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Tomek,W.G.

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STABILITY FOR PRIMARY PRODUCTS: MEANS TO WHAT ENDS?

by

William G. Tomek

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Department of Agricultural Economics
Cornell University

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I.

A large literature on price and income stabilization for primary products in less developed countries has developed over the past 25 years. The "goodness" of stability is often accepted rather uncritically, and a substantial part of the literature discusses and analyzes methods for achieving stability.[1] A number of issues with respect to the desirability of stability remain; also, some questions remain with respect to the consequences of alternate stabilization programs. The general objectives of this paper are to delineate some of these issues and to review the literature on stability. Emphasis is placed on identifying areas for additional research.

The discussion in this paper centers on instability of producer prices and revenues. The problem is implicitly assumed to be one of instability and not one of fundamental disequilibrium in resource allocations among economic sectors. Mellor [39; 40] argues that there are theoretical reasons for expecting relative agricultural prices, in a low income economy dominated by agriculture, to fluctuate with changes in weather but not to define an upward or downward trend. Nonetheless, with economic development, substantial resource reallocations occur and hence some fundamental changes in relative prices are likely with the passage of time.

In essence, this paper elaborates on three propositions. (1) The benefits of stability often are not clearly defined and in some cases are hypotheses subject to verification. It follows that researchers should be testing the hypothesized benefits of stability under specified circumstances. (2) A particular stabilization program, to be most effective, must consider the nature and source of instability. Price fluctuations may be a symptom of a more fundamental problem. Or, the major source of instability may be yield, rather than price, fluctuations. Thus, research should start by measuring the magnitude of instability, the sources of instability, and the relative importance of these sources. The major source of instability may change with the development process. (3) Specific programs can be destabilizing under certain economic conditions, as well as stabilizing under other conditions. Thus, it is not sufficient to determine that stability provides positive net benefits. The method of achieving stability may be counterproductive or result in costs which outweigh benefits.

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[1] For instance, Bauer and Paish [8, p. 763], while recognizing that stability is not an end in itself, state that stabilization of producers' incomes over time is widely regarded as desirable. Their emphasis is on specific stabilization schemes. More recently, Chandler and McArthur [13] have elaborated on the Bauer and Paish theme with a discussion of efficient equalization funds. The emphasis is on an "efficient" method of stabilization.

Consequently, section II of this paper is devoted to a discussion of potential benefits of stability as well as to some possible costs. The problem of identifying and measuring sources of instability is examined in section III. Programs for achieving stability of prices or incomes are outlined and discussed in section IV. In each section, subjects for additional research are identified.

Before turning to the main sections of this paper, some initial comments on defining and measuring stability seem appropriate. Stabilization schemes for primary products are typically concerned with one or more of the following types of variables: producer or consumer prices, producer or consumer incomes or revenues (real or money), or export earnings. Instability is typically defined in terms of the frequency and amplitude of variation of the variable in question. Hence, stability means a small amplitude and infrequent variation, but the perfect stability of no change is not necessarily implied.

The usual statistical measure of the magnitude of variability is the variance (or standard deviation). Thus, stabilization schemes may be viewed as having the objective of reducing the variance of a price and/or income series over a period of years. However, an objective of economic growth is higher real incomes. Therefore, if a variable is trending, a trend line may be fitted, the trend removed, and the variance computed on the basis of the residuals (the variance of regression).[2] A stabilization scheme hopes to reduce "random" fluctuations while encouraging economic growth. I shall argue subsequently that one of the problems of any stabilization method is distinguishing between changes due to random factors and to fundamental economic factors.

Another problem is that of defining the specific variable to be stabilized. The concept of income is a particularly tricky one to measure. Friedman [20], for example, points out that proposals to stabilize "income" really deal with annual cash receipts. Income refers to a flow that can be maintained indefinitely. On the other hand, a farmer's net cash revenue in a year can be influenced by the timing of sales and of purchases. In a similar way, stabilization methods which rely on certificates or promissory notes influence cash receipts in a particular year but not producer incomes [20].[3]

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[2] Bauer and Paish [8, p. 766] state that the aim of stabilization is clearly the removal of random fluctuations around the trend of incomes. It also should be noted that the measurement of "trend" and of variability is not a completely unambiguous exercise [e.g. 43, p. 76].

[3] Small producers in less developed countries may have little control over the timing of sales, and in the aggregate, the distinction between income and receipts may be rather small.

This paper deals mainly with farm-level prices or the annual stability of producer's total or net revenue. Total revenue equals total sales multiplied by price, and net revenue equals total revenue minus costs.[4] These concepts can be applied to the individual producer or to an aggregate. Aggregate revenue from the sale of one crop, by the way, need not coincide with the revenue received by a particular set of farmers. The crop may be grown by farmers who have other cash enterprises.

The variables "value of production" and "cash receipts" or "total revenue" often essentially coincide in high income countries. A high proportion of quantity produced is sold. This is not true for some products in less developed countries. Hence, should a stabilization policy be designed to stabilize value of production or receipts from marketings? In principle, one may wish to stabilize real incomes, including the value of home consumption.

Since economies of less developed countries are frequently characterized by inflation, real prices or real incomes are derived by deflating the nominal figure by a price index. However, the typical stabilization program is necessarily oriented toward the observed, undeflated figure. A program which successfully stabilizes the nominal price may destabilize the real price. Perhaps, as Houthakker states, particular markets cannot be stabilized "as long as the general economy is in disarray" [26, p. 52].

II.

This section provides a statement of <u>some</u> possible economic consequences of stability. The point of departure is the assumption that price (or income) stability can be achieved.[5] However, in an economy which is more-or-less price directed, price change is essential. Price has various resource allocating and income distributing roles to play as various underlying economic forces change [e.g., see 19 and 40]. Thus, price stability must in some sense mean stability of undesirable fluctuations, and a major cost of stabilization programs is their inability to distinguish between sources of price change (i.e., between desirable and undesirable price changes).

In addition, authorities may use so-called stabilization schemes to deliberately change terms of trade, to support prices above equilibrium levels, or for other objectives. Such programs must be judged, in part, on these objectives, e.g., to encourage production of specific commodities or to redistribute incomes to the farm sector. This paper attempts to confine itself to questions of stability. The discussion is necessarily in rather general terms. The problem of whether merits of stability

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[4] Obviously, many questions in the operational definition of costs and revenues are ignored here.

[5] Certain programs can increase instability under certain conditions; this is a topic for section IV.

outweigh the demerits must be decided in specific commodity-by-commodity and country-by-country situations.

Price and income stability might be justified by appealing to concepts of welfare economics. For example, Massell [35], using the concepts of consumer and producer surplus, shows that there can be a net gain from price stability. Namely, the expected value of the surplus is greater with stability than with instability, and in principle, one group can compensate the other and still have a net gain. Whether consumers or producers would be net gainers depends on economic conditions--namely, the slopes of the demand and supply functions and whether demand or supply are more variable. Massell also points out that price stability does not necessarily imply income stability and that there are other costs of stabilization schemes [35]. Hence, the stabilization program may not be warranted even though there is a net, say, consumer surplus.

Interestingly, Massell argues elsewhere [36] that stabilization schemes can be justified primarily from the viewpoint of producers. The sale of one crop may be the sole or major source of producers' incomes. Thus, price changes have large impacts on producer incomes.[6] On the other hand, consumers may purchase a variety of goods and services so that the change in the price of a single product has a relatively small impact on consumers' real incomes. This view, however, is subject to qualification [40]. For a small farmer who sells 10 per cent of his total production, a 10 per cent increase in price, other things constant, increases real income only one per cent. (The real value of home consumption remains constant.) A low income urban consumer may spend 70 per cent of his income on food, including perhaps a major staple item. Hence, a 10 per cent increase in the price of this item could reduce the urban consumer's real income more than the increase in the small producer's income.

