Chapter 4
Food Price Volatility

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Abstract The high food prices experienced over recent years have led to the widespread view that food price volatility has increased. However, volatility has generally been lower over the two most recent decades than previously. Over the most recent period, volatility has been high but, with the important exception of rice, not out of line with historical experience. There is weak evidence that grains' price volatility more generally may be increasing.

4.1 Volatility – Definition and Measurement

"Volatility" is both a technical term in economics and finance and a term used by laymen in discussing price developments. At the technical level, the volatility of a price or an asset return is a quantitative measure of the directionless extent of the variability of the price. Laymen tend to refer to prices as volatile when they are high. It is often the case that prices are indeed more variable when they are high since supply shortfalls and demand surges cause price to be both high and volatile. Nevertheless, a price can be both high and relatively constant, a sort of *alto piano*, or low and variable. The two usages are therefore distinct. The discussion in this chapter uses the technical definition.

It follows that volatility measures the second moment of the price distribution. The standard deviation is generally preferred to the variance itself since this is in the same units of measure as the price itself. More frequently, economists measure price volatility as the standard deviation of logarithmic prices since this is a unit-free measure. For low levels of volatility, the log standard deviation is approximately equal to the coefficient of variation.

Many economic series exhibit trends. For such series, volatility is measured relative to the trend. Measurement of volatility therefore requires that the series be detrended. Because trends are rarely linear and deterministic, detrending requires a

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trend model. This implies a judgmental trade-off between attribution of variability to the trend and to variation about the trend. As a consequence, the volatility measure can depend on the choice of trend model in an undesirable manner. In looking at price volatility, economists often circumvent these issues by measuring volatility as the standard deviation of price returns, i.e. the standard deviation of changes in logarithmic prices. This measure has the advantage that it relates directly to the volatility concept employed in asset pricing theory in finance.

It is conventional to quote return volatilities at an annual rate. The theory of (informationally) efficient markets implies that asset price returns should be independent over time. This implies that monthly volatilities can be annualised by multiplying by $\sqrt{12}$ and daily volatilities annualised by multiplying by $\sqrt{250}$ (on the basis that there are approximately 250 trading days in the year) (Taylor, 2008). Even though many markets depart to some extent from this definition of "efficiency", it remains convenient to use these standard conversion factors. In what follows, we measure volatilities by the standard deviations of the changes in the logarithms of monthly price averages at an annualised rate.

4.2 Causes of Food Price Variability

Agricultural prices vary because production and consumption are variable. Economists distinguish between predictable and unpredictable variability, the latter being characterised in terms of shocks. Shocks to production and consumption transmit into price variability. Production can vary either because of variations in area planted or because of yield variations, the latter typically being due to weather variability. Consumption varies because of changes in incomes, changes in prices of substitutes and shifts in tastes. It is generally supposed that the most important source of price variability in agriculture is weather shocks to agricultural yields. However, demand shocks, in particular income shocks (Gilbert, 2010a) and policy shocks (Christiaensen, 2009) may also play an important role.

The extent to which given production and consumption shocks translate into price volatility depends on supply and demand elasticities which, in turn, reflect the responsiveness of producers and consumers to changes in prices. It is generally agreed that these elasticities are low over the short term, in particular within the crop year. Farmers cannot harvest what they have not planted and will almost invariably harvest everything that they have planted. Consumers are reluctant to revise habitual dietary patterns and, in poor countries, they may have few alternatives. Furthermore, the commodity raw material may comprise only a small component of many processed foods with the consequence that even large commodity price rises have a small impact on retail prices of processed food products.

Stockholding is one cause of volatility bunching. When stocks are low, relatively small production or consumption shocks can have large price impacts but when they are high, the reverse is the case. Moreover, once stock levels become high, they will remain high until consumption has exceeded production for a sufficient time to absorb past surpluses. Stockholding, therefore, results in a cyclical pattern in volatilities. World grain stocks fell to low levels by 2006 and this is seen as one cause of recent high grains price volatility. Since it takes time to rebuild stocks, it is possible that volatility levels will remain high over the next few years. But this does not imply that volatilities will be permanently higher.

Stockholding will reduce volatility so long as stocks are accumulated in periods of excess supply and released in times of excess demand. This strategy will also be profitable at least so long as the opportunity cost of capital is taken into account. However, stockholding is more effective in reducing the extent of price falls in the event of positive supply shocks (abundant harvests) than in reducing the extent of price rises in the event of shortfalls since destocking depends on the existence of a carryover from previous years. Stockholding, therefore, both reduces volatility but also gives a positive skew to the price distribution (Deaton and Laroque, 1992; Wright and Williams, 1991).

