Risk, Market Failure and Agricultural Policy
by
Peter B.R. Hazell

Introduction

Problems associated with risks in agriculture have long been one of the reasons that many governments intervene directly in agricultural product and factor markets. But in recent years, changes in world commodity and foreign exchange markets, together with a trend towards more variable production, have greatly increased the magnitude of the risk problem for farmers, poor consumers, and governments in many country. The problem is particularly acute for the developing countries because they are much more dependent on primary commodities, and because they have least reserves for buffering shocks to their national economies.

We are particularly concerned with this problem at the World Bank, and are actively thinking about what can be done to help developing countries manage their risks more effectively. As a participant in that process, I welcome this opportunity to share my own thinking on this subject with such an illustrious group of risk experts. I particularly seek your advice on establishing priorities for our own research work at the Bank, and hope too that this discussion might encourage the S-180 Program to take a more active interest in the risk problems of the developing world.

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The Increasing Risk Problem

Recent years have seen a sharp increase in the volatility of world commodity markets (Blandford and Schwartz 1983, Myers and Runge 1984, Hazell 1988). Structural shifts in demand and changes in US storage policies were probably the dominant sources of this change (Myers and Runge 1984), but increased production variability for both importing and exporting countries was also important (Blandford and Schwartz 1983). The destabilizing effect of production variability is also amplified in world markets by the domestic price policies of many industrialized countries (Josling 1980).

From a long-term historical perspective, recent movements in world commodity prices are not unusual; witness, for example, the movements in wheat prices between the First and Second World Wars (Figure 1).

![Figure 1: History of the Price of Wheat: 1913-83](image)

However, the recent increase in volatility is substantial after the relative tranquility of the 1950s and 1960s. For example, the coefficient of variation (cv) of the detrended world wheat price increased by 400 percent between 1961-71 and 1974-81, while the cvs for rice and maize increased by 59 percent and 67 percent, respectively (Hazell 1988)--and
these periods omit the major upheaval in world cereal markets that occurred in 1972-73.

The recent increase in commodity price variability has been aggravated by three other considerations.

First, foreign currency markets have recently become much more volatile, and this amplifies world price movements when translated into the domestic currencies of most countries. This was not an important factor during the years of volatile prices prior to the Second World War.

Second, world cereal prices (after detrending) have become much more positively correlated since the 1960s, as shown below:

<table>
<thead>
<tr>
<th></th>
<th>Maize</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961-71</td>
<td>0.30</td>
<td>0.13</td>
</tr>
<tr>
<td>1974-81</td>
<td>0.89</td>
<td>0.82**</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961-71</td>
<td>-0.62**</td>
<td>0.78***</td>
</tr>
<tr>
<td>1974-81</td>
<td>0.82**</td>
<td>0.82**</td>
</tr>
</tbody>
</table>

Whereas previously the agricultural trade balance for a country was partially stabilized by off-setting patterns of variations between prices, this is much less true today.

Third, the absolute variability of production of many commodities is increasing, both at the national and global levels (Hazell 1984, 1986; Anderson, Hazell and Evans 1987). For example, Table 1 shows that the standard deviation of world cereal production (excluding China) has increased substantially since the 1960s. Relative variability as measured by the cv, has also increased, though the increase in Table 1 is not statistically significant. The probability that world cereal production could fall 5 percent or more below trend (an event which would lead to a comparable food crisis to the early 1970s) has also increased; from about 3
percent in the 1960s to 8 percent in the 1970s. A shift towards a positively skewed distribution implies that the probability of extreme shortfalls in production is declining, but that the frequency of falling below trend is increasing.

Consequences of Increasing Risk

In the sort of ideal world conceived by economists, a full range of contingency markets would exist for all economic agents, and it would not be necessary to worry about the consequences of more volatile commodity markets. But in reality, risk markets are largely absent or incomplete, and policy makers need to be concerned for a number of reasons.