In a less developed country, where a relatively high proportion of income is spent on food, governments may very well wish to stabilize the price of certain key foods. Sharp swings in the price of these foods imply sharp changes in real income. Sudden declines in the real income of urban consumers, even if temporary from the ex post view, may cause upward pressures on money wages, hence squeeze industrial profits and reduce the incentive to invest [40]. One may also argue that "random" fluctuations of prices of products primarily consumed within the country continually redistribute real incomes among producers and consumers without change in the total. Stability helps avoid political problems inherent in fluctuating food prices.

If the commodity is mainly used as a raw material in a manufacturing process, high prices imply high costs relative to substitutes. Again,

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[6] Producers also may have greater political strength because of their orientation, if not formal organization, about a single product.

although the change may be temporary, some markets for the finished product--hence the raw material--may be permanently lost. New substitutes are developed and become permanent fixtures. Fluctuating raw material costs may discourage investment in the processing industry. The outlook for profits on the average may be favorable, but investors may not be able to withstand a potential early loss. Processors faced with a choice between a primary product and its substitute apparently do consider stability of price as well as average relative prices in their decision [30, p. 155].

There also is a strong argument for stabilizing the flow of supplies of a farm product to the processing and marketing sector. A marketing system geared to the largest crop, by definition, has excess capacity (underutilized resources) most of the time. A system designed for the average sized crop would be underutilized for small crops and would waste a portion of large crops. Clearly, if supplies are stable or have a smooth growth curve, then the marketing and processing sector could more easily obtain an "optimum" level. Less developed countries are sometimes characterized by highly imperfect marketing systems handling highly irregular supplies. Thus, positive benefits could arise from stabilizing fluctuations in supply.

D. Gale Johnson [28] has emphasized that price instability may result in resource misallocations by growers of the product. In the short run, price instability can provide inaccurate signals to producers, resulting in the misallocation of available resources. For example, a higher price induced by a random event may induce producers to devote too many resources to the forthcoming crop relative to fundamental supply-demand conditions. Expected prices are often based on past prices, and these past prices fluctuate in response to random events (as well as fundamental economic changes). The cobweb model illustrates a situation of alternately too many and too few resources relative to those suggested by the equilibrium price.

Longer-run resource allocations also are likely to be influenced by price instability. The producer may emphasize short-time investments, flexibility, and diversification. Both internal and external capital rationing may occur. The producer maintains liquidity to meet the potential unfavorable contingency of a low price, and he is reluctant to borrow. Those controlling outside capital may be conservative in making loans with price uncertainty. Thus, investments which are justified by average long-run profits are not made because of the variance of annual profits. In other words, a favorable expected value of income is not the only consideration in making an investment; the time distribution, including possible early loss, also is important [28, p. 39]. The price support program for potatoes in the U.S. seems to illustrate some of these points. Substantial concentration and specialization in potato production was encouraged by the stability induced by the program [22].

One also may hypothesize that resources drawn in by high prices are not driven out by low prices because they tend to become fixed in particular uses [24, p. 160]. This implies, if the hypothesis is correct, the existence of too many resources relative to the average price. A recent

report [27, p. 21] states, "Instability of prices has often played an important role in causing overexpansion . . . The coffee surplus . . . was induced by excessive profits in the period of high prices in the late 1940's and the early 1950's."

However, substantial controversy exists about the relationship between instability of producer prices and incomes and the level and stability of producer savings and investments. Many authors [e.g., 9, p. 717; 46, p. 317] argue that producers in less developed countries do not save in periods of high revenue for periods of low revenue. Specifically, their hypothesis is that producers' marginal propensity to save out of transitory revenue is zero. (If this is correct, then the argument that years of high prices attract "too many" resources has less validity.)

In contrast, Friedman [21] takes the view that individuals with large transitory components in their income have large marginal propensities to save; i.e., consumption is a function of permanent income. Some investments are rather lumpy and hence may be facilitated by a year of high revenue. Expectations related to high prices may induce investment. Campbell [12, p. 101] believes that most farm savings are not held as contingency reserves but are characteristically invested in the farm business. Thus, fluctuating revenue may actually facilitate an increase in savings and farm investments (but perhaps also induce uneconomic fluctuations in resource use). It is true, at least in the United States, that capital formation in agriculture has been largely financed by farmers' savings and the direct efforts of farmers.[7] Thus, the unanswered question of the effect of instability of income on savings and investment by producers appears to be especially important.[8]

If the product in question is primarily exported, then stability of export earnings may be the major goal. Particularly if national income is largely dependent on export earnings, instability may have serious consequences for savings, investment, and economic growth. Fluctuations in income also imply social and political unrest. Thus, a country may be interested in stabilizing export earnings both for political and economic

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[7]Direct efforts include land clearing and other capital improvements derived from farmers' labor and requiring little outside financing. The cost of the investment is the opportunity cost of the labor.

[8]Perhaps the two sides or aspects of the argument should be restated in another way. The view that instability is unfavorable for farm investments is based (a) on the adverse influence on decisions to invest and (b) on capital rationing and the low propensity to save. The view that instability is favorable to farm investment emphasizes (a) the lumpy nature of investments coinciding with favorable years in terms of revenue and the influence of high revenue on expectations and (b) the high propensity to save out of transitory incomes.

reasons. However, the topic of stability of export earnings will not be emphasized in this paper [see 18; 23; 34; 37; 43; 46; 47].

The foregoing discussion has implicitly emphasized the undesirable consequences of annual variability of prices or revenues. Unstable seasonal (or other short-term) price patterns also may result in incorrect resource allocations. For instance, while prices for a seasonally produced crop may rise on the average by an amount necessary to cover storage costs, the rise may be much larger than storage costs in some years and may be perverse in other years. Hence, storers have substantial uncertainty about seasonal price changes in any particular year. A reduction in this price uncertainty may improve the seasonal distribution of supplies—i.e., leading to more nearly "correct" quantity stored each year and improving distribution through each year.

A major economic cost of stabilization schemes arises from their inability to separate the influences from "random" factors from those of "fundamental" factors.[9] If the economy were static or if it were changing in a precisely known way, then stabilization methods would eliminate only the random variations. The elimination of such price changes would prevent unnecessary resource shifts and reduce uncertainty.

However, price and quantity changes are likely to be a mixture of "fundamental" and "non-fundamental" changes. A fundamental change in price, say in response to improved technology or to growing incomes, implies some reallocation of resources. A stabilization method which prevents this reallocation is creating unnecessary costs to the economy.

In principle, a correctly specified econometric model would discriminate among sources of change. The important, systematic, measurable factors are represented by the endogenous and predetermined variables of the system. The disturbance terms represent the non-systematic factors influencing the system. For instance, if the price-quantity sequence through time is described by the following cobweb model, then it is possible to solve for the equilibrium values of price (P_o) and quantity (Q_o).[10] A stabilization scheme, in this much oversimplified case, could be developed to eliminate influence of the random shifts (u_t and v_t) and the cobweb cycle.

$$Q_t = c + dP_{t-1} + u_t$$

$$P_t = a - bQ_t + v_t.$$

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[9] Proposals by Bauer and Paish [8, p. 750] to stabilize producer incomes emphasize that they are to reduce ". . . the violence and magnitude of temporary fluctuations in the incomes of primary producers, whether due to variation in prices or in the size of the crop, with as little effect as possible on the rate of adaption of supply to long-period changes in demand."