Other factors may also be important in either amplifying or attenuating volatility. Speculation, which may take the form either of speculative stockholding or of speculative purchase and sale of commodity futures or other derivative contracts, may have either a positive or a negative impact on volatility. The traditional view among economists is that speculation will tend to be stabilising (i.e. volatility reducing) because destabilising speculation will be unprofitable and will therefore not persist (FAO, 2008). This view implicitly supposes that speculation is a route by which informed agents profitably exploit private information, thereby impounding this information in market prices. However, much speculation is undertaken by trend-following investors such as Commodity Trade Advisors or by amateur traders, and there is a worry that their extrapolatively based actions may result in self-fulfilling beliefs – a randomly induced price rise, if identified as a nascent trend, may generate further buying, thereby reinforcing the initial movement (De Long et al., 1990; Gilbert, 2010b; Gilbert and Morgan, 2010; Huchet-Bourdon, 2010).

More recently, a significant group of institutional investors have started to invest in commodity futures through index-based swap transactions as a portfolio diversification strategy and to assume exposure to the commodity "asset class". In agricultural futures markets, these positions are often large in relation to total activity – up to 40% of market open interest. There is evidence that these investments may generalise price changes across markets and amplify the extent of price movements (Gilbert, 2010b; US Senate, 2009).

Food price volatility arises from shocks which can come from a number of sources, with the impact being felt differently in each separate commodity market examined. On some occasions, these shocks will be correlated. Often this will be the case if common factors simultaneously affect a range of different markets, perhaps including non-agricultural markets. This appears to have been the case in 2007–2008 when most agricultural prices and many non-agricultural prices (energy, metals and freights) rose simultaneously. It was also the case in the 1973–1974 food price spike. In cases such as these, it appears likely that there are common causal factors. There is less agreement in the identity of these causal factors but demand growth, high oil prices perhaps generating demand for grains as biofuels feedstocks, dollar depreciation and futures market speculation are all candidates in this regard (Abbot et al., 2008; Baffes, 2007; Cooper and Lawrence, 1975; Gilbert, 2010a, b; Mitchell, 2009).

4.3 Historical Review

Agricultural prices, and prices of commodities in general, were very volatile over 2006–2010. It is this burst of volatility that has prompted interest in the likely course of volatility over the longer term. Previous periods of high volatility gave rise to the same questions but the historical experience has generally been that periods of high volatility have been relatively short and interspaced with longer periods of market tranquillity. It is, therefore, recognised that it would be wrong simply to extrapolate recent and current high volatility levels into the future. Nevertheless, there is a natural concern that on this occasion, matters may have changed permanently.

Gilbert showed that agricultural price volatility was low in the 1960s but was higher in the 1970s and the first half of the 1980s (Gilbert, 2006). It generally fell back in the second half of the 1980s and the 1990s but remained well above its 1960s level. Table 4.1 updates table 4 of Gilbert (2006) looking from 1970 to 2009. The sample is divided at the end of 1989, the half-way point. The first column of the table reports the volatility estimate for the commodity over the entire 40-year period. The second column gives the estimates for 1970–1989 (top) and 1990–2009 (bottom). The third column reports the standard F test for variance equality. The test outcome is summarised in the final column.

From the first column of Table 4.1, we see that agricultural volatilities have been lowest for grains and meats and highest for fresh fruit. Fruit is perishable and storage, which can limit volatility, plays a more limited role for fruits than for the other commodities considered in the table. Columns 2 to 4 of Table 4.1 show that there was a statistically significant rise in volatility for only two commodities – bananas and rice. By contrast, nine commodities saw statistically significant falls in volatility – cocoa, tea, soybeans, three vegetable oils (soybean, groundnut and palm) and the three meat and fish products (beef, lamb and fishmeal). Overall, therefore the most recent two decades have seen lower levels of agricultural volatility than in those of the 1970s and 1980s with rice the main exception to this tendency.

In splitting the sample at the end of the 1980s, the tests reported in Table 4.1 provide a relatively crude indication of whether volatilities have been changing. It is arguable that this comparison may to a large extent be driven by the experience of the 1970s, when volatility was acute, and that the high volatility levels of the most recent years (we take 2007–2009) is out of line with the experience of the more recent past even if it is not exceptional relative to the 1970s. This is difficult to judge since, as already discussed, volatility is itself highly variable over time and periods of high volatility tend to bunch. One way of posing the question in relation to recent levels of volatility is to ask whether they were cyclically high or exceptionally high even in relation to cyclical factors.[1]

To answer this question, we consider a set of structural time series models for intra-annual volatilities. The objective is to decompose measured volatility into three

[1] In Gilbert and Morgan (2010), we used a GARCH model to address this question.