Table 1: Variability of World Cereal a/ Production Around Linear Trend for Different Periods

<table>
<thead>
<tr>
<th>Decade Beginning</th>
<th>Average Production</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
<th>Skewness</th>
<th>Probability of a 5 Percent Shortfall below Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960/61</td>
<td>819</td>
<td>24.3</td>
<td>0.030</td>
<td>-0.31</td>
<td>4.65</td>
</tr>
<tr>
<td>1961/62</td>
<td>837</td>
<td>20.7</td>
<td>0.025</td>
<td>-0.39</td>
<td>2.17</td>
</tr>
<tr>
<td>1962/63</td>
<td>867</td>
<td>22.4</td>
<td>0.026</td>
<td>-0.64</td>
<td>2.62</td>
</tr>
<tr>
<td>1963/64</td>
<td>890</td>
<td>24.1</td>
<td>0.027</td>
<td>-0.21</td>
<td>3.22</td>
</tr>
<tr>
<td>1964/65</td>
<td>923</td>
<td>26.8</td>
<td>0.030</td>
<td>-0.32</td>
<td>4.18</td>
</tr>
<tr>
<td>1965/66</td>
<td>946</td>
<td>31.2</td>
<td>0.034</td>
<td>-0.32</td>
<td>6.55</td>
</tr>
<tr>
<td>1966/67</td>
<td>972</td>
<td>32.5</td>
<td>0.034</td>
<td>-0.39</td>
<td>6.68</td>
</tr>
<tr>
<td>1967/68</td>
<td>1001</td>
<td>34.3</td>
<td>0.035</td>
<td>-0.47</td>
<td>7.21</td>
</tr>
<tr>
<td>1968/69</td>
<td>1026</td>
<td>34.4</td>
<td>0.035</td>
<td>-0.27</td>
<td>6.81</td>
</tr>
<tr>
<td>1969/70</td>
<td>1057</td>
<td>40.0</td>
<td>0.037</td>
<td>0.05</td>
<td>9.01</td>
</tr>
<tr>
<td>1970/71</td>
<td>1081</td>
<td>40.0</td>
<td>0.037</td>
<td>0.34</td>
<td>8.85</td>
</tr>
<tr>
<td>1971/72</td>
<td>1108</td>
<td>40.1</td>
<td>0.036</td>
<td>0.37</td>
<td>8.38</td>
</tr>
<tr>
<td>1972/73</td>
<td>1132</td>
<td>39.5</td>
<td>0.035</td>
<td>0.46</td>
<td>7.64</td>
</tr>
<tr>
<td>1973/74</td>
<td>1159</td>
<td>38.5</td>
<td>0.033</td>
<td>0.37</td>
<td>6.68</td>
</tr>
</tbody>
</table>

a/ Does not include China.
First, for countries in which agriculture dominates the national economy—and this includes most of the poorest countries—their trade balance is becoming more volatile, and this has serious consequences for foreign exchange earnings, international debt repayment, and national income, employment and investment. The problem is particularly acute for those countries that depend on only one of two primary commodities for the bulk of their foreign exchange earnings. For example, Costa Rica depends on coffee, Ghana on cocoa, and Zambia on copper, and all three countries have experienced major upheavals in recent years.

Second, fluctuations in farm incomes, particularly the risk of catastrophic losses, present difficult welfare problems for rural people. For the households operating small farms in developing countries, these losses can too easily translate into episodes of misery and malnutrition. They can also cause distress sales of farm assets, with deleterious consequences for recovery and long-term agricultural growth. Poorer farmers may even lose their land in catastrophic years because of indebtedness to local moneylenders. There are also important spillover effects on other rural households. Destroyed crops reduce employment opportunities for the landless, as does the substitution of family for hired labor in harvesting a lower output. A lower output also reduces sales by agricultural merchants and agroprocessors. Reduced farm incomes have negative multiplier effects on income and employment among the producers and traders of rural consumer goods and services. These adjustments may lead to sizeable income distribution effects in the short terms.

Third, exposure to severe risks increases the likelihood that farmers will default on bank loans, particularly in years of natural catastrophe or depressed world prices. The provisions of subsidized farm
credit through agricultural development banks (ADBs) is a cornerstone in the development strategy of many countries. However, the performance and long-term viability of ADBs can be severely impaired by poor loan collection, particularly if many farmers default at the same time because of a common catastrophe. The problem is accentuated when ADBs deliberately target a generous share of their lending portfolio on small farmers, who are least able to withstand catastrophic losses without defaulting.