[10] The system tends to converge to equilibrium if $\left|-b\right| < \left|\frac{1}{d}\right|$

However, assume the following model is actually the correct one.

$$Q_t = c + dP_{t-1} + eR_t + u_t$$

$$P_t + a - bQ_t + v_t.$$

If R_t systematically increased with time (t), then Q_t should increase and P_t decrease. However, if the scheme treats a larger R_t as a random shift in supply, then price will be too high relative to the fundamental change in supply. Too many resources would be devoted to the product relative to the new equilibrium implied by the larger R_t.

Clearly there may be problems in specifying and estimating a sufficiently detailed model to guide a stabilization scheme in a less developed country. An additional problem is making sufficiently early ex ante forecasts of the variable being stabilized so that the model can be useful. Thus, one must have reservations about finding methods which can provide stability without preventing appropriate economic adjustments.

Schemes which stabilize annual prices also may overstabilize seasonal prices. If prices are completely stabilized within the year, then little or no incentive exists for private storage. The government would have to provide for seasonal supplies. Assuming, for instance, an identical demand function (for current consumption) for each month within the year, quantity demanded and price would be identical in each month. Consumption would be distributed as if storage were costless. This implies a smaller quantity demanded at harvest and a larger quantity demanded at the end of the season relative to that which would prevail with storage costs taken into account. Thus, total storage costs quite possibly could be larger with stable seasonal prices [see also 42]. Further, as prices rise seasonally for one product, consumers tend to shift consumption to other commodities.[11] The elimination or reduction of a seasonal pattern consequently influences the seasonal demand for the other, related products.

In general, stabilization programs have "indirect" consequences for marketing firms and institutions. As previously indicated, a program may reduce the incentive for private storage, or it may provide the benefit of more certain raw material supplies and costs to a processor. Old marketing channels may be circumvented. The net benefits may be positive or negative, but they should not be ignored.

Other obvious costs are those related to administering any particular stabilization method. For instance, the costs of storage in a buffer stock program include interest on capital tied up in stocks, spoilage and costs of preventing spoilage and insect damage, cost of storage capacity,

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[11] In commenting on this paper, Mellor points out that with the seasonal rise in wheat prices in northwestern India, low income consumers tend to switch from wheat to sorghum consumption.

transportation, and administration. In particular, trained manpower is a scarce resource in less developed countries, and one may intuitively believe that bidding this resource away from other uses to stabilize commodity prices may represent a misallocation.

The discussion to this point suggests a number of research topics. One question, related both to this and the next sections of the paper, is the extent to which observed variation in prices (or revenues) is the result of "random" fluctuations which logically should be smoothed and the extent to which they are the result of economic factors which should not be smoothed. Of course, one may hypothesize that the benefits of stability exceed the costs. Thus, a country may accept the costs of inappropriate resource allocations (because appropriate economic changes are suppressed) to gain the benefits of preventing instability. Clearly there is great scope for specific studies by commodity and country to test the hypothesis of whether benefits exceed costs.

In considering costs and benefits, a number of specific research topics are suggested. One important area is the impact of instability on farm investment and savings. Can evidence be produced that the size and character of investment differs with the degree of income instability? What is the marginal propensity to save by farmers with differing degrees of stability of income? Or, are other factors more important in explaining the magnitude of the propensity to save parameter? Are savings invested in the farm, or do they move to foreign banks?

Other questions or hypotheses include: Has price variability for specific primary products encouraged processors to develop alternative sources of raw materials? What is the size and character of resource misallocations due to eliminating seasonal price patterns? On the other hand, are seasonal price patterns sufficiently uncertain that a program which provides greater certainty of a "normal" pattern would improve the seasonal allocation of supplies? Do administrative costs of stabilization schemes exceed the net benefits otherwise expected?

III.

In this section, the topic of the source of fluctuations is explored in more detail. An implication of the (hypothesized) benefits of stability is that instability is an impediment to economic development. Thus, identifying sources of instability is a first step toward identifying appropriate solutions. However, it is also true that the process of development may influence the degree of price and income stability through the introduction of new techniques, changes in economic parameters, and so forth. After outlining sources of instability and possible changes in sources through time, selected techniques for partitioning the variance of a variable into various "components" are reviewed.

For purposes of analyzing variability and conceiving correct stabilization policies, it is useful to think in terms of a model. The variation of a particular endogenous variable in the model is related both to the systematic variation of other variables and to random influences. The

systematic influences can be classified as other endogenous and as predetermined variables. Stabilization schemes are not purely concerned with random influences. For example, a forward price scheme might be used to stabilize quantity supplied by influencing producers' expectations. Thus, the process of model building and estimation, if feasible, should help indicate those variables which are the major sources of instability and over which some control is possible. In addition, the major sources of growth (trend) may be suggested. A model may also be useful in simulating the effects of alternate policies.

Since agricultural commodities often have substantial time lags between the planning of production and its realization, a model that assumes price and quantity are generated recursively is plausible.[12] To the extent the assumption is correct, the variance of the dependent variable in each behavioral equation can be partitioned into that associated with the explanatory variables (R^2) and that associated with the unexplained residuals ($1 - R^2$). And methods exist for "decomposing" the variance of a variable which is defined by an identity [e.g., 6].

A model to explain aggregate net revenue per year of a particular commodity contains both identities and behavioral equations. Net revenue is identically equal to quantity sold multiplied by price minus cost. The quantity sold may (or may not) equal quantity harvested. Of course, quantity harvested is identically equal to area harvested multiplied by yield. Area harvested, yield, and price each are functions of certain systematic, perhaps predetermined, variables and of random disturbances--separate behavioral equations. The model would be more complicated when home consumption is a large proportion of quantity harvested. Even without considering the complication of marketable surplus, net revenue in any particular year clearly depends systematically on a variety of variables and random factors. Specifically, net revenue responds to changes in variables, to possible changes in parameters, and to changing random events.

The domestic demand for food products typically is relatively stable, growing with population and income. However, fluctuations in the production, hence price, of substitutes can result in fluctuations in demand. The demand for export crops is sensitive to economic conditions and to the trade policies of importing countries. Quantities produced in other countries compete with local production, and changes in "outside" supply appear as shifts in the local demand function. Thus, changes in demand may lead both to smooth trends in prices and revenues and to fluctuations about trend.

Similarly, on the supply side, persistent changes in technology, factor prices, and other variables may provide trends in product price, but fluctuations in supply also occur in response to changing weather,

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[12] However, while total production may be predetermined by prior events, quantity marketed and price may be jointly determined. This may be true, for instance, when revenue depends on "marketable surplus" and price.

pests, and so forth. It is also true that changing expectations about the future profitability of one enterprise relative to others, induced perhaps by past changes in costs and product prices, can result in variations in supply and price about trend.

To some extent, changes in various systematic variables and in random events may have offsetting effects. Also, variation in production among farms may imply greater fluctuations in the aggregate than actually exist [49, pp. 212 ff.]. Thus, yields may vary substantially among farms because of local differences in weather, soil and management skills, but the average yield for all farms may be relatively constant. Local differences can balance on the average. Casual inspection of data for some major farm products in the United States suggests that yield variability, net of trend, has been less important than acreage variability in "explaining" year-to-year variations in quantities produced. Of course, a general drought clearly can result in country-wide low yields or influence area planted and hence result in small total production. While the influence of many variables may cancel on the average, dominant explanations for annual fluctuations in revenue also exist. For example, acreage planted and harvested and hence quantity produced may clearly be responding to past price.