Table 4.1 Price volatilities 1970–2009

	1970–2009 (%)	1970–1989 (%)	1990–2009 (%)	Change (%)	*F*-test	Conclusion
Beverages plus sugar						
Cocoa	23.1	24.8	21.1	−3.7	1.38	Significant fall
Coffee	25.5	25.4	25.7	0.3	1.03	Insignificant rise
Sugar	27.1	27.6	26.6	−1.0	1.08	Insignificant fall
Tea	35.0	42.2	25.7	−16.5	2.69	Significant fall
Grains						
Maize (corn)	19.3	19.4	19.2	−0.2	1.01	Insignificant fall
Rice	21.1	18.9	23.3	4.4	1.52	Significant rise
Sorghum	20.4	20.2	20.6	0.4	1.05	Insignificant rise
Soybeans	22.4	24.9	19.5	−5.4	1.64	Significant fall
Wheat	20.0	19.5	20.5	1.0	1.11	Insignificant rise
Fats and oils						
Coconut Oil	32.4	30.9	33.4	2.5	1.21	Insignificant rise
Groundnut Oil	21.8	26.0	16.4	−9.6	2.52	Significant fall
Palm Oil	32.2	30.4	25.6	−4.8	1.39	Significant fall
Soybean Oil	22.8	25.9	19.2	−6.7	1.83	Significant fall
Sunflower Oil	27.2	25.8	28.6	2.8	1.23	Insignificant rise
Meat and fish						
Beef	15.0	15.9	14.0	−1.9	1.29	Significant fall
Fishmeal	22.2	26.1	17.4	−8.7	1.88	Significant fall
Lamb	15.3	17.4	12.7	−4.7	2.27	Significant fall
Fruit						
Bananas	56.1	45.2	65.5	20.3	2.10	Significant rise
Oranges	46.0	45.9	45.1	−0.8	1.08	Insignificant fall

Notes: Standard deviations of logarithmic changes in monthly average real US dollar prices at an annual rate, January 1970–December 2009. Nominal prices are deflated by the US PPI (all items)
Sources: IMF, *International Financial Statistics*, except coffee (International Coffee Organization)

components – trend, cycle and irregular – in order to separate out possible long-term changes on volatility from short-term fluctuations. To ensure that results are not driven by differences in specification across commodities, a common model is used for all nineteen commodities considered.

The volatility vol_t in year t is measured as the standard deviation of the log changes in monthly average prices over the year. To account for the skew in the volatility distribution, we model the logarithm $\ln \text{vol}_t$ of this volatility. The decomposition we employ is

$$\ln \text{vol}_t = \mu_t + c_t + \varepsilon_t \tag{4.1}$$

where μ_t is the volatility trend, c_t is the cycle and ε_t is an irregular component with variance σ_ε^2. The trend μ_t is modelled as deterministic but with a time-varying slope, i.e. a “smooth trend”:

$$\begin{aligned} \mu_t &= \mu_{t-1} + \delta_t \\ \delta_t &= \delta_{t-1} + \nu_t \end{aligned} \tag{4.2}$$

where δ_t is the trend drift or increment and ν_t is the drift innovation. This reduces to a linear deterministic trend in the case in which the trend innovation variance $\sigma_\nu^2 = 0$. The stochastic cycle c_t is modelled as

$$\begin{pmatrix} c_t \\ c_t^* \end{pmatrix} = \rho \begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \begin{pmatrix} c_{t-1} \\ c_{t-1}^* \end{pmatrix} + \begin{pmatrix} \kappa_t \\ \kappa_t^* \end{pmatrix} \tag{4.3}$$

where λ is the cycle frequency and κ_t and κ_t^* are two mutually uncorrelated white noise disturbances with mean zero and common variance. ρ is the damping factor – see Koopman et al. (2009). If the decomposition model is well-specified, the irregular component ε_t should be serially independent. However, like all decompositions, this model should be read as descriptive and not causal.

Within this decomposition, interest focuses on two issues:

(a) the end-sample (2009) trend level of volatility, which we compare to a historical average volatility over 2000–2006; and
(b) whether the most recent (2007–2009) observations are in line with the historically observed volatility levels or whether volatilities were extraordinary over these 3 years.

Results are summarised in Table 4.2. The first two columns of the table give the average intra-annual volatility over the 7 years 2000–2006 (top) and the end-sample (2009) level of the estimated trend μ_t (bottom). The third column reports Box–Ljung test Q(10) for residual serial correlation of order 10 (Ljung and Box, 1978). Given that the model contains five parameters,[2] it is distributed as χ_5^2. The final column of the table reports predictive failure tests for 2007–2009. These are based on the forecast residuals for these 3 years obtained from the model estimated up to 2006. Write the estimated variance of the irregular component as $\hat{\sigma}_\varepsilon^2$, then, on the null hypothesis that the model remains valid out of sample, the statistic $\sum_{t=2007}^{t=2009} e_t^2 / \hat{\sigma}_\varepsilon^2 \approx \chi_3^2$. If this test rejects, we are entitled to conclude that volatilities over 2007–2009 were exceptional, but this might imply exceptionally low as well as exceptionally high.