Fourth, farmers' efforts to avoid risks through management practices reduce the average returns to their resources. This not only reduces average farm incomes, with immediate welfare ramifications, but also leads to smaller supplies of the riskier agricultural commodities. If these are important food or export crops, curtailment of their production can affect consumers' welfare directly as well as reducing foreign exchange earnings. It also leads to a lower national income and to reduced long-term productive investments in agriculture.

Fifth, because of the time required for agricultural production, most farm inputs have to be allocated well before yields and product prices can be known. Farmers must allocate resources each year on the basis of their expectations about yields and prices. If these expectations are wrong, their resource allocations will be less than optimal. Such errors can be costly to national income. Typically they are also costly to farmers when their average incomes are compared to the incomes that could be achieved given perfect foresight.

For a given market, there is always a rational price expectation or forecast that utilizes all the available information to maximize the average income that farmers can realize in a competitive environment. If all farmers hold rational price expectations, competitive markets will be maximally efficient, given the existence of price and yield risks.
However, gains in realized social welfare might still be attainable if price risks could be eliminated, for example, through buffer stock schemes or price supports. Even larger social gains will be possible if farmers do not initially plan on the basis of rational price expectations (Newbery and Stiglitz 1981; Scandizzo, Hazell, and Anderson 1984).

Finally, fluctuations in food prices, together with greater variability in domestic production, present greater food security problems for the poor. The problem is particularly difficult for food deficit countries where domestic prices are less easily protected from world prices.

Given these concerns, the challenge is to devise appropriate policy interventions that can enable countries to exploit their comparative advantage, but at the same time provide an effective buffer to stabilize incomes, employment, food security, government revenue and foreign exchange earnings.

**Policies to Assist Farmers in Coping with Risk**

The major objective here is to stabilize farm incomes, since this in turn helps stabilize consumption, investment and debt repayment.

Some farm level risks can be reduced directly. For example, production variability arising from unreliable fertilizer deliveries can often be resolved by consistent import policies and improved transport, distribution, and storage systems. Likewise, some weather-related risks may be diminished through irrigation investments, which also contribute to increased production. Plant breeders might also be able to reduce some yield risks by selecting for lower sensitivity to environmental stress. But most farm-level risks lie beyond direct government control and can only be offset by some form of risk-sharing arrangement.
Private risk-sharing institutions are most widely available in developed countries. Farmers can borrow for production or consumption purposes to ease the transition from bad years to good. In most cases, they also have access to a variety of privately provided insurance against specific types of risks (such as fire, accident, or theft). They may even be able to trade in commodity futures markets. In developing countries these kinds of institutions are usually much more rudimentary, and may not be available at all for small farmers. Nevertheless, a range of informal risk-sharing arrangements have often evolved. These include share tenancy contracts, traditional moneylending, and risk-sharing within extended family networks. A major limitation to these arrangements is that the participants tend to come from the same region, or even the same village, and hence face much the same risks. Therefore, the arrangements do not pool risks as efficiently as they would if they spanned regions or broader sectors of the national economy, as do nationwide crop insurance or credit schemes.

In developing countries, publicly provided risk-sharing institutions almost always take the form of a price stabilization scheme, or a crop insurance program. Both have proved costly in terms of public subsidies, and neither has proved very effective in stabilizing farm incomes, particularly when tested against the willingness of participants to pay the full cost of the risk-reducing service received. They have been particularly ineffective in reaching the rural poor because the poor benefit the least from price supports (they are typically net buyers of food), and they rarely qualify, or can afford, crop insurance (or institutional credit to which crop insurance is often attached).

It is possible that these interventions might be improved to make them more cost effective. Price stabilization could be limited to a price
support or "underwriting" arrangement which is specifically targeted on "down-side" risks. To be effective in terms of farm decision making, the floor price must be both guaranteed and announced before the growing season commences. In the case of commodities which a country consistently trades internationally, stabilization within price bands can also be achieved through variable import or export levies (Siamwalla 1986). Both approaches avoid the need to carry large stocks, and hence may avoid the high costs associated with the more ambitious stabilization schemes usually attempted.

Similarly, if crop insurance is limited to very specific types of risks, such as hail, the damage from which lies beyond the farmers’ control and can be objectively and cheaply assessed, then the high costs associated with the more usual ‘multiple risk’ insurance schemes can be avoided.

