SAFEGUARDING FOOD SECURITY IN VOLATILE GLOBAL MARKETS

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Edited by Adam Prakash

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Chapter 1

Why volatility matters

Adam Prakash[1]

Volatility represents the directionless variability of an economic variable, i.e. the dispersion of that variable within a given time horizon. For example, high (low) price volatility is described by situations when prices fluctuate significantly (little) over a short time period in either direction.

Popular discussion often confounds volatility with high prices. As a matter of logic, it is possible for prices to be high but show little variability, or to be low but variable. In practice, price levels and volatilities tend to be positively associated, in part because a low carryover from the past will reduce current availability, exerting upward price pressure, and will reduce the possibility of using inventory to meet positive demand or negative supply shocks, thereby increasing volatility (Gilbert & Morgan, 2010).[2] Typically, therefore, when prices are high they are also volatile.

Episodes of prolonged price volatility generate considerable uncertainty and affect vulnerability. They spawn increased risks in productive activities and undermine food security in developing nations. Persistent volatility can also have adverse macroeconomic consequences by obviating economic growth in commodity-dependent developing countries. More worrisome is that large negative shocks to welfare can lead to irreversibility, setting in motion a downward spiral of rising vulnerability while fragile coping mechanisms are diminished. Crisis and extreme volatility generate risk and asymmetry of impact, which, as witnessed in recent episodes, accentuates poverty, leads to malnutrition and increases political insecurity and the risk of internal conflict.

Concepts and definitions

Regular price fluctuations - "day-to-day" or "normal volatility" - is both typical and requisite for competitive market functioning. The essence of the price system is that when a commodity becomes scarce its price rises, thus inducing a fall in consumption and signalling more investment in the production of that commodity. It is important to know why prices have risen in order to counteract the scarcity appropriately (Grossman, 1976). However, the efficiency of the price system begins to break down when price movements become increasingly uncertain and precipitous, and ultimately reaches the point of redundancy when prices undergo "extreme volatility" - or "crisis" - to use popular terminology.

[1] Statistics Division (FAO).

[2] "Availability" is carryover from the previous crop year plus production in the current crop year.

Volatility may seem a rather obvious concept, but a precise definition is elusive and its measurement is prone to much subjectivity. In mainstream economic theory, however, volatility connotes two principal concepts: variability and uncertainty;[3] the former describing overall movement while the latter referring to unpredictable movement. As households and planning agencies are able to cope better with predictable variation, unpredictable changes - or "shocks" - are of primary concern. When shocks surpass a certain critical size or threshold and persist at those levels, traditional policy prescriptions and coping mechanisms are likely to fail (Wolf, 2005).

In addition to the distinction between normal and extreme volatility, price movements may be excessive relative to changes in "fundamentals" - i.e. shocks to demand and supply - over and above that which is predicted by the efficient market hypothesis (see Chapter 14) and is termed "excess volatility" (Shiller, 1981; LeRoy & Porter, 1981). Shiller takes the view that excess volatility is attributed to investors' psychological behaviour, by which substantial price changes are the outcome of a market-wide cognitive process that can only be explained by its thoughts and beliefs about future events.

As will be discussed in the following chapters, the challenge is not to eliminate volatility in its entirety, but rather to remove excess volatility (not necessarily in the Shiller sense). The challenge will also involve enhancing a country's ability to cope with extreme events, shielding food security (see Box 1.1) and equipping productive sectors to respond when called upon. Furthermore, events that trigger episodes of global volatility pose extreme covariate risks to all who are vulnerable. It is these events that present the greatest challenge to policy design.

Box 1.1: Defining food security

The concept of "food security" has been interpreted in many ways. An FAO report (FAO, 2003) notes that there are more than 200 interpretations of the concept. The report defines food security as follows:

> *Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within the household as the focus of concern.*

A cursory view of many regions in the world, however, reveals that no matter how one defines the concept, food security as a goal of assuring an individual's access to food and nutrition has not yet been realized to any significant extent. This reality has become obvious with the increasing use of and reliance on the term "food insecurity". Over the decades, the concept of food security has continued to evolve with new twists and turns in its meaning appearing every few years or so. These food security evolutions can be pictured metaphorically as an "artichoke". At the heart of the artichoke is the core of the concept of food security, that is, access to adequate nutrition for physical and mental well-being, which always remains the same, but over time different uses of the concept by different users (both individuals and organizations) in pursuit of a wide and varied range of variations on the food security theme to suit their goals and needs add layer upon layer of outer leaves to the centre of the artichoke.

Source: FAO (2009b).

[3] To be more precise, Knight (1921) distinguishes between uncertainty and risk on the basis of the probability distribution governing outcomes. Risk refers to uncertain events, where the distribution of outcomes is known. Uncertainty refers to events for which the distribution of outcomes is unknown and probabilities assigned to events cannot be assigned.

Exceptional shocks and volatility

The literature on commodity price shocks assumes that large and unexpected changes in prices have a disproportional impact on the economies that endure exceptional shocks, and that impacts are nonlinear, typically being asymmetric (Dehn et al., 2005). This arises because governments and households are well-adapted to normal volatility but neither anticipate nor consider making worthwhile provisions against extreme shocks, and assign low probability to the risk of such events. Dehn et al. propose two ways in which to distinguish between normal and exceptional shocks:

- view the largest α percent of shocks in the absolute value of the price change over time as being exceptional; or
- view shocks greater than an absolute specified size, ε, as being exceptional.

The authors note that there will be a quantity $\varepsilon(\alpha)$ that will make the two definitions equivalent. Using a value of $\alpha = 2.5\%$ and $\varepsilon = 1.96$ standard deviations, Dehn (2000) identifies a total of 278 shock episodes in a sample of 113 developing countries over the period 1957-97. This amounts to 2.5 exceptional shocks per country, or one every 16 years. Interestingly, the author finds shocks more prevalent in the latter years of the sample, with an incidence of one extreme event every nine years. Also, around two-thirds of these shocks were positive.

Attempting to quantify the exact magnitude of a shock that could propagate crisis is problematic and is subject to a degree of arbitrariness. Such an exercise must take *vulnerability* into account. A cursory look at the dictionary defines the term vulnerability as:

> *the degree to which people, property, resources, systems and cultural, economic, environmental and social activity is susceptible to harm, degradation, or destruction on being exposed to a hostile agent or factor.*

For instance, a one-time 10 percent increase in the price of rice may be comfortably absorbed by consumers in developed countries, but not so in many low-income countries.

Box 1.2: Defining food security vulnerability

Reviewing the notions of vulnerability used in the literature reveals many different concepts depending on the specific application, whether in economics, sustainable livelihood, food security, sociology/anthropology, disaster management, the environment, or health/nutrition sciences (see Alwang et al., 2000). The main tension seems to be between conceptual and empirical strength. No concept employed so far seems to account for/contain both.

In its simplest form, food vulnerability for an individual or household can be measured as the probability that expected future consumption will fall below some minimum level. For a household at time t, let c_{ht} denote per capita consumption expenditure and let $\bar{c}$ denote the poverty line. Then, vulnerability, v_{ht} is the probability that the expected per capita consumption is below the selected poverty line, with an arbitrarily chosen probability threshold $\bar{P}r$ (of, say, 0. 25 or 50 percent):

$$v_{ht} = Pr(c_{ht\pm1} \leq \bar{c}) \geq \bar{P}r \quad (1)$$

To make this definition operational, a particular income-generating process is assumed for household consumption. This requires knowledge of the determinants of household consumption. A household's consumption in any period will depend on a number of factors including its assets, current income, and expected future income (i.e. permanent income). Cases of liquidity constraints or low permanent income will significantly impact future consumption levels and their volatility.

Source: Holzmann (2001).

Consequently, a better approach to characterize extreme volatility and crisis refers to the shock's likelihood to overwhelm a country's *ability* to dampen the shock or to mitigate its impact. "Ability" here is related to a country's degree of vulnerability.

Research has shown that extreme price volatility tends to lower investment in physical capital, human capital and also research and development (Jacks et al., 2009). The repercussions from sustained and/or exceptional shocks are attributable to two factors: first, the uncertainty they generate and the increased risks in productive activities; and second, the *irreversibility* of some of the effects.

Accordingly, when a shock leads to a loss of physical and long-run human capital, poverty traps may result. Diminished income in already low-income countries can result in malnutrition, mortality, withdrawal of children from education and sustained high unemployment. Irreversibility, in this regard, is a critical concern for policy-makers, as it can set forth a vicious downward spiral of increasing vulnerability as fragile coping mechanisms are eroded.

Measuring volatility

Chapter 2 catalogues the statistical and theoretical properties of volatility, including measurement issues. Briefly, volatility *per se* is typically measured based on the standard deviations of an observed (random) variable over a chosen history. A recurring formula in the literature (especially applied in finance) is the following:

$$\sigma = \sqrt{\sum_{i=1}^{n} [r_t - \mu]^2 / n - 1} \tag{2}$$

where σ is the standard deviation, r_t are the logarithmic returns[4] on prices P_t: $r_t = ln(P_t) - ln(P_{t-1})$ and μ is the average return, and n is the number of sample observations. Often, volatility is described in annualized terms, derived through multiplying the square root of time, $1/\sqrt{T}$, where T represents the frequency of the observation (e.g. daily, monthly, etc.).