Turning to the results, of the 19 commodities considered, 7 show an estimated trend volatility level above their 2000–2006 average (tea, maize, rice, soybeans, wheat, coconut oil and sunflower oil) while the remaining 12 commodities show a trend volatility lower than this recent average. The evidence, therefore, shows that food price volatility has in general terms continued to decline over the recent high food price period consistently with its behaviour over longer term. Against that background, however, the volatility of all four important grain commodities has risen relatively to the past. If there is a problem of rising volatility, this seems to

[2] ρ, λ and the three variances σ_ε^2, σ_ν^2 and σ_κ^2.

Table 4.2 Volatility decomposition model results

	Average 2000–06 (%)	Estimated trend 2009 (%)	Box–Ljung test Q(10,5)	Predictive failure χ^2_3
Beverages and sugar				
Cocoa	22.9	16.9	4.91 [42.7%]	4.01 [26.1%]
Coffee	21.6	20.7	9.74 [8.3%]	2.92 [40.5%]
Sugar	27.9	24.0	3.58 [61.1%]	2.31 [51.0%]
Tea	25.6	26.8	5.59 [34.8%]	0.23 [97.2%]
Grains				
Maize	18.6	22.7	**27.7 [0.0%]**	2.47 [48.1%]
Rice	12.2	21.9	3.86 [57.0%]	**15.7 [0.1%]**
Sorghum	21.4	20.2	7.92 [16.1%]	1.55 [67.1%]
Soybeans	22.2	24.2	2.96 [70.6%]	1.46 [69.1%]
Wheat	17.1	23.8	6.18 [28.9%]	1.12 [77.3%]
Fats and oils				
Coconut oil	23.2	23.5	6.69 [24.5%]	1.40 [70.7%]
Groundnut oil	18.6	16.9	**14.5 [1.3%]**	1.48 [68.7%]
Palm oil	26.8	22.0	7.76 [17.0%]	6.16 [10.4%]
Soybean oil	20.5	17.7	5.68 [33.9%]	5.87 [11.8%]
Sunflower oil	28.7	29.0	4.88 [43.1%]	**19.3 [0.0%]**
Meat and fish				
Beef	13.8	10.9	4.38 [49.7%]	**9.19 [2.7%]**
Lamb	13.0	9.7	8.97 [11.0%]	1.58 [66.5%]
Fishmeal	15.2	9.5	**12.7 [2.7%]**	4.25 [23.6%]
Fruit				
Bananas	60.9	28.5	3.01 [69.8%]	**9.32 [2.5%]**
Oranges	47.1	45.3	**11.2 [4.8%]**	0.13 [98.8%]

Note: Authors' calculations using the STAMP module of OxMetrics (Koopman et al., 2009)
Sample: January 1970–December 2009. The Box–Ljung statistic tests for up to tenth order residual serial correlation. The predictive failure statistic tests whether the residuals for 2007–2009 are drawn from the same distribution as those for 1970–2006. *P*-values are given in "[·]" parentheses. Statistically significant results (at the 5% level) are indicated in bold face
Sources: IMF, *International Financial Statistics*, except coffee (International Coffee Organization)

be confined to grains prices and not food prices more generally. The Box–Ljung tests reject independence of the irregular component (ε_t) at the 5% level for four commodities – maize, groundnut oil, fishmeal and oranges. Caution should be exercised in these cases in the interpretation of the estimated models. Although there may be merit in less parsimonious specifications in these four instances, we prefer to maintain a uniform specification across commodities.

Turning to the results of the predictive failure tests, rejections are encountered at the 5% level for four commodities – rice, sunflower oil, beef and bananas. For the remaining 15 commodities, volatility over 2007–2009, even where high, was in line with that experienced historically.

Table 4.3 lists the volatility experience over 2007–2009 for the four commodities where this has been found to be exceptional. Both rice and sunflower oil experienced very high volatilities in 2008 continuing to a diminished extent into 2009. In both cases, volatility had been very low in 2007, exceptionally so in the case of sunflower oil. Beef also exhibits an exceptionally high 2008 volatility but its 2009 volatility was close to its historical average. Instead, the volatility of banana prices was exceptionally low over 2007–2009 relative to the high values experienced historically. In summary, rice and sunflower oil are the only two commodities of the 19 considered which conform to the view that recent food price volatilities have jumped to a new high level.

Sunflower oil did experience a low, but not extraordinarily low, 2008 harvest. The major supply problem arose in Ukraine, the world's largest sunflower oil exporter, where some sunflower oil exports became contaminated with lubricant oil resulting in import bans, in particular on the part of the EU, the Ukraine's main trading partner for this product. Rice is more interesting and important. We discuss the rice market in the next section.

