

Annex B

# Review of the responses to food production shocks



# Contents

Executive Summary	1
Introduction	3
Inherent systemic risk in global food production	3
How this report was prepared	4
Price shock event analysis	5
Summary	8
Price and export responses	9
Government/agency responses	9
Market responses	11
Consumer and farmer responses	11
Import responses	13
Government/agency responses	13
Consumer and farmer responses	14
Amplifying and mitigating factors	16
Political trends	16
Economic / financial trends	19
Social trends	21
Environmental trends	24
Infrastructure and technology trends	26
Discussion	28
References	29

This report originates from a Taskforce of academics, industry and policy experts to examine the resilience of the global food system to extreme weather events. The Taskforce was brought together by the UK's Global Food Security programme and was jointly commissioned by the UK Foreign and Commonwealth Office and UK Government Science and Innovation Network. This Review of the responses to food production shocks sits in the context of two other detailed reports on Climate and global production shocks and Country level impacts of global grain production. There is also an overall Extreme weather and resilience of the global food system summary report.

This report brings together quantitative and qualitative evidence on the possible responses to food production shocks. It is a summary of data analysis, literature review and expert interviews. Dr Aled Jones undertook the quantitative assessment and literature review. The qualitative analysis, led by Dr Bradley Hiller, centred on a set of semi-structured interviews with a key set (approximately 40 individuals) of stakeholders. An initial list of stakeholders was identified through members of the UK-US Taskforce and a snowball process was followed (each stakeholder asked to recommend a further 2 people to interview). The preparation of materials for this report was supported by a grant from the UK Foreign & Commonwealth Office.

## Authors

The following are the lead authors for this report:

Dr Aled Jones (Global Sustainability Institute,  
Anglia Ruskin University, UK)

Dr Bradley Hiller (Global Sustainability Institute,  
Anglia Ruskin University, UK)

Electronic versions of the report series may be found at the addresses below:

**Extreme weather and resilience of the global food system summary report**  
[www.foodsecurity.ac.uk/assets/pdfs/extreme-weather-resilience-of-global-food-system.pdf](http://www.foodsecurity.ac.uk/assets/pdfs/extreme-weather-resilience-of-global-food-system.pdf)

**Climate and Global Crop Production Shocks**  
[www.foodsecurity.ac.uk/assets/pdfs/climate-and-global-crop-production-shocks.pdf](http://www.foodsecurity.ac.uk/assets/pdfs/climate-and-global-crop-production-shocks.pdf)

**Review of the responses to food production shocks**  
[www.foodsecurity.ac.uk/assets/pdfs/review-of-responses-to-food-production-shocks.pdf](http://www.foodsecurity.ac.uk/assets/pdfs/review-of-responses-to-food-production-shocks.pdf)

**Country level impacts of Global Production Shocks**  
[www.foodsecurity.ac.uk/assets/pdfs/country-impacts-of-global-grain-production-shocks.pdf](http://www.foodsecurity.ac.uk/assets/pdfs/country-impacts-of-global-grain-production-shocks.pdf)



# Executive summary

## Responses to global food production shocks

There is inherent systemic risk in the global food production system. Over the last century there have been several food production shocks that have seen 10 % of individual grains lost in a single year. These production shocks often, but not always, lead to policy responses, export or import shocks and price shocks.

A physical shock can often be the trigger for a much larger market shock especially when there are other issues that increase the size of the shock, such as export restrictions, re-stocking (demand increase) of low stocks, biofuel policy/growth and a devalued US dollar.

Individual grain prices have more than doubled in a relatively short space of time during some of the past shocks.

While governments around the world are implementing strategic responses to better manage food production, in particular following food shocks in the past decade, these responses have not (yet) created a resilient food system.

Developing a better understanding of potential responses is important if the worst impact of future production shocks are to be avoided.

There are two main agents whose responses determine the short term impact of these shocks – the market and governments. Other actors include farmers, private sector, consumers and relief agencies. As the main traded grains; wheat, maize and soybean production shocks are key drivers of overall food price shocks. However, a production shock in rice can more easily deliver a global price shock because it is thinly traded.

Therefore, we wish to capture potential market and government responses to food production shocks in wheat, maize, soybean and rice. This report is a summary of data analysis, literature review and expert interviews and lists those potential responses.

We categorise possible short term responses as either price and export responses or import responses. In addition we include various amplifying factors that over the medium term could make these short term responses more or less likely to occur or will alter the impact on market dynamics, prices and the availability of food.

## Price and export responses

A production shock can become a global supply shock if trade and export restrictions result. Export responses and price changes are intrinsically linked – price changes are a signal that something has happened in the supply system. There are many possible responses that either mitigate or amplify a price shock, including:

- **Government/agency responses**, such as export restrictions, oil price responses, drawing down on stockpiles, contract defaults and preferential trade agreements.
- **Market responses**, such as inter-grain correlation, large agribusiness coordination and speculation on food commodity markets.
- **Consumer and farmer responses**, such as offsets through geographic diversity, increased production areas, differential and insulated prices and black market exchange rates.

## Import responses

Import capability is dependent on institutional arrangements and physical infrastructure. Such factors can reinforce each other with regard to import capability challenges. There are many import responses that may either mitigate or amplify a shock, including:

- **Government/agency responses**, which can include:
  - o Panic buying;
  - o Financial capacity limitations;
  - o Changing strategic import arrangements;
  - o Relaxing self-imposed import restrictions;
  - o Implementing / altering import subsidies;
  - o International food aid relief;
  - o Importing countries becoming temporary traders;
  - o Unpredictable responses from large state actors;
  - o Awareness of potential ‘domino effects’; and
- **Consumer and farmer responses**, such as:
  - o Consumers temporarily changing habits;
  - o Domestic actors distorting the effectiveness of responses;
  - o Civil unrest.

## Amplifying and mitigating factors

In addition to short term export and import responses there are a number additional factors that act over a longer term that can amplify or mitigate the impact of a production shock. These factors have been broadly classified as:

- **Political trends**, at the international (e.g. G20 and World Trade Organisation), regional (e.g. integrated food stocks and trade agreements) and national levels (e.g. self sufficiency versus free trade pathways);
- **Economic / financial trends**, such as deflation of the US dollar, imperfect markets, and inelasticity of food prices to supply and demand shocks;
- **Social trends**, from urbanization and dietary changes to inequality between and within countries, and changing gender roles;
- **Environmental trends**, from macro climate change and resource scarcity issues to legislation changes and pests / diseases risks; and
- **Infrastructure trends**, critical infrastructure for export and import.

## Key recommendations

During the interviews the following were recommended as possible routes to mitigate the impacts of production shocks:

- **National governments should act to protect or stabilise agri-food markets.** There are many cases, including typically market focussed governments (e.g. USA), that have intervened in food markets.

- There is a need to **improve the availability and access to accurate information for all stakeholders**. Asymmetric information is problematic and can lead to inefficient market responses, speculation, panic buying, etc. Information sharing can help to mitigate or minimise the impacts of shocks. There is a need for much more effective and specific climate weather trends with the food system in mind.
- **Early warning systems are needed** to transfer information to other producers when there is a shock somewhere, so that those producers have time to adjust their own crop plantings.
- **Risk assessments** which develop international, regional and national agreements around agri-food production risks are required. These should be region specific and food specific. UK and USA could do more to survey the global agri-food situation.
- **Scenario modelling** is required to help inform decision- and policy-makers. These models may need to be developed to be bespoke for temperate and tropical challenges and incorporate social resilience components.
- **A holistic international framework and guide** is needed to help coordinate national processes. Help is also needed for national government agencies to come together and global organisations, such as the World Bank, could help increase resiliency of the agri-food system.
- There is a need to **accept that mitigation policies are not working effectively** and that we need to adapt. Governments and businesses need to prepare people for not being able to eat certain crops or products anymore.
- **Agricultural insurance options need to be redesigned** to be more helpful for farmers.
- Rather than measuring annual production figures, some respondents recommended **measuring and monitoring stock-to-use ratios** as a more relevant indicator of vulnerability to shocks.
- **Global food emergency reserves need to be large enough to be of assistance**. Emergency rice reserves are available now, at a regional level in East Asia, however it could be possible to encourage a global, regional, national and household reserve hierarchy system.



T. Krupnik/CIMMYT

# Introduction

- 1.1 Market and government responses to food production shocks are complex (Evans, 2009, Timmer 2010, Trostle, 2008; Headey and Fan, 2010; Abbott, Hurt and Tyner, 2011; Headey, 2011; Jayasuriya, Mudbhary and Broca, 2012; Baffes and Dennis, 2013; Tadesse *et al.*, 2014; Lagi *et al.*, 2011; Mitchell, 2008; McCalla, 2009; McPhail, Du and Muhammad, 2012; Coulibaly, 2013; Götz, Glauben and Brümmer, 2013; Sarris, 2013; Hochman *et al.*, 2014) and not well quantified. In addition, the interconnected nature of inter-country food dependence has increased dramatically over the last few decades (D'Odorico *et al.*, 2014). Headey and Fan (2010) examined the many possible causes of the 2008 crisis and highlighted that food commodity prices operate in a complex global system yet remain broadly consistent with market fundamentals whereby price is driven by interactions of supply and demand. However, others consider that supply-demand interaction cannot fully explain the price spikes of events such as in 2008 (Tadesse *et al.*, 2013). Natalini *et al.* (2015) explore the possible links of these price spikes to food riots.
- 1.2 What emerges from across the literature is that no one cause can be attributed solely to past changes in food prices.
- 1.3 There are two main broad types of agents who determine the short term impacts of large scale food production shocks:
  - *The market* - is the first respondent, via price signals which are driven by various actors (outlined below); and
  - *The policy respondents* – governments and agencies and specifically those who control export / import and food stock policies.
- 1.4 Other agents considered important in determining the short term impacts of large scale shocks include:
  - *Farmers/farmer groups in unaffected areas* (farmers in one hemisphere can change crop plantings / timings depending on market signals caused by production shocks)
  - *Private sector actors* (e.g. national and international commodity trading companies, private sector consumers such as agriculture / seed companies, livestock feeders, food and beverage / supermarket chains, manufacturers, importers / exporters, speculators, 'middle men') and/or state-owned grain enterprises (depending on the country)
  - *Stakeholders suffering from immediate shortages* (this could be farmers / consumers in shock affected areas or consumers in importing countries, and their response may include protesting, unrest, etc. Household consumers affected by shortages and/or price increases may alter purchasing preferences based on market availability / prices)
  - *Media* (reporting of shocks can influence the responses of consumers and governments, and increasingly so as information technology becomes more accessible)
  - *Relief agencies* (e.g. World Food Programme, FAO, multilateral agencies, ICRC, DEC, bilateral agencies particularly for shocks in developing / emerging economies. Research institutions and sub-regional bodies play an important role in building longer term capacities).

## Inherent systemic risk in global food production

- 1.5 There is inherent systemic risk in the global food production system - what happens in one part of the world can severely affect other parts of the world. The main actors are those directly affected by the shock and those who take action in response to the shock. Who those actors are will depend on the geographical location of the events, the crops affected and the customers / consumers of those crops. The most vulnerable regions to impacts in the agri-food production system, irrespective of the location of the extreme events, are considered to be the Middle Eastern and Northern African (MENA) and the sub-Saharan African countries. Marginal smallholders may be the most severely affected by shock events.
- 1.6 The main actors that would determine the short term impacts of large scale food production shocks are considered to vary by country and region. For example, in some countries, government intervention may be the main determining factor, while in other countries the market determines the impacts. Government preparedness and willingness to act during a shock event are important factors in determining the severity and extent of impact. Shocks at the global level can be minimised, delayed or avoided (or alternatively exacerbated and accelerated) by various government actions. On one hand, unpredictable actions / interferences by governments tend to upset private sector functioning and on the other, governments need to make appeals to donors / aid agencies to receive food assistance, so governments, particularly in developing and emerging economies, have a critical role to make those requests in timely manners. As a country, the United States is generally considered to be the most important exporting nation – its policies are considered to dominate trade in the key agri-food commodities. However, the United States is also a good example of a government that is subject to severe political pressures / lobbying in response to shocks from different interest groups from inside and outside the agri-food production sector (e.g. biofuel industry, maintaining more general free trade agreements, energy sector, livestock production sector, etc.). In contrast, for importing countries, the determining factor in responding to a shock may be the affordability of staple agri-food commodities and the ability of individual national governments to pay increased prices during such events.
- 1.7 Different factors affect the impact of a food production shock in different countries and markets. For example, while farmers in affected areas may have little opportunity for immediate response, individual actions from farmers in one hemisphere responding to shocks in the other hemisphere by altering their planting arrangements / schedules in response to (anticipated) market demands, as well as consumers adjusting their diet, can be important respondents. Traders may be able to influence upstream supply availability (directly in agri-food and also in livestock sector), while speculators and those able to make money through activities such as hedging are also deemed to play a role. Traders (e.g. merchants as middle men) are responsible for trading through ports and out to demand centres, hence these actors can help determine levels of hoarding and



speculation. While in many countries these may be private companies, in some countries (e.g. Yemen) oligarchical family groups control grain trade and in others (e.g. China) state-owned grain enterprises are the main actors. Relief agencies, such as the World Food Programme (WFP) coordinate crisis responses to fill food gaps, with governments also playing important roles in food aid, either in allowing food aid in or providing food aid to others during crises. In terms of building longer term resiliency, multi- / bi-lateral agencies, research organisations and sub-regional bodies can play important roles in improving on-farm resiliency through improved seed types, management techniques, training, information dissemination, etc.

- 1.8 The specific type of extreme weather event / shock will influence how impactful it is and who and how actors respond. For example, immediate and unpredictable events such as hurricanes or tsunamis can have acute impacts on crop production and major infrastructure. Such events are applicable mostly to coastal countries / regions. In contrast, more predictable and slow onset events such as droughts may allow time for preparation but endure for longer periods. Such events can affect both landlocked areas and countries with coastal access. Hence, both acute and more chronic extreme weather events pose varying challenges for exporting and importing nations. Furthermore, conflict events also pose significant risks for all countries and can be pervasive, long-term and can spread and create uncertainty in other locations, both local and more distant.

- 1.9 While compiling this report some interviewees took issue with the idea of a singular global food security, and instead drew attention to the granularity of food securities (plural) which differ greatly at local levels. Some pointed out that only 15 percent of globally produced crops are traded and hence the majority of production is consumed in country. The differences in food production systems and their connection or disconnection to global markets makes food securities highly variable. When addressing food security concerns, resolutions and local contexts are critical.



Thinkstock (2014)

### How this report was prepared

- 1.10 This report is a summary of data analysis, literature review and expert interviews (see Appendix G for list of interviews completed) on potential market and government responses to food production shocks. It is divided into several chapters. A price shock event analysis is presented in Chapter 2 which looks at past food production, export and price shocks and explores the temporal link between these. Chapter 3 then explores potential price and export responses. We then present possible import responses (Chapter 4) followed by several medium to long term trends that are considered potential amplifying (or mitigating) factors (Chapter 5). Finally a broad discussion and brief conclusion (Chapter 6) is presented. The appendices include the data from the last 80 years of food production, exports and prices for the 4 main grains (which was used to inform the discussion), as well as information on the status of World Trade Organisation negotiations and a summary of an investor workshop held in London in February 2015.

# Price shock event analysis

- 2.1 Here we examine past price shock events and look at whether there were production or export shocks that triggered these events. We explore events where price increases were more than double previous trends for wheat, maize and soybean. As rice is not a major exported commodity and is predominantly used in the country of production (China and India), rice is not included in detail here<sup>1</sup>. All figures quoted are rounded to make calculations simpler.
- 2.2 Figure 1 shows the deflated food prices, using the Food and Agriculture Organisation (FAO) Food Price Index<sup>2</sup>, over the past 50 years. There is a general downwards trend however it is also noted that under 'normal' conditions food prices are fairly stable.
- 2.3 Cereals follow a similar pattern to the overall Food Price Index (Figure 2) over this period however cereal extremes and volatility are larger. FAO cereals price extremes (90-100 % increase) are approximately 20 % larger than general food price index extremes as measured by the FAO food price index (75 % increase) between February 2007 and February 2008.

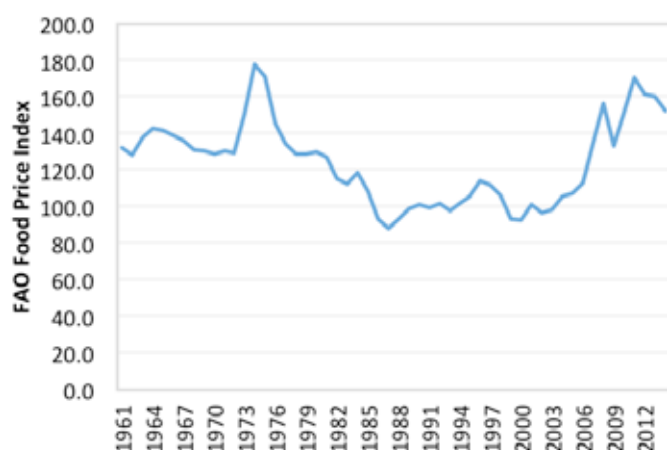


Figure 1: FAO Food Price index (annual deflated - cereals) - shocks in 1973 (40 % increase) and post 2006 (50 % -60 % increase although peak was the same as that in 1973 shock).

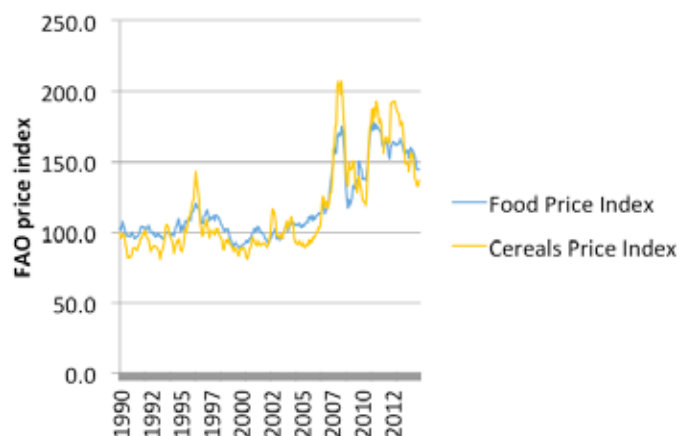


Figure 2: FAO cereal price index and food price index (monthly deflated) from 1990 onwards.

- 2.4 Individual grains show even more volatility and extreme responses with each experiencing an almost doubling in annual deflated prices (Figure 3) during the major shock events. However, it is clear that while the volatility of individual grains varies the macro-shock events are highly correlated in this period. Monthly grain price shocks (see Appendices A-C) are more extreme with wheat, maize and soybean all experiencing a 200 % increase in price over a similar period. Rice price shocks (Appendix D) are larger.

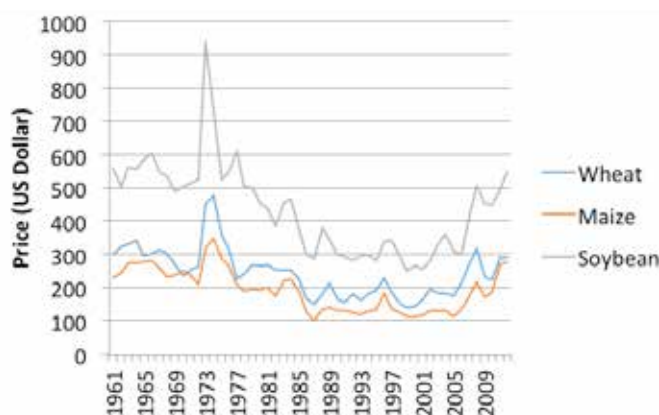
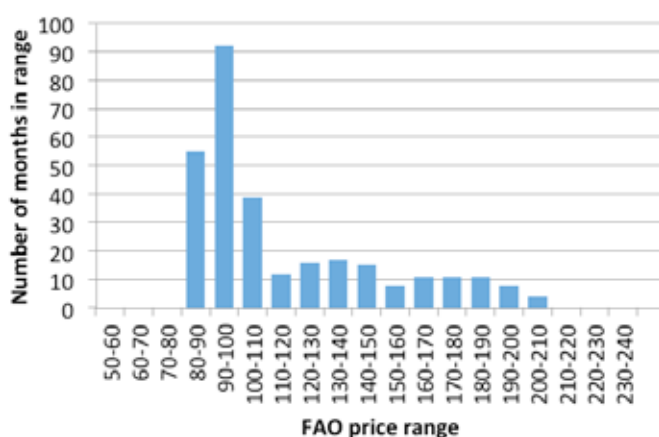


Figure 3: World Bank (annual deflated) prices for wheat, maize and soybean showing the high degree of correlation between the grains.

- 2.5 As can be seen when not in a shock event prices for the food index, cereal index or individual grains are all fairly stable.
- 2.6 The distribution of prices over months (Figure 4) shows a normal distribution for prices around this stable regime. This stable state has an FAO Food Price Index variability between 80 and 110. During shock events food prices rapidly increase away from this distribution and a long tail of high prices is seen



- 1 However, some reference to rice trade is made in other sections of this report where interviewees provided illustrative examples relevant to wheat, maize and soybean markets.
- 2 The FAO Food Price Index is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices, weighted with the average export shares of each of the groups for 2002-2004.

2.7 The drivers for these price shocks are complex and many. Each individual grain experienced price shocks that were sometimes, but not always, accompanied by price shocks in other grains.

2.8 Price shocks were experienced for each grain in the following years. The percentage calculations are approximate from the previous 5 years of baseline.

- Wheat shocks in 1973 (150%), 1979 (150%), 1988 (50%), 1991 (50%), 1996 (100%), 2008 (150%)
- Maize shocks in 1973 (150%), 1980 (100%), 1983 (100%), 1988 (100%), 1996 (150%), 2008 (250%)
- Soybean shocks in 1973 (200%), 1977 (200%), 1980 (100%), 1983 (100%), 1988 (100%), 1995 (50%), 2003 (100%), 2008 (200%)
- Rice shocks in 1989 (200%), 1994 (150%), 1996 (150%), 2004 (200%), 2008 (150%)

2.9 In general the main factors that determine the prices for each crop (see Appendices A-D) are:

- Rice – China/India for production shocks although thinly traded so smaller producers (Thailand, Vietnam) key for price. Export market becomes more important after 1982 (Thailand) and 1989 (Vietnam). Less than 10% of global production is exported
- Maize – US dominant (then China). Significant increase in exports (US) from 1973-1980
- Soybean – US, Brazil and Argentina. Brazil starts to export from 1997 onwards
- Wheat – much more diverse – USSR (Russia/Ukraine), China, India, USA, EU (Germany/France), Australia, Canada.

