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GRAINS STORAGE AND GLOBAL FOOD SECURITY

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Introduction

Grains[1] and grain-based products are critically important for world food security. They are main staple foods in practically every country and constitute essential sources of calories for large parts of the population, especially the poor. One characteristic that makes grains particularly important from a food security perspective, both at national and household level, is their storability, which is higher and less costly compared to many other food products such as meat and dairy as well as most fruits and vegetables.

Especially in developing countries, many households keep grain reserves to make it through the lean period between harvests while a large number of governments hold grain stocks to safeguard national food security in case of an emergency. Apart from helping guarantee the physical availability of food, grains are also stockpiled to protect against unexpected price spikes that might seriously limit people's access to food. While it is open to debate whether grain reserves are the most efficient instrument to achieve these two objectives, available data suggest that in recent years many countries and households have opted to increase their reliance on stocks as an insurance mechanism.

The objective of this paper is to provide a global food security perspective to the storage of grains, with a focus on public stockholding. After providing a quick overview of the main trends of grain storage over the past fifty years, the chapter goes on to briefly discuss a typology of food reserves based on their principal objective: those targeting food security in emergency situations and those aiming to stabilize prices. Subsequent parts present recent attempts and difficulties to measure grain reserves and understand their economic importance as a determinant of food price volatility.

Trends in grain stockholding

When international prices of main staple crops surged in 2007/082, and key exporters limited or completely stopped supplying to global markets for fears of national food shortages, many governments started to question whether relying on international trade would be sufficient to ensure their countries' food security. The period that is now commonly referred to as the world food price crisis led to a renewed interest in the use of food grain stocks as a way to protect against excessive food price volatility and supply shocks (World Bank 2012). Following the crisis, the volume of global food grain stocks reversed its previous declining trend and gradually started to increase, reaching a new record high in 2017/18.3 This overall pattern can be observed for all main food grain crops, including maize, rice and wheat (see Figure 1).

Grain stocks had already been considered an important, albeit expensive, tool to manage food price volatility and supply disruptions in the aftermath of the world food crisis of 1974, as illustrated by the creation of the International Emergency Food Reserve by the United Nations General Assembly. With a target of 30 million tons for the wheat and rice component, the reserve was expected to be an important pillar to ensure global food security, but the system never became fully operational as contributions significantly fell behind this intended volume (Shaw 2001).

While efforts to build stocks for food security purposes certainly contributed to the tripling of grain reserves between the mid-1970s and the mid-1980s, a large part of the accumulation was actually a by-product of farm support policies in developed countries, such as the Common Agricultural Policy (CAP) of the European Union. Under the CAP, farmers were guaranteed a fixed minimum price for their products, often set well above the world market price, which frequently led to overproduction and large surpluses of many products including grains that had to be stored or else exported at subsidized prices (Deuss 2015). Similar phenomena occurred in other countries that implemented price stabilization schemes, such as Australia (for wool) and the United States (for butter and cheese).

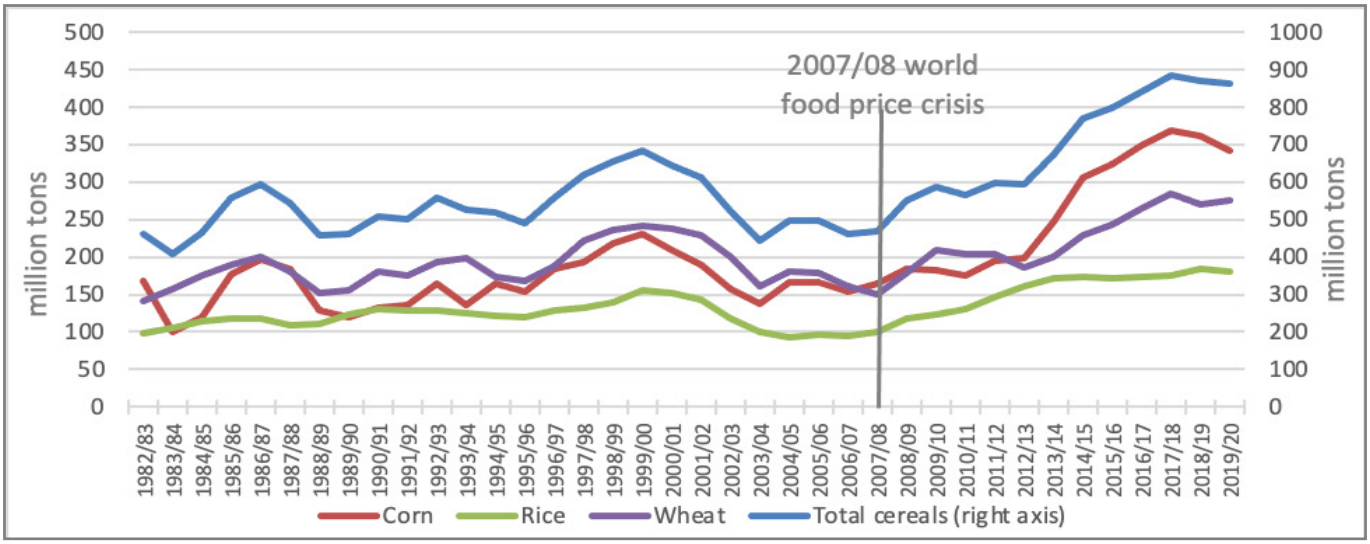
In view of their large costs and distortive effect on the economy, price stabilization schemes and other types of support programs were gradually phased out in developed countries starting in the 1990s, also to comply with international trade agreements under the Uruguay Round of the World Trade Organization. While developed countries held more than 200 million tons of grain stocks in the mid-1980s, this volume today stands

