# Fixity and Capital Costing Assumptions in Agricultural Risk Research With Implications to Livestock

by

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The objectives of this paper are to demonstrate 1) the importance of fixed asset assumptions in agricultural risk research and 2) the difference in risk-income choices when capital is costed by nominal vs. real interest rates. While these issues are broadly relevant to all agricultural risk research, the implications are particularly important to questions of livestock risk.

Livestock risk has not received the attention of agricultural risk researchers nearly to the degree that crop risk has. A number of reasons account for this. Data availability on livestock yield variability is a major limitation in livestock risk research. Beside some other minor problems, the other major difficulty results from the inability to make simplifying fixed asset assumptions as is commonly done in crop research. This is due to the fact that livestock activities are very heterogeneous with respect to their relative use of intermediate and long-term resources. In crop production this is generally much less the case, even though enough heterogeneity in intermediate-term asset usage exists among crop activities that this issue should be of greater concern in applied crop risk studies.

In addition, the issue of intermediate and long-term capital costing under inflationary conditions remains unresolved in the agricultural economic profession as evidenced by the varying capital costing assumptions used in applied work as well as various opinions expressed. The authors strongly contend that all capital inputs (short, intermediate and long) should be costed with real interest rates in economic analysis. What is not at issue is if that choice is irrelevant. The results of this paper clearly demonstrate the importance of real vs. nominal charges to risk-income choices.

The setting for this analysis is the common issue of ranking risky alternatives in both simple variability analysis as well as the use of the return distributions in agricultural firm diversification models (risk programming). In particular, the implications of the above two issues are directed at the comparison of riskiness among alternative crop and livestock activities as well as examining the role of livestock in risk-income selections on existing crop farms.

## Empirical Research in Crop and Livestock Risk

### Background

Early applied studies in agricultural risk estimated enterprise variances

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relative to simple means. Yield variability or gross income variability from different crops received the major emphasis. Heady (Chapter 15) compared crop yield risk for various agricultural production regions using the coefficient of variation (CV) of yield as the comparison concept. Later, Brown and Heady estimated CV's for livestock and poultry. Over time, however, the emphasis of crop risk has shifted to net return variability where yield, product price, and input cost variability are simultaneously considered.

A summary of Great Plains risk research conducted predominately in the early 1960's is provided by Bailey. A common characteristic of these studies is the use of CV's as the comparative tool. Crop yield and gross income variability for various irrigated and dryland crop alternatives for North Dakota was studied by Schaffner et al. In Nebraska, Finley studied gross income variability for five crops. Orazem and Herring computed variance of crop yields in Kansas for the 1916-56 time period. A northwest Oklahoma study by Greve, et al. estimated coefficients of variation for production and net returns above cash costs for crop and livestock activities. Texas research by Johnson and Tefertiller investigated variability of cotton and grain sorghum using constant prices and costs. ERS research by Bostwick in Montana included a study of crop variability using farm data rather than county or similar aggregate yield data. Larson and Thompson computed wheat yield coefficients of variation for areas of the Great Plains.

In addition to the Schaffner study, other studies examined the impact of irrigation on crop yield risk. These include Helfinstine and Asopa and Swanson. Great Plains Regional Committee GP-2 published a symposium (Eidman and Hatch) proceedings in 1967 on the impact of irrigation upon the survival of Great Plains farms.