2.10 It should be noted that grain stocks were historically low (below 80 days of consumption) in 1965, 1970-1975 and 2003-2008.

2.11 A summary of the major global shock events from 1973 up until 2012 is provided below.

## 1973-1975

150% wheat price shock (1973-1974)  
200% soybean price shock (1973-1974)  
150% maize price shock (1973-1974)  
40% annual deflated price shock on FAO food price index.

### Wheat

- 1973 17% increase in global wheat exports mainly from the USA which reflects a global increase in demand
- 1975 wheat production shocks in USSR (30% loss) following a smaller but significant loss in 1972 – (10% global loss)
- Average 3 year global wheat production dipped below trend line in 1974 (6% below in total).

### Maize

- 1974 maize production shock equal to 7% global production loss (15% USA loss)
- 1973 US starts to increase significantly its export of maize (until 1980).

### Soybean

- 1974 soybean production shock equal to 10% global production loss (20% USA loss)
- The United States imposed an export ban on soybean, upon which Japan was totally dependent. This resulted in Japan investing in Brazilian soybean.

### Key issues:

- World grain stocks at historic low levels (below 80 days of consumption) 1970-1975
- Oil embargo and oil price shock 1973
- Exchange rate considered a driver of commodity price movements.

## 1977-1980

150% wheat price shock in 1979  
100% maize price shock in 1980  
Soybean price shocks in 1977 (200%), 1980 (100%)  
No overall food price shock.

### Key issues:

- Preceded by 1977 – Minor shocks in USSR and China (smaller shock in USA) wheat production. Cumulative mean dipped below trend line in 1977 for wheat production
- Soybean production shock 1980 – USA
- US growth in maize export stops in 1980 (this could mean maize price increase was due to a larger demand for US maize or a supply shock due to expectations of lower export from the US)
- Second (larger) oil price shock coincides (1979)
- Exchange rate considered a driver of commodity price movements.

## 1983

100% maize price shock  
100% soybean price shock  
No overall food price shock

### Key issues:

- USA production shock (25% soybean and almost 50% of maize) (10% global loss of both – no loss in wheat)
- USA exports peaked for both maize and soybean in 1982 with a significant drop following over the next couple of years.



## 1988

100 % maize price shock  
100 % soybean price shock  
No overall food price shock

### Key issues:

- USA production shock in maize (45 % drop) and minor shock in China (10 % global drop)
- USA production shock in soybean (25 % drop) (10 % global drop)
- USA export drop in 1989 for soybean to a medium term low
- 14 % increase in wheat exports but no production shock (previous 2 years were a significant production shock in the US).

## 1996

100 % wheat price shock  
150 % maize price shock  
10 % annual food price index shock, 35 % monthly increase

### Key issues:

- 5 % global maize shock in 1995 (mainly US) leading to lower stock availability in 1996
- 3 % global wheat shocks in 1994 and 1995 (mainly USSR) leading to lower stock availability in 1996 (US stocks at historic low)
- USSR wheat production 20 % lower between 1993-95
- USA export shock in 1997 for maize
- This period coincided with a severe dry spell in south-east Asia. This induced export restrictions from many south-east Asian countries as they put domestic consumption ahead of exports.

## 2003

100 % soybean price shock  
No overall food price shock

### Key issues:

- 15 % production shock in the US soybean (4 % global shock).

## 2007-08

150 % wheat price shock  
250 % maize price shock  
200 % soybean price shock  
Overall FAO food price shock of 50 % annual increase, 100 % monthly increase.

### Key issues:

- 2000-2004 saw almost 20 % production loss in China wheat over business as usual and a shock in USSR in 2003 leading to cumulative negative 'shock' in 2007
- 2008 saw a 50 % loss in export from Australia. This follows a near 80 % reduction in Ukraine exports in 2007 (although a similar reduction in Russia is not seen – Ukraine implemented an export ban that year).
- Global wheat production down by 5 % in 2002, 2003 and 2007
- Between 2000 and 2007 China stocks reduce by more than half (60 %)
- No production impacts in rice (but export restrictions in place driven by speculation and hoarding).
- World grain stocks at historic low levels (below 80 days of consumption) 2003-2008
- In India, a country somewhat insulated from global price fluctuations, there were delayed price increases in domestic commodity prices. However, India did ban exports in response to global crisis
- Some interviewees referred to speculators playing a major role (through information asymmetry) in contributing to price increases which were not a reflection of reality. Hoarding was also reported to occur in some areas.

## 2012

Maize and soybean price shocks marginally larger than 2008 – volatility remains in all grains.

### Key issues:

- Maize production shock in USA
- Soybean production shock in Brazil, Argentina and USA
- Pressure on United States government to waive ethanol mandate but they did not, thereby contributing to price rise by 'responding by omission rather than commission'. The United States ethanol mandate is considered by some respondents as a quasi-export control.

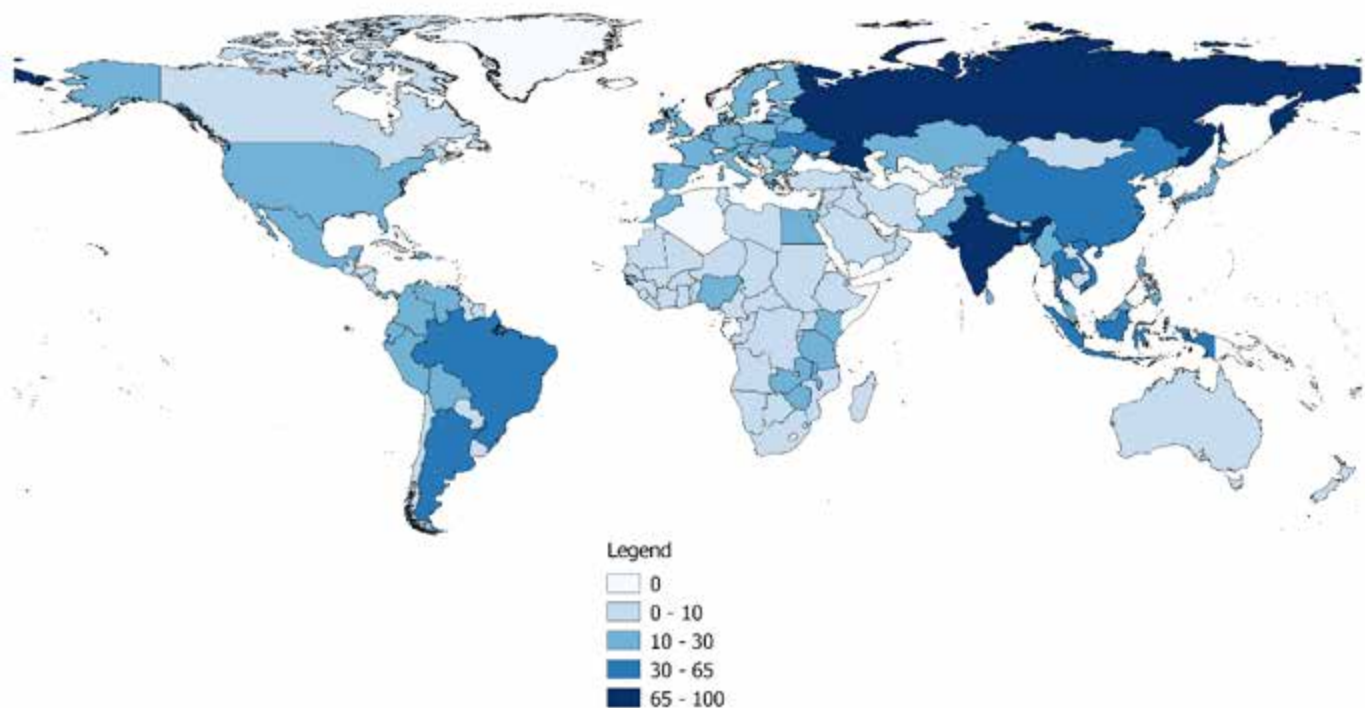


Figure 5: Consequences of the 2008 food price shock showing total number of policy responses including export and import restrictions between 2008 and 2014 by country. Source: World Bank Food Price Crisis Observatory [accessed 28 April 2015].

### Summary

- 2.12 From the past events outlined above it is clear that food price shock events are not rare. Indeed major shock events across multiple grains have caused significant increases in food prices during the 1970s and over the last decade.
- 2.13 The causes of these price shock events can often be linked back to underlying production shocks. However, the production shocks are always accompanied by policy responses which make predicting the scale of a price shock difficult.
- 2.14 Figure 5 illustrates the consequences of the 2008 food crisis in terms of the number of policy responses including export restrictions/bans, import restrictions and changes in subsidies or taxation. These policy responses include new policies introduced and temporary (or permanent) removal of policies.
- 2.15 Food prices are yet to recover to their pre-shock level following the most recent food price shock. A key issue is whether the current food production system, international trade, global political tensions and climate change make these types of events more likely or make the price shocks larger in future.

# Price and export responses

- 3.1 A production shock becomes a global supply shock if trade and export restrictions result (Headey and Fan, 2010, Headey, 2011). Export responses and price changes are intrinsically linked – price changes are a signal that something has happened in the supply system. The following summarises literature and interview respondent views on plausible market and government responses to food production shocks.

## Government/agency responses

### Export restrictions

- 3.2 Export restrictions are political responses. If an exporting government perceives food shortages or price rises (or volatility), they may impose export restrictions (and even complete bans) or enforce technical barriers (such as customs procedures including quality monitoring or other restrictions that reduce export potential – for example, loading of rail in Russia). Supply shocks from export restrictions are particularly clear in rice which is thinly traded. Export restrictions on rice have been put in place in the past in the absence of a production shock (when governments were nervous about supply – possibly because of a production shock in another grain – or when they wanted to re-stock reserves).
- 3.3 However, only some governments have recently imposed export restrictions. This is related to the internal political situation - some governments are more interventionist than others. For example, agricultural markets in Russia, India, China and Vietnam are controlled by the state or state-owned enterprises, whereas private sector actors play a more significant role in countries such as the United States and New Zealand. The United States has not issued an outright export ban since the 1970's. In such cases, while it may ultimately be the government's decision not to impose export restrictions, lobby groups can significantly influence government decision-making. For example, there will be political pressure to protect domestic interests (e.g. livestock industry, biofuel industry, farmers) and also restrictions may keep food prices low and therefore voters happy. Such reasons for restrictions are witnessed in countries such as Argentina (regularly), Thailand (in 2008) and Vietnam has considered it.
- 3.4 Notably, while countries such as the United States have chosen not to impose export restrictions explicitly (since the 1970s), they can use other means to protect their farmers and domestic markets as necessary. For example, they can cap exports of commodities for different purposes e.g. maize has many uses and its export for certain purposes could potentially be capped. The United States can also restrict exports in the maize sector indirectly by giving preference to biofuels. Taxes could also be levied at national borders (some developing countries regularly do this), but in the United States this could be politically difficult given the current institutional and legal structures and the dominant role of market players. In other countries domestic prices are kept higher than global export prices to encourage domestic markets to be satisfied first. This approach is adopted in China, which maintains a high domestic price and high domestic production levels.
- 3.5 When a country imposes export restrictions (ban), too much production in that country can lead to significant price drops. Hence, farmers in the country experiencing an export ban often suffer significant losses. However, long term export bans may stabilize domestic food prices in the country where they are imposed and may stabilize domestic production levels. Additionally, countries such as Tanzania have been raising the prices of their exports. Whilst this is politically motivated and related to national food security concerns, it has raised the floor price of exports of commodities from that country for importers such as the European Union.
- 3.6 While interviewees often stated that export restrictions are not recommended from a market function and efficiency point of view, some referred to evidence suggesting that countries that do restrict exports can benefit, at least initially, particularly in averting the worst effects of a crisis. Furthermore, some supporters argue that current food security and agricultural policies are not respecting populations worldwide equally and that under such conditions export restrictions may be highly justifiable. However, the dynamic impact of export restrictions can lead to other longer term challenges, for example export bans and lower domestic prices can lead to farmers planting less in successive years.
- 3.7 The following export restrictions were highlighted during interviews:
- Wheat export restrictions: (i) Russia 2010 and the Arab Spring occurring one year. The Russian export ban was considered one of multiple factors contributing to this, with high levels of discontent and low levels of governmental trust existing. Russia did not impose export ban in 2012 under similar circumstances – perhaps learnt from 2010 consequences of ban and/or changed trade approach; (ii) Ukraine 2007/08.
  - Soybean export restrictions: (i) USA in 1970s; (ii) Argentina in 2010.
  - Rice export restrictions: Thailand / Vietnam in 2007/08.
  - In 2007 / 08, a quarter of exporting countries globally reportedly issued export restrictions.
  - India issued an export ban in 2008.
- 3.8 Changes to export policy can be used to dampen a food production impact. For example Japan announced in May 2008 that it would allow the export of rice (following an earlier ban which contributed to rising prices) following an increase in production (Headey, 2011). However it has reported that it did not increase exports subsequently but this announcement may have contributed to lowering rice prices. An example of rice trade response to the 2007/08 crisis is outlined in Box 1.



## BOX 1

### Export restrictions and consequences: A rice case study

Some interviewees described export restrictions for rice as an example of a poorly functioning trade market. Rice is a thinly traded agri-food commodity and export restrictions / embargoes imposed by India and Vietnam compounded a 2007/08 crisis situation. A paper by Paul Durosh on price stabilization and price shocks illustrates counterproductive actions that occurred. Some of the decisions were seen as being more political than based on accurate information.

During the crisis, it quickly became evident that rice is not a globally traded commodity and is effectively unavailable for import from outside the Asia region. In response to the crisis, and associated market failures, countries such as Brunei, Malaysia, Indonesia and others want to establish rice self-sufficiency. This response is justified relative to what occurred, but market theory doesn't suggest that is a good idea necessarily. Singapore is seen to be a good model in the region, where it does stockpile some rice but it does not destroy markets in its actions during a shock event.

In the fallout, a regional stockpiling system may be pursued to protect against similar crisis events and ineffective responses.

### Oil price response

- 3.9 Oil is currently the main fuel used globally for transport and production. While higher oil prices increase the cost of agricultural production (see 'Amplifying factors') there is some evidence that when a food production shock led to a food price increase in the early 1970s the OPEC countries started to restrict oil supply to ensure that they increased their income and therefore safeguarded their ability to purchase food on international markets. Today, countries such as Pakistan, Nigeria, Egypt, Mexico, Iran and others – all of which may be regarded to be at least partly fragile politically and comprising large populations – are dependent on oil prices (either for export income and/or for importing the majority of their food stocks).
- 3.10 Seen from another perspective, India purportedly spends half of its overall export earnings on the import of fuels (oil, gas, etc.) to transport commodities from inland areas to port facilities for export. These huge transportation distances and costs are part of the reason why India has a low incentive for export and also why it may have an incentive to become self-sufficient with regards to food, since importing and distributing to demand centres is very costly.

### Drawing down on stockpiles

- 3.11 If an exporting country suffers from a shock event, that country may have a stockpile of products that it can draw down on to maintain its export output. In this case, the exporting country may be able to maintain its contractual relationships with

importing partners whilst also providing product for its domestic consumers throughout the shock event. Alternatively, there may be consequences for countries that default on their export commitments, i.e. subsequent financial repercussions.

- 3.12 Many respondents believe that globally traded commodity prices will always increase in response to a major shock to production for export. Some estimated that the price of some commodities would increase 50-100% if a 20% reduction in globally traded stock occurred. However, a major factor influencing the magnitude of the rise would be the state of world stocks at the time of the shock. If world stocks are high, then the magnitude of increase would be less. If world stocks are low, then the magnitude of increase would be higher. This also suggests that if multiple shocks occur, lowering world stocks in the process and not giving them time to rebound, then price increases (and associated challenges) may continue to increase each successive event. For example, a 2012 drought in the USA forced (domestic and export) maize prices to increase 50% because no stocks were on hand. The increased price of maize then also increased the price of wheat in the USA as well (soybean has more diversified source countries, so price increase was not so great due to the USA loss in production).

### Contract defaults

- 3.13 Governments can dishonour locked-in contracts. For example, interviewees reported a case where China did not honour a locked-in contract with Brazil on soybean importation as market prices changed. Instead, China bought from Argentina, saving ~US\$1 billion.

### Preferential trade arrangements

- 3.14 Free Trade Agreements (FTAs) between major exporting and importing countries have the potential to sideline poor countries. Even in cases where such poor countries have the capacity to pay, FTAs established between other parties may exclude them from accessing required products in a timely and affordable manner. For example, the United States could decide to supply agri-food commodities to China because of that country's significant market demand and its ability to reciprocate in trade of other goods that the United States wants to import. In contrast, countries in Africa are less able to reciprocate to the same degree and hence the United States could make a political decision not to trade agri-food commodities with them. Geopolitics and political posturing may play an important role in such decisions.
- 3.15 Conversely, FTAs may reduce the capacity of the exporting country to restrict trade and hence during crisis events there may be questions over if, when, where and how export restrictions may be implemented and the potential repercussions of such decisions domestically and internationally. For example, if the exporting country is affected by a shock, then the FTA partner importing country, which may be on the other side of the world, may also be negatively affected.

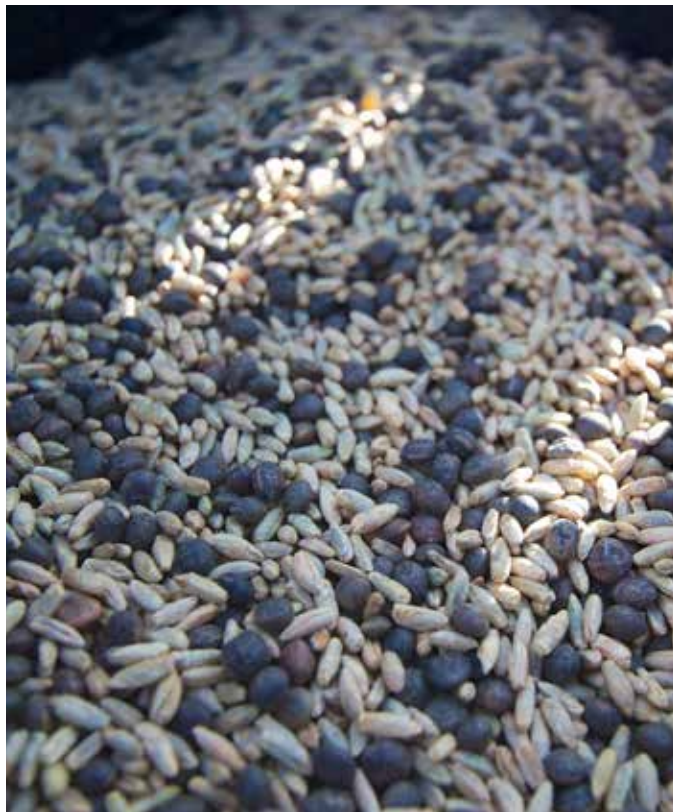
## Market responses

### Inter-grain correlation

3.16 There is some evidence (Heady, 2011) that restrictions in key grain exports can lead to sharp increases in demand for other grains. For example, maize and soybean often compete for land and hence see substitution of one crop by another when price spikes occur. This transforms price rises from one crop to another but may also smooth extreme price spikes as well – referred to as ‘substitution effect’. Heady (2011) describes an increased demand for maize (for example from biofuels) leading to a lower supply of soybean (due to land in the US being allocated to maize production over soybean) and a strong causal link between maize to soybean price shocks. Some interviewees suggested that while lower volumes of rice are traded globally, shocks to rice production may have elasticity effects on wheat and corn trade. If rice is not produced, then countries will ‘suck in’ crops that are traded. However, on the consumption side rice is not substituted for by other grains.

### Large agribusiness coordination

3.17 Agribusiness is dominated by a small number of influential actors, of which one benefit is the potential for coordinated and rapid response to shock events. If a shock occurs in one hemisphere, global agribusinesses are incentivized to offset losses in that hemisphere with increased production in the other hemisphere. Such companies may even maintain stockpiles for when prices rise and trade becomes more profitable. Measures such as these may go some way in helping to smooth the impacts of shock events.



### Speculation on food commodity markets

- 3.18 Financial speculation in food commodity (see Appendix F) and futures markets is of particular interest in academic discussions on the causes of food staple prices spikes (Timmer, 2010, Lagi et al., 2011; Tadesse et al., 2014) yet its influence remains controversial (Abbott, Hurt and Tyner, 2011). Increases in the futures markets for grains in 2008 and 2011 reflected market sentiment that prices would continue to rise, which ultimately turned out to be incorrect. Tadesse et al. (2014) details how futures traders can base decisions on past trends rather than new information on market fundamentals, making it harder to distinguish fundamental changes to price. Subsequent herd behaviour impedes speculators ability of price discovery. Even with the correct information on market fundamentals, traders may not intervene to correct prices where they stand to benefit from the resulting commodity bubble. Speculation can therefore amplify price increases. For example, World Bank estimates (Rob Townsend, Christoph Bardol) on the 2008 drought, reported that up to 30 percent price increases occurred based on anticipated fallout (from drought impacts and biofuel production on corn crops) rather than the shocks themselves.
- 3.19 Some interviewees stated that many consumers, particularly in developing countries, believe that when food prices go up that it is often due to speculative behaviour and/or cartel influence, particularly in rice consuming countries such as India and Bangladesh. Interviewees often felt that governments did not take this consumer perspective into account when devising or revising policies. Furthermore, elements of corruption and speculation were considered to occur at both national and local scales.
- 3.20 The magnitude of influence speculators have on prices varied among respondents – some felt that the evidence base for their role in price increases is low, while others felt that they were influential actors in price volatilities.

## Consumer and farmer responses

### Offsets through geographic diversity

3.21 A potential mitigating response has been proposed and modelled (see for example, Lybbert, Smith & Sumner, 2014). Here extreme weather impacts causing production losses in one hemisphere can be offset by farmers in the other hemisphere altering their land allocation for crop production for the subsequent harvest. This would allow a buffer to supply shocks resulting in shorter price shocks. However, Lybbert, Smith & Sumner show that the geographic spread of crops is not optimal for this buffering. While soybean production is evenly spread across the northern and southern hemispheres (although predominantly in the Americas) wheat is much more concentrated in the northern hemisphere. In addition, there is more flexibility in farmer response for soybean due to planting and harvesting times than there is for wheat. Lybbert, Smith & Sumner calculate that southern hemisphere shocks experienced over the last 30 years in wheat and soybean have increased the US monthly prices of those grains by 10%. These shocks

were of the order 1.2 % for global wheat production and 2.5 % for global soybean production. They estimate that half of the loss in soybean could be replaced by a change in US production in the following season, however this causes a similar loss in maize production (1.1 %). They do not model north to south responses and do not consider multi-breadbasket failures. The effectiveness of this strategy is dependent on strategies such as improved plant breeding (e.g. shorter harvest cycles), changes in planting strategies (e.g. increasing the density of plantings, planting on more marginal lands), and using more efficient and effective harvesting equipment.