[1] The Food and Agriculture Organization of the United Nations (FAO) refers to food grains as "cereals", which are composed of wheat, rice and coarse grains (maize, barley, sorghum, millet, rye, oats and other grains). In this paper, the terms "grains" and "cereals" are used interchangeably.

[2] World market prices of main food commodities soared in 2007/08. Prices of maize, rice and wheat, for example, reached their highest levels in 30 years. The crisis caused political and economic instability and led to food riots in a number of countries (FAO 2010).

[3] The recent trade tensions among several countries, most notably China and the United States of America, which included the introduction of new or the escalation of existing tariffs on food products, as well as a general loss of confidence in the multilateral trading system might have further contributed to this upward movement.

Figure 1: Evolution of global food grain stocks (1982-2020)



Source: Food and Agriculture Organization of the United Nations (FAO), 2020.

at less than half (USDA 2020). What is more, most of the reserves in developed countries are no longer managed by public agencies but are in the hands of private agents such as farmers, processors and traders.

By contrast, the most recent increase in global grain reserves since the 2007/08 food price crisis has been driven by developing countries, and the increase has been strongest for reserves held by governments. In addition, growing stock levels are no longer a by-product of other support policies but in many cases the intended purpose of these programs (World Bank 2012). Led by traditional holders of large public reserves such as China and India, grain stocks in developing countries more than doubled between the mid-2000s and today (FAOSTAT 2020).

Many countries also intensified their stockholding efforts through regional cooperation. The Association of Southeast Asian Nations (ASEAN), for example, upgraded its 1979 Rice Reserve System by partnering with China, Japan and Korea to form the ASEAN Plus Three Emergency Rice Reserve, which intends to help member countries overcome food shortages after natural and humanitarian crises (Mujahid and Korner 2016). Similarly, the South Asian Association for Regional Cooperation (SAARC) revisited its 1987 Food Security Reserve and created the SAARC Food Bank to overcome regional food shortages. On the African continent, the Economic Community of West African States (ECOWAS) has started building a regional grain reserve, aiming at a total storage capacity of one million tons. Despite the difficulties in managing stocks held at regional level, some scholars believe that they can be a viable and comparably cheap alternative to national reserves (e.g. Kornher and Kalkuhl 2016).