To summarise, this analysis has generated three conclusions:

(a) Agricultural price volatility was generally lower over the past two decades than in the 1970s and 1980s, the major exception being rice.
(b) Although many agricultural products exhibited high volatility over the 3-year periods 2007–2009, these volatilities are generally in line within historical experience. However, this is not the case with rice and sunflower oil, where recent volatility levels were exceptional.
(c) There is some evidence that volatility levels may be increasing relative to historical levels across the grains complex. However, we will need to wait for a few more years to know whether this is indeed the case.

Table 4.3 Exceptional volatility experience

	2007 (%)	2008 (%)	2009 (%)
Rice	8.2	60.6	25.9
Sunflower oil	3.9	83.3	35.7
Beef	6.0	29.3	10.1
Bananas	17.2	43.4	16.9

These findings are in line with those of other recent studies of agricultural price volatility, which used more sophisticated econometric methods but which again failed to find evidence of any general increase in volatilities (Balcombe, 2009; Gilbert and Morgan, 2010; Huchet-Bourdon, 2010; Sumner, 2009).

4.4 How Will Food Price Volatility Evolve in the Future?

Agricultural price volatility is caused by shocks to production and consumption. The extent of the volatility is determined by the variances of these shocks and by the elasticities of the supply and demand functions. Those who claim that food price volatility will be higher over a long period must believe either that shock variances have increased or elasticities have declined. Those arguments have yet to be made in a coherent way.

There are three leading possibilities in this regard:

– Some argue that *global warming* has increased the variance of agricultural production. It is certainly possible to find clear examples of specific crop-country combinations where this is the case but we are not aware of any scientific work which establishes this possibility as a general tendency. Theoretical models suggest damage to existing cropping areas if temperatures rise (FAO, 2008; Schlenker et al., 2005). It is also possible that global warming may have reduced yield variability in other more temperate areas, but these effects are less likely to have hit the headlines. In any case, it remains to be shown that increased yield variability in specific crops and countries generalises to the entire spectrum of food prices.
– Many have claimed that the demand *for food commodities,* in particular corn, sugar and vegetable oils, as biofuel feedstocks has increased the correlation between agricultural prices and the oil price (Mitchell, 2008). This allows transmission of oil price volatility to agricultural prices, in effect increasing the variance of demand shocks. If one concedes that oil price volatility has increased over time, this could lead to increased food price volatility. There has been no systematic study of the effect of biofuels demand on food price volatility, as distinct from on the level of food prices. Scientific studies of the effects of biofuels demand on food price levels fail to find clear evidence of an increased linkage between the oil price and agricultural prices over recent years (Gilbert, 2010a).
– Others have pointed the finger at *speculation.* There is no strong evidence that traditional momentum-driven speculation has increased markedly over recent years. However, the so-called "massive passive" of index-based investment in commodity futures has grown dramatically. In US Senate testimony, hedge fund manager Michael Masters argued that, by contrast with speculators who are liquidity providers, index investors absorb liquidity and hence may increase volatility (Masters, 2008). (This would amount to an effective reduction in supply and demand elasticities in the futures markets.) Again, this claim has not been substantiated by scientific research. We conjecture that any such effect may be confined

to high frequency (e.g. intraday) variation rather than the month-to-month or year-to-year volatility that is of interest to policy makers.

Overall, therefore, the theoretical factors are inconclusive, allowing the possibility that there may be permanent increases in volatility but falling well short of establishing this outcome. This tallies with the evidence on realised volatility documented above. While it would be rash to forecast that currently high volatility levels will inevitably fall back to historical levels, the evidence is consistent with the recent price spike being associated with bunched high volatility associated with cyclically low stocks and not with any underlying change in the statistical properties of the price process.

The major exception to this conclusion relates to rice. Rice is one of the major grains and is the staple food in much of Asia. It is also widely imported and consumed in Central and West Africa and in the Caribbean where it forms a major component of the diet. However, it is not closely linked in terms of either production or consumption with other major grains, maize and wheat – it is produced on different types of land and largely in different countries, and, in the main, is consumed by different groups of consumers. Rice production and consumptions shocks are not highly correlated with those in other grains. Furthermore, rice is not currently traded on a liquid futures market – futures markets exist in both Bangkok and Chicago but they attract little business. Hence, there is little transmission of price changes from other grains to rice, or vice versa. Rice prices, therefore, tend to follow their own peculiar path. Nevertheless, rice prices did rise strongly in 2007–2008 and remained high in 2009. Furthermore, the discussion earlier in this chapter singles out rice as the commodity in which volatility levels have most clearly jumped.