#### **Increased production areas**

- 3.22 When shortages occur and prices increase, some forms of production, which otherwise would not be cost-effective under normal market conditions, become viable. For example, marginal lands may become cost-effective for production under increased commodity price conditions. Such additional products coming into the market can help to lessen the shock.
- 3.23 Additionally, farmers respond to higher prices of certain commodities by switching from their regular crops to the higher priced crops. This response to relative shortages and higher prices for certain commodities helps to smooth the impacts of shock events. Examples of farmers in Asia switching from sugar cane to maize in response to global trade shortages in maize are well documented.

#### **Differential and insulated price**

- 3.24 Some locations, such as smallholders and consumers in rural areas of Africa, may be largely insulated from global export shocks. Local prices for crops may often not be correlated with global food prices (due to factors such as poor market connection, inefficient transport systems, etc.). This can mean that rural producers in such areas may not benefit from higher international prices (although some opportunistic trading may still raise local prices). However, consumers in cities may be more closely linked to global food prices and hence pay higher prices.

#### **Black market exchange rates**

- 3.25 There have been cases in countries where there is a discrepancy between official exchange rates and black market exchange rates. For example in Argentina farmers opted not to sell their grain through official means and effectively this temporarily stopped exports. This is an example of a local economic anomaly potentially impacting global export markets.



# Import responses

- 4.1 Many factors can contribute to import capability challenges. In particular, import capability is dependent on institutional arrangements and physical infrastructure. For example, if a crisis occurs across a region, and effects both exporting and importing country ability to trade, the importing country may suffer more because (i) prices of grains will increase due to the export disruptions, (ii) importing country physical infrastructure would be effected and could cause delays in being able to import, and (iii) the cost of import and distribution internally would be higher.
- 4.2 In terms of major importing countries, many interviewees regarded China and India as potential 'elephants in the room' – they could quickly become major importers of key traded crops and place significant added pressure on the global market. However, there are a number of key import responses that are possible under varying scenarios.

## Government/agency responses

### *Panic buying*

- 4.3 Panic buying in the market may result when a major exporting country hints at (and/or implements) export restrictions. Panic buying by governments can lead to wider (global) impacts, as evidenced by panic buying by Egypt which led to ~10% price increase. Such panic buying responses have led recently to some longer-term stock-building of grains in some MENA countries, particularly as a result of the Arab Spring events.

### *Financial capacity limitations*

- 4.4 The financial capacity of importing countries plays a major role in their ability to negotiate through production shocks. Countries with insufficient foreign reserves / currency to compete on the open market with other importing countries may be unable to import sufficient grains for their population. This may be particularly evident during crisis events when global market prices are inflated and competition for import products peaks. For example, the UK government and its consumers have capacity to pay higher prices on the open market as a result of shocks, however many other countries could be squeezed out. Small or medium-sized developing (poor) countries reliant on imports have the least influence in the globally traded markets and often rely on assistance from multilateral / bilateral agencies for development and relief agencies and NGOs during shock events. Broadly, Africa is one region where many respondents felt that national capacities to pay increased prices during shock events is more severely limited. Conversely, large importing countries (such as China) can more effectively leverage pressure on exporting countries during crises events. Evolving geopolitics could mean China, Russia and Brazil demand to be serviced before others.

### *Changing strategic import arrangements*

- 4.5 Some countries are highly dependent on importing agri-food commodities that form their staple food products. For example, Japan purportedly produces less than 40% of its consumed calories domestically (the remaining 60% is imported) and it

relies on trade agreements and buying on the global market for its food security. Similarly, the UK purchases from various sources based on market prices. Other countries, such as Saudi Arabia, are entering into long-term contracts (and in some cases even buying land) with other exporting countries (e.g. Sudan) as part of strategic partnerships for security of supply. However, if an importing country becomes too dependent on imports from specific exporting countries only and those countries suffer production losses, then the importing country may also suffer.

- 4.6 Asia is a major importing region, where many countries' agri-food trade systems are highly influenced by national government policies. In many countries, the private sector is permitted to act in selected roles, but strategic production is controlled by government. Asia is highly dependent on the Americas for the import of key crops (apart from rice, which it produces and consumes itself). Some governments, such as China, through their state-owned enterprises, are strategically securing food supplies by purchasing of land in countries such as Africa.

### *Relaxing self-imposed import restrictions*

- 4.7 Some countries with import restrictions, trade barriers (e.g. India for onions and sugar) or preferred suppliers may temporarily lift these restrictions during shortage periods. GMO restrictions / bans imposed by importing countries during non-crisis trading conditions may be tested during crisis events. Countries may choose to lift bans or continue to source products from non-GMO countries. Import restrictions may also be imposed through fear of disease and pest transfer from certain regions to others. Recent incidents, such as the Ebola epidemic, have the capacity to close down ports (the epidemic effected ports in West Africa). The incidence of disease and pests may be more likely to increase with increased temperature and moisture conditions.

### *Implementing / altering import subsidies*

- 4.8 Short term subsidies can insulate domestic markets from international price increases to some extent. Some countries have radically changed import subsidies within a 6-12 month period in response to shocks and increased global market prices. However, this can lead to cross border smuggling as well as affordability issues for the government subsidizing. Countries such as Jordan, Egypt, Nigeria and India have food subsidy programmes.

### *International food aid relief*

- 4.9 International food relief agencies (e.g. World Food Programme - WFP) can provide immediate food aid to countries in need. WFP is currently involved in both weather- and civil-related event responses globally. While food aid can be delivered quickly it requires the cooperation of the recipient country and the necessary infrastructure for distribution.
- 4.10 However, increased global food prices also mean that organisations such as the WFP pay more for food stocks for their crisis relief programmes. This means that the WFP must approach donors for more funds or ration their relief efforts.

The WFP does not yet effectively hedge price risk, buy options, or pursue approaches that private sector actors may adopt. WFP has limited strategic reserves and will need a more comprehensive strategy to protect it from endogenous shocks to ensure that core programs are not interrupted<sup>6</sup>.

- 4.11 In addition, while WFP and other food relief agencies try to source grains from regions close to disaster areas, countries such as the United States remain major suppliers of international food aid. Food aid from nation states is subject to market forces. Some interviewees reported that prior to ~1960, United States food aid was provided chiefly for eliminating surplus grain supplies and creating markets for United States farmers. Furthermore, during the 1973 food crisis, elevated food prices meant that the United States was not so keen to donate food or to provide it at lower prices when there was strong market demand for those commodities. An example of food aid relief challenges is provided in Box 2.

## BOX 2

### ***Drought relief importation delays***

A drought and associated famine conditions in southern Africa resulted in grain relief sent by ship. However, due to both physical and institutional restrictions, delivery of aid from the ship to the landlocked areas of need was severely delayed. Issues such as disorganisation, lack of capacity, bribery and different food standards / quarantine regulations between countries compromised delivery of the food aid via both ship and overland. The problem was not caused by a lack of food. Physical infrastructure problems are hard to surmount in the short-term, together with long standing institutional weaknesses.

### ***Importing countries become temporary traders***

- 4.12 Many of the key traded grains store well. Some climates are more conducive for effective storage than others (humid conditions are not good for long term storage). Stockpiling is a response that importing countries can employ (and many do) to guard against global market price increases and to protect against shock conditions. A response by some importing countries during a shock event could be to sell some of their import stock or stockpiled stock to the market at elevated prices during crisis events. This may only work for thinly traded crops, such as rice, as volumes of other grains may not be sufficient to influence market prices.
- 4.13 Long periods of low crop prices may generally lead to less focus on stockpiling. Hence, the impact of a shock event may be more severe after a period of low prices. In this case, importing countries outside a shock zone may not have significant reserves to trade. Conversely, high prices and greater volatility generally leads to more storage and building up of stockpiles on a country by country basis, and if a shock were to occur, some importing countries may be decide to trade their stocks because of the higher prices<sup>7</sup>.

### ***Unpredictable responses from large state actors***

- 4.14 Countries such as China have reserve stocks to help cope with shocks, but the size of those reserve stocks is not well known internationally. The condition and age of the stock is also largely unknown, with concerns about potential mould problems. Given that China is a major importer of maize and soybean (China constitutes 60% of globally traded soybean demand), any major change to their demand (increase or decrease) could affect world markets. The lack of information creates a degree of unpredictability.

### ***Being aware of potential 'domino effect'***

- 4.15 The UK is heavily reliant on food imports – an estimated 55% of all food is imported into the UK – the majority from the European Union. Most of those food imports are not necessarily raw grains, but processed or partially processed food products from the EU. Hence, any disruption to EU agri-food production or disruption to the exporting regions that supply to the EU would also impact the UK food situation. Hence, a shock to the EU grain suppliers may reduce food production in the EU and potentially the export from the EU to the UK.

### ***Consumer and farmer responses***

#### ***Consumers temporarily changing habits***

- 4.16 Altering demand to reduce / diversify import needs may be possible. Consumption data from some countries demonstrates that importing countries can reduce demands for certain grains by changing diets temporarily e.g. reducing grain-fed meat consumption, switching from rice to grain, etc. There is a perceived difference in propensity for consumers in different parts of the world to adapt dietary changes according to crop availabilities / prices. For example, some interviewees considered consumers in China, Russia and India more likely to accept temporary dietary changes than consumers in the United States and European Union.
- 4.17 Under any shortage situation individuals and communities apply various coping mechanisms, but particularly so in importing countries. 'Positive coping mechanisms' may include government support or insurance, while 'negative coping mechanisms' may include consuming less food or nutritionally inferior food or removing children from school to help with food provision.

#### ***Domestic actors can distort effectiveness of responses***

- 4.18 In cases where there is a major shock internally and international food aid relief is not provided / permitted, domestic actors may respond in undesirable ways. In the 1974

6 <https://www.wfp.org/stories/world-should-hedge-against-high-food-prices-says-economist>

<http://www.cgdev.org/publication/financing-food-assistance-options-world-food-programme-save-lives-and-dollars-working>

7 Similar dynamics around low prices / low stockpiles and high prices / high stockpiles may also play out for other actors such as exporting countries and private sector stakeholders.



---

famine in Bangladesh, grain farmers knew that the government was unable to import grains (due to Indian export restrictions and a lack of trade relations with other countries) and that no international food aid was being provided into the country. Price increases and speculative behaviour occurred and purportedly contributed to the deaths of approximately 1.5 million people (see studies by Martin Ravalion).

**Potential trigger for unrest**

4.19 Increasing food prices, in importing countries in particular, may be a potential trigger for unrest in some areas where there is already discontent and low trust in government. There are many areas around the world, particularly in MENA and other regions where such events may be possible.





# Amplifying and mitigating factors

- 5.1 A range of amplifying and mitigating factors will influence the resilience of the global agri-food production system to extreme shocks. Chronic and sudden onset climate change, with changing agro-climatic zones will significantly alter global food maps, possibly both positively and negatively. Infrastructure may need to be relocated. Exporting countries and importing countries may change. Countries may shift to and from food trade and self-sufficiency. There are a number of major environmental, social and institutional factors that will help or hinder responses to shocks.
- 5.2 Some of these medium and long term trends (classified into political, economic / financial, social, environmental and technical / technology issues), which may serve to amplify or mitigate the impact of production shocks, are outlined below.

## Political trends

### *The G20 need to prioritise global food security*

- 5.3 Many interviewees emphasized the importance of maintaining global food security and the increasing risk posed by extreme weather events on global stability and the G20 agenda. Rather than such issues being addressed reactively (e.g. after 2008), there is a need for a more considered long-term and global approach.
- 5.4 The Agriculture Market Information System (AMIS) is an initiative that has come out of the G20 and which promotes increased information and transparency to level out shocks and lead to opportunity for greater leadership by political actors.

### *Public stockholding (WTO)*

- 5.5 Under WTO conditions there is a clear distinction between stockpiling to build emergency food reserves or to provide subsidized food (permitted) and stockpiling to manage prices (not permitted). Stockpiling for food security purposes and distributing stocks at subsidized prices (as long as stocks are purchased at prevailing market prices) is allowed under WTO. This can provide some countries a buffer through which they can hold out until the next harvest/import. However, purchasing of foodstocks in a market price support fashion (i.e. above market prices in the manner of CAP intervention) is not allowed.
- 5.6 There are challenges related to the administration of stockpiles for emergency food reserves and/or to provide subsidized food. The stockpiles can be costly to run, and for some countries (e.g. India) there have been doubts about whether the stocks are being wasteful (allowing food to rot etc.). In countries such as China, where transparency is low, the volume and state of their reserves is largely unknown. This provides little comfort for the global market, particularly during crisis events. The magnitude of China's demand during a shock is not well known and could significantly impact other global buyers.
- 5.7 The OECD has conducted studies on the trade-offs between risk management and food security. A brief summary of WTO public stockholding conditions is provided in Appendix E and examples of different current approaches to stockpiling from Bangladesh and India is provided in Box 3.

## BOX 3

### *Bangladesh & India: different experiences with stockpiling*

Bangladesh provides an example of a food crisis and extreme weather event. By 2008, Bangladesh had reduced their public food stocks. This was done under the assumption that Bangladesh could import food products at any time, however India – their chief importing source – stopped exporting and at that time trade relations for agri-food products had not been established with other countries. Partly in response to the experience of 2008, Bangladesh has since diversified its trade relations with food exporting countries (to provide it with more importing options) and has improved trade infrastructure as well. Such incidents have sparked discussions around regional integrated food stocks to help support countries during such shocks.

In India, some stockpiling is reported to occur not driven by food security concerns but instead by government attempts to keep rural populations (voters) happy. Government guarantees prices of purchase and then covers the difference to keep sales prices low.

- 5.8 WTO trade and policy negotiations are currently not progressing well. Some interviewees felt that a new WTO agreement focused on interdependency and trade to share risk is about “as far off as a global climate change agreement”. In particular, pressure to move away from public stockholding was seen by some interviewees to be hypocritical as some exporting countries, such as the United States, subsidize their own crop production.

### *Regional integrated food stocks*

- 5.9 Regional integrated food stocks are being established (subject to ongoing discussions) in regions such as South East Asia. At the regional scale, such stocks can pool risk to help absorb shock and potentially to help smooth price shocks from interconnected extremes.
- 5.10 Many shocks in the SE Asia region may affect one or a number of countries, but unlikely the entire region. For example, the Philippines and Indonesia are highly vulnerable to typhoons, which can have severe impacts. However, mainland SE Asia may be less likely to suffer from those same events, meaning that a regional integrated food stock could help cover deficits in certain countries.
- 5.11 Such a SE Asian regional integrated food stock may be modelled on the European Union model of integration. Some interviewees felt that the region is now more resilient to shocks than in the past and there are ambitions in 2015 for ASEAN and APEC meetings to further regional integration. Some respondents advocate for a hierarchy of food stocks, from sub-national to supra-national (regional) level, as generally food stocks need to be available not too far from where shock occurs but also distributed enough so that not any single country controls the stocks. This would require more harmonized institutional arrangements. In Africa, there is some focus on

building up regional trade and promoting freer movement of grains between countries. Potentially, regionally integrated foodstock schemes could help promote collaboration in more volatile regions such as MENA. For example, an EU-North Africa strategic collaboration could be considered.

- 5.12 Skeptics question the effectiveness of such a system against larger shocks that could affect the majority of the region. Additionally, such a regionally integrated food stock may rely upon cordial political relations between member countries, particularly under crisis conditions – an arrangement that has yet to be tested.

#### **Transparency of information, particularly stock-to-use ratios**

- 5.13 Much of the agricultural and other data that is used by countries such as Vietnam and Indonesia is said to come from the United States Department for Agriculture (USDA). Hence, the USDA can influence market decisions and could be more accountable for this role. There is a call for more transparent, more regional and better quality data for regions such as SE Asia. There needs to be more public information on global inventories of food stocks, so that during crisis events there are accurate assessments of stocks versus demand (stock-to-use ratio). Greater transparency and coordination is required globally, and particularly in large demand centers, such as China where transparency is currently low.

- 5.14 Global decreases in grain stocks have been cited as contributing to the 2008 food crisis (Slayton and Timmer, 2008; Trostle, 2008; Piesse and Thirtle, 2009; Tadesse et al., 2014) however Headey and Fan (2010) find that the majority of the reduction in global grain stock is due to China running down its excessively large stocks. By excluding China from the analysis the fall in stock-to-use ratio globally is less pronounced (although the supply produced from China running down its stock could have delayed a supply shock by a few years). Stocks in the US however did decline due to rising demand (including from biofuels) and poor harvests which is believed to have affected the market. However Headey (2011) believes this to be a consequence of the supply shock rather than a fundamental cause of crisis.

- 5.15 Figures 6 and 7 show the historic level of global grain stocks over the last 50 years. Figure 6 shows total grain stocks and Figure 7 shows days of consumption available in stocks (more stocks are required today than 50 years ago to cover a higher level of global consumption per day).

- 5.16 Transparent stock-to-use ratios would provide information on the level of stocks held at any time, which is important in determining whether price spikes will be large or small. At the moment, it is difficult to distinguish genuine crises from apparent crises and there are attribution problems with issues such as speculation and panic buying playing influential roles where information asymmetry exists. A transparent and accurate system would help to distinguish between genuine crisis events and lower than average stock-to-use-ratios.

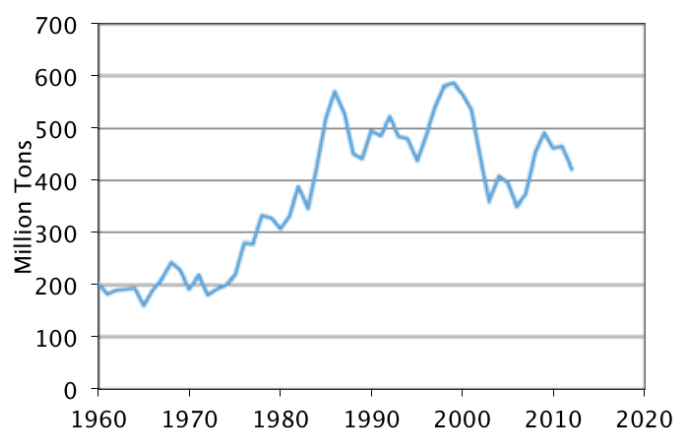


Figure 6: World grain stocks (USDA) for 1960- 2012 in million tons. Shows dip in grain stocks post 2000 which may have delayed the price impact from a supply-demand dynamic as stocks were sold until stocks started to increase again from 2007 onwards.

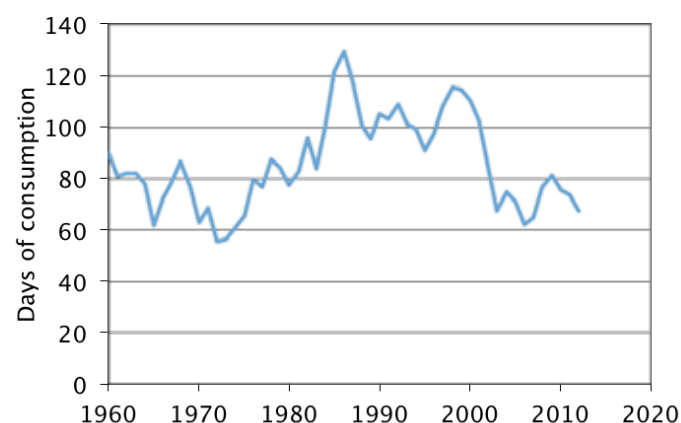


Figure 7: World grain stocks as days of consumption (showing drop in stocks from 2000 onwards).

#### **Biofuel production trends**

- 5.17 Over the last decade the increase in oil prices and, in the USA and EU, the introduction of subsidies, led to a significant increase in biofuel production. This increase in biofuel production can be seen as a demand shock which contributed to the recent food price spikes (Trostle, 2008; Headey, 2011; Coulibaly, 2013; Tadesse et al., 2014, Abbott, Hurt and Tyner, 2011). Increases in the area of land used to cultivate maize for biofuels in the US (as a response to rising oil prices) competed directly with land available for food crops (maize and soybean).
- 5.18 United States subsidisation of biofuel crops was seen by some interviewees as a managed supply shock overseen by the government. Others felt that with an estimated 35 % of maize production going towards producing ethanol, this portion could be used as a built-in buffer, where if a crisis hit, ultimate priority would shift from use for fuel to use for food. It is not clear what it would take for the United States to force maize production away from biofuels if a shock occurred and global

prices rose significantly especially given that production plants in the US are now geared towards using biofuels which could mean a supply shock in fuel being inevitable if a major shift in biofuel mandate was implemented. Conversely, in 2010/11 maize was reportedly diverted away from food production to biofuel production because of price drivers. Some respondents recommend dismantling biofuel mandates and increasing flexibility in its production to help free up the agri-food market.

- 5.19 US biofuel production has slowed down recently with the onset of fracking and low oil prices. Some respondents feel that the United States biofuel mandates / policies may have reached their limit and should decline as a percentage share of production of maize, and become less of a sticking point in future. However, there is uncertainty surrounding the trajectory of biofuel demands globally. While the EU market may be saturated and have stabilized, emerging and developing economy demands may increase and tighten the market and increase prices.

#### **Self-sufficiency or free trade approaches**

- 5.20 Given that governments are such important actors in responses to shocks, the level of intervention that they adopt is a significant determining factor of national and global impacts.
- 5.21 Countries are adopting varied approaches around self-sufficiency and free trade. Many countries, such as the UK, opt for free trade solutions and purchasing from a range of regions / countries to guard against production losses in any one or more suppliers (risk is spread across multiple suppliers, potentially across many global production zones). If countries opt for self-sufficiency, they may become more vulnerable to shock events in their own country and may not be able to re-establish trade arrangements quickly enough to help them in those crisis times. Governments such as Vietnam, export rice but also want to retain a national stockpile of ~4 million tonnes to protect their own population. Market-based trading approaches are not yet so common in Vietnam. In particular, large nations such as China and India may have significant impact on global trade markets depending on whether they pursue self-sufficiency or free trade goals. There are indications of government control loosening gradually in India (see Box 4), and perhaps China.
- 5.22 One major contributing factor for countries in their decision-making process in choosing free trade or self-sufficiency will be their approach to the international food trade system (and the broader trade system generally).