The nature and source of instability have implications for the type of stabilization method, if any, which is adopted. If highly variable yield is the major source of instability, then the "best" stabilization policy may be the development of a new variety which provides more stable yields. Or, it may be the introduction of an irrigation system to stabilize moisture levels. On the other hand, if the instability is of the cobweb type, then a forward price scheme <u>might</u> be the most appropriate way of achieving stability.

Does economic development imply smaller or larger variances for farm prices and farm revenues? Logic, I shall argue, does not provide strong support either for the hypothesis of smaller or of larger variances with development. Such a hypothesis probably has to be tested commodity by commodity within specific countries.

Economic development implies many changes. Average per capita incomes would be higher, the distribution perhaps more equal. The rural-urban distribution of the population likely would shift from rural to urban. Technology is improved. Better education, communication, and transportation may reduce the number and influence of random events. The economy becomes less "traditional" and more commercially or market oriented. These changes imply, among other things, shifts in various demand and supply functions and changes in various economic parameters.

Higher yields are likely accompanied by a smaller variance of yields, resulting from more drought and disease resistant varieties. In addition, new, high-yielding varieties may increase investment in factors that help control the environment (e.g., irrigation systems). For commodities with a large proportion of home consumption, Krishna [31] argues that quantity marketed is more variable than production. Thus, a shift to a more commercial agriculture could reduce this source of variability.

Mellor [40] hypothesizes that quantity supplied of an individual product in low income traditional agriculture is more price elastic or less inelastic than in commercial agriculture.[13] If the hypothesis is correct, then shifts in demand would have larger price effects as development takes place.

On the demand side, higher incomes and improved distribution of incomes may have stabilizing effects. It is thought that the income elasticity of demand for foods declines with increases in income.[14] It is not clear whether shifting distribution of the population from farming to other occupations would be stabilizing or destabilizing. Shifts to more sedentary jobs may imply shifts in diet, i.e., changes in demand.

In traditional agriculture, cash costs may be essentially zero. With purchased inputs, a new source of variance in net revenue is added. Commercialization may result in shifting enterprises and more specialization, resulting in less stability for the individual if not the aggregate. Technolological change can provide the grower with a choice among more enterprises (e.g., as a crop is adapted to a new region or as relative costs are changed), suggesting more variability in the acreage planted of any one enterprise. Of course, this is in contrast to a hypothesis of more inelastic supply occurring with development.

The demand for food products is thought to become more price inelastic with development.[15] A more price inelastic demand implies more variable price for given shifts in supply. However, technical change results in new substitute relationships. Artificial fibers now substitute for wool and cotton. The introduction of a commodity in a new region or country provides a new competitor (in essence, a substitute) for existing supplies. On the other hand, new uses may be found for existing commodities. In sum, whether development provides more or less stable farm prices and revenues is not clear.

Thus, with respect to additional research, this paper wishes to emphasize two points. First, the components or sources of fluctuations in the variable being considered for a stabilization program should be identified. This is in effect testing hypotheses about the causes of instability. The results should aid in decision making with respect to the benefits of

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[13] With high fixed investments in an enterprise, substantial barriers to supply responses to price exist in commercial agriculture.

[14] See [24, pp. 139 ff.] for some of the stabilizing effects of changes on the demand side.

[15] One argument starts with the proposition that income elasticities for foods decline as the level of incomes increase, and then if the zero-degree homogeneity conditions for elasticities is accepted, a smaller income elasticity implies a smaller (in absolute value) price elasticity.

stability and to appropriate stabilization techniques. Second, it is useful to study the implications of economic development for stability. This is in effect testing a series of hypotheses about the influence of economic development on variability of prices and incomes in the farm sector.

As previously suggested, stabilization schemes are concerned with "random" fluctuations from trend. Hence, the typical measure of instability has been based on deviations from trend, usually the variance of regression.[16] This paper goes one step further in suggesting that the variable in question be thought of as an endogenous variable in an econometric model. The model may contain both identity and behavioral equations. Burt and Finley [6] review and suggest methods of handling identities. Using the general notation of "Y's" and "X's" then

for
$$Y = X_1 + X_2,$$
the
$$\text{var}(Y) = \text{var}(X_1) + \text{var}(X_2) + 2\text{cov}(X_1X_2)$$
For
$$Y = X_1X_2,$$
the var (Y) is a somewhat complicated function of various expected values. Burt and Finley suggest the approximation

$$\text{Var}(Y) \simeq \bar{X}_2^2 \text{var}(X_1) + \bar{X}_1^2 \text{var}(X_2) + 2\bar{X}_1\bar{X}_2 \text{cov}(X_1X_2)$$

They also suggest "normalizing" the equation by dividing each of the components by the sum of the first two components on the right-hand side. Then, the first two ratios on the right-hand side can be interpreted as measures of the net influence of X_1 and X_2 on Y after compensating for the interrelationship between the X's. The third term is an interaction term, which may be positive, negative, or zero. The covariance is zero when X_1 and X_2 are independent.

Burt and Finley point out that the means can be replaced by an appropriate value computed from a trend equation. Alternatively, the computed values for the X's could be obtained from estimated behavioral equations, assuming the identities and behavioral equations are part of a recursive system of equations. To be more specific, the variance of farm revenue can be divided among the sources price and quantity. In a similar manner, the variance of production could be divided among acreage and yield variability (see Appendix A). However, the variability of price, acreage and yield are "explained" by certain underlying factors. These

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[16] Other measures are available, including deviations from a moving average. Also, since various types of trends (e.g., linear or semi-log) may be fitted, the residuals vary with the type of trend function.

may be viewed in terms of equations in a recursive model.[17] The proportion of the variation of each dependent variable which is associated with the variation in the systematic independent variables may be estimated (R^2 and other measures). In principle, a complete picture of the degree and sources of variability in the aggregate could be obtained.

IV.

Alternative Stabilization Policies

Many policies are available which may, at least under some conditions, stabilize prices and/or incomes received by primary producers. Several types of policies are briefly described in this subsection. Their contribution to stability for the aggregate of all producers is considered in a second subsection, and then the problem of achieving a stable flow of cash receipts for individual producers is discussed. The description and analysis is not exhaustive but perhaps suggests some of the problems of achieving stability.

A buffer stock controls producer prices through a purchase-storage-sale program. If no fundamental disequilibrium exists, then price may be fixed at an average level such that governmental purchases equal sales on the average. When events tend to depress price, the agency adds to stocks to support prices, and conversely when events tend to raise price, the agency sells from stocks to maintain the average price. The program does not work well when fundamental economic changes cause, say, a downward trend in price. In this case, the agency accumulates stocks with no chance to sell. The stabilization program becomes a price support program, holding price above equilibrium.

A buffer fund permits the market price to vary but uses a scheme of taxation and compensation to stabilize producers' price and hopefully gross receipts. The government, for example, may form an agency (say, a producer cooperative) to buy from producers and to sell in the market on behalf of the producers. The agency accepts the market price as given but "transforms" the instable series to a stable one through the payments made to farmers. When price rises above the specified level, the payment to

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[17] The system of equations, whether recursive or simultaneous in character, could be solved for the reduced form equations. In this form, the endogenous variable in question, say Y_i, is a function of all the predetermined variables of the system. In principle, this equation can be estimated by least squares, assuming there are more observations than variables, and this in some sense provides estimates of the influence of each predetermined variable on the dependent variable. Of course, an estimated R^2 is also obtained. However, the equation is likely to have a large number of independent variables, hence, relatively few degrees of freedom and perhaps high intercorrelations. Thus, this direct approach may not be very practical.

producers reflects the average price; a tax is, in effect, levied. When price falls below the specified level, payments still reflect the average price; compensation is made from the buffer fund. If the average or target price is correctly set, then taxes equal compensation, and the average size of the buffer fund would be zero. Of course, problems exist in determining the appropriate target price, and various authors have suggested modifications to permit adjustments for trends in price [8; 13].