Following Carter and Dean's 1960 study of crop variability in California, research on crop yield and income variability in the 1970's and 1980's emphasized an _ex post_ expectational perspective from which to base variability rather than a simple mean. Young has examined these alternative expectational models and compared the risk indexes resulting from each. Variability studies by Mathia (North Carolina), Patrick (Indiana), Yahya and Adams (Wyoming) and Bravo-Ureta and Helmers (1983) (Nebraska) used various expectational models. Some used the variate difference method of separating random variability from total variability with random variability generally suggested as the relevant measure of risk. Variances and net returns series estimated by this process have been used in QP and MOTAD models by Adams, et al., Bravo-Ureta and Helmers (1980), and Persaud and Mapp. It has generally been accepted in agricultural risk research that the removal of trend in estimating historical return series results in superior estimates whether used for simple comparison purposes or as input to risk programming models. This is likely based upon either 1) the influence of Heady's emphasis upon deviations from an expectation rather than the mean or 2) the practice of distinguishing systematic and nonsystematic risk in general finance theory. There are a number of reasons why this acceptance of the preferability of randomly estimated variability over total variability should be questioned. First the analysis of systematic and unsystematic trends in the securities market (finance) may not be comparable to the agricultural income variability setting in which diversification may, to a greater degree, assist the reduction of total variability rather than just nonsystematic variability. Second, finance theory, while tending to emphasize the usefulness of diversification in reducing unsystematic risk, does not ignore systematic risk. In fact, Tinic and West argue that systematic risk is the major financial risk, not the diversifiable portion or risk (unsystematic). Last, using ex post expectation estimation for outcomes rather than ex ante expectation models is of serious concern in developing "random" deviations. The use of long term linear trends in ex post yield analysis may be warranted. However, the use of non linear yield expectation models and ex post product and input price expectation models should be seriously questioned. It should be noted that the above concerns do not apply to inflationary adjustments which should always be made when analyzing economic series.

## Empirical Estimates

Schaffner et al. determined coefficients of variation for gross return per $100 invested for various crop and livestock enterprises for 1931-1959 (Table 1). Livestock enterprise risk is seen to be considerably less than crop enterprise risk. Greve, et al. found coefficients of variation for northwest Oklahoma as reflected in Table 1. According to these measures, net

Table 1. Estimated Coefficients of Variation From Selected Studies.

| | Study | | | | | |
|---|---|---|---|---|---|---|
| | N.D.[a] | OKLA.[b] | | OKLA.[c] | WY[d] | IOWA[e] |
| Units | $/100 | $/acre | Prod/Acre | $/acre | $/acre | $/100 |
| Enterprise | Coefficients of Variation | | | | | |
| Dryland Barley | 64 | - | | | | |
| Grain Sorghum | | 64 | 52 | 47 | | |
| Dryland Wheat | 50 | 43 | 33 | 35 | | |
| Irrigated Barley | 49 | | | | 25 | |
| Irrigated Alfalfa | 31 | | | | 24 | |
| Irrigated Corn Silage | 26 | | | | 44 | |
| Full Fed Calf | 21 | | | | | 28 |
| Beef Cow-Calf Fed | 18 | | | | | 25 |
| Feeder Lambs | 12 | | | | | |
| Stocker Steers on Native | - | 70 | 23 | 56[f] | | |
| Cow-Calf on Native | | 78 | 4 | 29[f] | | |
| Dry Beans | | | | | 97 | |
| Sugar Beets | | | | | 78 | |
| Irrigated Corn | | | | | 46 | |
| Grow Calves - 400# to 775# | | | | | 66 | |
| Hogs | | | | | | 26 |
| Dairy | | | | | | 12 |

[a] Schaffner.
[b] Greve, et al.
[c] Aanderud, et al.
[d] Woolery and Adams.
[e] Brown and Heady.
[f] The value of the cow herd was assumed constant in contrast to the Greve study.

return risk for the livestock activities are higher than for the crop activities. Aanderud obtained similar but lower CV's, with a much lower estimate for cows on native pasture when value of the cow investment was held constant.

Heady (Chapter 17) examined price and production variability for livestock as well as crops. Among the livestock enterprises studied, feeder lambs was most variable followed by cattle feeding, feeder calves, hogs, hens and dairy cows. Income was defined as returns above $100 of feed and labor cost. Brown's results from a later study with Heady are presented in Table 1.