#### **Regional (and intra-regional) trade arrangements**

- 5.23 In parallel to debates around public stockholding and regional integrated food stocks, promotion of regional and intra-regional trade is high on the agenda in some areas. For example, two major regional trade agreements are: (i) Trans-Pacific Partnership (TPP) (trade agreement between the Americas (north and south) and Asia-Pacific region), and (ii) TransAtlantic Trade Investment Partnership (TTIP) (trade agreement between the United States and European Union).
- 5.24 In Latin America there have been recent attempts to stimulate regional trade arrangements rather than orienting export

#### **BOX 4**

##### **India Government responses, 2008 and future?**

In 2008, India banned exports in response to global food crisis, even though the domestic market prices were somewhat insulated (or at least delayed) from global price increases (due to fairly tight government control over its domestic food economy and not a high reliance on import of key food crops). This was considered a knee-jerk reaction by some interviewees. India was able to do this because it has relatively tight control over its domestic food economy. However, there are some indicators which suggest that state controls may be reducing. If this occurs, then in future the Indian food economy may be more directly exposed to the impacts of global production shocks. One interviewee outlined three possible general future scenarios for India: (i) India retains its current level of strong government control in the food economy and its insulation from global markets and minimal impact from shocks to the global agri-food system; (ii) India liberalizes at its own pace and conditions and consumers become subject to global commodity price rises associated with shocks; or (iii) WTO accelerates India's reduction of public stockpiling (similar to scenario ii, but at accelerated rate) and consumers become subject to global commodity price rises associated with shocks.

markets solely to large demand centers outside the region, such as China. For example, Bolivia and Venezuela have engaged in soy-oil trade arrangements. This initiative has not been market-led but instead revolves more around regional solidarity and political cooperation. It has not expanded to the entire region – for example major actors such as Brazil and Argentina have not engaged.

- 5.25 Some respondents predicted that by 2050, up to two-thirds of global GDP could be Asian generated and that this predominance will lead to a common Asian market and hence a different global geopolitics. The Asian common market may be able to meet its own needs, with production of tropical and temperate food crops. China is purportedly already India's largest trade partner. Respondents also point to, for example, India's increasing focus on regional trading institutions such as APEC, ASEAN, etc. and China's expansion of road and rail networks into SE Asia and its initiation of the Asian Infrastructure Development Bank as indicators of movements towards an Asian Common Market.
- 5.26 Major markets, such as the European Union, have or may implement protectionist import policies which limit opportunities for grain exporting countries, such as those in Latin America (Brazil, Argentina, Bolivia, Paraguay, etc.). The Latin American countries argue for opening trade arrangements. However, during recent food price shocks the EU temporarily abolished existing import tariffs to keep prices of grains lower. Protectionist policies are often selective, for example beef and sugar have some of the most substantial existing tariffs in the EU.



5.27 Furthermore, intra-regional trade can be significant and in regions such as Africa, often highly informal. The Africa region is increasing production generally and, as an example of this, the WFP now procures approximately 70 % of food for its African programs from within the continent. Commercially focused farming activities in countries such as South Africa are exporting to other countries in the southern Africa region.

#### **Presence (or not) of government grand vision / strategy**

5.28 A lack of a strategic food strategy can result in neglect and under-investment in agricultural sector. In particular, under crisis conditions extreme responses are more likely and these will be more frequent as climate change impacts increase. Many respondents referred to the just-in-time nature of the current global agri-food system and policymakers being stuck in the 'here and now' rather than forward thinking. The short-term thinking liability of 2-5 year election cycles in democratic nations makes longer term thinking difficult.

5.29 In Brazil, a new national law and plan for agro-ecology is being introduced as a key pillar for climate change mitigation and adaptation, agricultural sustainability and ecology management. An increased focus on agro-ecology could be beneficial to both smallholder farmers and nationally for the country to become a resilient and sustainable producer of agri-food commodities. This is supposedly pioneering in terms of legislation and public policy.

5.30 More broadly, there is insufficient embedded adaptation in present trends – e.g. although the yield may increase, production per capita does not increase while population is also increasing. Hence, to produce real increases relative to population increase, climate change impacts, etc. will require significant concerted effort by both researchers and policies from governments. Otherwise, production crises will occur.

5.31 At present, there only seems to be consensus in response to major shocks. Some interviewees called for work towards global consensus around supply shocks before they happen. For example, some interviewees felt that greater strategic storage capacity managed by governments rather than private groups (who may hold stocks to make greater profits) could help better manage resources and reduce shocks more equitably. Such a system could be coordinated by groups such as the FAO and other United Nations agencies, or done by countries individually.

#### **Prioritization for export markets over domestic markets**

5.32 Some exporting countries, such as Brazil, Argentina, Bolivia and Paraguay are strongly orienting their agricultural economies for export to major demand centers such as China. This can be at the expense of domestic consumers. The expansion agricultural production onto previously undeveloped land may increase GDP but is causing significant social and environmental problems. Examples in Brazil were provided by interviewees of water allocated preferentially for agri-food production for export over local water supply needs. Additionally, the high demand (and price) for export commodities, such as soybean, means that prices for local consumers in those countries has also increased.

#### **Exporting governments access to finance**

5.33 One idea proposed to help exporting governments (particularly developing and emerging country governments) is to provide them with access to finance to help them respond to the needs of their own people rather than to impose export restrictions / bans. Some interviewees noted that there is insurance available for droughts, floods, etc. but not against governments intervening and affecting prices. Providing governments' access to finance and discouraging them from imposing restrictions could allow markets to function more efficiently during crises.

#### **Coordination between humanitarian and development sectors**

5.34 Some interviewees noted that the impacts of shocks on the poor and most vulnerable could be lessened by greater coordination and cooperation between humanitarian sector actors and development sector actors. There is opportunity for these actors together to be much more effective. Africa may be the most vulnerable continent to the adverse effects of climate change, and coupled with governance deficiencies, may face the greatest food security issues. Aid agencies and development organisations should focus on a framework to increase agricultural production in Africa. There is a need to help governments become more resilient and to help them to respond more predictably during shock events and hence be less reliant on humanitarian intervention.

#### **Economic / financial trends**

##### **Deflation of the US dollar**

5.35 Weakening of the US dollar makes commodities relatively less expensive in countries where the currency has appreciated against the dollar. This factor may have had a major role in both the 2008 and 2011 food price crisis (Mitchell, 2008; Headey and Fan, 2010; Abbott, Hurt and Tyner, 2011; Headey, 2011). However, literature is not in agreement over the scale of the impact of the depreciation of the dollar on prices with figures ranging from a 20 % to 50 % increase (Piesse and Thirtle, 2009). If food prices are quoted in Euros then the size of the price shocks can be as much as 25 % lower than the US dollar equivalent (Headey and Fan, 2010).

##### **Imperfect markets**

5.36 Price changes can occur due to incomplete market information and panic buying. They are not always directly linked to export restrictions or production shocks. Some respondents suggest fiscal safeguards to help guard against speculation and to buffer price spikes.

##### **Inelasticity of food price to supply and demand shocks**

5.37 As demand for food commodities become more inelastic, the price response to supply or demand shocks become more volatile. In their assessment of the drivers of food prices following price shocks Abbott, Hurt and Tyner (2011) found that as well as the land constraints, other factors such as US biofuel policy (resulting in a fixed minimum quantity of maize produced for ethanol) and stock depletion, impacted food price inelasticity. They presented evidence that the global trade of food commodities continue to rise despite rising prices, which demonstrates this inelasticity.

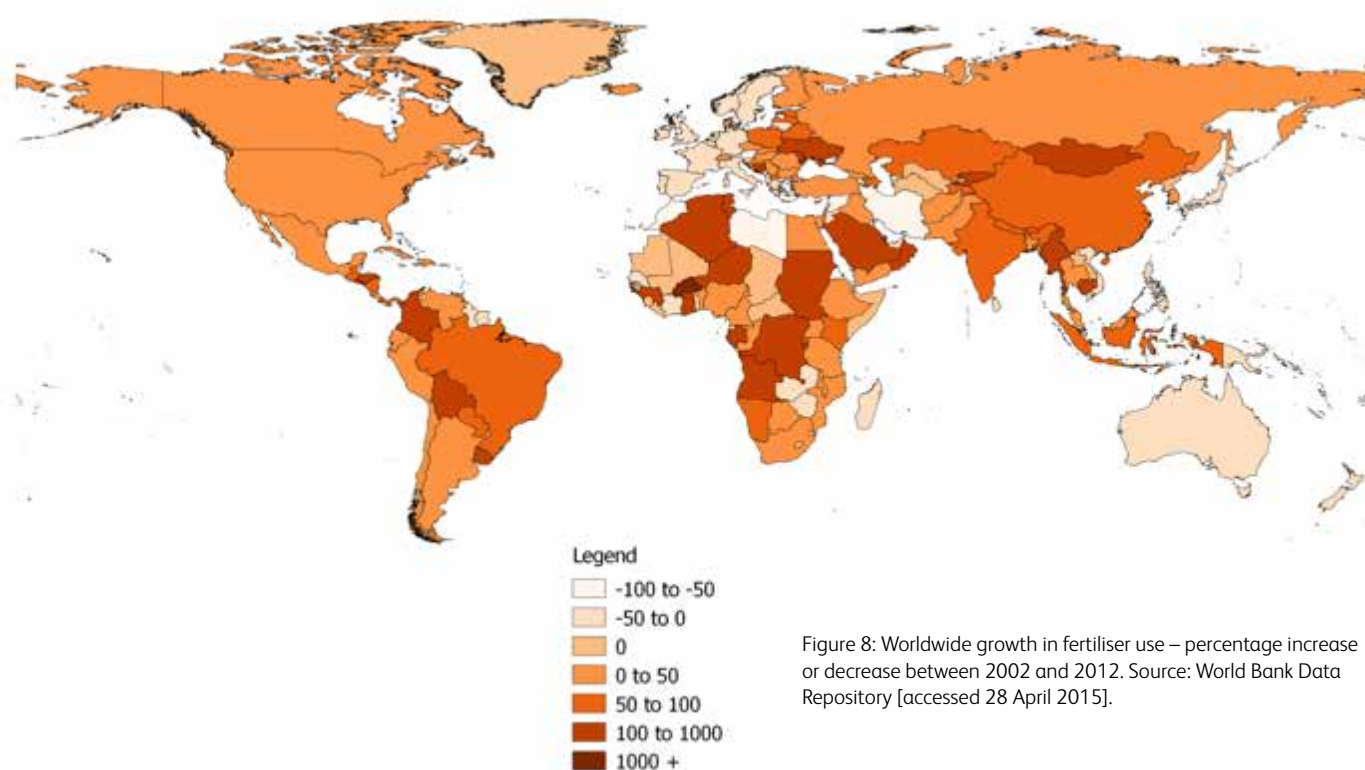


Figure 8: Worldwide growth in fertiliser use – percentage increase or decrease between 2002 and 2012. Source: World Bank Data Repository [accessed 28 April 2015].

### Price of farming inputs (chiefly fuels and fertilisers)

5.38 Higher oil prices can increase the cost of agricultural production due to oil intensity of the agricultural sector, particularly in the US (which dominates the global grain market) (Headey and Fan, 2010). Mitchell (2008) presents data on the increased production costs of grains in 2007 compared to 2002 and Tadesse et al. (2014) found an empirical link between oil price rises and food commodity prices although there is not convincing evidence of causation. Headey and Fan (2010) estimate that food production costs in the US were 40% higher due to the increase in oil prices over the period 2001-2007 (oil prices were 150% higher in 2007 than in 2001). Energy sector imports, mainly fuels, are important in the agri-food production system from both the production end which can be energy intensive, including in use of fertiliser, and the consumption end which often requires distribution and refrigeration. Figure 8 illustrates worldwide growth in fertiliser use (from the mid-1990s to mid-2000s).

Box 5 provides examples from Kenya and Thailand of agri-food input price increases.

### Financial resilience / insurance schemes

5.39 The use of agricultural insurance (including parametric insurance which is increasingly used in developing countries) could potentially provide some medium to long term resilience for food producers. Insurance schemes offer a rapid response

#### Box 5

##### Kenya & Thailand input price increases

**Kenya:** Food prices have increased rapidly in most parts of the North Rift region in 2007/08, sparking protests. The shortage has been attributed to the recent drought that hit most parts of the region and the effects of violence. The prices of maize and beans have both gone up dramatically. But farmers are not benefiting. Most have reduced their acreage because of the high price of fertiliser.

**Thailand:** Expensive animal feed is hurting small-scale dairy and livestock producers, while consumers are suffering from the rapid rise in food prices, especially for items such as pork, chicken, egg, rice and vegetable oil. Between 2005 and [2008], feed prices increased massively – maize prices rose from 6.3 baht/kg in 2005 to 9 baht in 2008; soybean meal rose from 10.30/kg baht in 2005 to 17 baht in 2008; and fish meal is 7 baht higher than in 2005. A representative of the Chicken Raising Promotion Association said that the small-scale producers are unable to compete with the large-scale producers and are going out of business.

Source: *The Nation*, April 7, 2008; Oxfam (Yowalak Thiarachow), Seville, D. 2008.

to extreme weather events that unlocks capital and allows food producers to either rebuild critical infrastructure, replace equipment or financially survive to the next season. However, current crop insurance schemes are heavily subsidised by governments and may therefore not be financially viable in the long term.

- 5.40 There is potentially a moral hazard around extreme food shocks where the provision of insurance could lead to lower yields being left un-harvested (when they would have been harvested if they had not been insured). Currently, there is little evidence for this behaviour although there is evidence for other crops that insurance has increased the volatility of production (as marginal crops are planted with farmers reliant on subsidised insurance for regular periods of production failure). Therefore, the impact of insurance on short term response to extreme weather is unclear.
- 5.41 Due to the increased frequency of extreme weather events, which affect both import and export capacities, risk exposure has increased and the premiums for corporations importing commodities has risen recently. For example, there is evidence of this in the Caribbean where premiums for shipping of goods and other components in the supply chain have risen sharply. In addition several insurance products may be impacted as a result of a food shock.

#### ***Subsidies can make small-scale local markets uncompetitive***

- 5.42 Highly subsidized production of commodities can undercut local markets in small countries and disrupt short-term local production chains. This creates an uneven playing field and increases the dependency of some countries on importing commodities rather than producing them locally. Maize production in the United States is a good example, receiving government incentives, tax breaks and export facilitation arrangements.

#### ***Strategic government vs private sector overseas investment***

- 5.43 Private companies from countries such as the United States and Europe invest in regions such as Latin America, Africa, etc. This may not align with government investment from their parent countries. State-owned enterprises from countries such as China are investing in global regions and this may reflect of strategic government investment decisions.

#### ***Global supply chain resilience and purchasing policies***

- 5.44 Private sector actors will need increased knowledge, investment and response systems to cope with more erratic weather events. Many multinational companies are trying to build sustainable global value chains. Increasingly, they understand their dependence on, and the vulnerability of their production systems to, environmental and social conditions in production zones often located in developing and emerging markets. Many companies are trying to promote improved conditions throughout their supply chain. Their purchasing policies will have influence (either positive or negative).
- 5.45 Much more effort is required. Multilaterals and bilateral donors, civil society and standard setters may be able to help

facilitate increased transparency and to advocate on behalf of stakeholders such as smallholders.

#### ***Under investment in agriculture & agricultural research***

- 5.46 Commentators identified a chronic crop yield gap. Yield increases are now expected to reach a plateau (Ray et al, 2012) and are more medium to long term responses rather than short term shock mitigation factors. Yield increases in wheat are currently below 1 % per year, which is not keeping pace with the increase in demand. Maize and soybean have received more corporate research and development focus, but overall there has been a general slowdown in agricultural R&D. Some studies, such as from IFPRI, forecast major crop deficiencies in the longer term, not related to shocks. Yield increases are not necessarily occurring at same rate as increases in demand and issues of increased threat from diseases and pests exist. The response to climate change – selecting crops for shock resilience or average climatic changes – could significantly impact average future yields. Additionally, if food waste is not curtailed then yield increases are not always so helpful.
- 5.47 Interviewees called for a focus on technology improvements – more fundamental biological research to better guard against variability, develop higher yielding crops, greater drought and flood tolerant crop varieties, greater moisture retention in soils, faster maturing crops (2 crop harvests in one season), etc. may all be possible with sufficient investment. Improvements in photosynthetic efficiency from 1 % to 1.5 % would have a major positive impact on meeting increasing demand. Gene editing technology also touted is a potential yield improvement pathway. Donor agencies and large NGOs, such as the Gates Foundation, could focus more on agricultural research and linking to longer term challenges.

#### ***Social trends***

##### ***Population growth, urbanisation and dietary changes***

- 5.48 Many commentators argue that demand growth in Asia (via population increase and economic development) and changing diets globally, particularly increased demand for meat, have increased pressure on global food systems (Popkin, 1994; Brown, 1995; Cordell, Drangert and White, 2009; Godfray et al., 2010), particularly on the main feedstock inputs, soybean and maize. However, others (Headey and Fan, 2010, Abbott, Hurt and Tyner, 2011, Headey, 2011) argue that China and India tend to be self-sufficient in relation to grain production and therefore have not increased traded demand. The exception may be soybean where pressure on land available for food production in the US was further exacerbated by increased soybean production to meet growing demand from China (after it abandoned its policy of soybean self-sufficiency).
- 5.49 The change in global dietary demands is also altering global supply chain dynamics and putting greater emphasis on soybean production (for feedstock) in many exporting countries. As one interviewee stated: ‘demand creates its own supply’ and there is an increasing orientation to the major demand centers, such as China. Demand growth is more likely to be a



spatial issue rather than a global one with particular increases in the volume of traded food seen (at least in the medium term) in Asia, and perhaps Africa. Geographical megatrends tied to economic development and increased living standards may include increased rice consumption in Africa, and increased meat and fish consumption in China, India and Africa. India has a strong vegetarian tradition and its development path is not expected to be as meat intensive as China's. However, consumption of chicken is rising and India has the potential to become a large maize consumer in the longer term.

5.50 The popularity of meat production does provide some elasticity in the global agri-food production system. If a crisis point occurred, there is the option to divert away from livestock production (more intense in its grain requirements) to direct grain consumption (more efficient).

5.51 A shift to greater meat consumption point includes low efficiency of converting plant to animal products, increased methane emissions and waste discharges from livestock production. There are also welfare concerns related to industrial farming practices<sup>9</sup>. The development of artificial meat, or meat generated in a laboratory, may change the dynamics of demand.

5.52 Urbanisation and the associated growing urban demand for food are trends that are occurring globally. Smallholder farmers are withdrawing from small-scale, subsistence agriculture and moving to urban areas where more opportunities may be perceived for them and their family. Particularly where industrial farming emerges, rural areas may function with fewer farmers on the land.

5.53 A rapidly growing urban middle-class exerts different pressures on the global agri-food system, particularly during food crises. The type of demand from urban consumers may also be for a higher diversity of nutritious foods. During crises, the urban middle-class may have incomes low enough to be affected by spikes in food prices but, unlike rural dwellers, purchase most of their food and do not have the ability to rely on subsistence food products when needed. Unlike some rural areas in some regions, which may be insulated from global commodity price changes, residents in urban areas may suffer from increased global market prices. Disgruntled urban consumers may more easily and more visibly protest in cities and get the attention of their governments.

5.54 At a generational timescale, if there is a higher acceptability of more seasonal supplies of products, then societies may have a higher tolerance to shortages and may better be able to cope with supply volatility. There are some examples of this adaptability occurring in Russia and China during shortages, but less evidence of more developed societies tolerating prolonged shortages.

9 Animal welfare concerns are justified but may also have implications for cost of production and area of land required.

5.55 There will need to be systems in place to protect those urban consumers from increasing price volatilities. Relief organisations, such as the WFP, are finding ways to effectively target the urban poor through new mechanisms (such as cash transfers) rather than the traditional mechanisms used for rural dwellers.

### ***Growing inequality between and within countries***

5.56 There are high levels of inequality both between countries and within countries. Such disparity may exacerbate conflicts between and within countries and issues of food security and affordability may play an increasing role in these events. Improved production from continents like Africa will help to make that continent more resilient to shocks, and it will also help to make the world more resilient by having a more diversified and greater number of export sources.

### ***Better preparation for conflict-related shocks***

5.57 Some respondents shared more concern about conflict-related shocks than climate / weather related shocks in relation to export / import challenges. There was a call for greater recognition and planning for shock events (e.g. hunger) emerging from conflict areas, rather than waiting for famine and other human tragedies.

5.58 For example, Nigeria is a highly populous, politically fragile nation currently facing an uprising from Boko Haram. Pakistan is a fragile state with a difficult relationship with neighbouring India, terrorist cells and is highly dependent on wheat as a staple food crop. These two examples highlight the risk of conflict-related shocks. The situation in Syria demonstrates the challenge for provision of food aid to conflict zones. Exporting countries such as Russia and Ukraine are subject to conflict-related and political instability production disruptions.

### ***Improved management practices and safety nets***

5.59 Beyond increasing research and development focus, improved management practices are emerging. For example, the System of Rice Intensification (SRI) is an evolving set of practices, principles, and philosophies aimed at increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients. SRI practitioners can try out best management practices locally and incorporate them into their practices where they find them successful to complement and build on their current practices. Additionally, conservation agriculture (CA) more generally will be important for increasing resilience because of its improved capacity to store nutrients and water. Some countries, such as the United States, have begun using CA effectively (see Box 6).

5.60 Social safety nets will play an important role in helping the poorest of the poor – to build an asset base, improve and diversify livelihood opportunities and to scale up production. A scaled up, adequately financed assistance delivery system is urgently required.

### ***Public awareness / support for climate change actions***

5.61 In some countries climate change is not yet part of the mainstream public discourse, such as India, or a substantial part of the population (or political leadership) rejects the science

## BOX 6

### ***Adaptive management and infrastructure utilization in the United States***

An example of adaptation to severe drought has occurred in California in the United States. The 2014 drought was one of the most severe on record. However, due to adaptation practices such as water transfers, crop switching combined with strong political and institutional leadership, agricultural production was only reduced by 5 %. This case demonstrates that in response to a severe shock such as a drought where there is sufficient funding, infrastructure (irrigation schemes) and effective coordination and leadership the impacts of the shock can be mitigated.

such as Australia and USA. In such countries governments may not be as active on climate issues or may not be held accountable by the public. Therefore, responses to extreme weather impacts may be met with some suspicion as the causal links may not be believed.

- 5.62 Both the public and national governments need to be aware that if climate change is to be seriously addressed, it may add some costs to agri-food production, at least initially, but this will be highly cost effective in the medium-to-longer term.