Price discrimination programs are based on the idea of charging different prices in different markets. Such programs require (a) that the different markets have different price elasticities of demand and (b) that the agency running the program has sufficient monopoly power to separate the markets. The major objective of such programs is to increase total revenue; they may also increase stability. Stability results from the diversion of a portion of a large crop into the more elastic (hence lower priced) market. The isolation and use of a market with a more elastic demand implies less variable prices (see next subsection). The problems of such programs are well-documented and are not reviewed here [e.g., see 24].

Commodity futures markets may, at least under some conditions, be used to stabilize farmer's revenues. The most frequent suggestion simply is that growers be encouraged to hedge their production decisions. A grower hedges by selling futures contracts at planting time, and then buying back contracts as cash sales are made at harvest and thereafter. In addition, some authors [33; 38] suggest that a government agency should facilitate grower hedging by stabilizing the price of a distant futures contract (by appropriate government purchases and sales of contracts) and by insuring farmers against some types of losses, say inability to deliver on, or buy back the contracts because of a crop failure. Also, a stable distant futures price is a method of "setting" a forward price for guiding farmers' plans.

Other programs have been proposed to provide stability. For example, a program to regulate the quality of the product marketed may stabilize prices.[18] The quality marketed through time may be made more uniform. Quality regulations sometimes are more strictly enforced in years with large production thereby controlling quantity beyond that implied by a uniform quality.

Other programs often represent variations from the methods outlined above. The following sections discuss the implications for stability of buffer stock, buffer fund, price discrimination, and futures market

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[18] Abbott and Creupelandt [1] discuss five types of marketing boards: (1) for advisory and promotional purposes, (2) for developing uniform quality standards for export crops, (3) to stabilize prices by use of reserve funds and deficiency payments, (4) to maintain buffer stocks of basic foods to stabilize producer and consumer prices, and (5) to maintain buffer stocks for major export crops.

programs. With the diversity of programs and with the potential diversity of administrative rules for each program, changing programs and changing rules may themselves become a source of instability and uncertainty.

Affect of Programs on Aggregate Revenues[19]

The analysis in this subsection is concerned with the annual aggregate revenue (V) of producers. Price is determined by the derived demand and primary supply schedules. The demand function is assumed to have a negative slope and the supply schedule a non-negative slope. The functions are assumed to be linear. Quantity produced (Q) in time t is assumed to be predetermined by price in time t-1. Price (P) is in turn determined by quantity. Thus, price, quantity, and total revenue are assumed to be determined by a simple cobweb model.

$$Q_t = c + dP_{t-1} + u_t \qquad \text{(supply)}$$

$$P_t = a - bQ_t + v_t \qquad \text{(demand)}$$

$$V_t = P_t Q_t.$$

In principle, the alternate year cycle implied by the model might converge, diverge, or be continuous, depending on the value of the parameters "b" and "d". We assume that random shifts in the functions provide a continuous cycle in practice.

In the following subsection, the effectiveness of buffer programs is examined when the source of fluctuations is (a) from the demand side and (b) from the supply side. As previously discussed, price changes may be the result of a combination of factors. Thus, the following analysis, which considers the special cases of a solely demand induced or supply induced instability, must be used with care.

Buffer stocks and buffer funds. If supply is constant (var (u) = 0), and demand shifts, then either type program stabilizes annual revenue. Price is fixed by the program. For positive shifts in demand, sales are made from the buffer stock to hold price at the target level; a buffer fund accepts the higher market price implied by the larger demand, but producers receive only the revenue implied by the target price. For negative shifts in demand, the opposite policies would be followed. With no changes in supply and with price fixed, revenue is a constant $\overline{V} = \overline{PQ}$.

If demand is constant (var (v) = 0), and variability arises from supply changes, then buffer schemes are much less successful in stabilizing total farm revenue. Success depends on the size of the price elasticity

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[19] The subsequent analysis benefited from discussions with Professor Robert Firch, which is hereby acknowledged without implying responsibility for any errors that may exist.

of demand, discussed here in terms of the price flexibility coefficient.[20] Price and quantity move in opposite directions without a program. This compensating movement helps stabilize revenue. Hence, stabilizing price does not necessarily stabilize revenue.

The influence of quantity on revenue can be examined through the concept of the elasticity of revenue with respect to quantity, which is defined as

$$E_{VQ} = \frac{\partial V}{\partial Q}\frac{Q}{V}.$$

It tells us the percentage change in total revenue in response to a one per cent change in quantity, and it is related to the price flexibility as follows:

$$E_{VQ} = 1 + F. \quad \text{(see Appendix B)}$$

A buffer program in essence fixes price so that $F = 0$; hence, $E_{VQ} = 1$. This simply states the obvious: with a constant price, revenue varies directly with quantity. Clearly, E_{VQ} could be smaller than one without a program. A buffer scheme reduces revenue instability <u>if</u> the absolute value of E_{VQ} (i.e., $1 + F$) is greater than one without the program. This occurs when F, which is always negative, has an absolute value greater than two--demand is very price inelastic. If F is in the range zero to minus one (roughly, when demand is elastic), then E_{VQ} is a positive number less than one. If F equals minus one, E_{VQ} is zero. If F is in the range minus one to minus two, E_{VQ} is negative and less than one in absolute value. That is, even if demand is "mildly" inelastic, a buffer scheme can increase revenue fluctuations. As long as F is in the range zero to minus two, E_{VQ} is less than one in absolute value. With a buffer program, $E_{VQ} = 1$. Thus, if the source of instability is supply fluctuations and if F is less than two in absolute value, then a buffer scheme increases the variability of total revenue.

The possibility that only a proportion of the crop is marketed further reduces the effectiveness of buffer schemes (if supply shifts are the source of instability). Again, price is assumed to be determined by total production (Q).

$$P = a - bQ.$$

Total revenue equals price multiplied by the marketable surplus.

$$V = PM.$$

$$Q = M + H.$$

$$M = Q - H,$$

where M = marketable surplus and

H = home consumption (by producers).

[20] The price flexibility is defined as $F = \frac{\partial P}{\partial Q}\frac{Q}{P} = b\frac{Q}{P}$, where b is the slope coefficient from the price dependent demand equation (above).

