data for both spot and futures prices are commonly available at good quality, and cereal prices are indicative of both agricultural output and input (as feedstock) prices. We categorize all available studies on cereal price volatility into significant and non-significant, and we repeat this categorization for the subset of studies which contain empirical price volatility analyses. For a given driver, dominance of blue colour in both columns thus indicates that the current literature unanimously ranks this driver as an important determinant of cereal price volatility. Different patterns between overall and empirical literature suggests further research needs because the role of the driver in question is still an open issue either in the theoretical debate or in empirical analyses.

Highlight

Some relevant drivers are largely ignored in the empirical literature, in particular the role of ad-hoc policy interventions.

3These terms are to be understood as referring to economic significance, i.e., whether a driver is exerting a substantial impact on price volatility or not.
An unanimous pattern is visible for oil prices as a driver of volatility, both in all available and in the subset of empirical studies. The literature is also largely in agreement that the importance of oil prices for agricultural price volatility has grown over time. Since this happened at a time when biofuel policies became more and more tangible in the price formation for cereals, the volatility-increasing impact of biofuel policies should be judged as a proven fact (even if the debate about the price level impact of these policies still continues).

For the impact of low cereal stocks, there is relatively more agreement in the overall literature than in the empirical subset. In addition, we find that the majority of empirical papers generally agrees that the level of stocks, usually measured as the stocks-to-use ratio, is economically important. The difference in the share of significant findings between overall and empirical literature highlights the difficulties in establishing firm empirical evidence for this driver: The lack of reliable information on cereal stocks. Public stocks are still treated as a state secret in some countries, and information on private stocks is rarely collected in a statistically appropriate manner.
The AMIS initiative\(^4\) could, if successful, improve this dire situation over the next years.

The literature offers a fairly clear picture on the impact of consumption and income growth. Cereal markets are affected not merely by increasing demand but by changing consumption habits, too. The westernisation of diets which seems to inevitably follow per capita income growth across the world involves a shift towards higher meat consumption, which exacerbates the burden on the cereal market balance. The unfavourable ratio of calories required to produce meat puts particularly strong pressure on maize and soybean markets; the tighter balance between supply and demand on these markets has contributed a lot to past price volatility. However, it is remarkable how few of the empirical studies take up the modelling of this issue.

... but many open questions remain

The definite answer to the remaining potential drivers listed in Figure 2 remains elusive up to now. This is particularly striking for the dominating object of attention in the literature, financialisation and speculation. The overall literature shows almost perfectly divided opinions, half of the papers identifying a significant impact, the other half fails to find this on cereal markets.

The empirical papers are a bit less ambiguous in that a majority finds that financialisation and speculation did not contribute to cereal price volatility over the past years. Moreover, those studies that find a significant impact on volatility do not all agree on its direction, since three studies provide evidence for a volatility decreasing effect of financialisation. Still, substantial uncertainty remains in the empirical literature, too. The lack of finding definite proof in the one or the other direction is likely affected by the heterogeneity of concepts employed, by the lack of adequate definitions, and by the lack of adequate measures. However, at this time, the majority vote of the literature on cereal price volatility is clearly against viewing financialisation as the major culprit for increased cereal price volatility in the past decade. This overall picture suggests a very careful approach towards imposing additional regulation on financial markets; the most promising route seems to start with imposing additional transparency requirements (in this field, EU regulation actually is still lagging behind US standards).

\(^4\) AMIS ([http://www.amis-outlook.org](http://www.amis-outlook.org)) is a G20 initiative to enhance food market transparency and encourage coordination of policy action in response to market uncertainty. The initial focus of AMIS is on four grains that are particularly important in international food markets, namely wheat, maize, rice and soybeans. AMIS’ secretariat, located in Rome, is formed by the following international organizations and entities: FAO, IFPRI, IFAD, IGC, OECD, UNCTAD, the UN High Level Task Force (UN-HLTF), the World Bank, WFP, and WTO.
Less uncertainty but with a similar pattern is found for the impact of bio-
fuel policies on cereal price volatility. The majority of the empirical studies
conclude that biofuel policies, in particular US ethanol mandates, are in-
deed a driver of cereal (in this case corn) volatilities, but the empirical find-
ings are less clear than the picture painted in the overall literature. This
again suggests that careful modelling of price volatility is necessary. In-
deed, all conceptual studies identify biofuel policies as a substantial driver
of volatility. Hence, the judgement over biofuel policies should probably not
rely on their impact on price volatility alone. Whether these policies make
economically sense or not should be rather based on a rational cost-
benefit analysis, taking into account their greenhouse gas reduction poten-
tial (and the associated economic costs) as well as their effects on price
levels and volatility.