#### ***Size of landholdings / industrialization of farming***

- 5.63 While some countries shift to smaller rural populations and more expansive industrial farming, countries such as India may see greater fragmentation of landholdings. Currently 80 percent of Indian farmers are smallholders and marginal, and it will be a major challenge to produce higher yields with so many smallholder plots. Unlike in Europe, USA, and Central/South America, India has not undergone 'supermarketization' – the farmers in the supply chain are still independent smallholders. While international supermarket chains have tried to penetrate the Indian market, to date the upholding of strong regional and local government policies has prevented them from establishing a foothold. However, this situation requires ongoing government policy commitment.
- 5.64 Marginal smallholders in countries such as India are vulnerable to shocks. For example, in India an estimated 300,000 farmers have committed suicide since 1995 (almost 50 percent higher than the rest of the population). Most farm suicides have been linked to debt, a sharp rise in input costs, serious water crises, price volatility and crop failure due to pest attacks and disease. Hence, empowerment and inclusion of farmers will be key to the effectiveness of responses. Options may include retaining smallholders on their land and forming cooperatives where they pool equipment use for efficiency and modernizing traditional inputs / systems. The evolution of the farming landscape, particularly in countries such as India, will be a highly political issue. Some respondents don't see countries such as India, or potentially China, going down the industrialized farming pathway.

- 5.65 Industrial farming systems may provide advantages of economies of scale, speed and ease of crop switching, access to capital for hardware and technological inputs, fewer stakeholders on the land to negotiate with. An example from the midwest of the United States, demonstrated that within two weeks an area could be seeded in response to a shock due to the economy of scale and machinery available through industrial farming. On the other hand, some interviewees saw benefits of smallholder systems for the livelihoods of local communities, local adaptation and diversity of crops being more resilient to shocks, continuity between traditional methods modernized with technological advancements. Some industrial farming monocultures may be more vulnerable to loss of the entire crop from exposure to pests, diseases or certain weather conditions.

- 5.66 Smallholders support could include access to high-quality seed, fertilisers, credit and insurance. Some interviewees felt that 15 years ago there was greater investment focus in local markets and smallholders, compared to today where industrialized farming is taking over in many areas and is being captured by political, multinational and other trading actors. Some went as far to say the democratic processes were being subverted with a disproportionate capture of public policy around industrial farming occurring too often. For example, in Brazil a recently appointed Agriculture Minister had transferred into the role directly from a senior role in industrialised agribusiness.

#### ***Changing gender roles***

- 5.67 Another social factor that needs to be considered is gender roles related to food production. With improving gender equality in many parts of the world and the rise of women in the paid workforce, there may be less time available for preparing food. Some interviewees related this to a rapid increase in the reliance of processed foods in some countries in Africa (e.g. Burkina Faso, Ethiopia) which are cheap, easy and quick to prepare.

#### ***Food safety concerns***

- 5.68 Given the increasing demand for food and the pressures on production, issues around food safety may become more pressing. In particular, techniques to increase productivity, such as pesticide use and genetically modified crops, may create concerns for consumers. A point may be reached where productivity improvements may be tempered by consumer food safety concerns. Increased temperatures and moisture conditions could require enhanced food safety and refrigeration for some agri-food products along the supply chain.

#### ***Minimizing food waste***

- 5.69 A significant proportion of food is wasted, either pre-processing (mostly in developing countries) or post-processing (mostly in developed countries). Any strategic response over the medium term to tackle food waste could increase the overall resilience of the food supply chain. Work in this area has begun in some countries. e.g. through the UN Think.Eat.Save campaign, in the EU and in the UK through WRAP with the Love Food, Hate Waste campaign.

### **Consumer health monitoring and behaviour changes**

5.70 Advances in information technology, particularly related to personal applications to track and influence consumer behaviour, are being used in developed countries. Such devices can help track nutrition and sustainability aspects of food consumption.

### **The role of orphan crops**

5.71 Orphan crops form the staple food crops for a large proportion of the world's population. Orphan crops are the next tier of crops below the key traded crops e.g. cassava, yams, plantains, millets. These crops are not highly traded and have had less research focus. Hence the opportunities for increasing their yields may be higher. These lesser traded crops may be able to help in mitigating shocks in many parts of the world, particularly for certain demographics. They may be used as substitutes if key crops are unavailable. For example, cassava is a versatile crop with multiple uses as food, feedstock and some industrial uses. It may be substituted for maize as it is considered more resilient to drought conditions. As a result, cassava is commonly planted in more marginal areas due to its greater tolerance to aridity than maize. Some interviewees reported that in Southeast Asia, the planting of more resilient crops - some of which are orphan crops - seems to be occurring now.

### **Environmental trends**

#### **Climate adaptation / mitigation measures**

5.72 Climate change will adversely impact agri-food markets with the increasing frequency and magnitude of extreme events and shifts in mean conditions and variability. Regional effects will differ greatly and hence production conditions will become relatively better or worse. In some areas, agro-climatic conditions will be pushed to the edge and become more vulnerable to shocks. Examples of forecast difference in climate effects on India and China are described in Box 7.

5.73 How well agriculture and agricultural production systems are incorporated into international climate change mitigation and adaptation agreements will be important in determining amplifying or mitigating factors. Some sustainability policies could change production methods. Many climate resilience activities will benefit agri-food production (e.g. irrigation, agroforestry, soil quality, terracing).

#### **BOX 7**

#### **Climate change impacts on regional water sources in India and China**

Countries such as India are highly dependent on the reliability of large-scale weather events, such as annual monsoons, which provide plentiful rainfall and so far have eliminated the need for major irrigation systems. While the timing and duration of monsoon events is expected to change, the total volume of rainfall is expected to remain similar. While India may rely on the monsoon and snow melt, China does not have monsoons so if snow melt reduces their water supplies could also be reduced.

5.74 A low number of globally produced and traded crops results in higher vulnerability, with reduced resilience and adaptation capacity. A proactive approach would promote a diversity of production systems (geographically and types of crops). This could be done on a national, region and global scales to improve resilience to various regional climatic changes.

### **Changing regional climate / weather cycles**

5.75 The ENSO phase (El Nino / La Nina) events already cause major food production impacts in countries including Australia, Indonesia and Sri Lanka to parts of South America and the United States. The ENSO phase is changing and its future patterns are less predictable, with potentially serious consequences for global food production. Better strategic foresight into these types of events and better predictions of regional disruptions is important.

### **Water scarcity, land degradation and restoration efforts**

5.76 In many areas non-renewable groundwater resources are being mined unsustainably, particularly as surface water resources are already allocated. This is occurring in certain parts of the United States, India, Iran, etc. Groundwater depletion is not a shock per se, but rather a gradual deterioration of a resource which will become increasingly essential in increasingly arid environments. Much agriculture around the world is already dependent on irrigation and may become increasingly so as temperatures and rainfall patterns change. Water availability influences both productivity and resilience to shock events such as droughts. Irrigation provides much more predictability and reliability of crop production.

5.77 Land degradation and reduced soil fertility have a major influence on agricultural production potential. Increased land degradation and increased weather variability have the potential to create and exacerbate multiple shock events. Some respondents call for greater consideration to be given to 'other species on the planet' and a 'better balance of quality and diversity of life, with associated food security improvements'. Through rehabilitation and restoration efforts across landscape scales, agricultural productivity can be improved in conjunction with environmental and social co-benefits (Liu & Hiller, forthcoming 2015) (see Figure 9).

### **New production areas being acquired / coming online**

5.78 In addition to advances in the science of yield improvements, some new areas globally are coming into production for export on the global market. For example, European markets have been expecting Eastern European agri-food production to come online for export. However, recent instability and a slowdown in economic development in the region e.g. in Ukraine and Russia have slowed down production in wheat and maize for export. The region has become more volatile recently and hence the European Union may have to source from elsewhere for their increase in demand for those commodities. At the same time, 'land grabbing' is taking place in other markets, such as in some African countries, where new export markets may develop.





Figure 9: An example of landscape scale restoration improving agricultural productivity and environmental and social indicators in Ho Jia Gou, Shaanxi Province, China between (a) September 1995 and (b) September 2009. Used by permission (c) Environmental Education Media Project (EEMP).

5.79 Additionally, climate change means that in the medium-to-long term more northern latitude areas, such as Canada, Russia and Scandinavian countries may produce some of the key traded commodities. However, there will be significant infrastructure required in these new areas to facilitate production and export. These regions may also experience higher production volatility due to the prevalent weather conditions at higher latitudes.

5.80 Expansion of agricultural land use into more and more marginal areas is currently utilized as a coping strategy in response to shocks. However less and less land will be available for such purposes as industrial, agricultural and urban areas continue to expand globally. The expansion of agriculture into new lands, particularly natural landscapes such as forests and other high carbon / value ecosystems may require users to rehabilitate degraded land for production and/or intensify production on lands currently in use. For example, in countries such as Brazil, interviewees described increasing production of major crops in spite of reducing yields offset by expansion into new agricultural areas. Such production is unsustainable and is said to be exacerbating local environmental and social problems. Globally, there is a limit on the number of countries considered to be able to significantly increase their land area under production. In addition expansion of agricultural land can lead to longer term impacts including deforestation, habitat destruction and loss of biodiversity.

#### **Environmental legislation developments**

5.81 Changes to environmental legislation (banning certain types of chemicals, runoff restrictions, etc.) can impact the productivity trends in agriculture. However the overall impact of this is highly uncertain.

5.82 In the United States, there is concern about excessive fertiliser use and nitrogen runoff into the Gulf of Mexico. Farmers may face restrictions on nitrogen use and this could affect productivity of maize and soybean.

#### **Pests / diseases and GMOs**

5.83 Climate change also increases the threat from pests and diseases. Mould, rust, blight and other pests / diseases spread more easily because of changes in temperature / moisture

and increased trade of products. Bio-resilience through diversification may be one strategy that could mitigate this risk. Different types of crops across different parts of the world are needed - crops with different tolerance levels to different physical conditions. This could include a greater variety of the key crops. It is unclear how important GMOs will be in meeting increasing demands and being resilient to such threats. What happens in a global trade market if different countries have different standards of acceptability of GMOs is also unclear.

5.84 The GMO issue can be a political economy issue. Some countries, particularly in Africa (e.g. Zimbabwe, Tanzania) and the European Union, do not permit importation of GMO products. The EU lobbies some African countries to change their policies via the large supermarket chains, which demand certain product standards. By not permitting GMO grain imports, the EU may ultimately be limiting their import options. For example, if Latin America (which does not use GMOs) has export problems, Europe may have problems importing sufficient non-GMO grain from elsewhere.

5.85 Additionally, livestock and human disease incidence may also increase with increasing frequency and magnitude of extreme weather events and chronic climate change, as well as with higher density living (through urbanization, industrial farming).

#### **East-west hemispheric production disconnect**

5.86 Beyond the benefits of the northern and southern hemisphere harvesting season offsets enabling some response to production shocks, some interviewees described the benefit of shocks in the eastern or western hemisphere production systems not being correlated. For example, major wheat production for export in the Ukraine or Russia is not correlated with shocks in wheat production for export in the United States (although this may change as the climate changes). This gives some stability to global production beyond the north-south offset.

#### **Access to information about probability of extreme events**

5.87 Greater information needs to be available at two broad levels: (i) At the regional / international level: There needs to be greater information on inventories of food stocks, so that during crisis events there is accurate assessment of stocks versus

demand; and (ii) At farm production level: Open data platforms for meteorological information, soil moisture, etc. to help farmers optimize crop types and timings for plantings.

- 5.88 At the international level, initiatives such as the Global Open Data for Agriculture and Nutrition (GODAN) initiative, and others (e.g. GCAMP model, IFPRI model, AGMIP model) are promoting increased transparency in agricultural production through open data and big data sets. Models are being developed to forecast the probability of extreme events occurring over a twenty year horizon. Such information can be incorporated into contracts and allows insurers to account for disruptive events. Models help provide stability of supply for supermarket chains by taking into account probability of disruptions to their supply chains. Efficient and effective supply chain management will help to minimise the impacts of shock events. Models need to include commodity to commodity dynamics as well as energy dynamics (oil prices, etc.). They also need to look more at shocks in modelling rather than equilibrium models, which the AGMET project is attempting to do.
- 5.89 In response to the 1972/73 Soviet Union wheat production shock and associated global market price increases caused by them purchasing wheat on the global market (particularly from the United States and Australia), the United States developed a remote sensing system for global crops. The system monitors area of crops and weather conditions and feeds this into a crop model in an effort to help reduce the surprise from extreme events. Similarly, major agricultural companies (e.g. Cargill) are also predicting crop production globally to help manage production shocks.
- 5.90 At the farm level, provision of reliable and real time information and data helps farmers to adapt to chronic climate change and even to more acute shock events. More effectively linking agrometeorological data and agri-production system data together could help in this regard. The role of increasingly accessible ICT services can help many stakeholders gain access to relevant and accurate information like never before. Agricultural advisory services can help farmers more effectively.
- 5.91 As well as increased access to information, the accuracy of the information is just as important.

### **Infrastructure and technology trends** **Critical infrastructure for import**

- 5.92 In terms of importing grains, there are two basic transportation issues: (i) importing to the country from the source country/s; and (ii) moving commodities around within the importing country. Both (i) and (ii) must function effectively to get supply to demand areas.
- 5.93 With regard to (i), large shipping lanes and large ports may both be exposed and vulnerable to major climate / weather events. Some key 'choke' points for global shipping exist, for example the Suez and Panama canals and the Malacca Strait in the China Sea are considered major importing and exporting bottlenecks. An estimated 80% of rice and most of China's

soybean imports are traded in the South China Sea, a transport route that has a non-trivial risk of naval conflict. In the Middle East and North Africa region, most imports must pass through at least one, and up to three, maritime chokepoints, depending on the origin, route and destination. All these critical sea traffic thoroughfares may be prone to political and civil stability risk and if interrupted would increase transport costs at least and lead to significant disruption at worst.

- 5.94 An ability to repair key infrastructure is an important factor to consider when assessing the impact of a shock on an importing or exporting country. Sea level rise threatens coastal ports and also the productivity of crops in low-lying coastal areas, such as deltas (where much rice production in Asia). Longer term investment in flood defences will lower the overall risk from shock events. The Middle East is a major importing region, and some countries have limited deep water port facilities. For example, Jordan has only 1 deep port. Other countries such as Syria, already with limited port infrastructure, now have conflict issues which have limited imports. In contrast, some wealthy Middle East countries – particularly oil exporting countries with large port facilities – have entered into long-term contracts exporting countries. Most Asian countries, including China, Indonesia, Japan, Philippines and India are reported to have sufficient and multiple large port facilities. However, countries such as Indonesia and the Philippines are severely exposed to typhoon events and hence much of their infrastructure for import and export is highly vulnerable to such extreme events. China has extensive overland transport routes to international markets, for example it has three main routes all the way to Europe. In comparison, India has fewer overland routes and is more reliant on sea routes.
- 5.95 The UK and Europe are also considered to have multiple large port facilities. Africa is seen to have infrastructure deficits more generally, particularly related to large ports and overland road/ rail networks. In terms of food security, Africa is seen to be at the highest risk with regard to infrastructure inadequacies. Throughput through the system is slower and there are more bottlenecks. This means that domestic prices are slower to respond than international markets and means that prices can generally be higher because of the additional costs associated with movement of goods and lower market connectivity. For example, a study on the elasticity of trade found that in the agricultural sector a one-day delay in delivery can influence price by 5 percent.
- 5.96 The ability to purchase transport ships is an issue – there has been a shortage of ships available globally. Furthermore, during a crisis, there may not be enough spare shipping capacity in the world to ship more grains. Otherwise, the ability to divert ships from freight or more lucrative cargoes / routes could be difficult and costly (difficult for countries that cannot afford it).
- 5.97 With regard to (ii), countries must have effective public distribution systems in place. These can be used to transport imported food products (for example, from coastal port areas) to areas of demand. For large countries with significant intra-

national trade, such as Russia, India, China, these internal transportation routes are critical to transport grain products from areas of food surplus to areas of food deficit and are of varying levels of efficiency and reliability and more or less resilient to infrastructure compromise. For example, in 2008, China had severe snowstorms which impacted national rail networks. They prevented coal transport from western provinces to demand centres in the east and resulted in brownouts in many areas. The same was true for food transportation in the opposite direction. This is an example of internal transport networks vulnerable to major weather events and the immediacy of the consequences for commodities such as food and energy. Similarly, in 2010, severe flooding in Pakistan compromised road networks and bridges which meant that resources and commodities could not be transported into or out of critical areas.

- 5.98 Beyond infrastructure to move commodities, options to store grain are also important. Technologies for bagging grains have improved and silos can be relatively easily constructed.

#### **Critical infrastructure for export**

- 5.99 Physical and institutional infrastructure can be as important for exporting countries as for importing countries, for shifting large volumes of stock quickly. While ordinarily importing countries can space out their imports in line with their storage / transport capacities, exporting countries often have to shift large volumes quickly once harvested.
- 5.100 Exporting countries such as the United States, Canada, Australia, Brazil, Argentina, etc. sometimes have problems exporting agricultural commodities due to infrastructure / labour limitations and susceptibility to climate change / weather events. For example, the United States transport network from production areas (e.g. Midwest) to ports (in the Gulf of Mexico) is highly reliant on the Mississippi River. The Mississippi River is limited as a transport route due to increased traffic for movement of other commodities (e.g. shale oil, etc.) and has suffered problems during times with low water levels (such as 2011/12). Furthermore, New Orleans and the Gulf of Mexico are vulnerable to sea level rise, with some infrastructure purportedly already below sea level and exposed to extreme weather events such as hurricanes. Countries such as Canada and Australia have limited rail capacity while Brazil and Argentina suffer from frequent labour disputes at key export points (importers sometimes prefer other exporters because of this unreliability of timely supply). Russia is dependent on ports for export, many of which are prone to freezing over, while some Central Asian countries, such as Kazakhstan, are landlocked and rely on export via other countries, such as Russia, China or Iran. Potential difficulties long journeys to sea ports, crowded rail routes, costly transportation, and reliance on good relations with neighbouring countries. Export centers can also become impeded and/or disconnected via conflict e.g. the Black Sea is a key export point for agri-food commodities from Ukraine and Russia via the Bosphorus Strait.

- 5.101 In addition to physical infrastructure, institutional and human capacities play significant roles. For example, in Argentina strikes by workers on the ports and other key infrastructure points limit export capacity and can delay deliveries to client countries. Such strikes may be more likely during critical times such as shocks, as unions try to negotiate better conditions for workers.

#### **New export market orientation impacting infrastructure requirements**

- 5.102 Changing global import markets have significantly altered the export infrastructure arrangements in some countries / regions. Latin America provides a strong example of export infrastructure reorientation. Historically, Latin America's export markets have been oriented towards Europe via the Atlantic Ocean. Hence, port infrastructure and internal rail and road transport routes have been geared to those export points. The major importer of Latin American produce is now China, across the Pacific Ocean. This has required heavy investment in rail, road, river and some port infrastructure to re-orient for this market. It has also, in some cases, changed the dynamic of relations between countries to collaborate on infrastructure to enable more efficient export (e.g. Brazil and Bolivia collaborating on road networks for export of commodities). Such increased efficiency of transport networks benefits other traded commodities (resource extraction) but has also led to more land speculation and clearing of natural areas.



# Discussion

- 6.1 The main traded grains (wheat, maize and soybean) are key drivers of overall food price shocks. However, rice can more easily deliver a global price shock because it is thinly traded, although most risk is within India and China.
- 6.2 A shock in the order of 10% in global production loss, leads to a significant price shock. Often multi-breadbasket failures are observed (in particular maize-wheat). A physical shock can often be the trigger for a much larger market shock especially when there are other issues that increase the size of the shock– export restrictions, re-stocking (demand increase) of low stocks, biofuel policy/growth or a devalued US dollar.
- 6.3 Key findings from the quantitative analysis include:
- A 10% global loss in production for any grain relates to approximately a 200% increase in grain price.
  - Wheat and maize price shocks are needed in the same year in order to produce an overall FAO food price index shock (or cereal price shock).
  - Maize and soybean are highly correlated due to the competition for land in the USA between these two crops.
  - These price shocks appear to not follow a normal distribution (a mean with symmetrical standard deviations) but appear in a long tail, which means an extreme price shock is more probable than would otherwise be considered.
- 6.4 Essentially the food production – export – price –import process is a dynamic system with many feedback loops. These include demand dynamics (including biofuels), slowing production, increasing cost of production, currency valuations, physical production shocks (weather, disease or political instability), aggressive purchase by countries, financial speculation and export restrictions.
- 6.5 A method to help better integrate these factors into a decision support tool does not currently exist although aspects are being developed by different groups such as the Global Resource Observatory of Anglia Ruskin University, the Vulnerabilities and Choke Points work of Chatham House or the Centre for International Earth Science Information Network at Columbia University.
- 6.6 The dynamic between food and oil prices is not straightforward. Oil prices increased prior to food prices in 2008, however there is some evidence that food prices increased before oil prices in 1973. This suggests that food importing and energy exporting countries (OPEC) can react to food shortages by increasing energy prices.
- 6.7 Many respondents in the interviews suggested that the current global agri-food system provides ‘just-in-time’ production, which is not resilient to shocks. In the future significant disruptions from major shock events will occur and will cause problems. Management strategies both before and after the shocks can reduce any adverse impacts.
- 6.8 During the interviews the following were recommended as

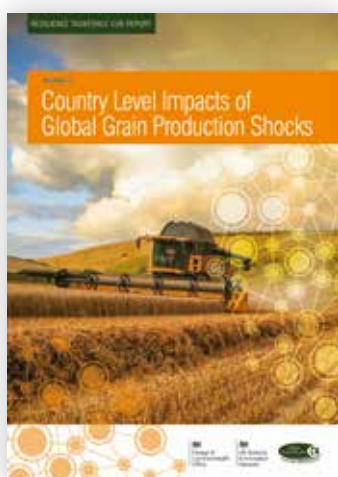
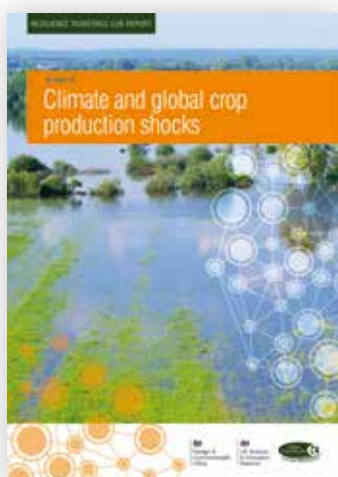
possible routes to mitigate the impacts of production shocks:

- National governments should act – there are many cases, including typically market-focused governments (e.g. USA) that have intervened to protect / stabilize agri-food markets.
- Improve availability and access to accurate information for all stakeholders – asymmetric information is problematic as it leads to inefficient market responses, speculation, panic buying, etc. Information sharing can help to mitigate / minimize impacts of shocks. There is a need for much more effective and specific climate weather trends with the food system in mind.
- Early warning systems - need to transfer information to other producers when there is a shock somewhere, so that those producers have time to adjust their own crop plantings.
- Risk assessments - develop international, regional and national agreements around agri-food production risks. These should be region specific and food specific. The UK and USA could do more to survey the global agri-food situation.
- Modelling – scenario modelling to help inform decision- and policy-makers. These may need to be bespoke for temperate and tropical challenges and incorporate social resilience components.
- Holistic international framework / guide – international guide to help coordinate with national processes and help national government agencies to come together. Global organisations, such as the World Bank, could help increase resiliency of the agri-food system. This may need to be bespoke for temperate and tropical challenges and incorporate social resilience components. It needs to be integrated and link to other food policy areas e.g. food security, role of agriculture in climate change mitigation / adaptation, etc.
- Accept that mitigation policies are not working effectively and focus on adaptation. Businesses and Governments need to prepare for people not being able to eat certain crops / products anymore.
- Agricultural insurance options need to be redesigned to be more helpful for farmers.
- Rather than measuring annual production figures, some respondents recommended measuring and monitoring stock-to-use ratios as more relevant indicator of vulnerability to shocks.
- Global food emergency reserves need to be large enough to be of assistance. At a regional level in East Asia, they do have a rice emergency reserve now. Governments could encourage a global, regional, national and household reserve hierarchy system.

