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Risk and Uncertainty in Domestic Production and Prices

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Agricultural production is typically a risky business. Farmers face a variety of price, yield, and resource risks which make their incomes unstable from year to year. In many cases farmers are also confronted by the risk of catastrophe. For example, crops may be totally destroyed by hurricane, fire, drought, pests, or diseases, and product prices may plummet because of structural adjustments in world markets.

The types and severity of the risks confronting farmers vary with the farming system and with the climatological, policy, and institutional setting. Nevertheless, agricultural risks seem to be prevalent throughout most of the world. They are particularly burdensome to small farmers in developing countries. There is also strong evidence that farmers are universally risk-averse (see Binswanger 1980) and that they seek to avoid risk through various managerial and institutional mechanisms. For example, they may diversify their crops, favor traditional farming techniques using less modern inputs, and enter into sharecropping arrangements.

The incidence of risk and risk-averse behavior in farming is important to policymakers for a number of reasons.

First, fluctuations in farm incomes, particularly the risk of catastrophic losses, may 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 term.

Second, exposure to severe risks increases the likelihood that farmers will default on bank loans, particularly in years of natural catastrophe. 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.

Third, farmers' efforts to avoid risks through management practices reduces 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.

Fourth, 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 1983).

Fifth, yield variability leads to unstable supplies of agricultural commodities. The problem is accentuated when farmers adjust input use and the area they plant to different crops from year to year in response to changing expectations about uncertain prices and yields. Instability in national food production tends to increase domestic price variability, pre-

senting food security problems for the poor and increasing uncertainty for farmers. Instability in export crop production leads to more volatile foreign exchange earnings, which can destabilize the national economy.

Given these concerns, there may be good grounds for government intervention to help farmers and consumers cope more efficiently with risk, to improve the efficiency of markets and aggregate resource allocation, and to curtail any risk-induced worsening of the distribution of rural income. Price policy can sometimes play an important part in achieving these goals.

POLICIES TO ASSIST FARMERS IN COPING WITH RISK

Risk-sharing arrangements can reduce the burden of risk for the individual farmer in two ways: one, by transferring the risk to other individuals or institutions who are better able or more willing to bear it; two, by pooling risks across regions, crops, or other sectors of the economy to take advantage of less than perfectly covariate risks. Efficient risk-pooling reduces the total risk burden to society and can sometimes prove beneficial to farmers, even if they have to pay the full cost of the risk-spreading mechanism.

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.

Risk management interventions have proved costly to governments and have not always been effective. Before embarking on such interventions, it is desirable to have a clear understanding of what is to be achieved, for whom, and the alternatives available. I shall assume that the primary objective is to help stabilize farm incomes, particularly in disaster years. This objective might be justified on the grounds of welfare, improving efficiency in resource use, or increasing loan recovery rates for ADBs. Assisting farmers in this way will also help stabilize the incomes of some other rural

households, such as the producers and traders of local consumer goods and services. However, it may do little to help landless workers or agricultural merchants and processors, since the demand for their services will still decline with farm production in bad years. If these groups are to be assisted, more direct types of intervention may be required such as emergency food rations or food-for-work programs.

Given the objective of stabilizing farm incomes, a government typically has a range of policy options, depending on the kinds of risk involved. It is important to begin by assessing the real sources of risk, since some 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 risk 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.

Many risks lie beyond direct government control and can only be offset by compensating farmers in years of low return. If price fluctuations are the primary cause of income fluctuations, price supports or price stabilization schemes may be the best approach. A well-functioning credit market can also help tide farmers over from poor to good years. Crop insurance works best when yield risks are the primary source of fluctuations in income, and particularly when there is the risk of catastrophic yield failure. However, to be effective, crop insurance schemes must be designed to provide protection for very specific types of risk, such as hail, the damage from which lies beyond the farmer's control and which can be objectively and cheaply assessed. Multiple risk crop insurance schemes have not proved effective and typically require substantial subsidies from the national exchequer (Hazell, Pomareda, and Valdés 1986).

If price and yield risks are both important in determining farm income, crop yield insurance can be effectively combined with price support or price stabilization schemes. In fact, if yields and prices initially move in compensating directions, yield insurance and price stabilization must be introduced together. Enacted separately, neither would have the desired compensatory effect on farm income.

POLICIES TO ALLEVIATE INSTABILITY IN NATIONAL FOOD SUPPLIES

Many countries have achieved impressive rates of growth in national foodgrain production in recent decades. Much of this growth can be attributed to new technologies and the increased use of modern inputs such as fertil-

izers. At the same time, the variability of national foodgrain production around trend has often increased (see chapter 3).