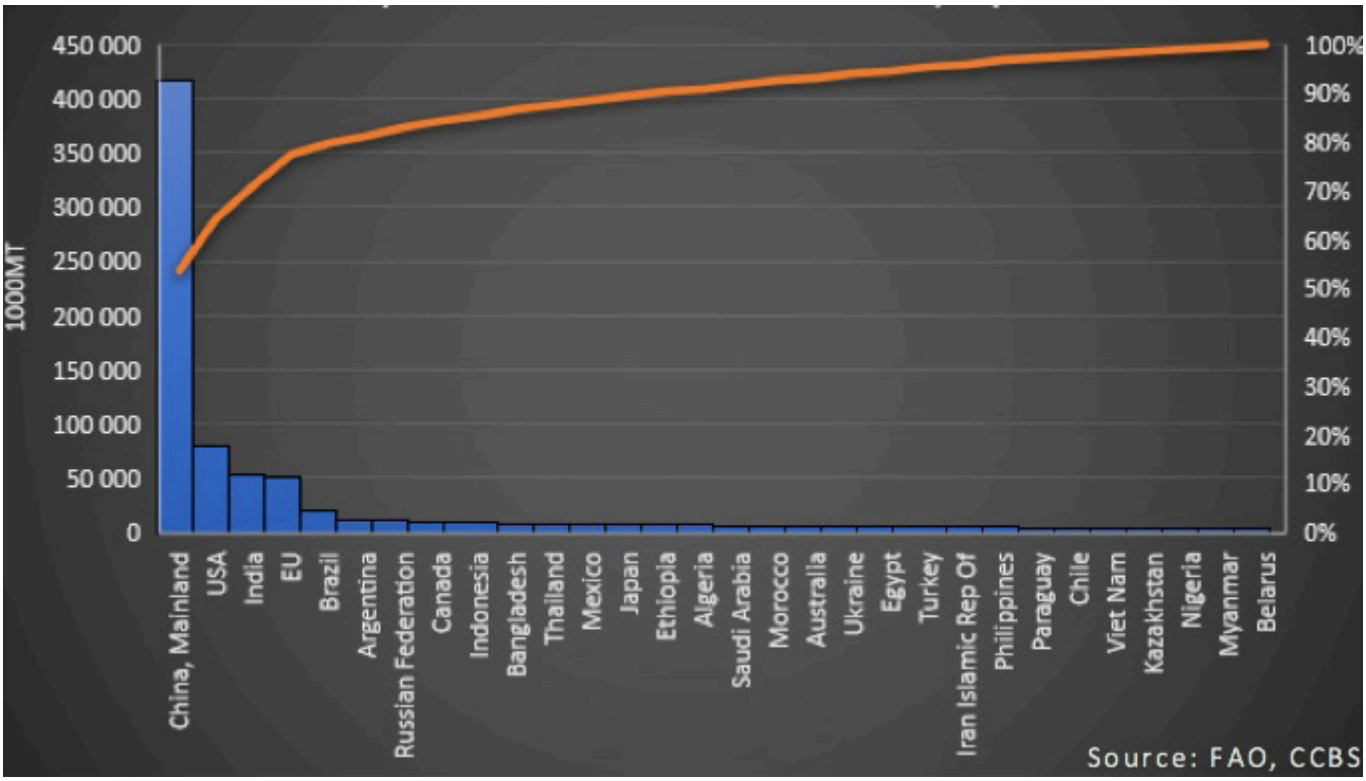
At their current levels of around 850 million metric tons, and especially when measured relative to utilization, global cereal stocks should be sufficient to "provide a solid buffer against adverse shocks, such as, for instance, bad weather" (Schmidhuber and Qiao 2020). However, it is important to note that not all of these reserves will be available to counter a global scarcity situation. Apart from the absolute level of stocks it is equally important to consider their distribution across countries, notably whether they are held by importing or exporting countries, and whether they are in the hands of many or only a few.

Looking at the global distribution of stocks, it is striking that almost three quarters of reserves are held by just five countries (Figure 2). While the concentration of stocks has traditionally been high, it seems to have further increased in recent years. This is particularly the case because China is now assumed to account for almost half of global reserves (FAOSTAT 2020). Similar to India, the third largest holder of grain reserves, these stocks are not destined for global markets but primarily target domestic demand.

Role of stocks

Although international grain trade has allowed tapping into the harvests of different climatic zones, grain

Figure 2: The distribution of cereal stocks across countries (2019/20)



Source: Food and Agriculture Organization of the United Nations (FAO), 2020.

markets remain seasonal. Supplies are harvested in a relatively short period of time, but are generally demanded throughout the year. What is more, production is frequently subject to great fluctuation, especially from unforeseen weather events, while consumption tends to be stable. This is certainly true for grains intended for direct human consumption, but also applies to those that are further refined or processed. Food processors, livestock feeders or biofuel plants, for example, maintain working (or pipeline) stocks to ensure the smooth running of their operations.

Grain reserves can help smoothen supplies and adjust them to actual demand. They represent the quantities of a commodity that are stored at any moment in time by the various actors along the agricultural supply chain. As explained by Abbott (2013), stocks can be classified according to who is holding the stocks and why, and what purposes they ultimately serve. To correctly understand the role of stocks it is also important to consider when during the marketing season they are being held. Stocks that are carried into the next season, for example, are usually considered the most meaningful when assessing food markets, while reserves held by households throughout the year are particularly important from a food security perspective.