# References

- Abbott, P.C., Hurt, C. and Tyner, W.E., 2011. What's driving food prices in 2011? *Farm Foundation NFP: Issue Report*.
- Baffes, J. and Dennis, A., 2013. Long-term drivers of food prices, *Policy Research Working Paper 6455*, World Bank Development Prospects Group & Poverty Reduction and Economic Management Network.
- Brown, L.R., 1995. Who will feed China. Washington, DC: *World Watch Institute*
- Cordell, D., Drangert, J. and White, S., 2009. The story of phosphorus: Global food security and food for thought. *Global Environmental Change*, [e-journal] 19 (2), pp.292-305.
- Coulbaly, A.L., 2013. The Food Price Increase of 2010–2011: Causes and Impacts. *Ottawa, Canada, Library of Parliament*
- D'Odorico, P., Carr, J.A., Laio, F., Ridolfi, L. and Vandoni, S., 2014. Feeding humanity through global food trade, *Earth's Futures*, 2, pp. 458-469
- Environmental Education Media Project, December 2009, Hope in a Changing Climate, *BBC World Service Television Documentary*.
- Evans, A., 2009, Feeding the Nine Billion, *London, Chatham House*
- Godfray, H.C., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. and Toulmin, C., 2010. Food security: the challenge of feeding 9 billion people. *Science (New York, N.Y.)*, 327 (5967), pp.812-818.
- Götz, L., Glauben, T. and Brümmer, B., 2013. Wheat export restrictions and domestic market effects in Russia and Ukraine during the food crisis. *Food Policy*, 38, pp.214-226.
- Headey, D., 2011. Rethinking the global food crisis: The role of trade shocks. *Food Policy*, 36 (2), pp.136-146.
- Headey, D. and Fan, S., 2010. Reflections on the global food crisis: How did it happen? How has it hurt? And how can we prevent the next one? *Intl Food Policy Res Inst.*
- Liu, J.D. & Hiller, B.T., forthcoming 2015, A Continuing Inquiry into Ecosystem Restoration China's Loess Plateau and Locations Worldwide & Emerging Implications, in *Land Restoration: Reclaiming Landscapes for a Sustainable Future*, Edited By Chabay, I., Frick, M. & Helgeson, J., Published by Elsevier.
- Hochman, G., Rajagopal, D., Timilsina, G. and Zilberman, D., 2014. Quantifying the causes of the global food commodity price crisis. *Biomass and Bioenergy*, 68, pp.106-114.
- Jayasuriya, S., Mudbhary, P. and Broca, S.S., 2012. Food price spikes, increasing volatility and global economic shocks: coping with challenges to food security in Asia. RAP Publication (FAO)
- Lagi, M., Bar-Yam, Y., Bertrand, K.Z. and Bar-Yam, Y., 2011. The Food Crises: A quantitative model of food prices including speculators and ethanol conversion. *arXiv preprint arXiv:1109.4859*
- Lybbert, T.J., Smith, A. and Sumner, D.A., 2014, Weather shocks and inter-hemispheric supply responses: implications for climate change effects on global food markets. *Climate Change Economics*, 5 (4), 1450010
- Martin, W. and Anderson, K., 2011. Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics*, pp.aar105.
- McCalla, A.F., 2009. World food prices: Causes and consequences. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 57 (1), pp.23-34.
- McPhail, L.L., Du, X. and Muhammad, A., 2012. Disentangling corn price volatility: The role of global demand, speculation, and energy. *Journal of Agricultural and Applied Economics*, 44 (3), pp.401-410.
- Mitchell, D., 2008. A note on rising food prices. *World Bank Policy Research Working Paper 4682*
- Natalini, D., Jones, A. and Bravo, G. Quantitative assessment of political fragility indices and food prices as indicators of food riots in countries. *Sustainability*, 7 (4), pp. 4360-4385
- Piesse, J. and Thirtle, C., 2009. Three bubbles and a panic: An explanatory review of recent food commodity price events. *Food Policy*, 34 (2), pp.119-129.
- Popkin, B.M., 1994. The nutrition transition in low income countries: an emerging crisis. *Nutrition reviews*, 52 (9), pp.285-298.
- Ray, D.K., Ramankutty, N., Mueller, N.D., West, P.C. and Foley, J.A., 2012, Recent patterns of crop yield growth and stagnation, *Nature Communications*, 3, 1293
- Sarris, A., 2013. Food commodity price volatility and food insecurity. *Bio-based and Applied Economics*, 2 (3), pp.213-236.
- Slayton, T. and Timmer, C.P., 2008. Japan, China and Thailand can solve the rice crisis—but US Leadership is needed. *Center for Global Development Notes*, August 22
- Tadesse, G., Algieri, B., Kalkuhl, M. and von Braun, J., 2014. Drivers and triggers of international food price spikes and volatility. *Food Policy*, 47, pp 117-128
- Timmer, C.P., 2010, Reflections on food crises past, *Food Policy*, 35, pp. 1-11
- Trostle, R., 2008. Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices. *Report from the Economic Research Services, US Department of Agriculture*

## Available related reports



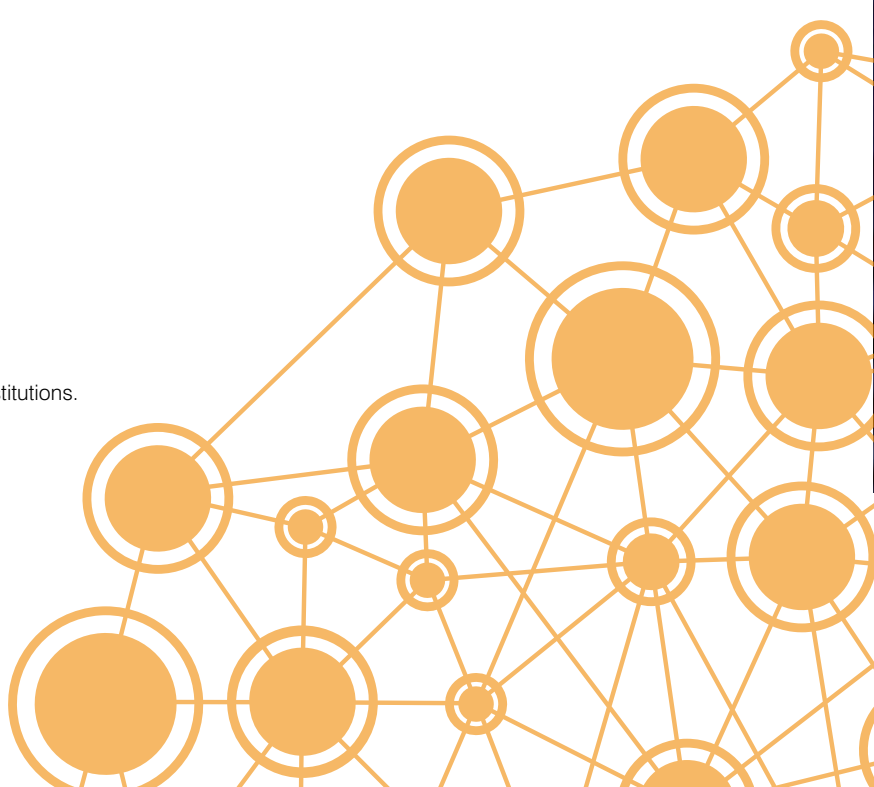
Global Food Security (GFS) is a multi-agency programme bringing together the main UK funders of research and training relating to food. GFS publications provide balanced analysis of food security issues on the basis of current evidence, for use by policy-makers and practitioners.

**For further information please visit:**

[www.foodsecurity.ac.uk](http://www.foodsecurity.ac.uk)

**Email:** [info@foodsecurity.ac.uk](mailto:info@foodsecurity.ac.uk)

This report has been developed in partnership with the following institutions.





# Appendix A: Wheat

The following provides quantitative information on past shocks to wheat production and consequent impacts on price. The data is presented in figures but no detailed discussion is included. This data was used to inform the shock event analysis presented in this document.

Just over 20 % of global wheat production is exported.

Production shocks in wheat were seen in:

- 1963 -USSR
- 1965 - USSR
- 1975 – USSR
- 1977 – Minor shocks in USSR and China (smaller shock in USA)
- 1981 - USSR

1975 = 30 % production loss in USSR wheat

2000-2004 = almost 20 % production loss in China wheat over business as usual (usage of stock to delay impact) and a shock in USSR in 2003

Main wheat export countries (accounting for 84 % of global export)

- USA
- France
- Canada
- Australia
- USSR (Russia/Ukraine)
- Argentina
- Germany

Main wheat consumer countries (representing 50 % of global usage)

- China
- India
- USA
- Pakistan
- Russia/USSR

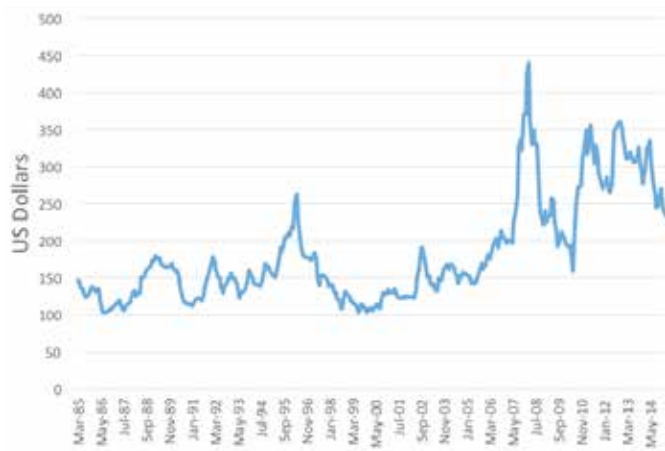


Figure A1: Quoted export prices for wheat 1985-current (monthly real) in US dollars. Source: [www.indexmundi.com](http://www.indexmundi.com)

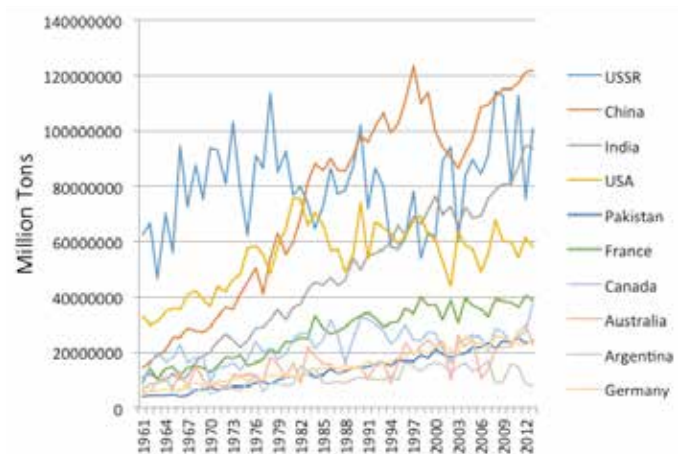


Figure A2: Wheat production by main exporters (and importers)

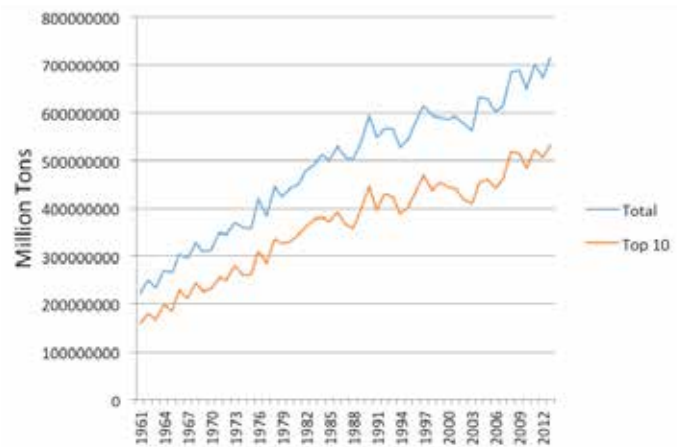


Figure A3: Total wheat production and top 10 producers

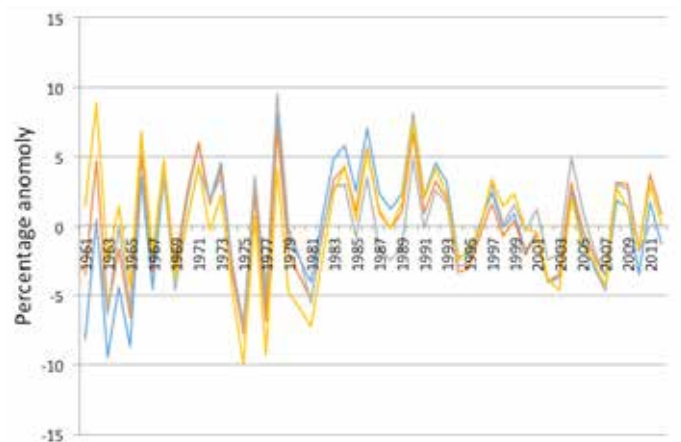


Figure A4: Wheat production away from global trend. The lines show apply four different methods of detrending. Three methods (linear, quadratic and moving mean) are applied at individual country level and then aggregated to global and the fourth method applied a quadratic algorithm to global production. Data supplied by Joshua Elliott.

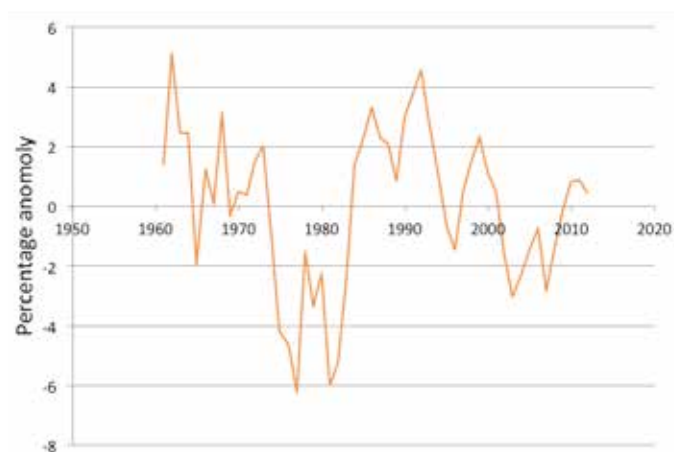
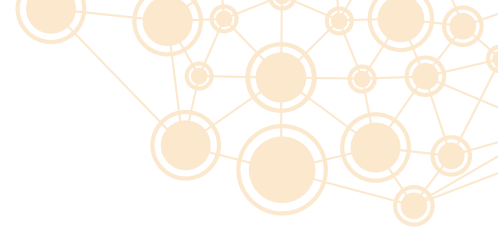


Figure A5: Wheat production 3 year smoothed average (current year and 2 year prior).

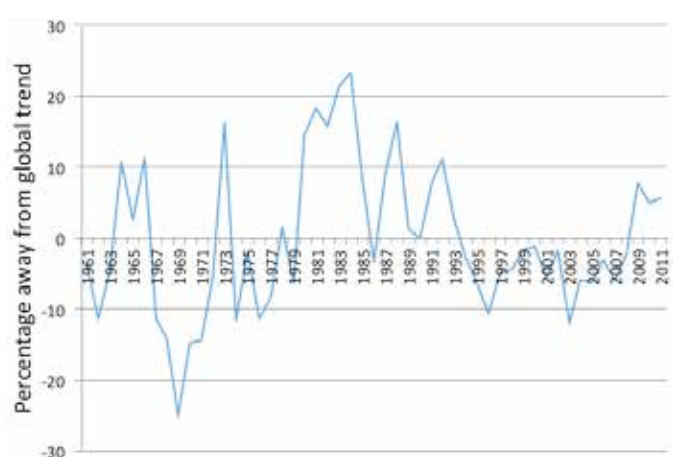


Figure A8: Percentage wheat exports away from global trend for main exporters (using straight line best fit – percentage is away from expected best fit line).

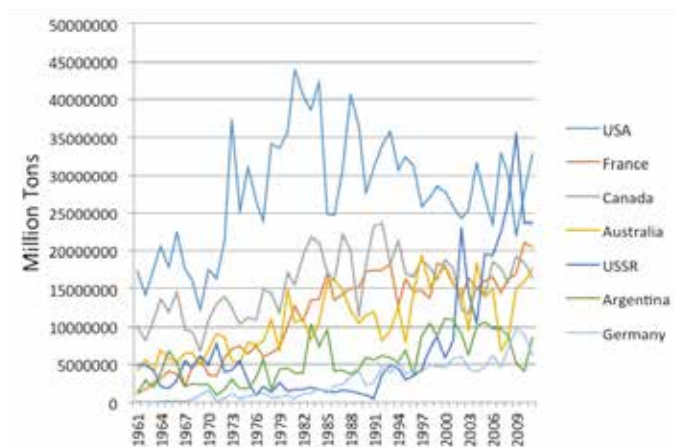


Figure A6: Exports by main wheat exporters.

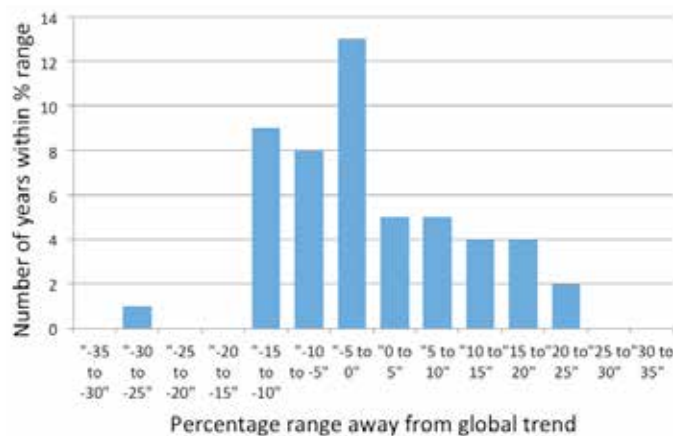


Figure A9: Percentage wheat exports away from global trend distribution for main exporters.

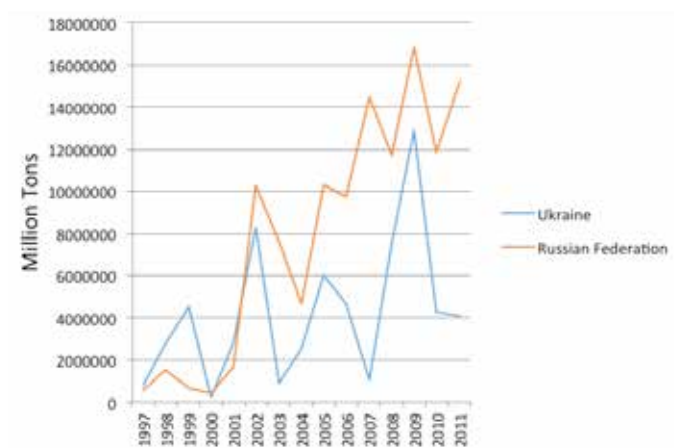


Figure A7: Exports by Ukraine and Russia showing USSR overall figures hide some country specific events such as a lower export from Ukraine in 2007.

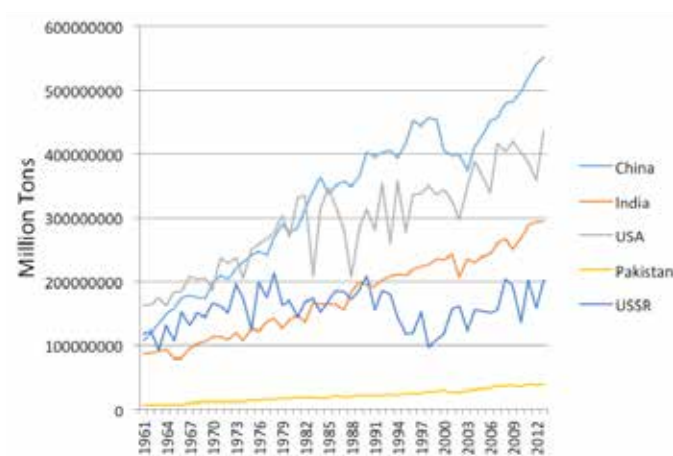


Figure A10: Production by main wheat users

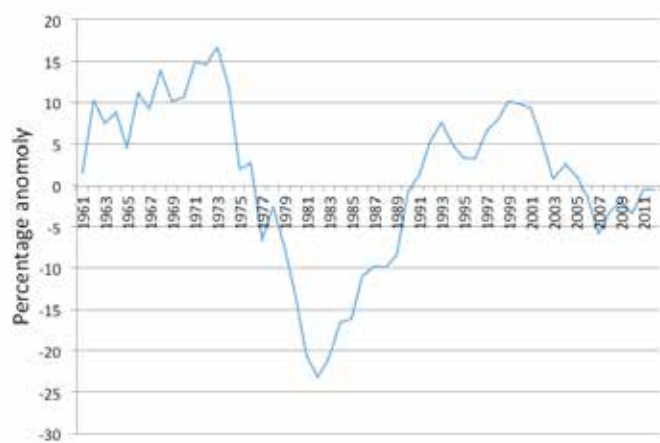


Figure A11: Cumulative total of wheat production from mean (global) (1961=0) (from Joshua data – this shows a drop in cumulative total in 1975 and post 2003).