Volatility measured in this manner is referred to as annualized *realized* or *historical volatility*. Seeing as many economic series contain trends, measuring volatility requires the series to be de-trended;[5] otherwise trend fluctuations will be accounted for in the volatility measures. Moreover, because such trends are often stochastic, de-trending requires a trend model that implies a judgemental trade-off between attribution of variability to the trend itself and to variation about the trend, hence the volatility measure will be prone to model-dependence in the choice of the trend (Gilbert & Morgan, 2010). It is for this reason that standard deviations of (logarithmic) price differences or returns are widely used to measure realized volatility.[6]

[4] Logarithmic returns represent continuously compounded returns, which can produce asymmetries in the balance of returns when compared with simple percentage returns. For example, a 10 percent return results in 9.53 percent continuously compounded return, while an equal negative results in a continuously compounded return of -10.53 percent.

[5] For seasonal series, pre-filtering would be required.

[6] Researchers also typically concentrate on the standard deviation of logarithmic prices as this is a unit-free measure. It can be shown that for low levels of volatility, the logarithmic standard deviation is approximately equal to the coefficient of variation.

Following this approach, Figures 1.1 and 1.2 plot real price levels and their respective historical volatility for a number of food commodities. It is seen that real historical cereal and oilseed price volatility has been rising over the past 50 years, a characteristic not shared by most other commodities. For instance, relative to the recent past, volatility in vegetable oil, livestock, sugar and beverage prices has generally fallen (though from very high absolute levels for the latter two product groups).

Notwithstanding the perils of drawing inferences from visual inspection of the data, understanding whether or not realized volatility has fallen or risen is not an issue of concern here. Instead, it is uncertainty and forward looking that are key. Realized volatility is backward-looking as its measure is based on past price movements after the resolution of supply and demand factors. But economic agents base their decision-making on expected variables such as future prices and the uncertainty about them, and not solely on their realized values.

Ramey & Ramey (1995) and Serven (1998) attach critical importance to the volatility-uncertainty distinction. Basically, uncertainty affects the decision-making of economic agents, while volatility - or total variability - is important to the extent that agents cannot smooth consumption, reflecting either unwillingness or an inability. It is important to note that if components in the variable of interest are deterministic and hence predictable, then uncertainty may be overstated.

Measuring uncertainty is particularly complicated, as it predominantly rests on a subjective choice of model that must capture perceptions about what is predictable about volatility and what is not. Dehn et al. (2005) highlight this complexity:

1. If prices and volatility are both unpredictable, then certainty is indistinguishable from uncertainty. In this case, realized volatility based on the most recent history would constitute the best available estimate for future volatility.
2. If prices are subject to mean reversion in that prices return to some fundamental or long-run equilibrium level value, e.g. the marginal cost of production, then prices may be partially predictable. If price trajectories are determined in this manner, but volatility is unpredictable, then uncertainty is measured by the volatility in the price innovations and not by prices themselves. For this reason, the residuals from some forecasting equation (e.g. error terms from an ordinary least squares regression) are often used in measurement.
3. If changes in price are not constant over time, in that they persist or cluster, then volatility may be predictable (e.g. through an Autoregressive Conditional Heteroscedastic (ARCH)) specification - see Chapter 2). Uncertainty in this instance is time-varying, and may be greater than volatility at any interval.

When components are predictable, such as in (1) and (2), then measuring uncertainty will be subject to the choice of model. Selecting a model that best approximates the phenomenon to be examined is a difficult task, given the host of models at the researcher's disposal. In fact, a whole body of econometrics is concerned with the study of methods for model selection.

So far, reference to volatility has been made in the context of *realized* volatility and conditional measures in the modelling of uncertainty. The data upon which realized and conditional volatility is calculated may no longer reflect the prevailing or expected supply and demand situation. There is, however, an objective metric available that focuses inherently on market-wide uncertainty. Being responsive to prevailing and future market conditions, *implied* volatility signals the market's *expectation* of how commodity prices might evolve.[7]

[7] If investors have a rational expectation of volatility, implied volatility would be an unbiased proxy for historical or realized volatility of the same period based on the measures (1)-(3) above. In other words, the expectation of future volatility can fluctuate around, but not consistently move in, one direction away from historical volatility (Wang, 2009).

Box 1.3: Measuring implied volatility

Implied volatility represents the market's expectation of how much the price of a commodity is likely to move in the future. It is called "implied" because, by dealing with future events, it cannot be observed and can only be inferred from the prices of derivative contracts such as "options".

An "option" gives the bearer the right to sell a commodity (put option) or buy a commodity (call option) at a specified price for a specified future delivery date (see Chapters 19 and 20). Options are just like any other financial instrument, such as futures contracts, and are priced based on market estimates of future prices as well as on the uncertainty surrounding these estimates. They are subject to the law of supply and demand. Hence, any excess or deficit of demand would suggest that traders have different expectations of the future price of the underlying commodity. The more divergent are traders' expectations about future prices, the higher the underlying uncertainty and hence the implied volatility of the commodity.

Does implied volatility matter? Prices that are observed today for commodities traded in the major global exchanges are influenced by the sentiment captured by implied volatility. When these markets are efficient, they convey all known information, future and the present, pertinent to the market and the commodity. Hence, implied volatility as a metric is an important instrument used in the price discovery process and as a barometer for where markets might be headed.

Implied volatilities for several major internationally traded foodstuffs are presented in Figure 1.3. In the last month of 2010, implied volatility stood at 36, 35 and 28 percent for wheat, maize and soybeans respectively. As implied volatility is measured as a percentage of the deviation in the futures price (six months ahead) from underlying expected value, under reasonable assumptions (price changes are drawn from a normal distribution) one can say the market estimates with *68 percent certainty* that prices will change by 36 percent for wheat, 35 percent for maize and 28 percent for soybeans.

In a similar vein, the likelihood that prices will exceed their current values by more than 50 percent in six months is perceived to have a probability of around 2 percent, in other words quite unlikely. This is not to say that such events will not take place. The surge in maize prices in September 2006 that set the stage for that particular episode surprised the markets. Although traders were betting on higher prices, they handed only a 5 percent chance for a 50 percent or more increase in the price of maize in six months. Instead, prices actually climbed by almost 60 percent in that period. Implied volatility can be a useful metric in revealing how traders expect prices to develop, but it also exposes just how wrong expectations can be.

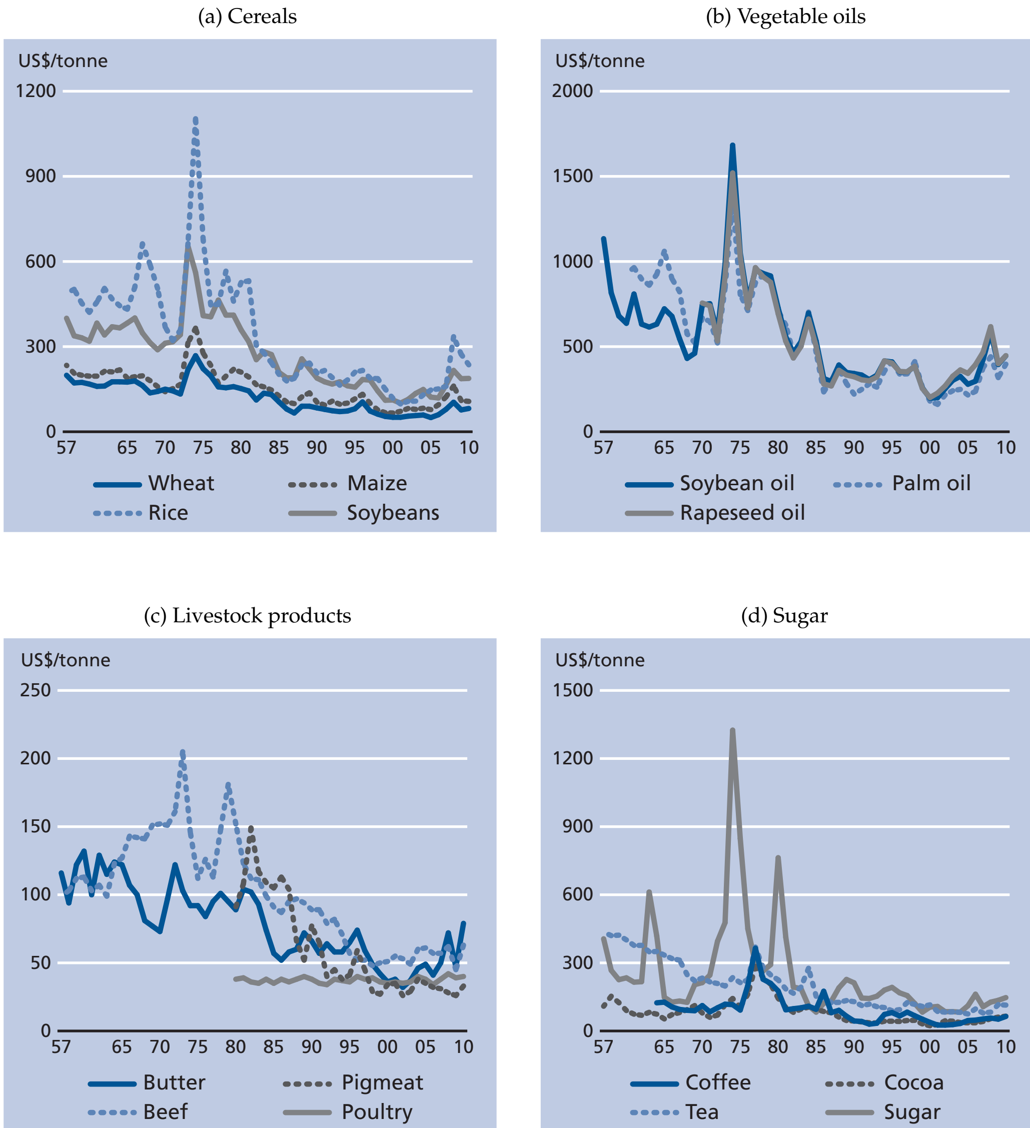
The large upswings in implied volatilities that have recently been witnessed bear testament to the enormous uncertainty that markets face in predicting how agricultural commodity prices may evolve in the future. There appears to be irrefutable evidence of a secular rise in uncertainty for traded commodities key to food security.