In the context of public stockholding programs, reserves can be classified according to two main objectives that they serve, although this distinction might not always be precise: those intended to provide food supplies in an emergency situation and those intended to stabilize prices. In the first category, emergency stocks (or strategic reserves) aim to overcome temporary supply shortages and avoid impending humanitarian crises. In the second category, so-called buffer (or intervention) stocks aim to stabilize prices by absorbing oversupplies that would otherwise depress market prices or releasing supplies in times of escalating prices.[4]

Emergency reserves for food security

Many countries keep strategic reserves that are intended for emergency situations, which can broadly be defined as the outcome of an extreme and unexpected event that leaves people without sufficient supplies to satisfy their dietary needs. Such emergencies can be caused

[4] Some analysts also distinguish safety net stocks (e.g. World Bank 2012), which are somewhat of a hybrid. Similar to emergency stocks, their primary purpose is to improve the physical availability of food for those who are food insecure, even in the absence of a supply shock. However, they might also impact prices as safety net stocks are frequently released through subsidization schemes.

by natural disasters, such as droughts and floods, as well as armed conflicts that lead to humanitarian crises. Following the 2007/08 food price crisis, a broader notion of an emergency situation would also include large and sudden price hikes, possibly triggered by or in combination with export bans of major suppliers (Briones 2011).

Stockholding is always a costly business, but especially so in the case of emergency reserves that follow a humanitarian rather than an economic rationale. Investments are needed to build silos and warehouses, while regular maintenance such as moving and rotating the grain has to minimize losses due to spoilage (e.g. animal, insect, mite, and mold damage). To keep costs manageable, the size of the emergency reserves needs to be continuously adjusted to estimated needs, so having good information on the number of people who could potentially be affected by an emergency situation as well as efficient distribution channels to transfer the released stocks to the targeted populations are critical. A study of different emergency reserve systems in Africa (Rashid and Lemma 2011) found large differences between countries, with costs ranging from USD 20 to USD 46 for storing a metric ton of food, depending on institutional design, appropriateness of the stock size and the level of integration with other transfer and social protection programs. As part of this calculation, the potentially lower costs of having private agents keep and release stocks need to be considered. Publicly managed emergency reserve systems have often shown to be inefficient compared to those managed by private agents while at the same time risking to crowd out private investment in stockholding.

While the track record of emergency reserve systems is not untainted, there are several examples of programs that seem to be working effectively. Especially small and targeted strategic reserves have demonstrated that they can be a viable option to improve the food security of vulnerable people (CCP 2014). Good management and flexibility; compliance with rules and procedures; mechanisms to adjust reserves to needs; as well as functioning systems to detect an emergency have been identified as the main drivers that determine a positive performance (World Bank 2012).

Even large reserves held by countries with large populations have served important purposes and strengthened national as well as global food security. The sharp drop in Indian rice production in 2002/03, for example, could have led to major turbulences in international rice markets if India had decided to massively increase its imports; instead, the country drew on its domestic reserves (Calpe 2017). The potentially positive role of grain stocks is particularly significant for thinly traded commodities, where production shortfalls in a few exporting countries can have drastic implications in global markets. For China and India, for example, domestic rice consumption far exceeds the entire volume of rice that is being traded internationally, so relying on current production and trade alone would be a risky strategy.

Stocks to stabilize prices (buffer stocks)

Buffer stocks differ from emergency reserves in that they try to actively intervene in the food market, usually with the aim of stabilizing prices for the benefit of national producers or consumers. While more stable prices can indeed provide several welfare gains, buffer stocks are generally not seen as an effective instrument to enhance the performance of the agriculture sector and/or improve a country's food security.

Several studies demonstrate the importance of more stable grain prices, especially in developing countries, for example in reducing farmers' risks and enhancing the overall investment climate, which would ultimately help raise production (Demeke et al. 2012). If prices are predictable, farmers can more easily adjust their outputs to changing demands and enhance their supply response. They might furthermore diversify their production to higher-value crops if they know that they can satisfy their basic food needs by purchasing, rather than producing, grains at affordable prices. Some researchers (e.g. Timmer 2004) also emphasize that stable prices of grain crops can positively affect food consumption, for example by diversifying diets and increasing the intake of proteins, vitamins and minerals.