The rice story in 2007–2009 is peculiar and in some sense pre-modern (Christiaensen, 2009; Timmer, 2009a). There were no significant production or consumption shocks in the rice market which was in surplus through the whole of 2007–2008. Neither could futures markets factors have contributed to high volatility. However, rice is peculiar in that only a small proportion of world rice enters into international trade – most major consumers are also major producers – and that much rice which is traded is bought or sold at contracted and not free market prices. The free market is, therefore, residual and has the potential to exhibit high volatility. The initial price rise came in October 2007 when the Indian government limited rice exports in order to offset the effects of rising wheat prices of the cost of living index. Fears that this might lead to a shortfall led to panic buying by governments of poor rice-importing countries which drove prices up to unprecedented levels. Prices fell back in July 2008 when the Japanese government agreed to sell rice from its WTO stockpile. In the end, no rice was sold but the offer was sufficient to cool the market.

The international rice market is evidently highly problematic as well as politically important – most of the so-called food riots in 2007–2008 involved rice. It is urgent and important that steps are taken to avoid repeat of this episode (Timmer, 2009a). In our view, however, it would be an error to see the problems affecting the rice market as generalising to other grains markets or to wider agricultural markets.

Both the sequence of events over 2007–2009 and the volatility statistics discussed earlier underline that “rice is different”. Whether or not rice price volatility increases or declines over the coming years will depend on how well the international community addresses the particular problems of that market, not on any general tendency of volatility in general to increase or decline.

4.5 Consequences of Food Price Volatility

Grains form the major staple food across the globe and also are an input into the production of meat products and as such are key within the food price volatility question. Even within grains, there are specific issues too as we can make a distinction between the major glutinous grains of say, wheat and maize, and that of rice. Wheat is a major concern for developed (richer) nations as it is the major input to bread and pasta. Direct consumption of grains declines as societies become richer. The consequence is that the impact of high and volatile grain prices is concentrated on the poorer rather than the richer economies and on the poor rather than the rich within each economy. In general terms it is probably correct to argue that energy price volatility is more problematic than food price volatility in the richer developed economies such as Britain. In Africa, white maize is the major grain staple. Because many maize-importing countries are landlocked, maize price volatility can be very high (Dana et al., 2006). As discussed above, rice is an outlier both in terms of trade and marketing and in terms of the volatility experience.

The impact of food price volatility can be viewed at both the economy level and at the individual (producer and consumer) level, although the impact will depend on which economy and which individuals are being examined. Focusing on the economy level first, there are a number of key factors that will affect the way food price volatility will create an impact. Virtually all economies trade in food – as importers and/or exporters – and thus volatility in world food prices will potentially have trade bill effects, the net outcome of which will depend on the predisposition to net exportation of food, the extent of integration in world markets. As such, a country-by-country approach to evaluating the effect of food price volatility would need to be carried out before precise impacts could be measured and even then, specific periods of time would have to be identified over which the effects were to be measured. However, it is possible to review some of the generic outcomes alongside case studies of particular countries.

Importing, richer nations are concerned about food price volatility in terms of the impact it might have on consumer price inflation (Bloch et al., 2007). Mundlak and Larsen (1992) explored the transmission of world prices to domestic levels. They found that the null hypothesis of the law of one price rarely holds due to a number of factors, in particular the impact of exchange rates and degrees of imperfect competition within domestic supply chains. It is possible to characterise richer nations as being more open to world price effects given established trading policies, which could suggest a greater concern over volatility, but this is dampened by the relatively low expenditure on food as a proportion of national income. The same concerns arise with respect to oil price volatility but pass-through has been low over the most recent decade.

Focusing on individuals in richer nations, consumers of food, now largely in the form of processed food products, are affected to the extent that world agricultural prices are transmitted into the prices paid for products in retail outlets. Retail sectors are often imperfectly competitive (Clarke et al., 2002) and thus pass-through is often incomplete dampening volatility effects. More pertinent is the possible link to rising wage demands to compensate for higher food prices but this is now a relatively weak link given the relatively low proportion of household income spent on food (10–15% in many countries is typical). Perhaps of some interest is the relative impact on poorer consumers in rich countries who do spend a higher proportion of their income on food and thus who could potentially suffer greater welfare loss from more volatile (higher) prices. It is notable however that the high food prices in 2007–2008 were much lower on the political agenda in the rich countries, including Britain, than the high energy and fuel prices.

Despite the inherent risks in agricultural production (Mitchell, 2008), producers in many richer nations may in principle cope with these risks and the resulting food price volatility through a range of different mechanisms such as forward and futures markets and crop insurance. While these arrangements do little to reduce price volatility, they do allow producers to cope more effectively with this volatility. As such, food price volatility can bring some short-run uncertainty but in aggregate terms the welfare impact for producers in richer nations is relatively minor.