Social and economic costs of volatility

Episodes of high prices and extreme volatility are a major threat to food security in developing countries. Their impact falls heaviest on the poor, who may spend well over 80 percent of their income on food (see Figure 1.4). The lack of dietary diversification aggravates the problem, as price increases in one staple cannot easily be compensated by a switch to other foods.

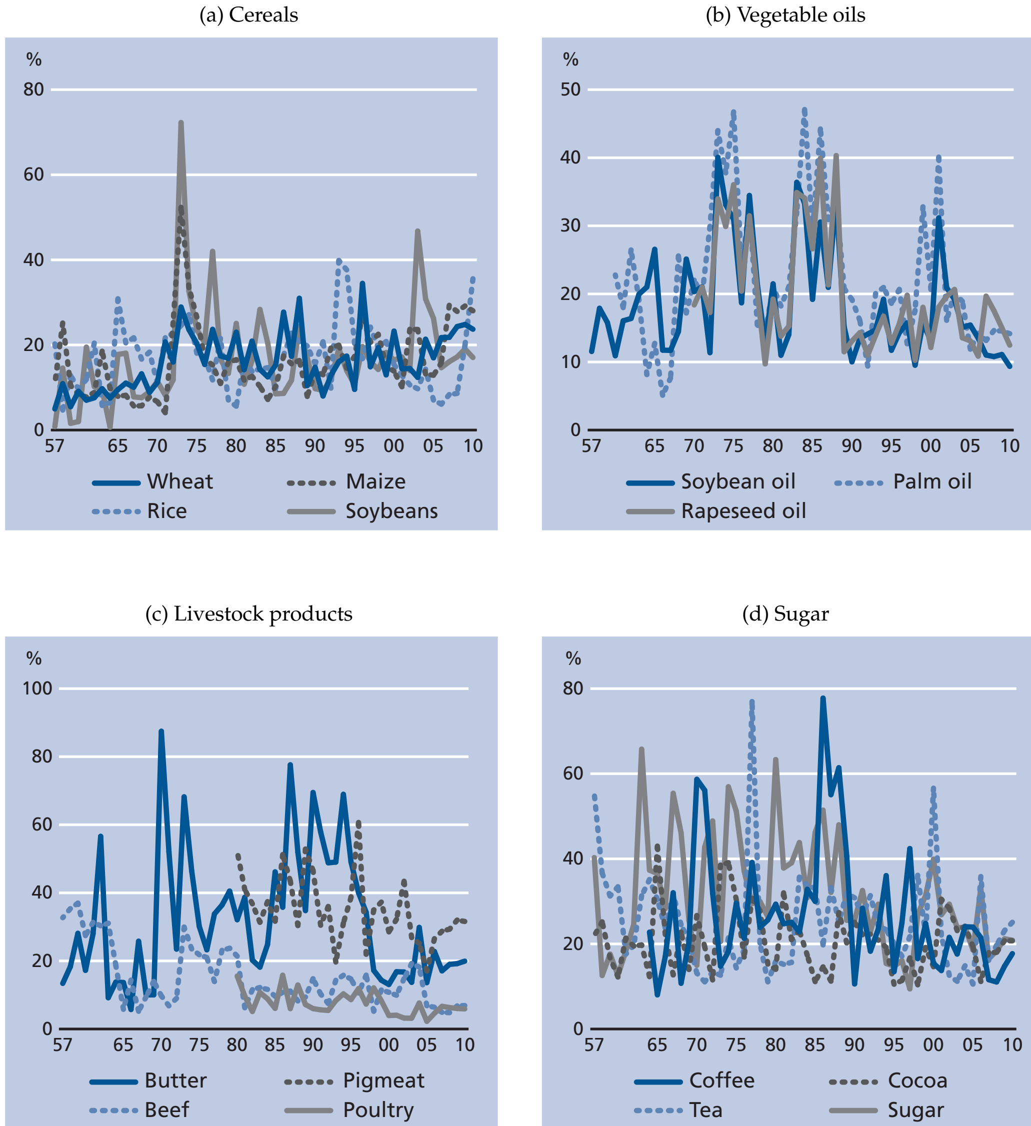
Coping with high food prices poses extreme adjustment costs that undermine food and nutritional food security. Figure 1.5 illustrates possible household response options and

Figure 1.1: Annual real prices of selected foodstuffs: 1957-2010



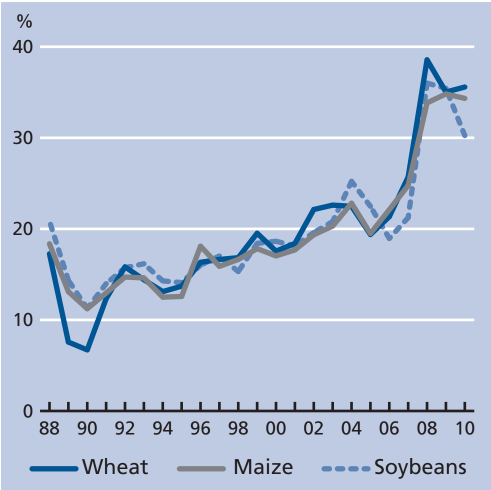
Note: Real prices refer to nominal prices adjusted for changes in US Producer Price Index (2000 = 100). Sources: Cocoa (ICCO); coffee (ICO); cotton (COTLOOK A Index 1-3/32"); maize (US No. 2, yellow, US Gulf); rice (white rice, Thai 100% B second grade, f.o.b. Bangkok); soybeans (US No. 1, yellow, US Gulf); sugar (ISA); tea (total tea, Mombasa auction prices); Wheat (US No. 2, soft red winter wheat, US Gulf); beef (Argentina, frozen beef cuts, export unit value); butter (Oceania, indicative export prices, f.o.b.); pig meat (United States of America, pork, frozen product, export unit value); poultry meat (United States of America, broiler cuts, export unit value); rape oil (Dutch, f.o.b. ex-mill); Soya oil (f.o.b. ex-mill).

Figure 1.2: Annualized real historical volatility of selected foodstuffs: 1957-2010



Note: Real prices refer to nominal prices adjusted for changes in US Producer Price Index (2000 = 100). Sources: Cocoa (ICCO); coffee (ICO); cotton (COTLOOK A Index 1-3/32"); maize (US No. 2, yellow, US Gulf); rice (white rice, Thai 100% B second grade, f.o.b. Bangkok); soybeans (US No. 1, yellow, US Gulf); sugar (ISA); tea (total tea, Mombasa auction prices); Wheat (US No. 2, soft red winter wheat, US Gulf); beef (Argentina, frozen beef cuts, export unit value); butter (Oceania, indicative export prices, f.o.b.); pig meat (United States of America, pork, frozen product, export unit value); poultry meat (United States of America, broiler cuts, export unit value); rape oil (Dutch, f.o.b. ex-mill); Soya oil (f.o.b. ex-mill).

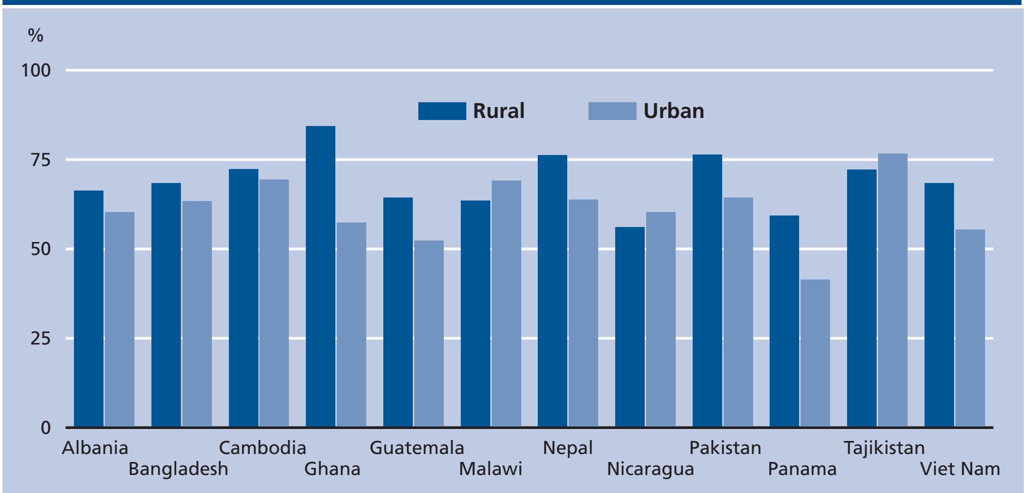
Figure 1.3: Implied volatilities: 1987-2010



The Black-Scholes model is used to compute implied volatilities from Chicago Board of Trade underlying data. Key inputs and assumptions are as follows: (i) six-month time expiration on contracts; (ii) settlement premium for the call options "at the money", i.e. with a strike price nearest to the settlement price for the futures contract associated with the call option contract (mid-monthly prices were used); (iii) option strike price; (iv) futures settlement price; and (v) six-month US treasury bill yields which are assumed as the risk-free rate.

Source: CME, FAO.