However, the downsides of keeping stocks for price stabilization purposes generally outweigh these potential benefits. The high costs of maintaining the reserves reduce available resources to invest in agricultural productivity and rural infrastructure. The continuous intervention of a public entity for the purchase and release of grain stocks also distorts markets, potentially distorting price signals and crowding out the private sector from investing in grain production and storage. More importantly, many analysts question the overall effectiveness of reserves as a mechanism to stabilize prices, pointing out that buffer stocks have had limited success in reducing food price volatility. While they might succeed in moderating downward price movements, they have frequently failed to prevent excessive prices surges. As explained by Gilbert (2011), a buffer stock agency can only release into the market what it has previously purchased. Once its reserves are exhausted, a further upward pressure on prices can no longer be restrained.

Buffer stocks have virtually disappeared in developed countries due to their high costs, limited success and market distorting effect. In developing countries, however, price stabilization schemes still enjoy some popularity, especially in Africa and Asia. The challenge there is to design schemes that help reduce short-term volatility without harming long-term agricultural growth (World Bank 2012) or displacing the commercial exports of competitive international suppliers. But even then, it is questionable whether the relatively small efficiency gains from price stabilization justify the substantial costs involved in maintaining the schemes. Thus, rather than investing in storage programs, many analysts suggest that alternative policies should be considered that might more effectively protect against unexpected price swings, such as facilitating the flow of food from surplus to deficit areas within regional trade corridors or deepening international trade.

Measuring stocks

The previous sections implicitly suggested that global grain reserves are well studied and understood. Unfortunately, this is not the case. In fact, the paucity of available stocks information, especially at the global level, has been considered one of the main obstacles to better monitor food market dynamics and anticipate food price spikes such as those witnessed in 2007/08. As explained by Dawe (2009), there are several important reasons why measuring stocks is problematic. For one, stocks are frequently held for strategic purposes, so the stockholders (e.g. private traders) might be reluctant to disclose their positions to competitors, which weakens the reliability of their information. For stocks held by smaller commercial entities and households, the sheer number of agents that need to be monitored is making measurement difficult. As for public stocks, many countries consider their reserves as vital to protect their national food security and/or influence markets, so they, too, will be hesitant to reveal any information that they consider sensitive. For global estimates, there is also an important methodological challenge to make stocks data comparable across countries.

To measure the size of stocks, two main methods can be applied: conducting surveys or deriving stocks as the residual in a balance sheet calculation. While surveys arguably provide the most accurate and complete information on current stockholding, the residual approach is more widely used.

A main deterrent for regular data collection through surveys is the high costs involved. In the developing world, only the Philippines regularly conducts stocks surveys. However, even in developed countries, including major exporters that have an economic interest in sound agricultural market information for their commercial operations, stocks surveys are rarely applied. A notable exception is the United States that conducts quarterly stocks surveys covering all main food commodities, while Brazil and Canada use surveys for selected grains.

In order to obtain a good overview of the stocks situation, numerous agents have to be interviewed, including smallholder producers (who might store grain to cover their families' consumption over the year); commercial farmers (who might store grain in anticipation of more favorable prices); grain elevators and traders (who stockpile grains for subsequent shipping); food processors, feed compounders, as well as livestock and biofuel producers (who store grains to keep their operations running); and of course managers of public storage facilities. In developing countries, stocks are frequently also held by consumers, which further increases the list of agents to be interviewed.

Another challenge is to determine when to measure the stocks. If surveys are applied, they are usually only conducted once a year in order to minimize costs, so the timing of the survey is critical. To be most meaningful for the understanding of food market dynamics, an annual stocks survey should measure the level of reserves at the end of the crop season, when stocks are the lowest in anticipation of the new harvest (Abbott 2013). The so-called "carry-out" (or ending) stocks of the previous season become the "carry-in" (or opening) stocks of the new season. As explained by Sharples and Krutzfeldt (1990), the metric is particularly important as it "shows in one number the daily decisions, accumulated over the grain marketing year, of people and governments about how much of the current grain supply to consume and how much to save as insurance against future shortages."

Determining the moment when reserves are the lowest can be tricky as crop calendars change over time and might shift the start of the harvest forward or backward. The situation is even more complex for crops that exhibit multiple seasons over the year. In the case of rice, for example, ending stocks should refer to the volume of reserves just prior to the start of the main harvest, i.e. the one with the largest output.