The percentage change in revenue corresponding to a small percentage change in production now is

$$E_{VQ} = E_{MQ} + F. \quad \text{(see Appendix C)}$$

E_{VQ} and F are defined above. $E_{MQ} = \frac{\partial M}{\partial Q}\frac{Q}{M}$. This is the percentage change in marketable surplus for a very small percentage change in production. Since $M = Q - H, \frac{\partial M}{\partial Q} = 1$ for given H. Thus, $E_{MQ} = \frac{Q}{M}$.[21] Therefore, $E_{MQ} \geq 1$. With M small relative to Q, E_{MQ} is large, but it declines rapidly as M increases. As M approaches Q, E_{MQ} approaches 1. In other words, when M = Q, then V = PM = PQ, and this is the situation previously described. However, if the entire crop is not marketed, then buffer methods are even less successful in reducing variability of revenue. For example, if 40 per cent of production is marketed, then $E_{MQ} = 2.5$, and

$$E_{VQ} = 2.5 + F.$$

In a buffer scheme, F = 0 and hence $E_{VQ} = 2.5$. Notice $|F|$ must be greater than 5.0 for the buffer scheme to reduce variability of revenue. On the other hand, if for instance F = -2.0 and if $E_{MQ} = 2.5$, then $E_{VQ} = 0.5$, which is clearly smaller than with the buffer scheme. The following example table emphasizes the point.

			no scheme		a buffer scheme	
Situation	Q	M	P	MP	P fixed	MP
(a)	100	40	1.00	40.00	1.00	40
(b)	102	42	.96	40.32	1.00	42
(c)	98	38	1.04	39.52	1.00	38

Buffer schemes may be justified by some economic conditions, as emphasized in the introduction to this section. Since buffer stocks and buffer funds tend to fix prices to producers, price uncertainty is reduced. If price uncertainty has caused resource misallocations, then price certainty would improve allocations. Supply schedules based on the period of uncertain prices are not relevant in determining quantity supplied in periods of certain prices. Farmers who diversified in the fact of uncertainty may specialize, and production may be concentrated in regions less subject to random supply changes. Thus, even though total

[21] Perhaps it should be reemphasized that elasticities are defined at a point on a function. Clearly, as H changes, the ratio Q/M changes.

revenue is more variable for given supply shifts with a buffer program, the program might reduce the magnitude of supply shifts.

Stable prices may have different implications for the variability of total revenue for an individual than for the group. This is true because the individual's production and sales may not vary in direct proportion to the total. While further elaboration is deferred to the next subsection, the reader should note at this point that variability in aggregate revenue for a crop can differ from the variability in aggregate revenue for a particular set of farmers. The variability in a crop's revenue may arise, at least in part, because producers make substitutions among enterprises. For instance, farmers may switch resources from wheat to grain sorghums, influencing the revenue received from each crop. However, without further information, we cannot say that the aggregate revenue of producers (from the two crops) has changed. A buffer program for one product has consequences for other products. These effects may in sum be stabilizing (or destabilizing).

A price discrimination program helps stabilize total revenue when supply changes relative to demand. Assuming conditions for successful discrimination exist, the program diverts part of the crop to a secondary market with a more elastic (or less inelastic) demand than the primary market or the one for all sales (without discrimination). For a given change in production, the proportional change in sales is larger in the secondary market than in the primary market. Thus, the secondary market helps cushion changes in supply because of its relatively more elastic demand.

A price discrimination program is not particularly helpful when instability is induced by demand shifts. Such changes probably would influence all of the markets involved. Of course, the main objective of most price discrimination schemes is to increase total revenue rather than increase stability.

The method of paying producers (i.e., distributing the revenues of the program) can influence quantity supplied. If the producer is paid an average price based on sales to all markets, then quantity supplied will be too large relative to that implied by the price in the lower valued use. Increased production is mainly sold in the lower priced, secondary market, and the payout scheme to producers should reflect this fact. Otherwise the program will distort resource use even beyond that implied by a monopoly practice of price discrimination.

Futures markets may contribute to aggregate stability in several ways. Such markets were first developed for seasonally produced crops with continuous inventories. The relationship between current cash price and distant futures contract prices provides a guide to inventory policy, and the futures market facilitates hedging of inventories. If, for example, a shortage in supplies is anticipated in the future relative to current inventories, then this is reflected in the temporal price relationships which provide an incentive to store. The merchant can take advantage of the price difference through hedging. The incentive to store

results in current prices which are higher and distant prices which are lower than they otherwise would have been. Of course, some inventories would be carried without a futures market, but a viable futures market does provide a constellation of prices which reflects available information. It facilitates the carrying of inventories through hedging. Thus, a reasonable hypothesis is that a viable futures market reduces the variance of prices for the seasonally produced, continuous inventory commodity.

Futures markets may provide stable forward prices, especially if a government program stabilized the price of a distant (delivery month) contract. A stable forward price may stabilize growers' revenue through grower hedging (see next subsection) and by influencing supply by influencing price expectations. However, farmers appear to react to an expected normal price and not to a price in a particular month [44, p. 230]. It is not clear whether producers would treat price for a particular delivery month as an expected normal price.

The agency charged with "manipulating" price for the distant delivery month is faced with a problem in setting price. Price in a particular month reflects both general economic conditions for the year and conditions particular to the month. When inventories are involved, the monthly price differs from the average crop year price by an amount to reflect an appropriate inventory policy. The temporal constellation of prices for such commodities are closely related. If the agency sets a monthly price at a long-term average level, then the agency risks misallocations of inventories [50].

Affect of Programs on Individual's Revenues

Buffer programs. The annual revenue received by an individual is not necessarily stabilized even if revenue in the aggregate is stabilized. The individual's revenue varies directly with quantity sold when price is constant. If the source of instability is shifts in demand and the supply of individuals is relatively constant, then the buffer program can be quite successful in stabilizing revenues. When aggregate supply shifts are the major source of price instability, then the stability of an individual's revenue depends on the behavior of the individual's sales relative to the aggregate.

If an individual's quantity sold is positively correlated with aggregate quantity, which seems likely on the average, then the analysis of the foregoing subsection tends to hold. If the correlation is perfect (i.e., the individual's quantity changes one per cent with each one per cent change in the aggregate), then the analysis in the previous section holds exactly for the individual. If the individual's quantity sold is more stable than the aggregate, then a constant price can stabilize the individual's revenue under circumstances which do not stabilize revenue in the aggregate. For example:

no program				with program	
aggregate production	market price[22]	individual's production	individual's revenue	price	individual's revenue
up 5%	$ .90	102 units	$ 91.80	$1.00	$102.00
constant	1.00	100 units	100.00	1.00	100.00
lower 5%	1.10	98 units	107.80	1.00	98.00
			$299.60		$300.00

If both price and production are stable, then revenue is constant. On the other hand, if the individual's quantity is less stable than the aggregate, the program can be destabilizing. For example:

no program				with program	
aggregate production	market price	individual's production	individual's revenue	price	individual's revenue
up 5%	$ .90	108	$ 97.20	$1.00	$108
constant	1.00	100	100.00	1.00	100
down 5%	1.10	92	101.20	1.00	92
			$298.40		$300

If by chance the individual's sales are inversely correlated with aggregate production, then a buffer program is stabilizing for such an individual. In the following example, the individual has a fairly small variation in production, but it is inversely correlated with the assumed 5 per cent aggregate production changes.

no program				with program	
aggregate production	market price	individual's production	individual's revenue	price	individual's revenue
up 5%	$ .90	99	$ 89.10	$1.00	$ 99
constant	1.00	100	100.00	1.00	100
down 5%	1.10	101	111.10	1.00	101
			$300.20		$300

[22] The price flexibility is assumed to be -2.0; hence the variance of aggregate revenues are equal with and without fixed price.