It is very difficult to generalize regarding the relative degree of risk among livestock enterprises from these studies and their risk position relative to crops. First, there is not a consistent variable used throughout to measure returns. Yields, returns per dollar invested, gross returns, etc. are inexact proxies for the relevant net return measure dealing with yield, product price, and input cost variability. Hence, comparisons differ in these studies depending upon the variable used to represent returns. Next, livestock yield variability is almost always excluded from livestock risk studies because of the lack of data (Walker and Helmers). Livestock risk studies are generally limited to product price variability and in some cases, input price variability. Finally, the issue of what costs should be removed in constructing series of net returns will be seen to have a major influence on risk comparisons and programming results. These issues will be addressed by first examining the relevance of the CV under different costing assumptions.

## Coefficient of Variation

A major difficulty in comparing livestock risk variability lies in the incompatibility of estimates between enterprises when the level of fixed resources differs among enterprises. The difficulty is most obvious when comparing crop vs. livestock risk using the coefficient of variation. The denominator (mean net returns) is strongly influenced by fixed resource assumptions (those resources for which no charge is made). For example, in comparing net returns for wheat and cattle feeding, mean net returns per acre of wheat could be relatively high if land is not costed which is the usual practice. In cattle feeding, the costing of land may be irrelevant. Further, mean net returns may be nearly zero if few resources are considered fixed. This tends to "blow up" the coefficient of variation for cattle feeding and distort variability comparison between the enterprises (Helmers and Atwood). Hence, net returns to "what" becomes an important issue.

Obviously where a resource is common for all alternatives, rankings of relative variability among those activities are not affected by the inclusion or exclusion of a charge for that resource. For example, among only crop alternatives it makes no difference whether land is costed in computing net returns when those crop alternatives are ranked with the coefficient of variation. However, when livestock activities are included in the analysis, care must be taken in costing fixed resources because fixed resource usage is no longer common across enterprises.

Where activities differ in their use of resources, only by costing all resources will comparisons be legitimate. Livestock enterprises are very heterogeneous, hence full costing of all resources is generally necessary to make relative variability comparisons. It should be noted that full costing of resources does not resolve the problem of the scale or unit of the activity used in the comparison process. In past crop comparisons not only was land not charged but returns for each crop were based on a per acre basis. Land became the basis for comparability among activities with respect to activity size. Of course, this is arbitrary in the sense that comparable size with respect to land is not necessarily more important than comparable size based on labor or capital requirements. When livestock is included in the analysis this issue becomes more obvious. At an extreme a livestock activity may not use land yet an assumption is needed with respect to the size of that activity. Generally the common scale factor among activities for such comparisons is based on investment, although arbitrariness is involved here also. Hence, using the previous example of wheat and cattle feeding, net profit variability (after removing labor and capital costs) to wheat and cattle feeding can be compared based on equivalent size (say net profits per $1000 investment).

Asset Fixity

In the previous section it was stressed that asset fixity assumptions are critical when comparing the relative variability of different activities with the CV. Thus, the only solution to that problem is to fully cost all resources if general risk comparisons are desired. The same procedure of full costing is necessary in risk programming for general risk analysis. While not emphasized here, programming models involve an additional fixed cost issue. Programming solutions are not neutral to the inclusion or removal of a cost common to all activities in the same manner that CV rankings are. That is, suppose a programming problem is developed around crop activities in which all crop activities require identical land requirements. It cannot be assumed that whether or not to cost land to each crop activity is irrelevant to the problem because solutions may indeed differ depending upon that costing assumption.

An exception can be made to these assertions regarding the need to fully cost all resources if the analysis is directed to a specific firm with specific resource availabilities. In such cases both CV analyses and risk programming analyses can be completed assuming some resources are not costed by activity resulting in a short-run analysis. In general risk research, however, this is not the desired objective.