A problem arises in that the more one trims the scope of such schemes to make them cost effective, the less risks they cover and hence the less they can contribute to income stabilization. In fact, it might be more relevant to view cost-effective price stabilization and crop insurance endeavors as protective devices against catastrophic losses rather than as income stabilization measures.

Some industrial countries have effectively used their income tax systems to help farmers buffer fluctuations in their incomes, e.g., through income averaging or, in Australia, through income equalization deposits (Lloyd and Mauldon 1986). But these are not viable approaches in most developing countries.

In principle, credit schemes could be an effective risk sharing device, but this would require that loans be made available for consumption purchases, and that repayment schedules be sufficiently flexible that farmers could borrow in bad years and repay in good years. This is a far
cry from existing farm credit schemes which tie loans to specific farm inputs and which typically must be repaid within the same year.

Futures markets and forward contracting have yet to emerge in developing countries, and their potential needs to be carefully assessed. It is hard to conceive of many poor, illiterate farmers participating directly in sophisticated trading transactions, but farm cooperatives or marketing boards might act as viable intermediaries.

Policies to Promote Market Efficiency

Policies that help farmers cope more efficiently with risk will also lead to more desirable resource allocations for national income and welfare. In particular, such policies should help increase the production of riskier crops toward more optimal levels as their risk costs are reduced.

Despite these adjustments, however, farmers are still likely to confront the difficult problem of forecasting yields and prices each year when committing their resources. As discussed earlier, forecast errors can lead to two types of losses in market and resource allocative efficiency. The first type arises when farmers do not hold rational price expectations, so that their forecast errors are larger than necessary. The second loss arises because even with rational expectations, forecast errors still occur. These could be eliminated if prices and yields were stabilized.

In competitive markets, the efficient price forecast for each farmer should take account of the correlation between price and his yield (Scandizzo, Hazell, and Anderson 1984, p.16). Often this correlation is negative; the market price is inversely related to variations in farm yields. The rationale for considering this correlation is apparent if we consider a farmer who seeks to maximize the expected profit from his crop.
Let $p$ denote the product price, $y$ the yield, and $c$ the per hectare costs of production. Then in any given year profit per hectare $w$ is: $w = py - c$.

If price and yield are both risky (we shall assume $c$ is not), then the farmer must form an expectation about gross revenue $py$. In the absence of structural shifts in demand and supply, an unbiased prediction is the average of past gross revenues. This can be written mathematically as the expected value: $E(py) = E(p)E(y) + \text{Cov}(p, y)$. That is, the average gross revenue per hectare is the product of the average price and the average yield plus the covariance between price and yield.

If we divide this per hectare return by the average yield $E(y)$, the resultant measure of return per unit of output is comparable to a price forecast; it is defined in similar units, for example, dollars per ton. This unit revenue price forecast, $P* = \frac{E(py)}{E(y)}$, embodies full information about the mean price, the mean yield, and the price-yield covariance. It is a rational forecast for the farmer, and in the absence of storage schemes it is also the price forecast which maximizes expected social welfare (Hazell and Scandizzo 1977).

If prices and yields are negatively correlated, the unit revenue forecast will be less than the average price. In this case rational farmers will produce less of the commodity than calculations based on average prices would suggest, a point often overlooked by many economists and policymakers. The opposite will happen when the correlation is positive. Farmers should produce more of the commodity than calculations based on average prices would suggest. Note that these supply effects will arise even if farmers are risk-neutral. The correlation effect will be amplified if farmers are also risk-averse.

Using time series data from a wide range of countries, Scandizzo, Hazell, and Anderson (1984) provide some evidence that farmers in
industrialized Western economies do take account of price and yield correlations but that farmers in developing countries and in the centrally planned economies do not. If these results are correct, then there is relatively greater scope for policy intervention to improve market efficiency in developing countries.

Given less than rational price forecasting behavior, the magnitude of market inefficiencies increases with the variability of yields. The inefficiency is also greater the more inelastic is the market demand. On the other hand, the more risk-averse farmers are, the less important it is to consider the correlation between prices and yields when forecasting prices.