Figure 1.4: Shares of income in poorest households spent on food in selected developing countries

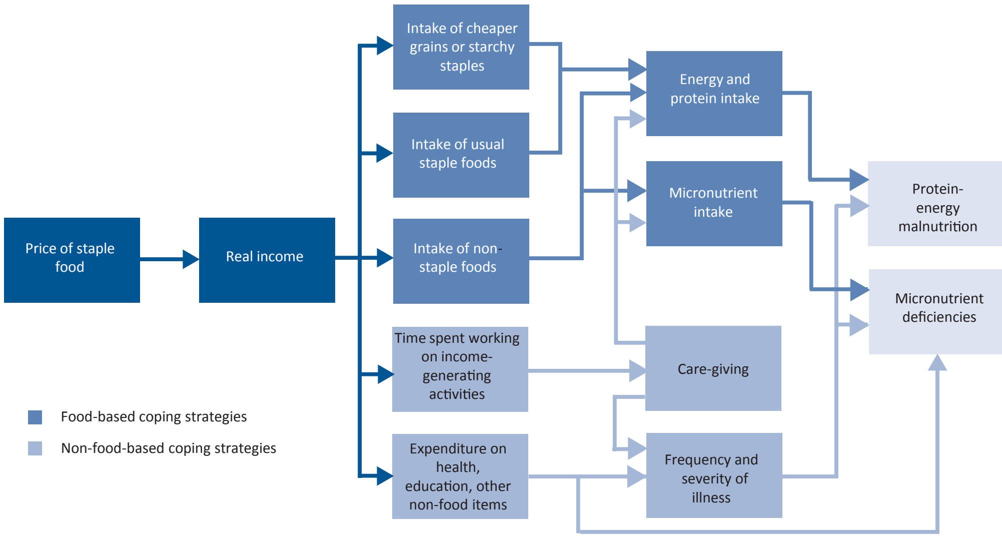


Source: Davis et al. (2007).

the impact that various food-based and non-food based coping strategies may have on the nutritional status of individuals.

Among the food-based coping strategies, a sudden loss in purchasing power may result in changes in the quantity, quality and/or diversity of food items consumed. In countries where people have access to a more diversified diet, households will respond to a sudden and dramatic increase in food prices by first reducing the number of foods consumed

Figure 1.5: Household coping behaviour and nutrition impacts following a sudden rise in food prices



Source: FAO (2008).

from different food groups while leaving overall consumption of staples unchanged. But, low-income households with little or no choice to reduce the diversity of their diets will predominantly respond by simply eating fewer meals per day and reducing non-food expenditure.

Non-food based coping strategies may involve a reduction in expenditure on health care and education, in addition to seeking other sources of income to offset the loss in purchasing power. Households may attempt to engage in new income-generating activities. Time constraints among women with small children may have negative health and nutrition-related consequences for children. Increased female employment may lead to less or lower-quality child care at home; it may interfere with breastfeeding, home-based food preparation, sanitation practices and seeking medical assistance when children are sick. Older siblings may have to take over from mothers in providing childcare though they are less equipped to do so. Increased child labour at home or outside may have further negative nutritional consequences and interfere with children's education.

The recurring issue of poor dietary diversification in staple foodstuffs is an important determinant on the impact of food price volatility on households. The dominance of a particular foodstuff in diets limits the potential to shift to other staples using trade as a means to moderate volatility in prices. The lack of dietary diversification is also the single most important variable influencing vulnerability (as well as political sensitivity) to unstable food prices, as when consumption is highly concentrated on one staple, the implication is that the staple makes up a large share of consumer expenditures (World Bank, 2005). Evidence of the lack of dietary diversification in vulnerable countries is illustrated in Figure 1.6, where it is seen that over one-third of all Low-Income-Food-Deficit Countries (LIFDCs) have a Herfindahl concentration index of 0.5 and above.

Box 1.4: Dimensions of consumer vulnerability: food security in sub-Saharan Africa during the 2006-08 episode

Research carried out by FAO examined the impact of food price increases on consumption, food expenditure and food security in Eastern and Southern Africa. Maize is the most important staple in these regions. For example, the annual per capita consumption of maize in Malawi amounts to about 130 to 160 kg, while that in Zambia ranges between 120 and 150 kg. The analysis suggests that an average household facing a 50 percent increase in the price of grains would reduce maize consumption by 8.5 and 15.6 percent in Malawi and Zambia, respectively. Poor and food-insecure households were found to reduce maize consumption to a lesser extent as compared with this average, reflecting that the poor have limited possibilities for substitution.

The analysis also suggests that in spite of the reduction in maize consumption, household food expenditure increases as prices soar. On average, household expenditure in Malawi was found to increase by 9.7 percent, as the 8.5 percent decrease in maize consumption did not suffice in keeping total food expenditures low. For the poor households that allocate approximately 33 percent of total food expenditure to maize, food expenditure was estimated to increase by 16 percent. In poor, female-headed households where food expenditure is characterized by a high share of maize, approximately 43 percent was found to experience significant increases in food costs. In Zambia, similar price increases were found to result in an increase of 8 percent in average household food expenditure. Nevertheless, as poor households in Zambia allocate about 20 percent of their food budget to maize, a 50 percent increase in grain prices was found to result in an 8.6 percent increase in total food expenditure.

High food prices and increased food expenditure imply decreases in purchasing power, leading to more households falling into poverty and becoming food insecure. The analysis suggests that in Zambia, a 50 percent increase in grain prices could result in a 5.4 percent increase in the number of food-insecure households. The corresponding increase in the number of food-insecure in Malawi was found to be significantly larger, reaching estimates of nearly 16 percent owing to the higher share of maize in food consumption and expenditure.

Staple dietary diversification is important in determining the impact of food price volatility on households. In Uganda, maize consumption amounts to an average of 29 kg per capita, a quantity significantly lower than that consumed in other countries in the region. Ugandan households consume a variety of staple foods such as rice, millet, matooke and cassava. Although the prices of rice and millet also rose, the prices of matooke and cassava roots (neither of which are internationally traded) exhibited weaker increases of about 35 and 20 percent respectively as compared with an increase of 75 percent in the price of maize. Wide staple diet diversification and the large quantities of domestically-produced staples consumed significantly moderated the negative impact of the international price surge on Ugandan households. FAO's analysis suggests that a 50 percent increase in the price of grains could result in an increase of 2.5 percent in the number of food-insecure households, an impact significantly smaller than that experienced by other countries in the region.

Evidence regarding the behaviour of rural households during the recent price surge is sparse. In Kenya, an examination of households' responses suggested that approximately 38 percent experienced a food deficit and resorted to various coping strategies. These included selling livestock, seeking farm and non-farm employment, decreasing the purchase of agricultural inputs and disinvesting in human capital.

These coping strategies affect future production and income streams. Delays in the payment of school fees and reduction in health care were also found to be common responses, suggesting that price upswings can cause irreversible impact on human capital.

Source: FAO (2009a).

Figure 1.6: Staple concentration and the share of traded staple in LIFDC diets (2007 data)

Note: The Herfindahl index, H is calculated as $H = \sum_{i=1}^{N} S_i^2$ where S_i is the consumption share of the starchy staple i in diets and N is the number of staples consumed. For a single staple consumed, the index would equate to one and declines as the staple base becomes more diversified. Source: FAO.

In addition, the main staples for most diets are, in large part, subject to global trade (e.g. rice in Bangladesh, Lao People's Democratic Republic and Myanmar; wheat in Azerbaijan, Tajikistan, Turkmenistan and Uzbekistan). Consequently, consumption expenditures are potentially vulnerable to international price rises.

As a further sign of vulnerability in food security, Figure **??** shows the tendency towards a positive relationship between the contribution of staples in overall diets and the dependence on a single-traded staple. This again confirms country-level evidence that international price fluctuations can have a direct consequence on consumption levels.

For farmers, who are highly dependent on commodities for their livelihoods, extreme volatility can result in large income fluctuations for which they have little or no recourse to the mechanisms that assure safeguards, such as savings and insurance. The delay between production decisions and actual production creates additional risks, as farmers base their investment and planning on expected prices.

Sandmo (1971) shows that uncertainty in output prices can give rise to firms employing fewer inputs and foregoing expected profits in order to hedge against price volatility. Since this seminal study, and another by Newbery & Stiglitz (1981), it is now commonly understood that producers (whose primary source of income is from agriculture) will prefer certainty in income generation to uncertainty with the same expected value.

Supply response to price uncertainty will therefore depend upon the degree of producers' risk aversion. Under increasing price volatility, supply will be reduced if risk aversion is moderate, but will be increased if risk aversion is high, as farmers are required to do more in order to cope with extreme events (Subervie, 2008). Consequently, the response of farmers to volatility depends on their degree of risk aversion. However, in a more dynamic setting, the expected supply response is more likely to be lower, with price volatility discouraging investment and innovation having a more uncertain return.

But the stakes are higher. There is extensive literature on the linkages between commodity price volatility and economic growth. The magnitude and persistence of a shock can lead to severe economic disruption. An extreme shock is often much more severe than a minor one seeing as credit and fiscal constraints or the exhaustion of a finite buffer reserve can produce chain effects. For example, a LIFDC may be able to cope with a one-time terms-of-trade[8] shock of, say, 10 percent, but if the terms-of-trade does not subsequently recover and the shock persists, the capacity of the country to cope may be exhausted.[9] Generally, a low degree of diversification and greater specialization in more volatile activities yields more volatile terms-of-trade, which is a major source of the overall economic instability which poor countries face (Jacks et al., 2009).

In reality, many of the least developed countries are net importers of food products, either in raw or processed form. For these nations, the proportion of the import bill that goes to food is generally much higher than in richer countries.