For the majority of countries that do not conduct regular surveys, stocks estimates are derived as a residual from food balance sheets that track the supply and demand of a specific commodity. After considering the level of production, trade and various types of usage (including

waste and loss), any amount left unaccounted for is accrued to stocks. Although widely applied, this approach has several flaws. For one, it only measures the change in stock levels from one season to the next, without providing information on the absolute quantity of reserves. Consequently, this volume has to be established – ideally surveyed, but usually estimated – at some point in time to provide a reference for the annual changes that follow. Setting this initial value has proved quite difficult for all main providers of international stocks data, including the United States Department of Agriculture (USDA), the International Grains Council (IGC) and the Food and Agriculture Organization of the United Nations (FAO). Over the years, all three have had to make revisions to their historic stocks data for some countries in order to prevent these numbers from becoming negative, which obviously is not possible.

The residual approach furthermore requires very good information on the other elements in the supply and demand balance. While the level of production and trade (imports and exports) can be measured with relative precision, this is not the case for the various categories of crop use. Arguably the least problematic component in the use category is human consumption, which, in the case of grains, is relatively stable over time, which means that it can be calculated applying assumptions on average diets as well as considering official population statistics. Industrial use (such as biofuel production from grains) is hardly measured by surveying the respective firms, so countries rely on more or less plausible estimates. Feed use is frequently calculated using a model approach that considers the (estimated) herd size and nutritional needs of the respective animal populations. Finally, for waste, loss and seed use, a general practice is to apply fixed percentages, which fail to reflect possible changes from one year to the next.

Even with good estimates for individual countries, either from surveys or through the residual approach, it is difficult to derive the global stocks situation. Apart from distinct national definitions of what constitutes a reserve, ending stocks will also be measured at different months, depending on the start of the main harvest in each country. Similar limitations apply to stock measures that group different commodities, such as grain or cereal reserves, which might not follow a consistent methodology across countries. In this regard, global stock estimates should be perceived as a tool to better understand the overall supply situation rather than a measure to know exactly what is in store at a particular moment in time.

Stocks and food price volatility

The reason why global initiatives such as the Agricultural Market Information System of the G20 (AMIS) focus on improving the measurement of food grain stocks relates to the importance of this measure for food security and overall food market dynamics. Stocks that are carried from one season to the next add to available supplies, which will impact on key economic variables such as prices. Low levels of stocks are usually associated with higher prices and increased food price volatility, which can harm a country's food security (HLPE 2011). However, the relationship is not always clear, and there are many cases where prices have surged despite large reserves or where they haven't reacted at all although warehouses were empty. While low stocks do not necessarily lead to price spikes, they nevertheless seem to be a necessary condition for such shocks to occur (Gilbert 2014).

One indicator of particular relevance in this context is the stocks-to-use ratio, which measures ending stocks as a ratio of total utilization. Similar to measuring the level of strategic reserves in the number of days of consumption they would cover, the stocks-to-use ratio provides a proxy for the available supply buffer. In the mid-1970s, following the world food crisis, the Intergovernmental Group on Grains adopted the measure as the lead early-warning indicator for monitoring global food security (FAO 1974). The Group defined a level of 17-18 percent cereal stocks relative to annual consumption as adequate to effectively stabilize prices and markets, which was later endorsed by the Committee on World Food Security. While any exact threshold estimate should be treated with some caution, for example to account for changes over time such as a lower propensity to keep national reserves because of a more liberalized trade environment, there is general agreement that higher stocks-to-use ratios are associated with more comfortable market situations while low rates can be an indicator of market risk (Greb and Prakash, 2018).

Some have argued that stocks-to-use ratios might be less meaningful at the global level as they also reflect reserves held by countries that will not release them into international markets. The large grain stocks of China, for example, are first and foremost intended for domestic consumption, so including them in an analysis of global supplies might be misleading. Against this background, some analysts have proposed the stocks-to-disappearance ratio as a more adequate measure, which is defined as the sum of ending stocks held by major exporters divided by these countries' domestic utilization and exports.