Last but not least, the empirical literature on cereal price volatility is
completely silent on the issue of underinvestment in agriculture. We
have discussed possible reasons already above. It should be noted, how-
ever, that for medium-term volatility projections, as they are part of the
Ulysses concept, will probably have to tackle this issue. Technical pro-
gress usually will not fall like manna from heaven but will require invest-
ments; and today's actions will have substantial impact on tomorrow's po-
tential supply in agricultural and food markets. Modelling the role of (lack
of) investment in agriculture and the associated impact on total factor pro-
ductivity will be a crucial factor for the tightness of the market balances in
the medium run, and should thus be incorporated in sector models as a
medium-term driver of volatility.

One reason for the ongoing controversy about the role of increasing fi-
nancialisation and speculation is the difficulty to find appropriate measures
for these developments. An even more fundamental measurement issue
affects all research on food price volatility: Price volatility is – unlike the
price itself – not directly observable, but has to be estimated. Moreover,
volatility refers to the unexpected component of a price change, as op-
posed to an expected price movement, which implies that volatility estima-
tion requires modelling of the price levels, too. In Figure 3, we illustrate the
potential impact of the estimation approach on the resulting volatility. The
figure provides estimates of annualised monthly volatilities for wheat be-
tween 1982 and 2012. It concentrates on the two most common estimation
methods used in the literature. The upper part shows “realised volatilities”
that use the daily returns within a month; the lower part shows volatilities
obtained from a time-series volatility model fit to monthly returns (“model
volatilities”). The two series clearly give a different picture on how volatility
changes over time, with “model volatilities” being relatively smooth and
“realised volatilities” being relatively spiky.
The assumption of a constant mean is quite restrictive. More sophisticated mean specifications would consider seasonality or past returns, which could lead to better volatility estimates. Moreover, more sophisticated estimators also exist for the realised volatility. The most basic assumptions are chosen here because they are widely used in the literature.

Since the empirical literature on volatility drivers basically looks for explanations why volatility goes up and down over time, the "model volatilities" leave relatively little to be explained compared to "realised volatilities". This observation provides a rationale why the empirical literature has not yet reached a consensus on all potential volatility drivers and casts doubts on the robustness of some findings reported in the literature. It is part of our research agenda to use a variety of different volatility measures to distinguish between robust and non-robust results.

**Figure 3**

Different volatility measures - wheat market. The figure shows annualised return volatilities for wheat between 1982 and 2012. The upper part of the figure depicts realised volatilities calculated from the daily returns within each month. The lower part provides the volatilities obtained from a GARCH(1,1) model, using monthly returns. Returns are calculated from spot prices that refer to the underlying of the CME wheat futures contract. The expected return is assumed to be constant over time.\(^5\)

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\(^5\) The assumption of a constant mean is quite restrictive. More sophisticated mean specifications would consider seasonality or past returns, which could lead to better volatility estimates. Moreover, more sophisticated estimators also exist for the realised volatility. The most basic assumptions are chosen here because they are widely used in the literature.
Conclusions and outlook

The current literature offers already many insights on the drivers of price volatility on agricultural markets over the past years. There exists broad agreement that the following drivers played a major role, at least on cereal markets: Oil prices (which are notoriously volatile and became increasingly intertwined with agricultural markets), low stocks-to-use ratios, and, to a lesser extent, consumption and income growth, all are found to have increased price volatility in the recent past.

No unanimous message, however, is found for other hotly debated potential drivers. Financialisation and speculation, although triggering a lot of public attention, seem not to be among the most important explanatory factors. Similarly, the direct impact of biofuel policies on price volatility is still debated. Hence, policies which aim at addressing these drivers should be devised with a great deal of caution. At least, policy instruments should be sufficiently flexible to be able to respond to new findings in the literature.

A major caveat which certainly applies to the available empirical literature should be kept in mind. Price volatility seems to be sensitive to methodological choices in setting up an empirical model. Hence, empirical results on the impact of potential drivers for price volatility might be severely affected by these methodological choices. This is probably a major source of the uncertainty which is still present in the literature on a number of drivers, most notably the role of financialisation and speculation. Hence, in ULYSSES, robust estimation approaches will be explored and refined, in order to shed further light on those factors which contributed to price volatility in the past. These methodological improvements will also be used to integrate future expectations on these drivers into medium-term forecasts for agricultural markets, another important part of the ULYSSES project.
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