Figures 1.8 and 1.9 shows the burden of food import bills faced by economically vulnerable groups of countries in contrast with the developed group of nations. Imported food expenditures have been rising globally, reaching USD 1 trillion dollars in nominal terms in 2008 and in 2010 (FAO, 2010). Even in real terms, expenditures have escalated alarmingly. This situation could lead to increased stress if income growth and export earnings to sustain food imports are not adequate and/or if growth in imports undermines otherwise viable domestic production (i.e. owing to low international prices).

In order to put these developments into a perspective that would allow such an assessment to be made, Figure 1.8 presents the shares of total food import bills in GDP (Gross Domestic Product) and total merchandise imports, while Figure 1.9 shows the strain of importing against current account deficits that are both rife and persistent in the most economically vulnerable group of countries.

A clear picture emerges: while the rate of growth in food import bills has matched income growth for both groups of countries (in that the share of these bills as a percentage of GDP remains little changed) food import costs since the 2006-08 event account for a much higher share of total merchandise imports, reversing the positive trend of the previous decade.

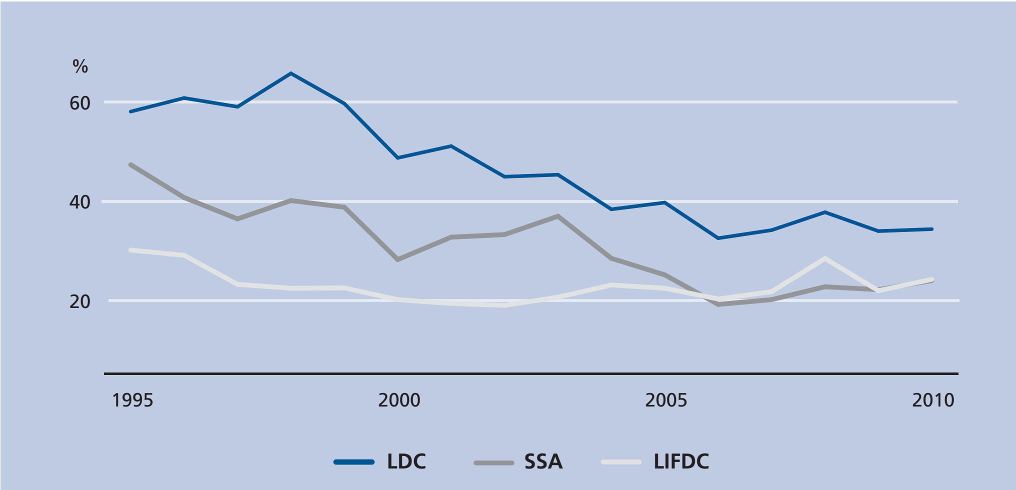
A price-induced rise in food import bills can place a severe burden on the balance of payments to meet food needs, depriving disadvantaged countries of limited foreign exchange reserves that could finance other essential goods and services, such as energy and inputs. High international prices and volatility also create a significant hurdle in planning and financing imports given sovereign credit ceilings. These trends and outcomes are by in large a stark contrast to those in developed countries.

The capacity of vulnerable countries to achieve basic food security from world markets exposes them to shocks originating externally. Figure 1.7 shows the value of cereal food imports as a share of foreign exchange reserves in vulnerable groups of countries. The gains from falling shares of foreign exchange reserves to meet imports began to stall during the 2006-08 episode, and has in some cases gone into reverse.

8 At the simplest level, "terms-of-trade" is the price of exports relative to the price of imports.

9 The country's exchange rate regime affects its ability to absorb fluctuations in their terms-of-trade. According to theory, a country faced with volatility in the terms-of-trade will be able to dampen movements under a flexible exchange rate with little impact on economic activity by contrast to a country with a fixed exchange rate regime.

Figure 1.7: Share of foreign exchange reserves to meet cereal import bills: 1995-2010



Source: IMF, FAO.

Quantifying the costs of volatility

In the modern policy era, welfare costs and the impetus to intervene have been framed in the context of how changes in aggregate economic activity, induced for example by volatile output prices, affects consumption or specifically, the quantity of foregone consumption. Much of this thought and ensuing policy design is owing to the Nobel laureate Robert Lucas, who proposed a simplified framework to assess the welfare cost of volatility, which has since been termed Lucas' formula (Lucas, 1987). Lucas gained prominence by challenging the foundations of macroeconomic thought and subsequent policy formulation by vehemently arguing that macroeconomic models should be conceived as an aggregate of microeconomic models. His findings have shifted the policy agenda away from economic stabilization to measures that sustain long-term economic growth.

To begin, assume the utility, U, of an economic agent over an infinite horizon can be depicted by the sum of the present value of utility derived from consumption c in each period t, discounted by the factor β:

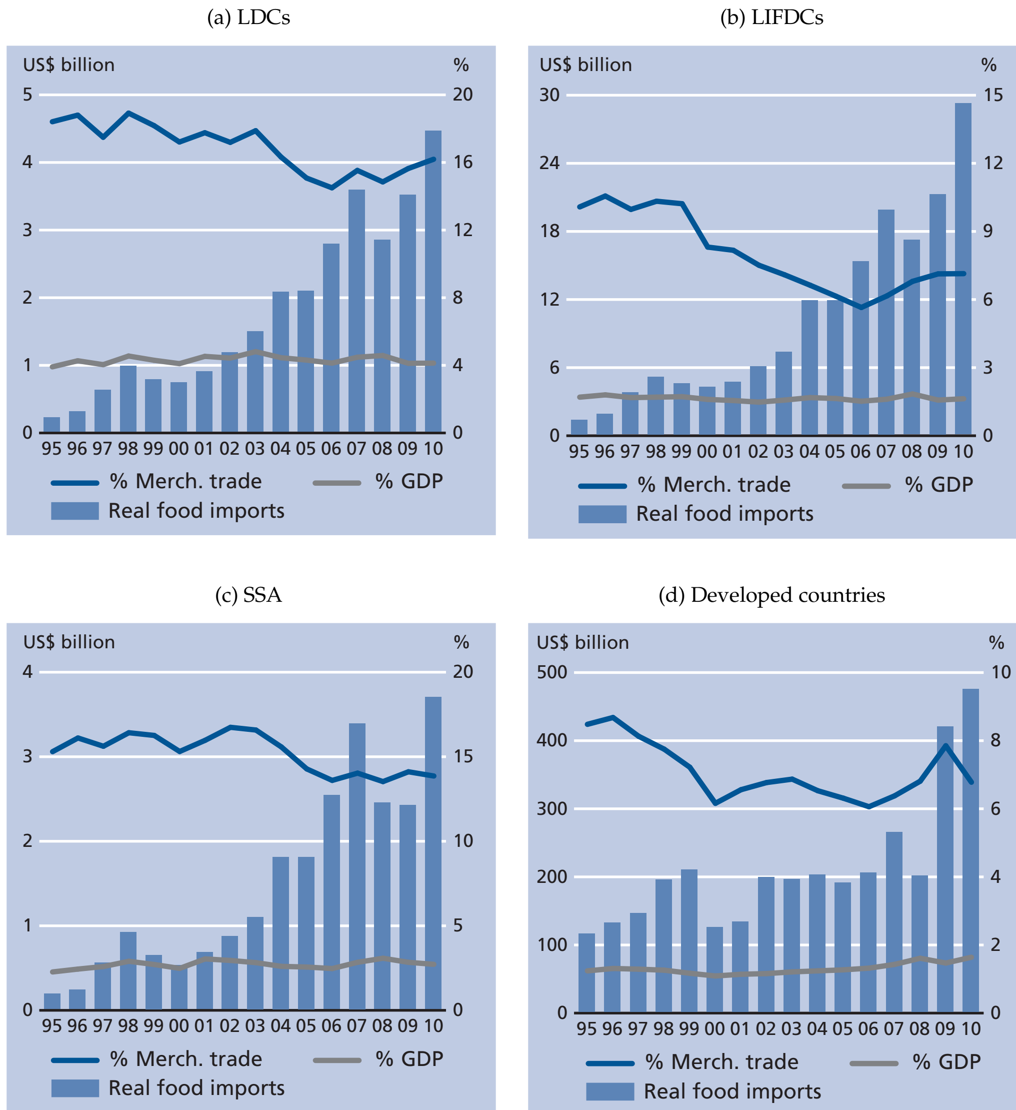
$$U = \sum_{t=0}^{8} \beta^t u(c_t) \tag{3}$$

The agent's utility is assumed to be risk-averse, such that $u(c_t) = \frac{c_t^{1-\gamma}-1}{1-\gamma}$, where γ is the degree of risk-aversion. In the absence of volatility, consumption is a smooth process governed by:

$$c_t^s = Ae^{gt} \tag{4}$$

where A is the base level consumption and γ is the rate of consumption growth. In the presence of volatility, however, consumption in each period is determined by the stochastic

Figure 1.8: The burden of importing food: 1995-2010 (a)



Source: IMF, FAO.