Despite such increased instability, there is no question that the growth in foodgrain production in most countries has been desirable for meeting the increase in domestic demand. However, increased domestic production variability is reflected in increased market and price instability, which, if not compensatory or offset by government intervention, may pose difficult problems for low-income people. It also increases the size of emergency food stocks that need to be held within countries to ensure that consumption does not fall precipitately below trend.

In chapter 3 we showed the importance of yield variability as a component of production variability and examined some of the links between the widespread adoption of the improved seed and fertilizer-based technologies and increases in yield variability. The yields of crops grown with the new technologies appear to have larger variances, but typically their coefficients of variation are lower than those of traditional technologies. However, because they require modern inputs, their yields may also be sensitive to year-to-year variations in input use arising from frequent price changes or from supply restrictions. Yields may also be more positively correlated across farms and regions with the new technologies (Hazell 1982, 1984).

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 problems for consumers posed by increasing instability can also be alleviated through appropriate policy interventions. Food supplies and prices can be stabilized through storage schemes and international trade. Emergency ration schemes and food-for-work programs can assist low-income people in disaster years. 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.

Within this broader perspective, agricultural research can usefully contribute to limiting yield risks for farmers when the tradeoff against higher yields is low or when there are no public policies to permit farmers to diffuse their risks efficiently. Such reductions in yield variability for farmers may also help reduce variability in national foodgrain production, but not if they aggravate the problem of increasing interregional yield correlations. In terms of containing future increases in aggregate instability, greater attention should be given to containing the increasing yield correlations across farms and regions. If these are due to the narrowing of the genetic base that has accompanied the development of high-yielding varieties, the broadening of this base through more regionalized breeding and seed release programs should be given greater priority in agricultural research.

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: $E(py) = E(p)E(y) + \mathrm{Cov}(p, y)$. 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 price forecast, $P^* = E(Py)/E(y)$, which we shall call the unit revenue forecast, embodies full information about the mean price, the mean yield, and the price-yield covariance. It is a rational forecast for the farmer, and as Hazell and Scandizzo (1977) have shown, in the absence of storage schemes it is also the price forecast which maximizes expected social welfare.

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.

Where markets are very inefficient, a government can choose between three basic policy approaches. First, production quotas could be imposed to limit the average output levels of risky crops to their socially desired norms. Second, market information services could be established or improved to help farmers forecast better. Third, the government could attempt to reduce or eliminate risks from the market through price stabilization schemes. Using a simulation model, Scandizzo, Hazell, and Anderson (1983) have shown that the social return from price stabilization is likely to be much less than the cost of stabilization where farmers plan on the basis of revenue expectations. Larger gains are possible where less appropriate

price forecasting is pursued, but then the largest part of the social gain may more easily be attained through improved market information services (see also Newbery and Stiglitz, 1981).

CONCLUSIONS

Risk has significant effects on the welfare of farmers and low-income people. It can also lead to distortions in resource allocation that are costly to the national economy.

Governments may have an important role to play in reducing risk for farmers. Some public investments, such as irrigation, can reduce yield risks while also enlarging average production. This risk-reducing aspect may enhance the value of such investments in cost-benefit analysis. Risk-pooling schemes such as crop insurance can also reduce the cost of yield risk to farmers and allow them to allocate their resources more efficiently. But such schemes should only be implemented when their benefits are commensurate with their costs. Too many crop insurance schemes are heavily subsidized by governments.

Price risks are often as important as yield risks in agriculture. If prices are negatively correlated with yields, the correlation has a stabilizing effect on income over time, and policies that stabilize yields or prices alone would act to destabilize farm incomes. The appropriate intervention in this case is to stabilize both prices and yields or not to stabilize either. Where the correlation is zero or positive, stabilizing either prices or yields will suffice to help stabilize incomes.

Price stabilization schemes based on buffer stocks are likely to be too expensive in terms of the benefits they generate. More realistic policies to reduce price risks are minimum support prices. These can be achieved through deficiency payments or, where the commodity is traded internationally, through variable levies and tariffs (Siamwalla 1986).

An additional advantage of reducing price variability is that it helps farmers to forecast prices more accurately when committing their resources. However, market and resource allocative efficiency still depends on farmers' holding rational price expectations, such as the unit revenue forecast, so as to take account of any nonzero correlations between prices and yields. Where alternative and less efficient price forecasting prevails, significant improvements in resource productivity might be attained by introducing or improving market information services for farmers. Such programs might range from assistance to farmers in recording and calculating weighted averages of past revenues and yields to more elaborate intelligence services that provide timely and detailed information throughout the year on prices, weather, sown areas, and the like.

Finally, the government may also have an important role to play in protecting low-income people from fluctuating food prices. Again, buffer stock schemes to stabilize prices would seem to be too expensive. Emergency food stocks might prudently be carried as insurance against major catastrophes in production, but emergency ration schemes, food subsidies, and food-for-work programs can also be useful.