Many poorer nations are net importers of food products, either in raw or processed form. For these countries, the proportion of the import bill that goes on food is generally much higher than in richer nations. Grains are the principal commodities for concern, followed by vegetable oils. Rice is the principal grain throughout most of Asia and food security concerns, therefore, relate primarily to the adequacy of rice supplies. In Southern and Eastern Africa, white maize plays this role. Wheat, which is a temperate crop and which is consumed predominantly in the temperate zone, is of greater importance in the developed world. The major use for soybeans is in meat production and hence volatility in soybean prices feeds through into meat prices. Soybeans are substitutable in production for both wheat, maize and consequently the prices of all three grains tend to move together. Rice exhibits much lower substitutability and rice prices therefore often follow an independent course.

For governments, volatile world food prices can create major import bill uncertainty with concomitant exchange control uncertainty. Scarce foreign exchange reserves can be exhausted relatively quickly with a sudden spike in food prices as the elasticity of demand for food imports is relatively low. The FAO has shown how increasing cereal import costs as a percentage of GDP can lead to a significant widening of the current account deficit (FAO, 2008).

Many developing country governments act to stabilise the domestic prices of food staples in order to avoid importing volatility from the world market. In most cases, the countries will also be significant producers of the staple. Stabilisation will then limit the incentive for domestic farmers to respond to signals from the world market. If a sufficient number of countries act in this way, the resulting reduction in the world supply elasticity will exacerbate volatility. Where countries are net importers, stabilisation will require fiscal resources. Food price volatility, therefore, introduces volatility into government expenditure. (The same is true of oil price volatility when governments stabilise petrol and other domestic energy prices).

In the poorest nations, where poverty levels are high and where food security becomes a pressing concern, food price volatility can *in extremis* lead to great hardship for consumers and even revolt (riots in Indonesia and Haiti, e.g.), reflecting the fact that food expenditure constitutes a significant proportion of total income (70–80% of income). Large and sudden increases in prices, or indeed large increases alone, can ultimately cause hunger, poor nutrition and illness if consumers are unable to buy their staple needs. Equally, as with richer nations, there are potentially inflationary effects in poorer nations too. The FAO has shown the relationship between CPI increases and food price increases for a number of countries, for example, Egypt had seen CPI rise by 15.4% while food prices rose 24.6% (Jan 2007–Jan 2008) and Haiti 10.3 and 14.2%, respectively, for the same period (FAO, 2008).

Clearly such dramatic impacts on the population are unpalatable for governments who often employ controls on markets or subsidisation of prices to mitigate the effects. Controls can take a number of forms but in periods of very steeply rising prices, some governments have sought to limit food shortages by banning exports of staple products grown in their own country. Others try to stem the impact of higher prices by buying at the world market and then selling onto the domestic market at lower (subsidised) process. The resulting fiscal cost can cause great stress on government finance as the difference between world and domestic prices gets larger.

4.6 Combating Food Price Volatility

There have been many attempts to deal with the problems associated with price volatility. These can be reviewed in terms of the time period of interest – the short (immediate) term and the longer term. Taking the short term first, this refers to an instant and short-run response to increased volatility often in conjunction with rising price levels. Many developing and middle income countries have sought to deal with significant price volatility by either banning exports of products (such as seen in South East Asia in relation to rice) or through subsidising prices so that world market effects are not transmitted to domestic consumers. Richer nations tend not to make short-term response but instead rely on the market to adjust back to a long-run equilibrium, although where possible, judicious use of stock release can and has been utilised to smooth prices. The interesting aspect of these short-term measures and indeed some longer term ones based on insulation of the domestic market is that while domestic markets might experience a degree of greater stability as a result of intervention, the impact on the world market and more open countries is that volatility increases. Such "beggar my neighbour" policies often arise when world markets are in decline or in periods of great instability.

Longer-term policies and responses are more systematic and expansive in what they try to achieve. At the aggregate level, governments have sought to work collectively to limit fluctuations in world prices of commodities, an approach manifest in the international commodity agreements that dominated the 1960s and 1970s for a range of commodities including sugar, coffee and cocoa. Control in these markets came via buffer stocks or export quotas and restraints with the explicit aim of maintaining prices within target bands that were agreed between consumer and producer nations. Gilbert showed these arrangements were more successful in raising prices above market levels than in reducing variability (Gilbert, 1996). Moreover, over time the benefits of higher prices became eroded by rent-seeking in the exporting countries (Bohman et al., 1996). As world commodity prices fell back in the 1980s, countries tended to lose faith that intervention would deliver more stable prices and the intervention clauses of the remaining commodity agreements were allowed to lapse.

Alternative measures for stabilisation of price took the form of ex post policies such as the EU's STABEX scheme that focused less on prices *per se* but instead on the impact volatility had on a country's current account balance. Under STABEX, payments were made to those countries which experienced large current account swings due to increasing import bills or indeed a collapse in export earnings due to price declines. However, such schemes were often viewed as insensitive to specific country concerns and were quite slow to respond to crises with the consequence that their impact was probably to amplify rather than damp the effects of price cycles (Collier et al., 1999). The successor FLEX scheme is generally seen as ineffective.