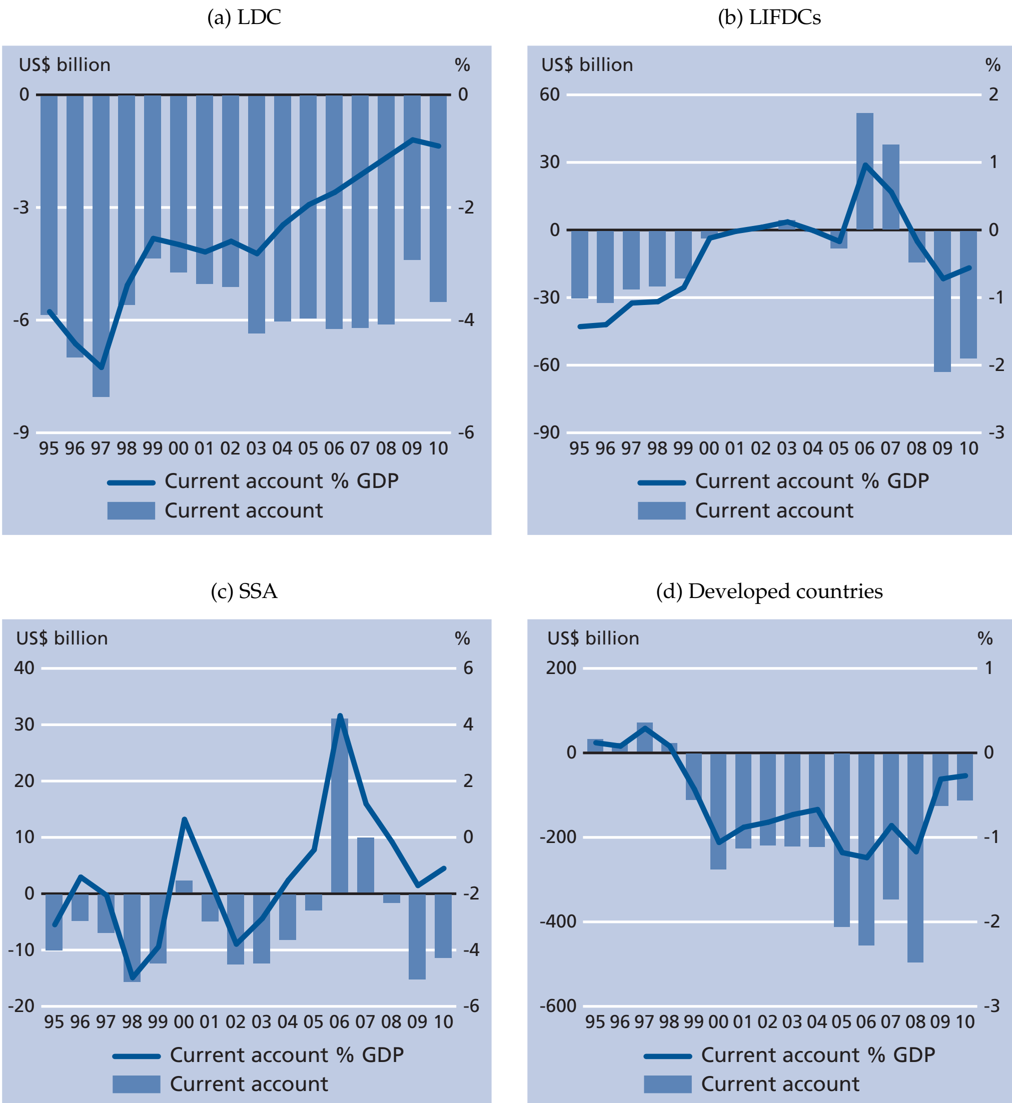
stream, which arises from stochastic prices confronting consumers:[10]

$$c_t^v = Ae^{gt}e^{-0.5\sigma^2}\varepsilon_t \qquad (5)$$

with σ^2 being the variance of the natural log of consumption and ε is an innovation where

[10] The consumption stream is stochastic on the basis that prices are stochastic.

Figure 1.9: The burden of importing food: 1995-2010 (b)



Source: IMF, FAO.

$\ln(\varepsilon_t) \sim N(0,\sigma^2)$. Taking expectations, the stochastic component reduces to $E\left(e^{-0.5\sigma^2}\varepsilon_t\right) = 1$, so that on average, trend consumption under volatility mirrors that under certainty.

By maintaining the same mean level of consumption over the horizon, the risk-averse economic agent would choose a stable path over a volatile one where consumption increases (decreases) in periods of low (high) prices relative to incomes. The difference in utility can be measured by multiplying the volatile path by a constant factor $1+\lambda$ with the value of λ chosen to compensate all agents in terms of additional consumption, uniform across time and different shocks, so that they will be indifferent between the smooth and fluctuating consumption paths (Imrohoroglu, 2008).

To solve for λ, two different consumption paths (2) and (3) are equated through (1):

$$\sum_{t=0}^{\infty}\beta^t u\left(c_t^s\right) = \sum_{t=0}^{\infty}\beta^t u\left(c_t^v\right) \tag{6}$$

$$\sum_{t=0}^{\infty}\beta^t\left(\frac{\left(Ae^{gt}\right)^{1-\gamma}}{1-\gamma}\right) = \sum_{t=0}^{\infty}\beta^t\,\frac{\left((1+\lambda)Ae^{gt}e^{-0.5\sigma^2}\,\varepsilon_t\right)^{1-\gamma}}{1-\gamma} \tag{7}$$

Taking logs and simplifying yields:

$$\lambda \cong 0.5\gamma\sigma^2 \tag{8}$$

The compensation parameter λ constitutes the welfare gain from eliminating consumption risk, and depends, naturally enough, on the amount of risk that is present, σ^2, and the aversion people have for this risk γ (Lucas, 2003). The results are even more lucid if utility is logarithmic such that $u(c_t) = ln(c_t)$ which corresponds to the case of $\gamma = 1$, so that $\lambda \cong 0.5\sigma^2$ That is, the welfare cost of volatility is roughly equal to one-half the variance of the natural logarithm of consumption, or simply put, a number so small that it trivializes the benefits of consumption derived through stability.

In an empirical example, Lucas (2003) examines the log of real per capita consumption data in the United States over the period 1947-2001. He finds the standard deviation of consumption changes around a linear trend to be in the order of 0.032. Assuming different degrees of relative risk aversion commonly observed in the literature, ranging from one to four in magnitude, the welfare cost of volatility varies between one-twentieth of 1 percent to one- or two-tenths of a percent of consumption. Just as the welfare cost of volatility is seemingly negligible in an absolute sense, it is also the case when compared with the welfare costs of other dimensions of the economy. For example, Lucas (2003) determined that the welfare cost of a 1 percent decline in the economy's annual growth rate could amount as much as 20 percent of yearly consumption, and when the welfare loss of inflation reaches 10 percent the result could be a total cost of around 1 percent of annual income. Both estimates are of a much higher magnitude compared with the welfare cost of economic volatility. Lucas has repeatedly argued that one must take seriously the estimated findings for the size of potential gains when designing policies that would eliminate fluctuations in economic activity. Taking these results seriously is exactly what the profession has done (Imrohoroglu, 2008).

Studies have also shown that volatility-reducing policies would be an impediment to increased profit streams and higher investment for competitive firms with full access to capital markets. Assuming that the area of the producer surplus is a quadratic function of the price facing firms, Aizeman & Pinto (2005) show that the profit function is convex with respect to the price of the output, and so higher price volatility would yield higher profits. Such messages attesting to the redundancy of stabilization policies would seemingly be welcomed by firms.

Lucas' formula, however, remains the subject of intense controversy in the more than two decades since it first appeared. Many economists have challenged its conclusions either by assuming more complexity in risk preferences, or by bringing more empirical realism into the framework (i.e. the functional form of utility, hence γ and also the stochastic nature of σ.

The wider environment in which agents confront volatility also matters, as the structure and completeness of markets and the depth of insurance markets heavily influence welfare costs.

For example, the premise of Lucas that all agents are identical and have access to fully developed capital markets has come under scrutiny. It is conceivable that while the costs of volatility may be low for some consumers (such as those with large savings or access to insurance markets), they may be excessive for others who do not have the means to insure themselves against these shocks.

This is mainly because households are insufficiently insulated from risk owing to the inaccessibility and/or unavailability of credit institutions and insurance markets. Therefore, having been exposed to shocks, vulnerable households are unable to smooth expenditures and income streams. Such households are likely to change their income-generating activities by diversifying towards low-risk technologies with relatively lower returns, as well as curtailing investment plans (Roumasset, 1976, 1979; Rosenzweig & Wolpin 1993; Dercon 2004; Fafchamps 2003).

Subervie (2008) demonstrates that producers in developing countries are particularly vulnerable to the fluctuations of world prices because they are widely exposed to price shocks and have little ability to cope with them. She shows that the effectiveness of risk-coping strategies is conditioned by the influence of macroeconomic factors such as infrastructure, inflation and financial deepening. Underdevelopment of infrastructure decreases a producer's capacity to cope with price instability, inflation increases a producer's vulnerability, while poor financial development discourages investment and self-insurance. Dehn et al. (2005) argue that a lack of diversification is both a reason for and the result of ineffectual risk coping mechanisms.

In this context, several studies have investigated the welfare costs of volatility for heterogeneous agents with limited access to capital markets. An extensive review can be found in Lucas (2003). Imrohoroglu (1989), however, assumes that individuals are subject to idiosyncratic shocks and face liquidity constraints. The resulting imperfect risk-sharing among agents leads to welfare cost increases at about three times that of Lucas' 2003 estimate.

Box 1.5: Four dimensions of producer vulnerability: a survey

Infrastructure. Several authors share the view that public investment in infrastructure has a positive impact on agricultural supply, especially through the influence by generating productivity increases (Binswanger & Deininger, 1997). In an analysis of agricultural policies in 18 countries between 1960 and 1983, Krueger et al. (1991) show that the macroeconomic environment and the supply of public goods may influence performance in the agricultural sector. They demonstrate that investing in rural infrastructure and coordinating with social services and viable systems of credit for small producers enabled agricultural production to rapidly grow and reduced poverty in Southeast Asia and China. Similarly, Heath & Binswanger (1996) point out that in Kenya, where infrastructure supports market access, growth in agricultural production more than compensated for growth in rural population; while in Ethiopia, a country deprived of infrastructure favourable to producers, the strong population density implied significant degradation of land.