In firm profitability and risk studies a tendency has existed to program representative farms with some levels of resource fixity. The tendency to assume fixed resources in general farm management research has probably occurred for the following reasons: 1) the position that some resources, by their nature, are fixed and 2) that very specific assumptions regarding a firm's resource structure is essential to "reality." The tendency to categorize land, operator labor, machinery, and facilities as innately fixed is probably derived from the long-run nature of these resources. However, length of life does not necessarily transcribe into fixity. Any resource may be fixed depending upon the decision maker's setting and orientation. In fact some programming analyses are totally contradictory regarding this issue. Sometimes resources are assumed fixed while, at the same time, longer-run product prices are analyzed and perhaps allowance for investment activities.

The tendency to perceive shorter-run analyses over longer-run analyses as "more realistic" is interesting. Actually such a framework yields less "realistic" results. Again, this refers to general economic results not specific results for a specific firm. One cannot capture the range in fixed resource levels on farms in one or a few short-run models. Further, firms are simultaneously making long and short-run decisions as evidenced by their continuing investment in long run resources. Hence, for purposes of general economic analysis longer-run analyses provide a more "realistic" framework than short-run analyses.

It should be stressed that asset fixity related to depreciable capital investments refers only to capital requirements not the depreciable portion of capital asset costs. That is, the cost resulting from the use of a capital item (depreciation) should always be costed in accordance with use for both long-run and short-run models. In other words, use cost of machinery should more commonly be classified as a variable cost rather than as a component of ownership costs. The cost of that use will be evidenced in the value of the asset and the sooner need for replacement even though that cost will not be evidenced in annual cash expenditures. The failure to properly account for this use cost leads to the common error of not analyzing the use or non use of machinery properly. It is common to suggest that ownership costs (capital and depreciation) are fixed costs but variable costs (operating) are the only relevant costs to consider relative to returns. For even short-run analysis (capital investment ignored) the impact of use on the value of the machine should be included in the cost of using the machine.

For long-run economic analysis it is important that each activity include an explicit entry for the capital investment cost portion of depreciable investments. The estimation of these activity costs involves some complex issues such as activity size assumptions, assumptions of common use investments, etc. Fortunately, with the large availability of different sized machinery and facility investments in agriculture, the difficulties arising from these estimation problems are not overwhelming.

## Inflation Adjustments

As previously noted, a wide range of capital costing assumptions are used by agricultural economists analyzing capital costs under conditions of inflation. These charges are critical when constructing data for enterprise budgets, programming studies, econometric analyses, cost-benefit analyses, financial research, resource valuation and productivity studies, and other research. Indeed there tends to be little economic analysis untouched by the need for capital charging assumptions.

The concern in this paper is the removal of inflation from time series of activity net returns used in risk programming models. However, the same issues also apply to the development of such series in variability (CV) studies. It will be assumed that the objective of such models relates to economic decision making not cash flow decision making. Some of the common deficiencies encountered in developing consistent time series under conditions of inflation are discussed by Helmers and Watts. These include the mismatching of the deflation instrument time base to the net return time base, inconsistent time bases between costs and returns, and the lack of the use of real capital charges for short, intermediate, and long-term inputs. These will not be repeated here except to stress that the proper accounting for inflation involves two steps: 1) the use of real discount rates in establishing costs for capital inputs and 2) the deflation of net return series to a constant dollar basis. Quite often short-term capital is costed at a nominal rate rather than a real rate probably because of the inclination to perceive that such a procedure is justified because the costs of the use of short-term capital occurs within the year. However, this is a faulty interpretation of real cost changes within the year. The real-nominal issue related to interest costs has its greatest impact on risk-income frontiers when capital requirements differ among activities, as assumed in the subsequent analysis. Technically, all agricultural activities will differ with respect to short-term capital uses, even if long and intermediate term capital requirements are equivalent. Because of the nature of programming, small changes caused by differences in short-term capital requirements may or may not impact risk-income frontiers.

## Procedure

The demonstration of the impact of fixed asset assumptions and real vs. nominal capital charges for those assets is developed by generating four risk-income frontiers for a representative farm. These frontiers are developed using MOTAD. The deficiencies of MOTAD as a risk-income model are well recognized. Here MOTAD is used only for demonstrating differences caused by the asset and asset costing issues. Five crop activities and one livestock activity are used in the analysis.