In richer nations, agricultural policies have been established often with an explicit target of price volatility reduction, as seen in the original rationale for the EU's Common Agricultural Policy (CAP). While ostensibly more about raising farm incomes, as also was the case in US policy, CAP did seek to stabilise prices for both producers and consumers through input controls (set aside), output controls (buying up surpluses) and through trade restrictions (import tariffs and export subsidies). However, all three have at some stage fallen foul of GATT/WTO rules and as such are being either downplayed or removed from the policy makers' toolkit. The CAP is now set to evolve more towards environmental protection.

Instead, greater attention is being paid to market-based measures of price risk management (Morgan, 2001). Insurance markets are well-developed in most rich nations and offer some cover for crop failure but not for price risk. Futures and options markets instead provide a means to hedge price risk that is far cheaper than the alternative use of forward contracts and major exchanges in the United States, Britain and increasingly China offer contracts in a range of major commodities such as grains, soybeans and other soft commodities like sugar, coffee and cocoa. Direct uptake by producers can be limited (Pannel et al., 2007) even when communication is good, awareness of opportunities is high and the advantages would appear strong. Instead, supply chain intermediaries, who need to protect the margin between their purchase and sale prices, tend to be the main users of these tools (Dana and Gilbert, 2008).

In cases where producers do not have such conditions – in poorer nations – use of futures and options markets becomes much more difficult. A World Bank-sponsored project sought to explore ways to design intermediation between producer nations and major commodity exchanges so that the benefits of hedging could be opened to all (ITF, 1999). Dana and Gilbert review this experience and argue that the major impact is likely to be seen through the protection of supply chain intermediaries than directly by the producers themselves (Dana and Gilbert, 2008). Producers benefit indirectly from lower intermediation costs and from the greater pricing flexibility that futures-based risk management offers to their counterparties, such as grain elevator companies. They also note that in countries in which there are active domestic futures markets, many of the access problems associated with foreign exchange and anti-money laundering regulations are considerably lessened. UNCTAD has discussed the conditions under which commodity futures markets can function successfully in developing economies (UNCTAD, 2009).

The 2007–2008 food price spike has reawakened interest in food security issues. Governments, whether or not democratic, have found that they cannot afford to leave these issues to the operation of the market. Indeed, the perception on the part of the private sector that governments are unable to commit to staying outside food issues makes it difficult for private traders to ensure adequate supply until government has declared its own hand. In many developing countries, the private sector makes insufficient preparation for food supply problems knowing that government will, in the end act and government does act justifying the necessity to do so on the basis of the inadequate actions of the private sector. The question is, therefore, not whether governments should ensure food security, but how they should do so and how they should involve the private sector.

Over the past two decades, Western governments and multilateral agencies have emphasised trade over national food reserves. Food reserves were seen as expensive, inflexible and prone to generate corruption. To the extent that supply shocks are uncorrelated across countries, it is less costly to import to meet a domestic shortfall. This advice worked well until 2007 when agricultural prices rose across the board. However, in 2007–2008, exactly when many countries needed to import additional food, they found prices rising against them or, in the extreme case of rice, markets being closed with the result that supplies were not available at any price. Governments have drawn the conclusion that the advice to rely on trade was incorrect and are now attempting to re-establish food security stocks.

Governments rightly value stability in the prices of basic food commodities. The right balance of policy will vary from commodity to commodity. Many Asian rice-producing countries have long histories of successful stabilisation of domestic rice prices using a combination of import and/or export levies and food reserve stockpiles (Dawe, 2007; Timmer, 2009b). However, it seems unlikely that this experience can easily be generalised to the maize and wheat markets where there is greater geographical separation of production and consumption. Furthermore, successful domestic price stabilisation will often be at the expense of greater volatility in world rice prices, effectively pushing the costs of any shortfall on many of the world's poorest consumers.

For food importing countries, the dichotomy between reliance on trade and on national food security stocks may be too stark. Maize, wheat and soybeans all benefit from active futures trading which would allow governments to hold virtual food security stocks through contingent title to exchange stocks. Call options are the natural instrument to achieve this objective. For a relatively low price, perhaps 5–8% of contract value, governments can contract for contingent delivery at a price somewhat above current market levels in the event that the futures price at the delivery date exceeds the contract strike price. This essentially puts a ceiling on food import costs (on the contractually specified quantities) and hence on the price that the government needs to seek from purchasers. Of course, inventory in Chicago is not equivalent to inventory in one's own country so governments also need to ensure that the appropriate contingent transportation arrangements are in place. Dana and Gilbert describe the 2005 option negotiated by the Malawian government based on the South African futures market, SAFEX, which had this structure (Dana and Gilbert, 2008). It is worth pursuing this model in order that we can obtain a clearer idea of where it is likely to provide a feasible route to food security and at what cost.

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