In reality, there are constant structural shifts in the market (e.g., through technological change) and farmers' ability to make reliable forecasts about revenues is strongly influenced by the availability of market information. The key policy issue is the extent to which existing investment, both public and private, in the provision of information is optimal. The public-good nature of much of the relevant information ensures that private investments will be much less than is socially optimal. There is, however, a dearth of research on how adequate have been the public initiatives. One thing is certain, given the diversity of level of investment around the globe, namely that, if the level in industrial countries is somewhere near the socially optimal intensity, most developing countries are still severely underinvesting.

While the economic value of information to farmers has been evaluated in a few developed country studies (e.g., Freebairn 1976), to my knowledge, no such studies have been undertaken in developing countries. Policy makers particularly need guidance on the design of suitable data
systems to service third world farmers, as well as the justifiable level of investment.

Policies to Enhance Food Security

There are two aspects to the food security problem. The first is to ensure adequate supplies of food each year to meet domestic demand at prices that most people can afford. The second is to ensure that the poorest segments of society have adequate income, or entitlement rights, to meet basic nutritional requirements. The latter issue has to be tackled through policies to obtain more equitable growth, or through direct public assistance programs, and although these are very important issues, they are less germane to my immediate topic and I shall not pursue them here.

In order to obtain adequate and stable supplies of food, many developing countries have opted for national self-sufficiency programs and, in the few cases in which this objective has been fully achieved, to carrying sizeable food stocks over time (e.g., India and Indonesia). This approach has proved costly because it diverts resources away from their comparative advantage. Food stocks are also expensive to maintain, both because of the high capital costs incurred in providing storage and handling facilities, and also because of high damage and deterioration losses incurred through improper management and a tropical environment.

Most studies (e.g., Valdes 1981) show that food supplies can be stabilized far more cheaply by trading in world markets, and the IMF even has a special Food Facility to provide short-term, hard currency loans to governments wishing to purchase food imports in deficit years. But this approach is rarely preferred, perhaps because of the difficulties of anticipating import needs sufficiently in advance to allow time for the necessary transactions and deliveries. There is also the recurrent fear that the exporting countries may use food as a political weapon.
Given that many developing countries fail to use world markets to stabilize their food supplies, then the issue of variability in domestic food production becomes an important one.

In previous work (Hazell 1984, 1985), I have shown that the variance of total cereal production has increased since the mid-1970s in most countries, and that this increase is largely attributable to more variable yields that have also become more positively correlated between regions and between crops. Some researchers (e.g., Mehra 1981) have argued that the higher yielding varieties (HYVs) associated with the green revolution are more risky, hence their introduction since the late 1960s is an important source of increasing variability in farm and national yields. The early rice HYVs, for example, proved susceptible to pest and disease attacks, and their rapid and widespread adoption did lead to severe yield losses in some countries before more resistant varieties were released. There is also the concern that HYVs only perform well in favorable environments, and that they do not do as well as traditional varieties in unfavorable years or regions. However, there is now accumulating evidence (e.g., Pfeiffer and Braun 1988; Pham, Waddington and Crossa 1988; Witcombe 1988) that while HYVs typically lead to higher yield variances, nevertheless their cvs are not generally larger than those of alternative varieties when grown under a range of trial conditions; in fact, in many cases, HYVs have smaller cvs.

HYVs are selected to be more responsive to good growing conditions--indeed, this is how yield increases are largely obtained. This implies, however, that yields will fluctuate more if the use of inputs varies. Input variation may have increased with increases in price variability since the early 1970s, and with the difficulties of reliably supplying inputs in developing countries to meet the growing demands of the
green revolution (Jain, Dagg and Taylor 1986). Input variation thus leads to behaviorally-induced variability in yields, and the phenomenon is perhaps an inevitable consequence of the modernization of agriculture.

Weather patterns, it is sometimes argued, may have become more variable since the 1960s, although there is little evidence for this (Carter and Parry 1986). If anything, weather in some areas may have become more stable, at least in the U.S. Corn Belt (French and Headley, 1988).

National yields may also have become more variable because increases in the areas cropped have pushed some cereals into more marginal land (e.g., barley in Syria, Nguyen 1988), although there is a contrary example in Australia of the growing importance of less-variable Western Australia in the national wheat crop (Brennan and Spohr 1985). Other sources of increased variability include changes in policy and land reform (e.g., Tarrant 1988, Nguyen 1988).