The situation is further complicated when home consumption is important for the crop. Assuming (1) a market price flexibility of -3.0, (2) that the individual's production is perfectly correlated with the aggregate, and (3) that the individual markets the entire crop, then a buffer program reduces the variability of revenue for the individual.

no program				with program	
aggregate production	market price	individual's production	individual's revenue	price	individual's revenue
up 5%	$ .85	105 units	$ 89.25	$1.00	$105
constant	1.00	100	100.00	1.00	100
down 5%	1.15	95	109.25	1.00	95
			$298.50		$300

However, if the individual markets only 30 per cent of his crop while other assumptions remain the same, then a buffer program is destabilizing.

no program				with program	
market price	home consumption	sales	sales revenue	price	sales revenue
$ .85	71	34	$28.90	$1.00	34
1.00	70	30	30.00	1.00	30
1.15	69	26	29.90	1.00	26
			$88.80		$90

Mellor states [40, p. 33] that a "buffer stock operation probably slightly stabilizes real incomes of the higher income farmers who sell a high proportion of what they produce and destabilizes real incomes of lower income farmers who sell a small proportion of what they produce." The foregoing analysis suggests that Mellor's statement is a correct generalization. However, a buffer scheme does not provide stability for large producers when their production is positively correlated with aggregate production and when their production is less stable than the aggregate, unless demand is severely inelastic. Further, if an individual's sales happen to be inversely correlated with aggregate supply, then a buffer scheme is stabilizing for that individual.

Since a few large farmers could produce a relatively large portion of the crop, it is conceivable that a program could have positive stabilizing benefits (or net costs) for the aggregate crop but not for the largest number of individual producers. Some very interesting research on the distribution of benefits and costs of stabilizing programs for specific crops in specific countries is suggested by the reasoning in this paper.

Since a program can stabilize aggregate revenue and not the individual's revenue (and vice versa), programs dealing directly with individuals have been suggested [8]. The details of such programs are not discussed here; clearly one of the problems is that of record-keeping and administration for a program at the individual level. When programs do not involve individual records, it obviously would be most helpful to have some estimate of the distribution of any aggregate benefits (and costs).

Price discrimination program. This program, as noted above, provides some stability for total revenue when supply shifts relative to demand. Individuals whose production varies less than or the same as the aggregate benefit from smaller revenue variation. The same is true of individuals whose production happens to be inversely related to the aggregate.

If the individual's production is more variable than the aggregate but positively correlated with the aggregate, then the program could conceivably destabilize the individual's revenue. This depends on the magnitude of the individual's instability of production and the change in the average elasticity induced by the program. To illustrate, assume that without a program the price flexibility is -2.0 for all sales and that a particular individual's production tends to change on the average two per cent with each one per cent change in aggregate production. In this hypothetical situation, the individual's total revenue is stable without a program; the price change tends to offset the quantity change. (Aggregate revenue, of course, is not stable.) If a program were introduced which had the effect of reducing the flexibility to -1.6, then the price swings induced by aggregate supply changes would no longer completely offset the production changes of our hypothetical producer.

Grower hedging on futures markets. A grower hedge stabilizes revenue only if it can be placed at a price that is more stable from year to year than the cash price at which the grower typically sells. For instance, if a farmer sells November contracts in April (at planting time), the April price of the November contract must be less variable than the subsequent cash price for the hedge to be stabilizing.

Recent evidence [50] suggests that futures markets can be divided into two types--inventory-hedging and forward-pricing--depending on the temporal relationship among cash and futures prices for the particular commodity. Futures markets first developed for seasonally produced commodities with continuous inventories, the inventory-hedging market. Futures and cash prices are closely related (the price of storage concept), and the annual variance of futures prices is almost as large for cash prices [50]. Futures markets have recently developed for commodities without continuous inventories, the forward-pricing markets. The temporal

price relationships appear less close and the variance of prices for distance futures appears to be much smaller than for cash prices. The forward-pricing markets would seem to be useful for grower hedging for stabilization purposes. Government intervention in inventory-hedging markets also could stabilize these forward prices, but this would be at the cost of misallocations of inventories.

McKinnon [38], assuming hedges can be placed at a constant price through time, derives optimal hedging strategies for producers. The analysis takes into account the potential variability of the producer's output and cash prices. He concludes [38, pp. 848-49], "(a) the greater output variability is relative to price variability, the smaller will be the optimal forward sale and (b) the more highly negatively correlated are price and output, the smaller will be the optimal forward sale." Assuming a stable futures price, the usefulness of hedging as a stabilizing device for producers depends on the relationship between the variability of the producer's output and cash prices received.

The assumption that hedges can be placed at a constant price each year is critical to McKinnon's analysis. As previously indicated, futures prices for seasonally produced commodities with continuous inventories are typically almost as variable from year to year as are cash prices. McKinnon, it should be noted, implicitly acknowledges this point by arguing that public authorities should stabilize price in a distant futures.

There are other potential problems which may discourage grower hedging. The hedge depends on a close relationship between futures and cash prices. Differences in quality, location, and delivery conditions between the producer's product and the futures contract specification can reduce this relationship. Most hedging illustrations assume that the farmer's cash sale takes place at a point in time; often sales are spread through time. These and other factors [see 50] imply that hedges typically are not perfect.

Additional Research

At the aggregate level, empirical analysis for specific commodities is necessary to determine the applicability of alternate programs. Are the major sources of instability on the demand or on the supply side? What are the magnitudes of the relevant elasticities? What are the implications for various policies when instability arises from a mixture of demand and supply changes? Hence, would a particular policy stabilize aggregate revenue for the particular commodity in question?

Assuming adequate data are available, empirical analyses of the consequences of various policies for individual producers would be of interest. What is the distribution of costs and benefits of a particular policy? What is the influence of the level of marketable surplus on benefits?

With respect to futures markets, additional analysis of the U. S. (and other available market) experience would be useful in determining

the stabilizing role of such markets. The markets for various commodities seem to form a continuum from emphasis on "inventory-hedging" to emphasis on "forward-pricing." However, forward-pricing markets are relatively new, and additional evidence on the temporal relationships among prices should be developed as data become available. These data can be used to test hypotheses about futures markets as guides to production decisions (hence stabilize acres planted) and as a method of stabilizing grower's revenue through hedging.

Appendix A: Components of Variability of Production and Value

Wheat in India

First, the relative importance of yield and of harvested area fluctuations in "explaining" variations in Indian wheat production is examined. Two 16-year periods are compared--the crop years 1925-26 to 1940-41 and 1951-52 to 1966-67. The data for the earlier period are those reported by Blyn [10]; the data for the recent period are the most recently revised official statistics available to the author.[23] Techniques proposed by Burt and Finley [6] are used in the analysis. Since many of the variables have trends, linear trend equations are fitted by least squares (see Table 1), and the measures of variability are based on deviations from trend. (Inspection of graphs indicated that a linear function would fit the data as well as or better than other functions.)

Table 1. Linear Trend Equations for Yield and Area of Wheat in India, Two 16-Year Periods

Equation	Intercept	Slope	r	s[c]
		1925-26 to 1940-41		
Yield[a]	658.4	3.0 [d] (2.9)[e]	.26	54.2
Area[b]	23,874.1	169.2 (36.5)	.78	673.1
		1951-52 to 1966-67		
Yield	614.7	9.6 (2.9)	.67	53.0
Area	25,722.8	566.9 (115.5)	.80	2,130.0

a/ yield in pounds per acre.
b/ area in 1000 acres.
c/ s is the standard error of estimate.
d/ regression not "significantly" different from zero.
e/ estimated standard error of regression coefficient.

In the 1925-26 to 1940-41 period, wheat production trended upward about 85 thousand long tons per year on the average. The arithmetic mean of production for the period is 7,730 thousand tons. The standard error of estimate (about trend) is 560 thousand long tons. The major source of annual variability in wheat production apparently was fluctuations in

[23] The author had access to current data maintained by the Food Research Institute, Stanford. I especially wish to acknowledge the aid of Rosamond Peirce, Associate Statistician.

yield. The average yield is 684 pounds per acre and the estimated standard deviation is 54 pounds. Yield had no significant trend. In contrast, area harvested has a significant positive trend, averaging 169 thousand acres per year. About 90 per cent of the variability in production is attributable to yield fluctuations; the other 10 per cent to variation in area (net of trend). These per cents are estimates of the net influence directly attributable to each variable after compensating for the covariance between variables and for significant trends.[24] Analogous interpretations hold for subsequent illustrations.