Figure 3a: International wheat price and global stocks-to-use ratios

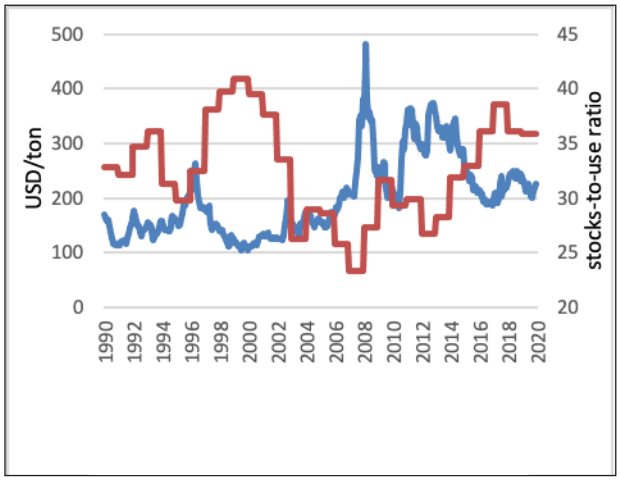


Figure 3b: International wheat price and global stocks-to-use ratios

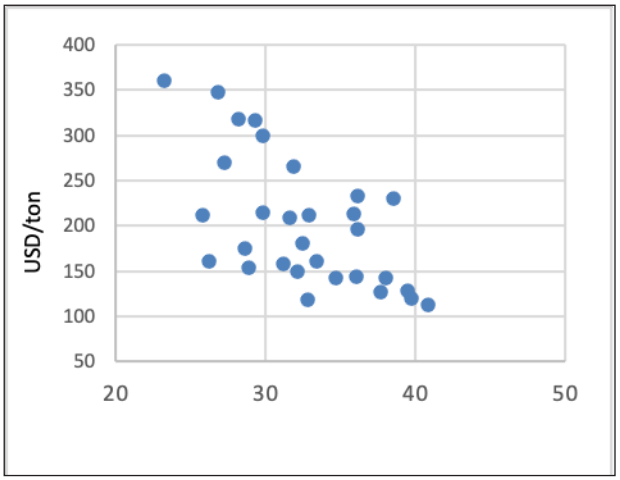


Figure 4a: International maize prices and global stocks-to-use ratios

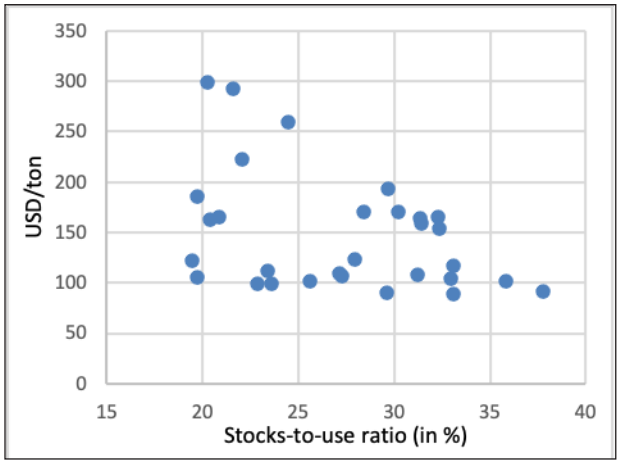


Figure 4b: Correlation between stocks-to-use ratios and average annual prices (maize)