Reasons for the increase in yield correlations between regions are still speculative but include:

i. the potentially narrowing genetic base--or is it the "too few" varieties problem? Whatever, there does seem to be a more common susceptibility to weather and pest stresses (Coffman and Hargrove 1988);

ii. varieties that are screened for stability across sites are likely to be more highly correlated across sites too;

iii. more homogenous cultural practices (Duvick 1988);
iv. yield variability induced by input variations is also likely to be more covariate, e.g., fertilizer application is adjusted in the same way to price signals by all farmers facing the same price movements. This problem is compounded by the green revolution which has resulted in more farmers becoming more dependent on fertilizers, etc.

v. irregularities in input supplies are likely to have covariate effects on yields, e.g., electricity blackouts in India worsened just when more farmers become dependent on electric pumps for irrigation (Hazell 1982);

vi. an increase in irrigated area. Although irrigation may be effective in reducing yield variability within fields, it may, by reducing some dispersed climatic influences on yields, lead to more synchronized patterns of variability across locations;


The tendency for correlations between crop yields to increase is probably a price-related phenomenon. This is suggested by the sharp increase in correlations among world cereal prices that I mentioned earlier. To the extent that producers of cereal are price responsive in yields, more correlated prices for grains will predispose more correlated crop yields.

If part of the increase in production instability is technological in origin, it can be asked whether the solution should be sought primarily through changing agricultural research priorities. There are two arguments against such an approach for developing countries. First, continued growth in foodgrain production is of paramount importance, and any tradeoff that
might exist between breeding for growth and stability may prove costly. Second, there are other more important sources of increased variability in production which would not be affected by changing agricultural research priorities. In many cases instability may be caused by government policy, or it may be amenable to changes in government policy. For example, policies to provide more stable farm prices and fertilizer and electricity supplies could make a direct and useful contribution toward stabilizing cereal production in India (Hazell 1982). Increased irrigation investment can also contribute to greater stability (Mehra 1981).

Some of the behaviorally-induced variability and covariability in yields could be reduced by reducing the variability in farm-gate prices. Interregional correlations in production can also be exploited to reduce aggregate production variability. This can be done by focusing producer incentives and public investments to increase production in regions with lower production variability or regions in which production is negatively or only weakly correlated with the production of other important regions (Hazell 1982, Tarrant 1988).

A greater regional focus in agricultural research and seed release programs could also help by (a) increasing the number of suitable varieties (and hopefully the range of the genetic base) and (b) reducing the tendency to select varieties that perform well in many locations at the same time. Both aspects should contribute to a reduction in the interregional yield correlation problem, as well as improve the relevance of new technologies within the regions served. But this approach would require greater public expenditure on agricultural research.
Policies to Buffer the National Economy

So far, I have largely been concerned with policies to assist private individuals—producers and consumers—in managing risks when making their individual resource or consumption allocation decisions. But some of the more important risks confronting developing countries express themselves through fluctuations in such aggregate variables as the national trade balance, foreign exchange earnings, and the government’s budgetary deficit. These sorts of variables have an important bearing on national economic welfare, but they lie beyond the control of private decision makers. Even if all private economic agents act in risk averse ways, it is not at all clear that an optimal risk-averse strategy will be arrived at for the economy as a whole, at least as long as there are imperfect or missing risk contingent markets.

Arrow and Lind (1970) argued that governments should act in a risk neutral way, but this only seems to make sense given either a diverse economy in which risks can be efficiently pooled, or a country in which risks are small relative to the size of the economy. The theorem seems irrelevant for the smaller and specialized economies of the developing world in which risks in the primary sector can cause substantial fluctuations in national income. The domestic possibilities for successfully buffering these risks seem inadequate, and international risk-sharing arrangements are largely absent or very partial. Within this context, social welfare might be enhanced if decisions about public policies and investments were made in a risk-averse way.