For the non full-costed analysis, the series of net returns are developed with a charge removed only for short-term capital. That short-term capital is charged at both a nominal and real rate, yielding two frontiers. A second set of frontiers is developed assuming different levels of intermediate and long-term capital requirements for the activities in addition to the previous short-term capital differences. One full-cost frontier is estimated with real capital costs and another with nominal costs.

Each frontier is then mapped into common frontier space (full cost-real). Differences in risk-income frontiers cannot be directly compared unless a common framework is used. This is done by forcing solutions from each frontier (non full cost-real, non full cost-nominal, and full cost-nominal) into the return deviation matrix of the full cost-real model generating four distinct frontiers.

The setting is for an eastern Wyoming 400 acre farm with five labor periods. The alternative crops are sugar beets, dry beans, corn silage, corn grain, and alfalfa. The feeding of steers is also considered. The basic data for the net return series is the deflated gross returns minus variable costs for the 1975-80 period.

## Results

The four time series of gross returns for the six activities corresponding to the four settings are presented in Table 2. These settings are 1) costing of short-term capital at a nominal rate, 2) costing of short-term capital at a real rate, 3) full costing of capital at a nominal rate, and 4) full costing of capital at a real rate. For the latter two settings, a charge for intermediate (machinery) capital and long-term (land) capital is

Table 2. Activity Net Return Deviations From Mean and Mean Net Returns For Each Costing Alternative.

| Year | Beets | Beans | Silage | Corn | Alfalfa | Steers |
|---|---|---|---|---|---|---|
| | | | Deviations | | | |
| 1 | 118.39 | -64.95 | 6.93 | 95.35 | 17.88 | -92.42 |
| 2 | -120.18 | -150.31 | 73.27 | 1.96 | 46.54 | -134.32 |
| 3 | -59.93 | 43.54 | 29.98 | -38.50 | -3.90 | 158.28 |
| 4 | -112.07 | -109.41 | -82.37 | -49.95 | -22.14 | 99.68 |
| 5 | 31.55 | 101.54 | -37.24 | -46.82 | -8.44 | -51.82 |
| 6 | 142.23 | 179.56 | 9.40 | 37.98 | -29.92 | 20.58 |
| | | | Mean Returns | | | |
| Short-Term @ Nominal Charge | 454.18 | 286.07 | 214.91 | 151.01 | 115.41 | 12.72 |
| Short-Term @ Real Charge | 479.18 | 306.07 | 234.91 | 166.01 | 120.41 | 50.22 |
| Full-Cost @ Nominal Charge | 26.62 | -83.99 | -78.47 | -104.01 | -101.21 | 12.72 |
| Full-Cost @ Real Charge | 254.24 | 118.13 | 96.27 | 52.05 | 31.09 | 50.22 |

included in addition to the short-term capital requirements of the first two settings.

For the demonstration a real interest rate of four percent is assumed which, with an assumed inflation rate of ten percent, corresponds to a nominal interest rate of 14 percent. For the six activities (beets, beans, silage, corn, alfalfa, and steers) the following per unit levels of short-term capital were respectively assumed: $250, 200, $200, $150, $50, and $375. These were developed for the assumed operating requirements of each activity taking into account the flow and portion of the year for which the capital was required.

Ownership costs (depreciation plus capital investment) of intermediate-term capital for the full costed settings were developed by amortization (10 years) as a single annual cost using 4% and 14% for the real and nominal based cost estimates respectively. That is, use cost was included in ownership costs, not separated as a variable cost. The per unit intermediate-term capital investment requirements for the six activities were assumed to be $1500, $1200, $800, $600, $400, and none respectively. These capital investment levels were selected based upon a high annual use of the machine for the crop in question. An alternative method is to use custom charges.