In the 1951-52 to 1966-67 period, by contrast, fluctuations in wheat production were larger, and about 54 per cent of the annual variability is attributable to yield fluctuations and approximately 46 per cent to area variations. Production trended upward an average of 304 thousand long tons per year; the standard error of estimate is 897; both figures are larger than in the earlier period. The relative increase in the importance of area is the result of an increase in variation in area, rather than a decline in yield fluctuations. The standard error of estimate for area is an estimated 673 thousand acres in the earlier period and an estimated 2,130 thousand in the recent period. Yield increased about 10 pounds per acre on the average per year in the recent period, and the standard error is 53 pounds.

Second, an attempt is made to estimate the relative importance of components of variability of the real value of wheat in the 1951-52 to 1966-67 period. To estimate real value, the production data are multiplied by a deflated farm-level price. The resulting variable is an estimate of the value of the total crop, not revenue from quantity marketed.

The annual farm price is computed from monthly prices in Chaudausi, Uttar Pradesh,[25] assuming an April 1 - March 31 crop year. These prices display a "typical" seasonal pattern. However, a simple rather than a weighted average of prices is used because appropriate weights are not available. The computed average is deflated by the Index of Wholesale Prices for all items to obtain real prices. It is hoped that the year-to-year fluctuations, if not the average level, of this price series is representative of all-India wheat prices.[26] Frankly, the author is somewhat skeptical of achieving even this. The price and production data have essentially no inverse relationship. Given the use of a price series from one location and the lack of weights in computing the annual price, it is, perhaps, too much to expect these data to be a representative series.

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[24] Stated another way, each is the per cent of the total direct influence (not including covariances) attributable to the particular variable [see 6, pp. 737 ff.].

[25] A consistent, continuous series of prices at the farm level in India is not easy to obtain. Another approach would be to use wholesale or retail prices.

[26] There is evidence that prices in different markets are fairly closely related [15; 32].

There are at least two additional reasons why these results may be misleading. Marketing patterns for food grains in India are such that the previous crop year's production is important in determining current price [41]. Current marketings and price are inversely related, but marketings apparently depend on production both in the current and previous crop year. Further, changes in area devoted to one crop imply changes in area devoted to other crops. Thus, variation in the value of one crop arising from variation in area may be offset by compensating changes in value of a second crop arising from the negatively correlated change in area. The value of the two crops to producers may fluctuate very little.

The results of the analysis, for what they may be worth, are as follows. The deflated price has no trend; the average price for 1951-52 to 1966-67 is 2,024 rupees per long ton; the standard deviation is 388 rupees. However, with increasing production, value trended upward an average of 714 million rupees per year. The estimated standard error (about trend) is 4,298 million. Price variation is estimated to be 78 per cent of the total direct contributions to variation in value. Yield represents 12 per cent and area only 10 per cent. The major factor influencing variations in value of wheat production is changes in price. Given the uncertainty about the appropriateness of the price series, this conclusion is subject to qualification.

Ponlai Rice in Taiwan

The techniques used for wheat in India are also applied to 13 observations (1952-1964) for yield, area, and deflated price for Ponlai Rice in Taiwan [48]. The farm price of rice is deflated by an Index of Prices Paid by Farmers to obtain the real price. Estimated linear trends are reported in Table 2. Deflated price does not have a significant trend; yield and area have highly significant trends. The average price is 54 NT$ per 100 kg. The standard deviation is 2.4. Real value increased an average of 322 billion NT$ per year; the standard error of estimate is 311.

The relative components of the annual fluctuations in the real value of rice are estimated to be as follows: price 46 per cent, yield 14 per cent, and area 40 per cent. In other words, variation in price and in area harvested appear to be the major components of value fluctuations. Fluctuations in yield about trend are small (Table 2).

A scatter diagram relating price and production does not suggest a strong simple relationship. Thus, the influence of a small crop is not necessarily offset by a higher price (and vice versa). Of course, this statement is based only on an inspection of a scatter diagram; perhaps a more detailed statistical analysis would lead to qualification of this statement.

Table 2. Linear Trend Equations for Deflated Price, Yield, and Area for Ponlai Rice in Taiwan (1952-1964)

Equation	Intercept	Slope	r	s
Price[a]	52.2	.268[d] (.171)	.43	2.3
Yield[b]	2,110.3	61.7 (4.4)	.97	59.1
Area[c]	379.9	10.1 (1.3)	.92	17.8

a/ Price in NT$ per 100 kg., deflated by Index of Prices Paid by Farmers 1952=100.
b/ Yield in kg. per hectare.
c/ Area in 1000 hectares.
d/ Coefficient not significantly different from zero.

Concluding Comment

The analysis presented above essentially represents case studies. They are not offered as a basis for policy decisions. However, they illustrate that the major component of variability of value of a crop can vary from commodity to commodity, country to country, and from time period to time period. Fluctuations in production do not necessarily decline with the passage of time. Variations in area planted (and harvested) can be as important as yields in explaining production variation. Hence, policies both to stabilize area planted and yield can be useful in stabilizing production.

Appendix B

The derivation of $E_{VQ} = 1 + F$ follows

Recall we assume a constant demand

and fluctuations in supply (Q) result in fluctuations in price and hence in revenue (V = PQ). Hence,

$$V = PQ = (a + bQ)Q = aQ + bQ^2.$$

$$\frac{\partial V}{\partial Q} = a + 2bQ.$$

Hence,

$$E_{VQ} = \frac{\partial V}{\partial Q}\frac{Q}{V} = (a + 2bQ)\frac{Q}{PQ},$$

Or,

$$E_{VQ} = \frac{a + 2bQ}{P}.$$

Since $a = P - bQ$,

$$E_{VQ} = \frac{P}{P} - b\frac{Q}{P} + 2b\frac{Q}{P}$$

$$= 1 + b\frac{Q}{P}$$

$$= 1 + F.$$

Of course, since "b" is negative, F is negative.

Appendix C

The derivation of $E_{VQ} = E_{MQ} + F$ follows. Given

$$P = a + bQ$$

$$Q = M + H \text{ and } M = Q - H$$

$$V = PM.$$

$$E_{MQ} = \frac{\partial M}{\partial Q}\frac{Q}{M} = \frac{Q}{M}, \text{ since } \frac{\partial M}{\partial Q} = 1. \quad \text{(see footnote 21 of text)}$$

Therefore.

$$V = (a + bQ)M = aM + bQM, \text{ or}$$

$$= aQ - aH + bQ^2 - bQH.$$

$$\frac{\partial V}{\partial Q} = a - bH + 2bQ.$$

$$E_{VQ} = (a - bH + 2bQ)\frac{Q}{V} = \frac{aQ - bHQ + 2bQ^2}{PM}$$

Since $a = P - bQ$,

$$E_{VQ} = \frac{PQ - bQ - bHQ + 2bQ^2}{PM} = \frac{Q}{M} - \frac{QH}{PM} + \frac{Q^2}{PM}.$$

Recall $F = b\frac{Q}{P}$,

then $E_{VQ} = E_{MQ} - F\frac{H}{M} + F\frac{Q}{M} = E_{MQ} + \left(\frac{Q - H}{M}\right) F$. Or, $E_{VQ} = E_{MQ} + F$.

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