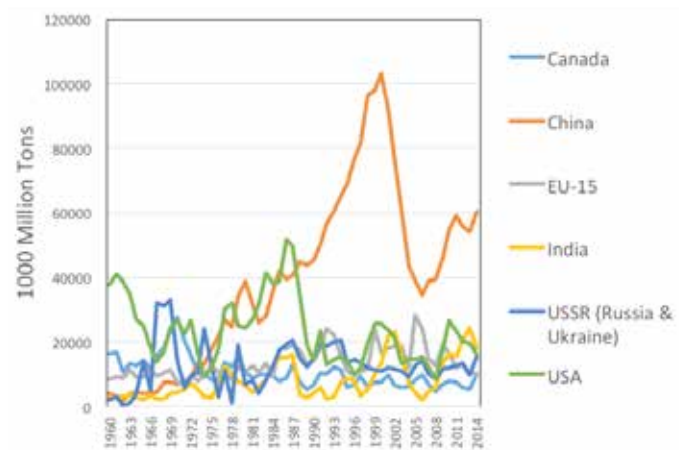


Figure A12: Wheat stocks (this shows a significant increase in stocks in China in the 1990s followed by a large decrease post 2000). The decrease post 2000 coincides with the cumulative total production of wheat decreasing and therefore delays the wheat 'availability shock' until 2006.

As part of the analysis linear regression modelling was performed to test for a direct link between price and production shocks. Deflated wheat price data from the World Bank was tested against the production anomalies for wheat. It was anticipated that these results would be statistically insignificant (mainly as no literature indicated a direct and straightforward link between production shocks and prices). This was found to be the case (Tables 1 & 2).

#### Coefficients<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	239.105	10.367		23.065	.000
1 WheatProd	-85.525	373.991	-.045	-.229	.820
WheatProd3	-655.379	565.031	-.230	-1.160	.252

Table 1: Wheat production (anomaly from mean) and smoothed over 3 years against wheat price dependent variable. Linear regression is not significant (higher than 0.05).

#### Model Summary<sup>b</sup>

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.263a	.069	.029	72.42178

Table 2: Wheat production (from mean) and smoothed over 3 years against wheat price dependent variable showing only 6.9 % of variability of price can be explained.



# Appendix B: Maize

The following provides quantitative information on past shocks to maize production and consequent impacts on price. The data is presented in figures but no detailed discussion is included. This data was used to inform the shock event analysis presented in this document.

Just over 10 % of global maize production is exported.

Production shocks in maize were seen in:

- 1974 – USA
- 1983 – USA
- 1988 – USA and minor shock in China
- 2012 - USA

Main maize export countries (accounting for over 81 % of global exports)

- USA
- Argentina
- Brazil
- Ukraine
- France
- India

Although the United States dominates world maize trade, exports account for a relatively small portion of demand for U.S. maize--about 15 percent. This low demand for exports means that maize prices are largely determined by supply-and-demand relationships in the U.S. market, and the rest of the world must adjust to prevailing U.S. prices. The high influence of U.S. maize supply makes world maize trade and prices dependent on weather in the U.S. Corn Belt.

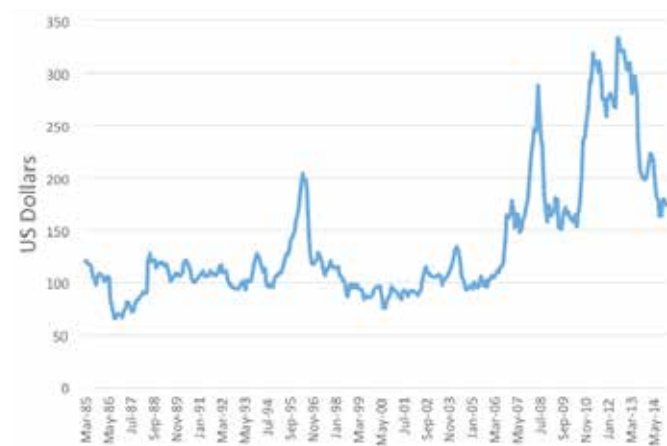


Figure B1: Quoted export prices for maize 1985-current (monthly real) in US dollars. Source: [www.indexmundi.com](http://www.indexmundi.com)



Figure B2: Total maize production and top 6.



Figure B3: Maize production by main countries.

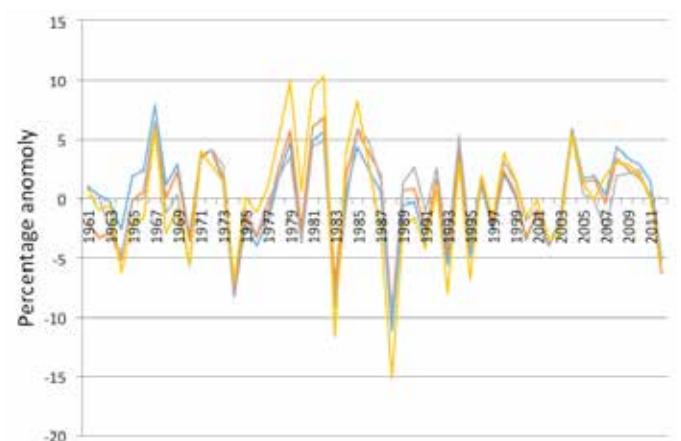


Figure B4: Maize production (away from global trend). The lines show apply four different methods of detrending. Three methods (linear, quadratic and moving mean) are applied at individual country level and then aggregated to global and the fourth method applied a quadratic algorithm to global production. Data supplied by Joshua Elliott.

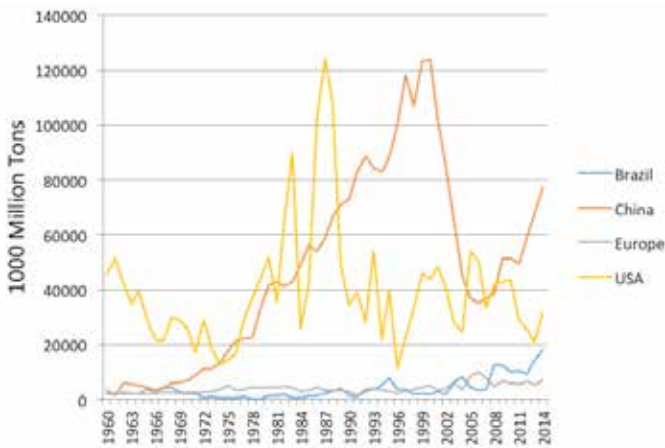
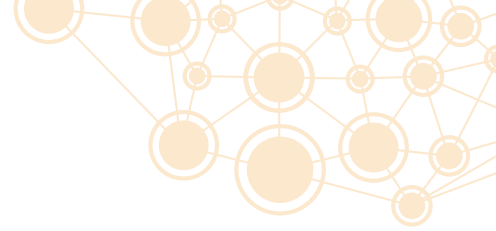


Figure B5: Maize stocks (1000 million tons).



Figure B8: Percentage maize exports away from global trend (using straight line best fit – percentage is away from expected best fit line).



Figure B6: Total global maize exports.

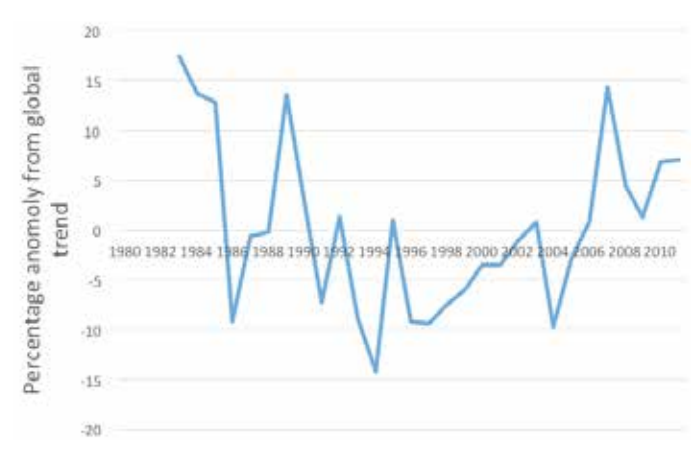


Figure B9: Percentage maize exports away from global trend (using straight line best fit – percentage is away from expected best fit line for the period beyond 1983 after the period of massive expansion in the USA).

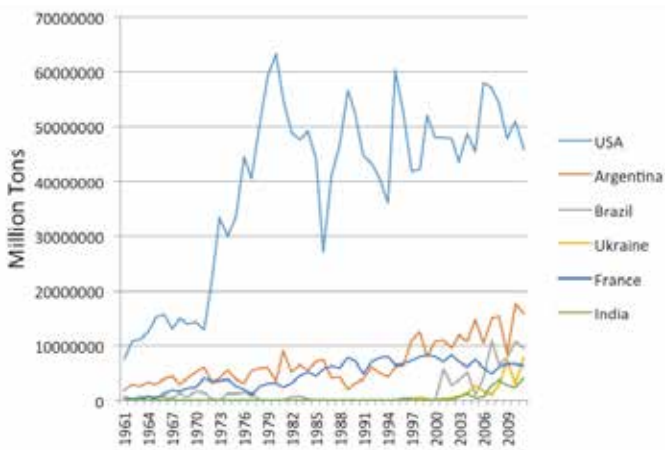


Figure B7: Top 6 exports (USA, Argentina, Brazil, Ukraine, France, India – 81 % of global exports in 2011)

As part of the analysis linear regression modelling was performed to test for a direct link between price and production shocks. Deflated maize price data from the World Bank was tested against the production anomalies for maize. It was anticipated that these results would be statistically insignificant (mainly as no literature indicated a direct and straightforward link between production shocks and prices). This was found to be the case (Tables 3 & 4).



**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	189.008	9.360		20.194	.000
1 MaizeProd	-89.992	230.652	-.072	-.390	.698
MaizeProd3	122.343	388.246	.058	.315	.754

Table 3: Soybean production (anomaly from mean) and smoothed over 3 years against soybean price dependent variable. Linear regression is not significant (higher than 0.05).

**Model Summary<sup>b</sup>**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.059a	.004	-.040	65.50888

Table 4: Soybean production (from mean) and smoothed over 3 years against soybean price dependent variable showing only 0.4 % of variability of price can be explained.



# Appendix C: Soybean

The following provides quantitative information on past shocks to soybean production and consequent impacts on price. The data is presented in figures but no detailed discussion is included. This data was used to inform the shock event analysis presented in this document.

Just over 30 % of global soybean production is exported.

Production shocks in soybean were seen in:

- 1964 – USA
- 1974 – USA
- 1980 – USA
- 1983 – USA
- 1988 – USA
- 2009 – Brazil and Argentina
- 2012 – Brazil, Argentina and USA

Main soybean export countries (accounting for over 96 % of all exports)

- USA
- Brazil
- Argentina
- Paraguay
- Canada
- Uruguay

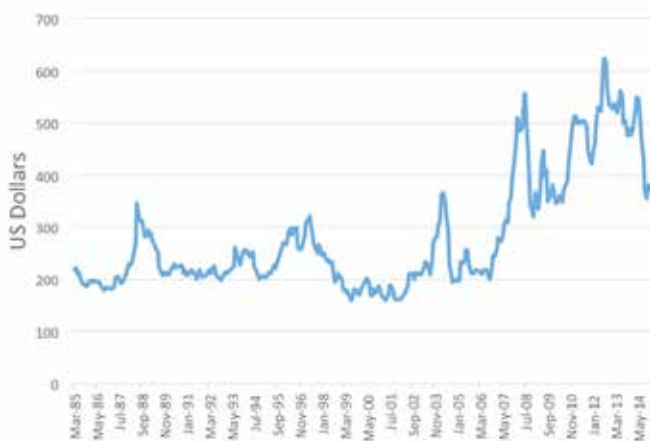


Figure C1: Quoted export prices for soybean 1985-current (monthly real) in US dollars. Source: [www.indexmundi.com](http://www.indexmundi.com)

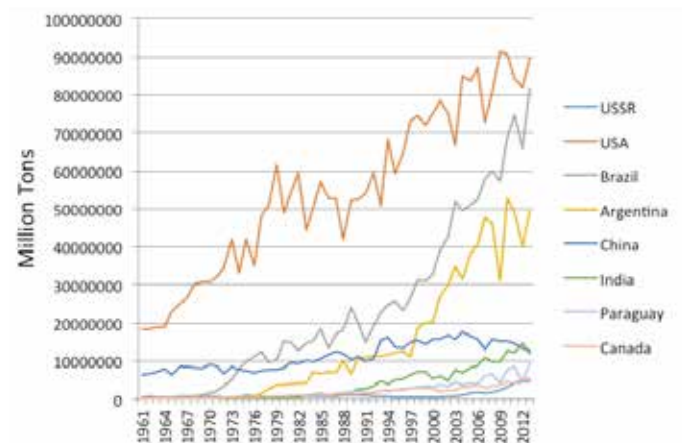


Figure C2: Soybean production by main countries.



Figure C3: Total production and top 8 country production.

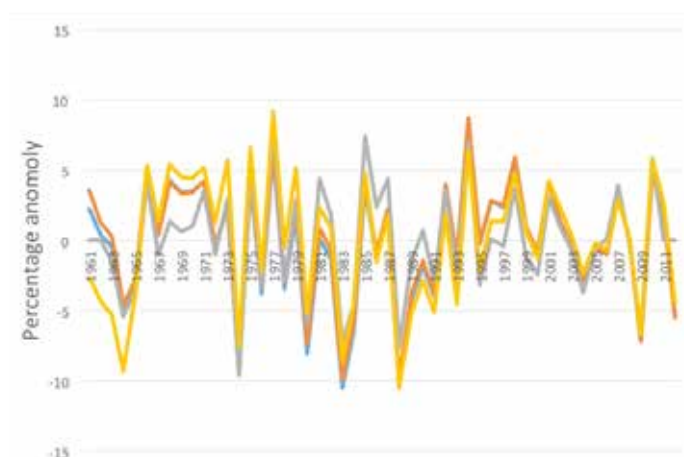


Figure C4: Soybean production (away from global trend). The lines show apply four different methods of detrending. Three methods (linear, quadratic and moving mean) are applied at individual country level and then aggregated to global and the fourth method applied a quadratic algorithm to global production. Data supplied by Joshua Elliott.

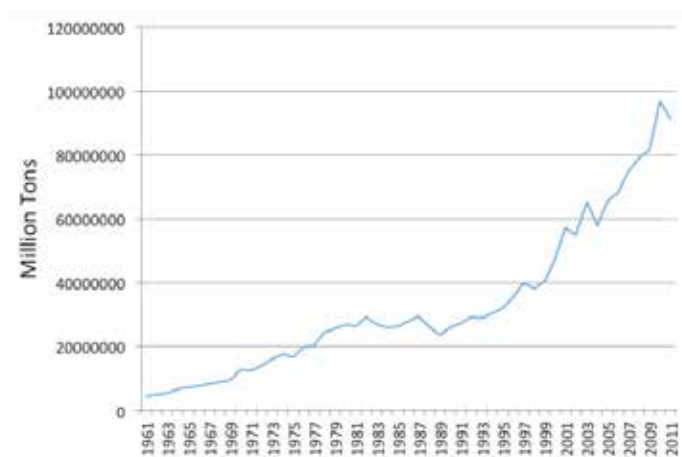
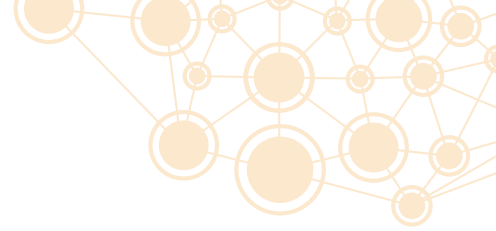


Figure C5: Total exports of soybean (by weight).

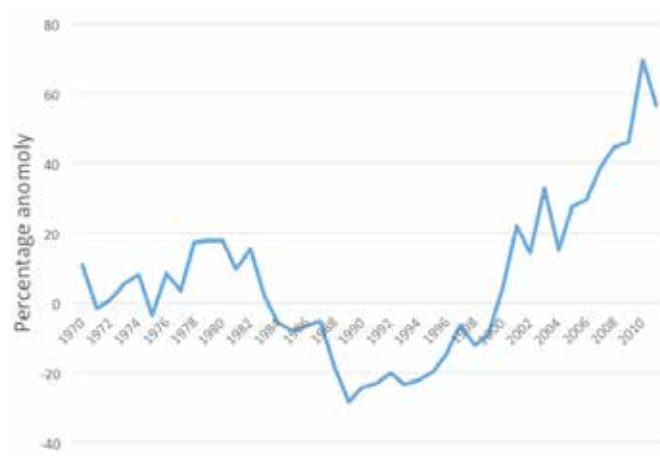


Figure C8: Percentage soybean exports away from global trend (using straight line best fit – percentage is away from expected best fit line). Data for best fit (see grey line in figure 46) was for 1961-2005 to avoid significant increase in USA between 2005 and 2011 which may skew trend data.

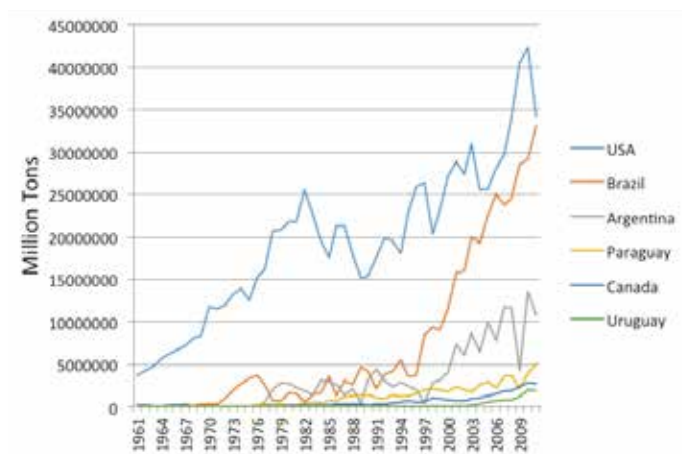


Figure C6: Exports in top 6 countries (USA, Brazil, Argentina, Paraguay, Canada and Uruguay – 96 % of all exports in 2011).

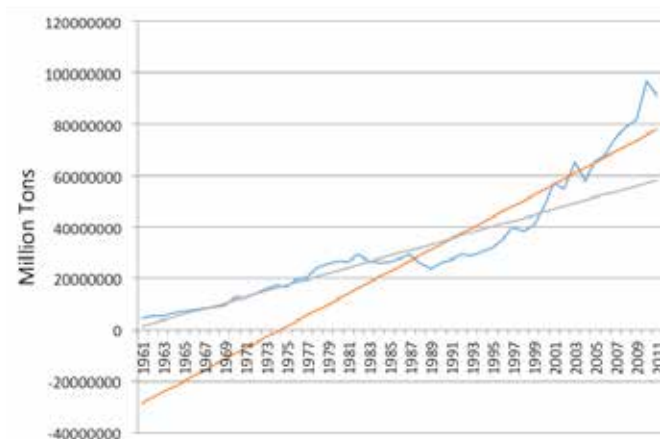


Figure C9: Soybean exports (by weight) showing best fit lines for the two trend periods (1980-2011 in orange and 1961-2005 in grey).

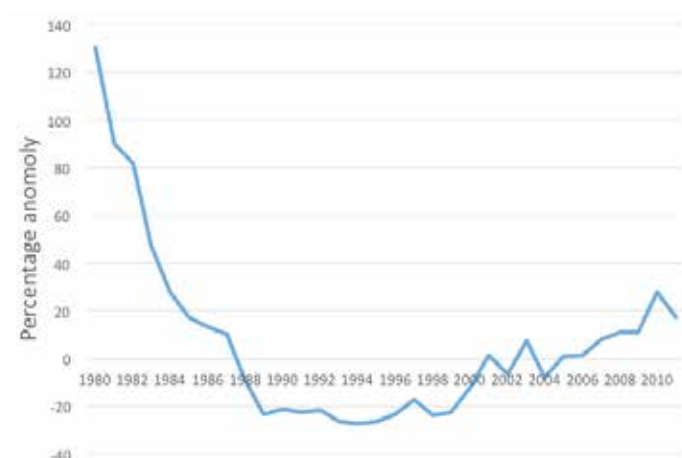


Figure C7: Percentage soybean exports away from global trend (using straight line best fit – percentage is away from expected best fit line). Data for best fit (see orange line in figure 46) was 1980-2011 to capture more recent growth in soybean exports.

As part of the analysis linear regression modelling was performed to test for a direct link between price and production shocks. Deflated soybean price data from the World Bank was tested against the production anomalies for soybean. It was anticipated that these results would be statistically insignificant (mainly as no literature indicated a direct and straightforward link between production shocks and prices). This was found to be the case (Tables 5 & 6).



**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	429.009	19.888		21.571	.000
1 SoyProd	-186.648	573.012	-.063	-.326	.746
SoyProd3	1152.379	918.711	.241	1.254	.216

Table 5: Soybean production (anomaly from mean) and smoothed over 3 years against soybean price dependent variable. Linear regression is not significant (higher than 0.05).

**Model Summary<sup>b</sup>**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.205a	.042	.000	139.06312

Table 6: Soybean production (from mean) and smoothed over 3 years against soybean price dependent variable showing only 4.2% of variability of price can be explained.



# Appendix D: Rice

The following provides quantitative information on past shocks to rice production and consequent impacts on price. The data is presented in figures but no detailed discussion is included. This data was used to inform the shock event analysis presented in this document.

Less than 10% of global rice production is exported.