If this is accepted, then we need to figure out practical ways of doing this in public policy decision making. Procedures for incorporating public risk aversion within the context of cost/benefit analyses have been derived (e.g. Scandizzo 1980), but I am not aware of any applications.
Jabara and Thompson (1980) incorporated a risk-averse government objective function into a price-endogenous, agricultural sector model and applied it to a food security problem for Senegal. However, there are two limitations to their approach. First, they assumed that producers and consumers were risk neutral and hence did not address the question of whether risk-averse behavior on the part of government and private decision makers may be unnecessarily duplicative in guiding diversification decisions. Second, by maximizing a government objective function rather than the sum of the producer and consumer surpluses, their model simulates a command rather than a competitive economy. Unless the government can fix the price of all relevant outputs and resources, then there is no way that the optimal solution to their model can be implemented in practice.

Public risk aversion also implies that greater weight should be given to flexibility in the design of future investments than has been done in the past. For example, investments in physical and institutional infrastructure that enhance the flexibility of the economy to adjust to price movements should receive greater attention, possibly through some kind of weighting procedure in cost/benefit analysis. In Asia, many large-scale irrigation investments have been undertaken in the past which were designed exclusively for growing paddy. Had greater consideration been given to flexibility at project design, these systems would now be more suitable for crop diversification in response to the current economic climate. The question is how do we modify project appraisal techniques to give a greater selection bias towards more flexible projects.

In searching for practical procedures for incorporating public risk aversion into policy prescription, additional thought also needs to be given to the kinds of policy instruments available to governments for managing risks, and especially those which involve risk sharing at the
international level. Appropriate development of world futures markets or forward contracting arrangements might enable more efficient risk sharing between producers, traders and consumers at the global level. Commodity bonds also show useful promise, although these have not yet been exploited by any of the developing countries (Priovolos 1987).

A related issue concerns the cost of forecast errors in public decision making. If, for example, government policy makers seriously underestimate future world prices and hence underinvest in primary production (including the maintenance of rural infrastructure and agricultural research), the cost of being wrong may be very high indeed. There is not only an opportunity cost of potential income foregone, but also the cost of rebuilding rural infrastructure and rural institutions. The lags involved in getting agriculture moving again can be very long once rural infrastructure and agricultural research and extension have been neglected. Public decisions must be made on the basis of expected prices, but real economic costs are incurred if the forecast is wrong (both on the upside or downside). In risk decision theory one constructs 'regret'--the cost of being wrong--functions (after Savage) to represent such situations. Then, given the assumption that policy makers in LDCs should be risk averse, one could derive a set of shadow prices that offer an optimal tradeoff between expected income and 'regret'. Such an analysis might lead to significant departures from the usual world reference prices used in project appraisal studies.

Conclusions

I have reviewed quite a long list of policy instruments potentially available to policy makers for managing risks. In undertaking this exercise I was struck by how few instruments are actually used in developing countries, and of those that are used (especially price
stabilization and crop insurance), how costly and ineffective they have proved to be. Perhaps there are really few reasons to be optimistic that public policy can contribute significantly to risk management, at least within the confines of the kinds of institutions that have hitherto been conceived,

The problem is not limited to the developing world. Australian agriculture is subject to wide output fluctuations and depends heavily on world markets for its prosperity. The country has a rich institutional setting which evolved in the presence of active research and public debate on policy alternatives to deal with risk and rural income fluctuations. Until the mid-1970s, the principal policy approach to stabilizing incomes was to stabilize commodity prices. These schemes provided considerable price assistance to farmers but had little impact on stabilizing their incomes (Lloyd and Mauldon 1988). Since then, there has been a shift in emphasis towards instruments that operate directly on the income and cash flow of individual farmers. But for the most part, these do not seem to have been very effective, and more recent proposals by the Australian Industries Assistance Commission, of which rainfall insurance and variable amortization schemes for credit are perhaps the most important, have yet to be implemented.

Gardner, Just, Kramer and Pope (1984) seem less than sanguine about the effectiveness of US agricultural policy in achieving stabilization goals. Indeed, they even discuss how government interventions actually contribute to the risks confronting farmers.

Perhaps the EEC and Japan have been more successful in achieving stability for their farmers, but only at very high cost to their national exchequers, and by pursuing trade policies that transfer most of the variability in their domestic production to world markets.
Risk is an important and increasing problem for the world's agricultural community. The fact that past attempts to deal with it through public policy have been less than successful only increases the challenge that now confronts us.
Bibliography