Faini (1992) suggests that the level of infrastructure could improve the supply response to producer price changes - for example, by reducing the high costs for transporting locally produced commodities to the border for export through the development of road networks. It can be argued that infrastructure development may also improve the efficiency of public expenditure for education and health services. Agenor & Moreno-Dodson (2006) find that investment in infrastructure interacts with social public services, thus influencing growth via a complementary effect. In addition, Knight & Woldehanna (2003) and Weir & Knight (2004) suggest that education and health services can reduce producers' risk aversion. Moreover, infrastructure can help develop risk-sharing networks (Dercon, 2002; Fafchamps, 2003) and improve, in turn, a producer's capacity to deal with price volatility.

Inflation. Mundlak et al. (1997) have studied the direct effect of inflation on agricultural production in a cross-country analysis covering 37 countries between 1970 and 1990. Inflation can influence agricultural productivity directly as an incentive and indirectly via investment. However, it can also affect a producer's capacity to cope with price risk by reducing real producer prices and the real value of their savings. When inflation reduces the real value of a producer's revenues and assets and devalues precautionary savings, producers may be forced to reduce their supply. Furthermore, producers may be forced to liquidate their productive assets - land, cattle, bullocks and tools - in the face of price shocks, even though inflation makes such liquidation less profitable. Thus, inflation can exacerbate producers' responses to price volatility.

Financial development. There have been many attempts by the international community to deal with commodity price volatility, though these stabilization or compensatory mechanisms have been abandoned as financially unsustainable. International commodity agreements have either collapsed (sugar, tin) or have been replaced by agreements whose primary role is to improve information (cocoa, coffee) (Gilbert, 1995). While market instruments can reduce uncertainty arising from volatile prices, they are typically less effective for inter-year volatility. They are only used in a very few developing countries (which have relatively low levels of governmental intervention in terms of commodity production and trade of commodities) and, as of yet, have hardly provided a global solution. Microfinance can help producers cope with price volatility. Better access to credit markets helps improve productivity through increased savings and investment (Levine, 2004) and can attenuate supply response to price shocks by buffering income and revenue shocks. Although informal mechanisms of credit and insurance are most common (see Besley, 1995), the development of formal credit institutions can influence the risk-coping capacity of producers in an indirect manner. Guillaumont Jeanneney & Kpodar (2005) argue that the development of informal credit, which is often the only source of borrowing for the poor, is made easier by improving the formal financial system, which offers profitable investment opportunities to informal financial institutions that are not directly offered to small producers (Beck et al., 2004). Furthermore, the formal financial system gives producers financial opportunities for savings. Producers who are forced into self-financing and self-insurance have access to interest-linked deposits, and thus have a savings incentive (McKinnon, 1973). Therefore, by facilitating the build-up of savings, financial development may also contribute to reducing the supply response to price volatility.

Lack of diversification. Farmers in many developing countries are prevented from participating in high-return activities because downside risks will be too severe in the advent of a crisis. Wealthy households can borrow during such times as they have assets that can be collateralized. Even if credit is unavailable, they are able to smooth their income by selling their assets. With no access to income buffers, poor households tend to restrict their enterprise to low-risk and hence low-return strategies. Behaviour here does not reflect risk preferences but rather reveals the lack of risk-coping strategies, such as risk management, insurance and finance.

Source: Subervie (2008); Dehn et al. (2005).

Research has also highlighted the importance of understanding the interaction between aggregate and individual shocks, as well as permanent and transitory shocks. Storesletten et al. (2001) demonstrate that in an environment where small shocks can have long-lasting impact on agents' income streams, the welfare cost of volatility can be much higher than the original estimates. Moreover, if the effects of a negative shock are assumed to be permanent (as in Krebs, 2003), then the welfare costs can be as high as 7.5 percent of consumption. In such a framework, even if credit markets are perfect, individuals will not borrow to smooth the negative shocks they face as the effect of those shocks will persist permanently.

In a similar vein, van Wincoop (1994) shows that if consumption follows a random walk, then the welfare gain associated with the entire elimination of variability is likely to be large because consumption will not revert to a deterministic trend. Prasad & Crucini (2000) use this result to ascertain the cost of eliminating risk posed by terms-of-trade volatility. Taking commodity import price data as a panel comprising 66 developing countries and representative export prices for 33 commodities, the authors show that the welfare costs of terms-of-trade volatility is substantial, amounting to around two-thirds of consumption on average across the sampled countries, and several orders of magnitude higher than that of Lucas' formula.

Pallage & Robe (2000) computed the welfare cost of output volatility in a series of low-income countries, and found that the median cost ranged from 15 to 30 times the estimate for the United States. Strikingly, for many of those countries, the authors estimated the welfare gain to be so large as to exceed that of receiving an additional 1 percent of growth permanently. Pallage and Robe conclude that "while policy advice to developing countries has focused heavily on growth, our results suggest that policies that reduce output volatility may bring about substantially higher welfare gains in countries other than the United States. Stabilization policies, at least for those countries, should not be dismissed too hastily".

Ramey & Ramey (1995) also demonstrate a strong negative relationship between volatility and growth using a panel of 92 countries, most of which are developing. They further identify that the negative effect of volatility arises principally from the volatility in the innovations to GDP growth, reflecting the role of uncertainty in economic decisions.

The indirect utility framework to measure welfare costs under volatility has also been applied to the household level in vulnerable developing countries. Recognizing that many farmers both produce and consume the same foodstuffs, it has been understood that there will be a range where households tend to be either price risk-averse, risk-neutral, or risk-loving (e.g. Finkelshtain & Chalfant, 1991, 1997; Barrett, 1996) for a commodity bundle (e.g. Turnovsky et al., 1980). The body of this work is motivated by the perception that: (i) poor households are widely believed to value price stability; (ii) the poor are widely perceived to suffer disproportionately from food price volatility; and (iii) futures and options markets for hedging against food price risk are either unavailable or inaccessible to poor consumers and producers.

Based on these premises, Bellemare et al. (2010) obtain total welfare impacts of price vector volatilities by considering the variance in each price series alongside the covariances among them. The authors argue that disregarding the covariances between prices for commodities i and j leads to bias in the estimate of the total welfare impacts of volatility unless price vector fluctuations are independent, which presupposes that commodities are neither complements nor substitutes. The welfare cost of volatility under this setting becomes:

$$\lambda \cong 0.5 \sum_{i=1}^{K} \sum_{j=1}^{K} \sigma_{ji} \gamma_{ji} \tag{9}$$

Bellemare et al. (2010) employ a panel dataset covering seven major food commodities from rural Ethiopian households and find that typical households are willing to forego as much as one-third of their consumption (including storage) to stabilize the price.

In light of such evidence, the welfare cost of volatility in developing countries, where insurance markets are nonexistent or are thin at best and capital markets are underdeveloped, appear to be much higher than in their developed counterparts. Eichengreen et al. (2003)

highlight that the economies of developing countries are hampered by international capital markets' lending constraints owing to sovereign risk exposure and the prevention of external borrowing owing to their currencies being non-convertible.

This is particularly true for governments of commodity-dependent developing countries that rely heavily on revenues from tariffs levied on imports and exports. Volatility in international prices causes revenues to destabilize, and given problems in accessing international capital markets, lower public investment will follow and economic growth will be interrupted.

Summary

Historically, bouts of extreme volatility in agricultural commodity markets have not been common. Like natural disasters, they have a low probability of occurrence but bring with them extremely serious risks and potential high costs for society. Economic adjustment to sustained periods of either high or low prices can be accomplished. However, this is not true for when prices become volatile: adjustment is at best very costly but more likely unattainable.

The Nobel Prize-winning economist Milton Friedman argued that volatility means that market prices are a less efficient system for coordinating economic activity. In his Nobel Memorial Lecture, he states:

> *A fundamental function of a price system ... is to transmit compactly, efficiently, and at low cost the information that economic agents need in order to decide what to produce and how to produce it, or how to employ owned resources. ... If the price level is on the average stable or changing at a steady rate, it is relatively easy to extract the signal about relative prices from the observed absolute prices. The more volatile [are prices], the harder it becomes to extract the signal about relative prices from the absolute prices: the broadcast about relative prices is as it were being jammed by the noise coming from the inflation broadcast. ... At the extreme, the system of absolute prices becomes nearly useless, and economic agents resort either to an alternative currency, or to barter, with disastrous effects on productivity.* (Friedman, 1976)

Friedman makes the link between volatility and uncertainty, and how it can undermine economic decision-making, resource allocation and, ultimately, the efficiency of the price system. Consequently, measures of volatility must explicitly account for uncertainty.

At a deeper level, episodes of sustained volatility generate considerable uncertainty. They spawn increased risks in productive activities and undermine food security and economic growth in developing countries.

Interventionist polices that aim to bring stability have been discouraged given the lack of clear evidence, supported by theory, that price volatility has adverse macroeconomic consequences. However, this theory presupposes that markets are complete, insurance and credit markets are well-functioning and accessible to all, and furthermore, that shocks are mostly transient. These assumptions do not characterize the environment facing many developing countries. Extreme price shocks clearly expose the vulnerability of poor nations.

More worrisome is that large negative shocks to welfare can lead to irreversibility, setting in motion a downward spiral of rising vulnerability as fragile coping mechanisms are diminished. Crisis and extreme volatility generate risk and asymmetry of impact, which impedes growth, accentuates poverty, leads to malnutrition and increases political insecurity and the risk of internal conflict.