Production shocks in rice were seen in:

- 1972 – India and China
- 1974 – India
- 1976 – India plus minor China
- 1979 – India and China

Main rice export countries (accounting for over 84 % of all exports)

- Thailand
- Vietnam
- India
- Pakistan
- USA
- Brazil

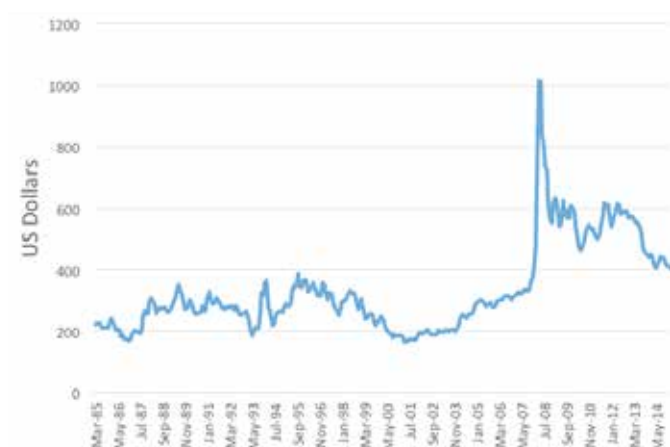


Figure D1: Quoted export prices for rice 1985-current (monthly real) in US dollars. Source: [www.indexmundi.com](http://www.indexmundi.com)

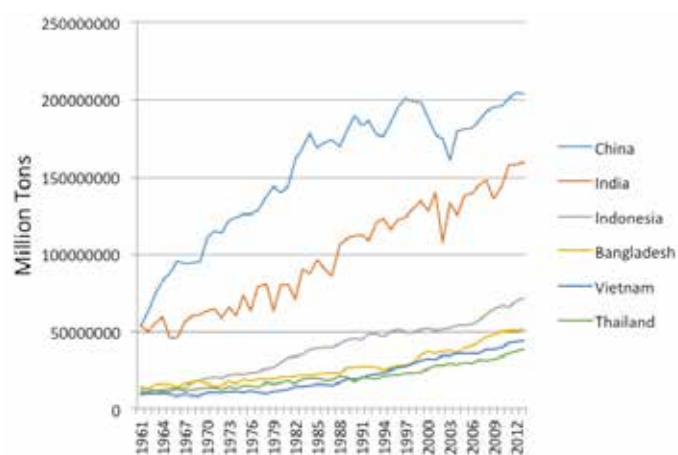


Figure D2: Rice production by main countries.

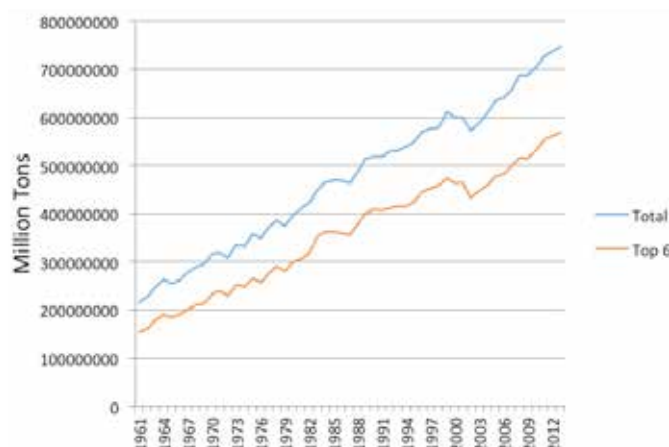


Figure D3: Total global rice production and top 6 country rice production.



Figure D4: Rice production (away from global trend). The lines show apply four different methods of detrending. Three methods (linear, quadratic and moving mean) are applied at individual country level and then aggregated to global and the fourth method applied a quadratic algorithm to global production. Data supplied by Joshua Elliott.



Figure D5: Total rice global export.

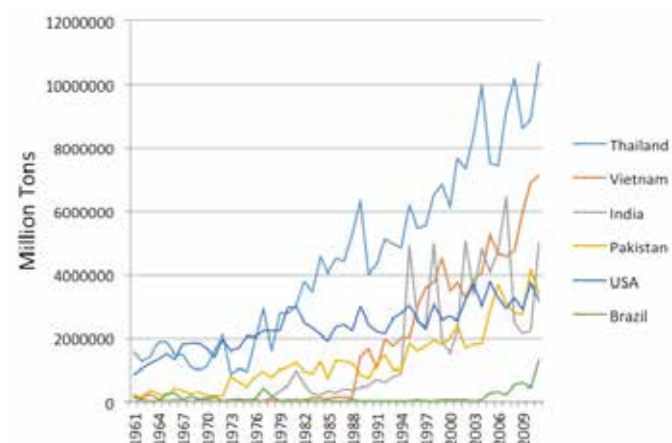
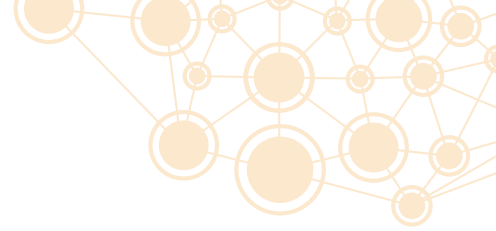


Figure D6: Top 6 exporters (Thailand, Vietnam, India, Pakistan, USA, Brazil - 84% of total exports in 2011)



Figure D8: Rice exports (by weight) showing best fit line for the trend periods 1975-2011 in grey).



Figure D7: Percentage rice exports away from global trend (using straight line best fit – percentage is away from expected best fit line). Data for best fit (see grey line in figure 55) was for 1975-2011 to capture the export market following the growth in Asia in the mid 1970s.

The linear regression modelling was not performed on rice due to the scarcity of rice pricing data availability.



# Appendix E: The Uruguay Round of WTO

---

The present rules and commitments on agriculture – often called the “Uruguay Round reform programme” — include reductions in subsidies and protection as well as other disciplines on the trade.

The agricultural package of the Uruguay Round has fundamentally changed the way domestic support in favour of agricultural producers was treated under the GATT 1947. A key objective was to discipline and reduce domestic support while at the same time leaving scope for governments to design domestic agricultural policies in the face of, and in response to, the wide variety of the specific circumstances in individual countries and individual agricultural sectors. The approach agreed upon ensured that the specific binding commitments in the areas of market access and export competition were not undermined through domestic support measures.

There are two main categories of domestic support:

- i. support with no, or minimal, distortive effect on trade on the one hand (often referred to as “Green Box” measures) and
- ii. trade-distorting support on the other hand (often referred to as “Amber Box” measures). For example, government provided agricultural research or training is considered to be of the former type, while government buying-in at a guaranteed price (“market price support”) falls into the latter category.

Under the Agreement on Agriculture, all domestic support in favour of agricultural producers is subject to rules. In addition, the aggregate monetary value of Amber Box measures is, with certain exceptions, subject to reduction commitments as specified in the schedule of each WTO Member providing such support.

Source: [http://www.wto.org/english/tratop\\_e/agric\\_e/ag\\_intro03\\_domestic\\_e.htm](http://www.wto.org/english/tratop_e/agric_e/ag_intro03_domestic_e.htm)

An update on the process is provided at [http://www.wto.org/english/tratop\\_e/agric\\_e/factsheet\\_agng\\_e.htm](http://www.wto.org/english/tratop_e/agric_e/factsheet_agng_e.htm)

# Appendix F: Financial and investment market responses

## Summary of investor workshop

5th February 2015

Aviva Investors

### Overview

This workshop explored possible impacts of 'black swan' events on the investment community – specifically institutional investors (pensions and insurance). There are both potential systemic economic risks as well as specific investment asset risks.

The following people attended:

- Aled Jones, Global Sustainability Institute
- Steve Waygood, Aviva Investors
- Morgan LaManna, IIGCC
- Niall Moten, Lloyds of London
- Kajetan Czyz, F&C Asset Management
- Meryam Omi, LGIM
- Ed Bailey, Sarasin and Partners
- Kenneth Donaldson, Institute and Faculty of Actuaries
- Efundem Agboraw, Global Sustainability Institute

The following summarises the discussions around asset and economic risks. In addition data was gathered over the period covering past shocks (see Figures F1-5) to help quantify the size of the impact on the share prices of different asset types.

### Asset risks

- Commodities
  - o There is little exposure to food commodities within institutional investors at present. There may be slightly higher exposure to oil (and in particular Sovereign Wealth Funds are likely to be significantly impacted by oil). Any indirect impact on oil prices as a result of a food shock are therefore likely to be of more significance.
  - o The power of the large commodity trading companies (Arch Daniel Midlands, Bunge, Cargil and Louis Dreyfus) was discussed and it was agreed that they were not in a position to manipulate market prices in the way that OPEC does as they could not alter production in the same way.
- Equities (public and public)
  - o The overall risk on public equities is likely to be relatively small (direct food and agriculture equities being a small percentage of all share equities). However, there is high volatility for agriculture stocks.
  - o Particular companies may see impacts above and beyond their competitors depending on where the production shock occurs and which companies are directly exposed (for example, ADM could not export from Russia because of an export ban but still had to deliver on a contract).
  - o Food company stocks are generally not significantly impacted (this is likely due to the cost base for food production including many factors beyond basic grains).

- o Ethanol and meat companies can experience high volatility because of their changing cost base (grains) compared to the higher prices for their outputs (in particular fuel over the recent years).
- o Following food production shocks in 2006-07 the following (approximate) impacts were seen over a 12 month period (January – December 2007) followed by a crash in early 2008 (which pre-dated the stock market crash in late 2008):
  - Agriculture commodity stocks: 100 % increase in price
  - Agriculture chemical stocks: 500 % increase in price
  - Agriculture engineering supply chain: 150 % increase in price
- o Risks for institutional investors (pension and insurance) are likely to be through country exposure. Therefore, political instability impacts mapped into country investments are important.
- Corporate bonds
  - o Likely to be similar to private equities (country exposure dependent).
- Government bonds/gilts
  - o There is a risk of both default and flight to quality. However, the impact is now likely to be smaller than it would have been before the financial crisis because of investor 'complacency' (quantitative easing by governments, including the recent announcement by the European Central Bank, means no real movement in bonds/gilts has been seen following major political events such as those in Russia-Ukraine as investors believe the returns on these bonds are now insulated from real market conditions).
  - o Defaults are more likely in more vulnerable countries (for example, see Kraemer, M. & Negri, L, 2014, Climate Change Is A Global Mega-Trend For Sovereign Risk, S&P RatingsDirect who rate the following 10 countries as most likely to experience pressure on credit ratings due to climate change – food production being a key risk factor – Cambodia, Vietnam, Bangladesh, Senegal, Mozambique, Fiji, Philippines, Nigeria, Papua New Guinea and Indonesia). Defaults have been seen in countries such as Russia and Argentina in the past. These have had significant but time limited impact. China has a substantial foreign reserve so is much less likely to default.
  - o Flight to quality is most likely to impact US government bonds (and other AAA rated bonds) however it was noted this could be a good thing for institutional investors who currently have high(er) exposure to these bonds.

### Systemic economic risks

- Inflation and overall credit risks
  - o Credit Default Swaps are used to manage these types of credit events and therefore short term (1 year) shocks may have a limited impact on investments. However, if food prices remain high (and potentially linked to high energy prices) for 2-3 years the events will start to have a more significant impact on investment funds. These 2-3 year events will



be much more significant for institutional investors than individual asset risks as they are associated with the entire investment holding.

Issues to consider includes:

- The main markets investors would be worried about include China, Russia, Saudi Arabia, Argentina, India and Thailand.
- A multi-breadbasket failure is needed to have a major investment impact.
- Linked climate events may cause more direct investment losses (for example, if a causal factor for a food shock includes a drought in Brazil then there may also be a major energy shock in Brazil due to hydro power restrictions).
- Multi-year price events are more likely to impact institutional investors as they will not be insulated against shocks through derivatives (such as CDS).

### 2007-08 food shock event

From February 2007 to February 2008 cereal prices increased by almost 100 % on a monthly deflated figure. This pre-dates the major financial crisis in September 2008.

Key issues:

- 2000-2004 saw almost 20 % production loss in China wheat over business as usual and a shock in USSR in 2003 leading to cumulative negative 'shock' in 2007.
- 2008 saw a 50 % loss in export from Australia. This follows a near 80 % reduction in Ukraine exports in 2007 (although a similar reduction in Russia is not seen – Ukraine implemented an export ban that year).
- Global wheat production down by 5 % in 2002, 2003 and 2007
- Between 2000 and 2007 China stocks reduce by more than half (60 %)
- No production impacts in rice (but export restrictions in place driven by speculation and hoarding).
- World grain stocks at historic low levels (below 80 days of consumption) 2003-2008

In response to the above price and food production shocks public equities experienced major volatility. In late 2006, early 2007 the anticipation of a food shock event in 2007 caused stock valuations of commodity traders and agriculture businesses to increase by as much as 800 % within a 12 month period.

However, as the market began 2008 these stocks were seen to be significantly over-valued and a crash occurred – the crash continued until the financial crisis in September 2008 where the majority of all stocks crashed. However the crash in agriculture had started nine months before the financial crash. Food companies did not experience the same volatility (likely because the input costs from grains are much lower for food companies).



Figure F1a: Agriculture commodity stocks (ADM). Historical share prices in US Dollars.



Figure F1b: Agriculture commodity stocks (Bunge). Historical share prices in US Dollars.

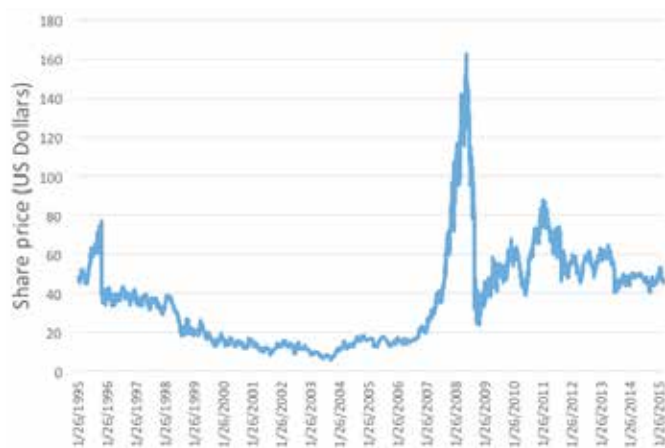


Figure F2a: Chemical/crop nutrient/fertiliser stocks (Mosaic). Historical share prices in US Dollars.

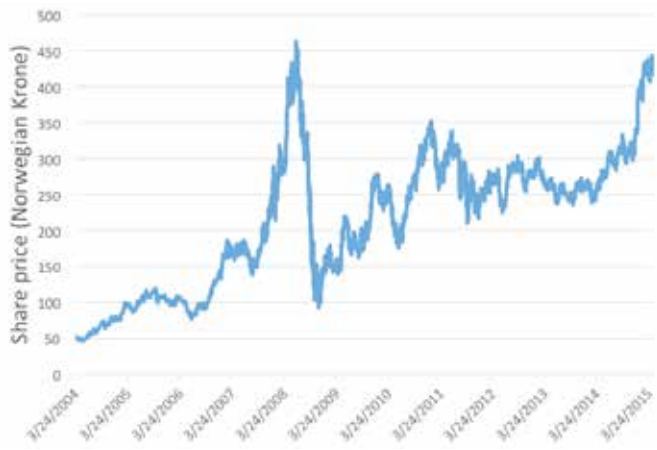
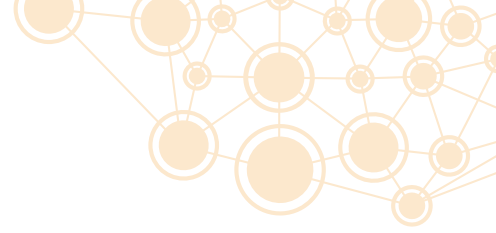


Figure F2b: Chemical/crop nutrient/fertiliser stocks (Yara International). Historical share prices in Norwegian Krone (NOK).



Figure F4a: Food stocks (Mondelez). Historical share prices in US Dollars.

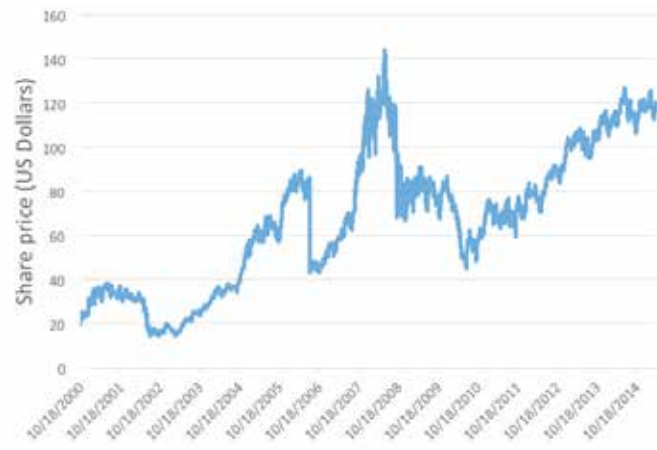


Figure F2c: Chemical/crop nutrient/fertiliser stocks (Monsanto). Historical share prices in US Dollars.



Figure F4b: Food stocks (Nestle) – loss in value occurs at the same time as the financial crash. Historical share prices in Swiss Francs (CHF).



Figure F3: Agriculture engineering stocks (Deere & Co). Historical share prices in US Dollars.



Figure F4c: Food stocks (PepsiCo) – loss in value occurs at the same time as the financial crash. Historical share prices in US Dollars.



Figure F5a: Meat and ethanol stocks (Tyson) – grain is one of the main supply costs for meat or ethanol companies (if they are not also grain companies). Ethanol stocks benefited from high fuel prices. Historical share prices in US Dollars.

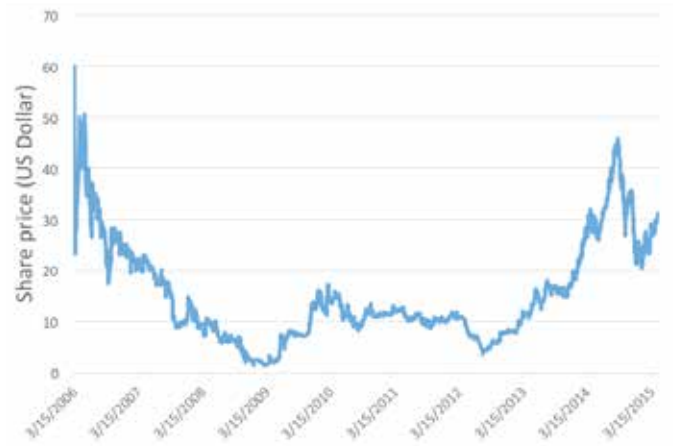


Figure F5d: Meat and ethanol stocks (Green Plains). Historical share prices in US Dollars.

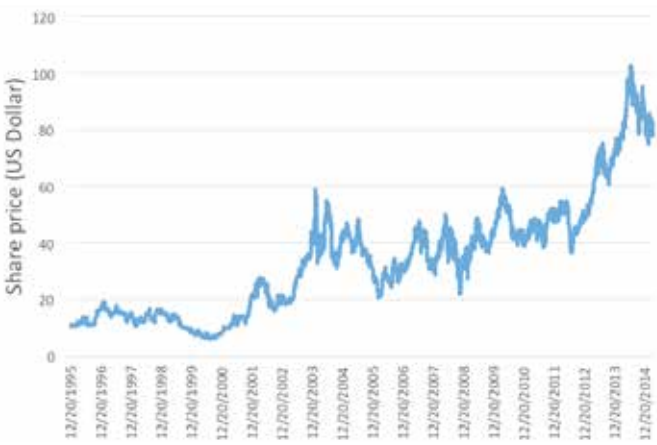


Figure F5b: Meat and ethanol stocks (Sanderson Farms). Historical share prices in US Dollars

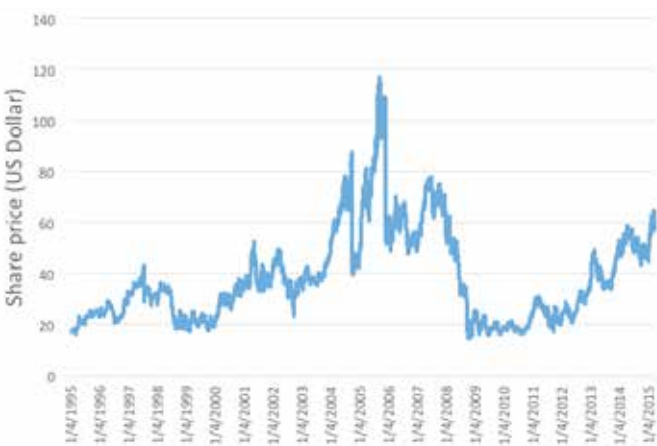


Figure F5c: Meat and ethanol stocks (Valero Energy). Historical share prices in US Dollars.



# Appendix G: Interviews and acknowledgements

The following have been interviewed to date as part of this work:

1. Zhang Hongzhou, Nanyang Technological University, Singapore
2. Rob Bailey, Chatham House, UK
3. Nancy DeVore, Bunge Global, USA
4. Karimah Hudda, Mondelez, Canada
5. Jonathan Horrell, Mondelez, Canada
6. Gordon Friend, DEFRA, UK
7. Corey Cherr, Thomson Reuters, USA
8. Chris Brown, ASDA Walmart, UK
9. Jerry Hjelle, Monsanto, USA
10. Jay Gullede, Oak Ridge National Laboratory, USA
11. Marc Sadler, World Bank, USA
12. Puvan J. Selvanathan, UN Agriculture / Global Compact, USA
13. Samir Saran, ORF, India
14. Tom Lumpkin, CGIAR, Mexico
15. Jerry Skees, University of Kentucky, USA
16. Professor Paul Teng, National Institute of Education, Singapore
17. Stephen Lorimer, Ministry of Business, Innovation and Employment, New Zealand
18. Jonatan Lassa, United Nations University, Singapore
19. Dave Gustavsen, ILSI, USA
20. James Jones, University of Florida, USA
21. Mark Rose Grant, IFPRI, USA
22. Don Seville, Sustainable Food Lab, USA
23. Chris Joknik, Oxfam, USA
24. Gerald Nelson, University of Illinois, USA
25. John Antle, Oregon State University, USA
26. Erik Chavez, Imperial College, UK
27. Margaret Walsh, USDA, USA
28. Eija Pehu, World Bank, USA
29. Mukul Sanwal, Institute for Defence Studies & Analyses / UMass Amherst, India
30. Arunabha Ghosh, CEEW, India
31. Naomi Hossain, University of Sussex, Indonesia
32. Robin Lougee, IBM, USA
33. Biraj Patnaik, Supreme Court Commissioners Office on Right to Food, India
34. John Magrath, Oxfam, UK
35. Tassew Waldehanna, Addis Ababa University, Ethiopia
36. Anne Roulin, Nestle, Switzerland
37. Felino Lansigan, Univ. of the Philippines Los Banos, Philippines
38. Simon Ticehurst, Oxfam, Brazil
39. Elias Fereres, Irrigation Science, Journal, Spain
40. Sir Gordon Conway, Imperial College, UK
41. Joanna Syroka, WFP, USA
42. John Ingram, Oxford University, UK
43. Bruce Babcock, Iowa State University, USA
44. Helen Edmundsen, DfID, UK

A workshop hosted by Chatham House on February 11th 2015 refined this document. Those attending the workshop were:

1. Nick Silver, Institute of Actuaries
2. Paul McMahon, Associate Fellow, Chatham House / Managing Director, SLM Partners LLP
3. Gordon Friend, DEFRA
4. Maria Lacunza, DEFRA
5. James Ballantyne, FCO
6. Rowan Douglas, Willis Research Network
7. Olivia Gray, Willis Research Network
8. Laura Wellesley, Chatham House

The authors would like to thank Catherine Cameron for a detailed review of this document.