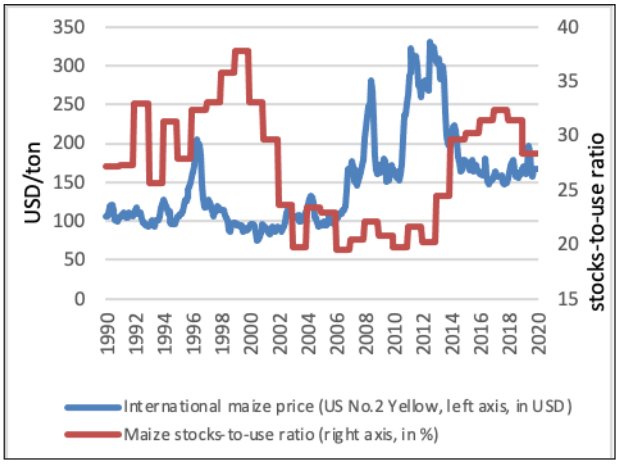


Figure 5a: International rice price and global stocks-to-use ratios

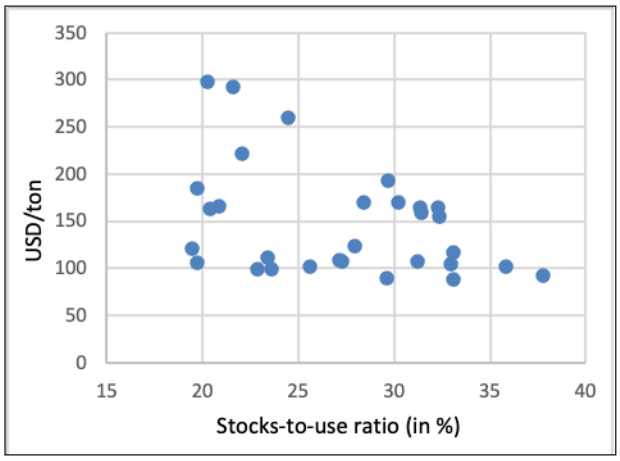
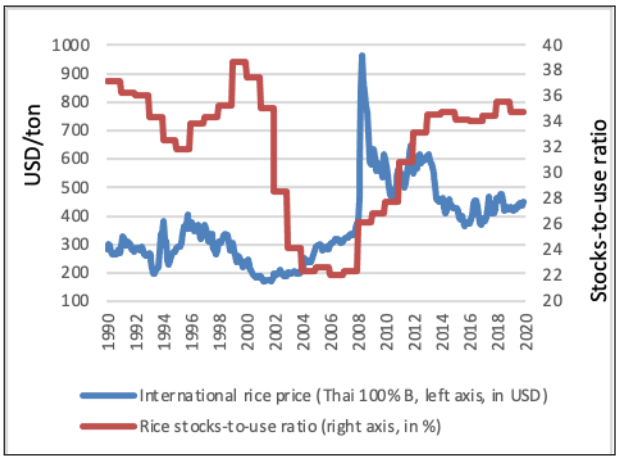


Figure 5b: Correlation between stocks-to-use ratios and average annual prices (rice)



Stocks can represent additional demand or additional supply, depending on whether current demand exceeds or falls below production. Assuming that the interplay between supply and demand is correctly reflected in prices, stocks can have a smoothening effect on markets as there will be an incentive to build reserves when prices are low and to release them when prices are high, especially for private stockholders. The "supply of storage model" extends this analysis to future periods by considering the expectation of prices in the next season. An economic actor will add to storage until current prices plus costs of storage equals the expected value of prices in the next period.

Empirical analyses provide some support for the negative relationship between stocks-to-use ratios and prices, keeping in mind the difficulties to correctly measure reserves. Available data for main food commodities suggest that periods of high prices coincide with low stocks-to-use ratios, while high stocks-to-use ratios are mostly associated with low prices. As indicated in Figures 3a-5a, the food price spike in 2007/08 (and for some commodities also 2010/11) occurred while stocks were relative low compared to consumption. By contrast, the high stocks-to-use ratios observed in the late 1990s/ early 2000s were accompanied by a period of relatively low and stable prices. However, low stocks-to-use ratios do not automatically signal a pending food price crisis (e.g. maize in 2003) while prices might continue to remain high and volatile although the stocks-to-use ratio has increased (e.g. rice in 2012).

While the relationship between stocks-to-use ratios and prices might not always be clear and can vary depending on the specific commodity and time period under consideration, simple regressions (Figure 3b-5b) generally confirm a downward sloping relationship between stock levels and prices. Specifically, all charts have empty space in the top right corner, suggesting that price hikes have not occurred during the observed period when the stocks-to-use ratio was high. The picture is less clear at the other end of the spectrum (i.e. the bottom left corner, which seems much more crowded), but even there the charts provide some evidence that low stocks-to-use ratios are usually associated with high rather than low prices. However, inferring any causality might be misleading as low prices could actually trigger the build-up of stocks while other external factor might equally be responsible for this correlation.

Concluding remarks

The storage of grain is important from a food security perspective as reserves provide a supply cushion in emergencies and influence food market dynamics by impacting key parameters such as prices. Grain stocks, especially measured against expected consumption, are therefore considered an important indicator to monitor global food security, which received renewed attention after the 2007/08 food price crisis and the market turbulences that followed. While the exact correlation between stocks and food price volatility is yet to be defined, there is broad consensus that low levels of stocks are usually associated with an increased market risk. In order to better understand the role of stocks in mitigating price volatility, improve early warning systems and support evidenced-based policy making, stocks data need to be collected more regularly and reported to the public. National statistical offices, in collaboration with international partners and initiatives such as the Agricultural Market Information System of the G20, should continue efforts to measure the size of reserves to help design more effective policies and strengthen global food security.

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