Seeing vulnerability as closely tied to the causes and consequences of volatility, measures to reduce vulnerability - both at the macroeconomic and at household levels - must be part of the overall solution.

References

Agenor, P.-R. & Moreno-Dodson, B. 2006. Public infrastructure and growth : new channels and policy implications, *Policy Research Working Paper Series 4064*, The World Bank.

Aizeman, J. & Pinto, B. 2005. *Managing Economic Volatility and Crisis, A practitioners Guide*. Cambridge University Press, World Bank, New York.

Alwang, J., Siegel, P. & Jorgensen, S. 2000. Does the term "vulnerability" mean everything or anything?, *Voices from the Literature, Social Protection*, The World Bank.

Barrett, C. B. 1996. On Price Risk and the Inverse Farm Size-Productivity Relationship, *Journal of Development Economics*, 5: 193 – 215.

Beck, T., Demirguc-Kunt, A. & Levine, R. 2004. Finance, inequality, and poverty: cross-country evidence, *Policy Research Working Paper Series 3338*, The World Bank.

Bellemare, M. F., Barrett, C. B. & Just, D. R. 2010. The welfare impacts of commodity price fluctuations: Evidence from rural Ethiopia, *MPRA Paper 24457*, University Library of Munich, Germany.

Besley, T. 1995. Savings, credit and insurance, in *Handbook of Development Economics*, ed. by Behrman, J. & Srinivasan, T. N., pp. 2123–2208. Amsterdam: North-Holland.

Binswanger, H. & Deininger, K. 1997. Explaining agricultural and agrarian policies in developing countries, *Journal of Economic Literature*, 35: 1958–2005.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quinones, E., Zezza, A., Stamoulis, K., Bonomi, G. & DiGiuseppe, S. 2007. Rural income generating activities; a cross country comparison, *Working Papers 07-16*, Agricultural and Development Economics Division of the Food and Agriculture Organization of the United Nations (FAO - ESA).

Dehn, J. 2000. The effects on growth of commodity price uncertainty and shocks, *Policy Research Working Paper Series 2455*, The World Bank.

Dehn, J., Gilbert, C. L. & Varangis, P. 2005. Agricultural commodity price volatility, in *Managing Economic Volatility and Crises*, ed. by Aizenman, J. & Pinto, B., pp. 137–185. Cambridge University Press.

Dercon, S. 2002. Income risk, coping strategies, and safety nets, *World Bank Research Observer*, 17: 141 – 166.

——— 2004. *Insurance Against Poverty*. Oxford: Oxford University Press.

Eichengreen, B., Hausmann, R. & Panizza, U. 2003. Currency mismatches, debt intolerance and original sin: Why they are not the same and why it matters, *NBER Working Papers 10036*, National Bureau of Economic Research, Inc.

Fafchamps, M. 2003. *Rural Poverty, Risk and Development*. Cheltenham: Edward Elgar Publishing.

Faini, R. 1992. Infrastructures, relative prices and agricultural adjustment, in *Open Economies: Structural Adjustment and Agriculture*, ed. by Goldin, I. & Winters, L. Cambridge University Press.

FAO 2003. Food security: Concepts and measurement, in *Trade Reforms and Food Security: Conceptualizing the Linkages*. FAO.

——— 2008. *The state of food insecurity in the world 2008: High food prices and food security - threats and opportunities*, Rome.

——— 2009a. The 2007-2008 food price swing: impact and policies in Eastern and Southern Africa, *Commodities and Trade Technical Papers 12*, Rome.

——— 2009b. *Coping with a changing climate: considerations for adaptation and mitigation in agriculture*, Rome.

——— 2010. *Food Outlook, November issue*, Rome.

Finkelshtain, I. & Chalfant, J. 1991. Marketed surplus under risk: Do peasants agree with Sandmo?, *American Journal of Agricultural Economics*, 73 (3).

——— 1997. Commodity price stabilization in a peasant economy, *American Journal of Agricultural Economics*, 79(4): 1208–1217.

Friedman, M. 1976. Inflation and unemployment, *Nobel Prize in Economics documents 1976-1*, Nobel Prize Committee.

Gilbert, C. L. 1995. International commodity control : retrospect and prospect, *Policy Research Working Paper Series 1545*, The World Bank.

Gilbert, C. L. & Morgan, C. W. 2010. Food price volatility, *Philosophical Transactions of the Royal Society B*, 365: 3023–3034.

Grossman, S. J. 1976. On the efficiency of competitive stock markets where trades have diverse information, *Journal of Finance*, 31(2): 573–85.

Guillaumont Jeanneney, S. & Kpodar, K. 2005. Financial development, financial instability and poverty, *CSAE Working Paper Series 2005-09*, Centre for the Study of African Economies, University of Oxford.

Heath, J. & Binswanger, H. P. 1996. Natural resource degradation effects of poverty and population growth are largely policy-induced, *Environment and Development Economics*, 1: 65–83.

Holzmann, R. 2001. Risk and vulnerability: The forward looking role of social protection in a globalizing world, *SP Discussion Paper 0109*, World Bank, Washington.

Imrohoroglu, A. 1989. The cost of business cycles with indivisibilities and liquidity constraints, *Journal of Political Economy*, 97: 1364 – 1383.

——— 2008. Welfare costs of business cycles, in *The New Palgrave Dictionary of Economics. Second Edition*, ed. by Durlauf, S. N. & Blume, L. E. Palgrave Macmillan.

Jacks, D. S., O'Rourke, K. H. & Williamson, J. G. 2009. Commodity price volatility and world market integration since 1700, *NBER Working Papers 14748*, National Bureau of Economic Research, Inc.

Knight, F. H. 1921. *Risk, uncertainty, and profit*. New York: Harper and Row.

Knight, J. W. & Woldehanna, T. 2003. The role of education in facilitating risk-taking and innovation in agriculture, *Journal of Development Studies*, 39: 1–22.

Krebs, T. 2003. Growth and welfare effects of business cycles in economies with idiosyncratic human capital risk, *Review of Economic Dynamics*,, 6: 846 – 868.

Krueger, A. S., Schiff, M. & Valdes, A. 1991. *Political Economy of Agricultural Pricing Policy*. Princeton, NJ: Johns Hopkins University Press.

LeRoy, S. & Porter, R. 1981. The present-value relation: Tests based on implied variance bounds, *Econometrica*, 49: 97–113.

Levine, R. 2004. Finance and growth: Theory and evidence, *NBER Working Papers 10766*, National Bureau of Economic Research, Inc.

Lucas, R. E. 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.

——— 2003. Macroeconomic priorities, *American Economic Review*, 93: 1 – 14.

McKinnon, R. I. 1973. *Money and capital in economic development*. Brookings Institution, Washington, DC.

Mundlak, Y., Larson, D. & Butzer, R. 1997. The determinants of agricultural production : a cross-country analysis, *Policy Research Working Paper Series 1827*, The World Bank.

Newbery, D. M. & Stiglitz, J. E. 1981. *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*. Oxford: Clarendon Press.

Pallage, S. & Robe, M. 2000. Magnitude X on the Richter scale: Welfare cost of business cycles in developing countries, *Working Paper 124*, Center for Research on Economic Fluctuations and Employment (CREFE), University of Quebec.

Prasad, B. & Crucini, M. 2000. Commodity prices and the terms of trade, *Review of International Economics*, 8: 647 – 666.

Ramey, G. & Ramey, V. A. 1995. Cross-country evidence on the link between volatility and growth, *American Economic Review*, 85(5): 1138–51.

Rosenzweig, M. R. & Wolpin, K. I. 1993. Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India, *Journal of Political Economy*, 101(2): 223–244.

Roumasset, J. A. 1976. *Rice and Risk: Decision-Making among Low-Income Farmers*. Amsterdam: North-Holland.

Roumasset, J. A., Boussard, J.-M. & Singh, I. 1979. *Risk, Uncertainty and Agricultural Development*. New York: Agricultural Development Council.

Sandmo, A. 1971. On the theory of the competitive firm under price uncertainty, *American Economic Review*, 61(1): 65–73.

Serven, L. 1998. Macroeconomic uncertainty and private investment in LDCs: an empirical investigation, *Manuscript*, World Bank, Washington.

Shiller, R. J. 1981. Do stock prices move too much to be justified by subsequent changes in dividends?, *American Economic Review*, 71: 421–436.

Storesletten, K., Telmer, C. I. & Yaron, A. 2001. The welare cost of business cycles revisted: Finite lives and cyclical variation in idiosyncratic risk, *European Economic Review*, 45(7): 1311–1339.

Subervie, J. 2008. The variable response of agricultural supply to world price instability in developing countries, *Journal of Agricultural Economics*, 59(1): 72–92.

Turnovsky, S. J., Shalit, H. & Schmitz, A. 1980. Consumer's surplus, price instability, and consumer welfare, *Econometrica*, 48(1): 135–52.

van Wincoop, E. 1994. Welfare gains from international risk sharing, *Journal of Monetary Economics*, 34: 175–200.

Wang, Z. 2009. Volatility risk, *Issue Briefs 2009513*, South Dakota State University, Department of Economics.

Weir, S. & Knight, J. 2004. Externality effects of education: Dynamics of the adoption and diffusion of an innovation in rural Ethiopia, *Economic Development and Cultural Change*, 53: 93 – 113.

Wolf, H. 2005. Volatility: Definitions and consequences, in *Managing Economic Volatility and Crises*, ed. by Aizenman, J. & Pinto, B. Cambridge University Press.

World Bank 2005. Managing food price risks and instability in an environment of market liberalization, *Agriculture and Rural Development Department*, Washington D.C.