Land (long-term) capital requirements were assumed for the five crop activities only. This capital level was $1000 per unit. It can be seen that steer feeding was assumed to require neither long or intermediate-term capital. The feeding of steers with little or no levels of intermediate and long-term capital is not unrealistic in some cases. Thus, the costs of that activity are born by purchased inputs and short-term capital investments (investment in the feeder animal, feed, and other operating inputs).

MOTAD Solutions By Setting

The MOTAD solutions for each cost setting are presented in Tables 3-6. Each frontier is developed at comparable deviation levels. Income is obviously different by setting for a given deviation level even if organizations were identical. The solutions were developed for the maximum profit point and then for ten thousand dollar differences in deviation level down to 30,000 deviations.

It can be seen that solutions are different not because of differences in income but because of different organization. For example, at 120,000 deviations each solution has identical beet acreage. However, no other activity level is common across settings. The short-term capital-nominal costed alternative (Table 3) has relatively high levels of beans and low levels of steers at the 120,000 deviation level. The short-term capital-real charge (Table 4) and the full costed-real charge (Table 6) setting have minor differences in organization. The full cost-nominal charge setting (Table 5) is the most different of all settings. Because of the nominal costing of resources the full cost-nominal charge setting idles all crops except beets because of the negative returns for each crop (Table 2).

At lower deviation levels, it can be noted that beans tend to be retained at relative higher levels and steers at low levels in the short-term capital-nominal charge setting. The opposite tendency occurs for the full costed-real charge setting. The short-term capital-real charge tends to fall in between with respect to these activity levels. The impact of full vs. partial costing is most obvious with respect to steer levels. At full costing steers enter the solutions at higher levels because the relative capital investment for steers is lower than for the competing crop alternatives. When only short-term capital is costed, the land based alternatives are more competitive and steer feeding less competitive. These relations result because of the different levels of short and longer term capital required by the crop activities vs. steer feeding.

At very low deviation levels all settings tend to converge with the exception of the full costed-nominal charge alternative. This occurs at 40,000 deviations and below.

MOTAD Results Within Common Space

The differences in organization which occur at comparable deviation levels may or may not be significant with respect to resulting income. Those differences can only be examined by analyzing such organizational differences in an identical income setting. That is, by mapping the organization for a given deviation level for each cost setting into a common cost setting, relative income differences can be determined. This is done by forcing such organizations through one income-deviation matrix. The income-deviation matrix selected as the base from which to compare others was the full costed-real capital charge setting. This is selected because of its theoretical superiority, the fact that it provides the only setting in which all

Table 3. Efficient MOTAD Solutions (Income, Deviations, and Organization) For Short-Term Capital-Nominal Capital Charge Setting.

| | Deviations | Income | Organization | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Beets (acre) | Beans (acre) | Silage (acre) | Corn (acre) | Alfalfa (acre) | Steers (unit) |
| (LP) | 156,497 | 143,768 | 167.5 | 211.7 | 0.0 | 5.7 | 0.0 | 490.7 |
| | 150,000 | 143,667 | 164.5 | 211.9 | 0.0 | 15.8 | 0.0 | 465.8 |
| | 140,000 | 143,478 | 164.9 | 208.0 | 0.0 | 14.5 | 12.4 | 428.4 |
| | 130,000 | 142,730 | 169.2 | 202.9 | 0.0 | 0.0 | 27.9 | 362.4 |
| | 120,000 | 141,728 | 169.2 | 202.9 | 0.0 | 0.0 | 27.9 | 283.7 |
| | 110,000 | 140,727 | 169.2 | 202.9 | 0.0 | 0.0 | 27.9 | 205.0 |
| | 100,000 | 139,726 | 169.2 | 202.9 | 0.0 | 0.0 | 27.9 | 126.3 |
| | 90,000 | 137,757 | 169.2 | 185.0 | 14.9 | 0.0 | 30.8 | 93.8 |
| | 80,000 | 134,378 | 169.2 | 141.3 | 51.6 | 0.0 | 37.9 | 128.7 |
| | 70,000 | 130,999 | 169.2 | 97.5 | 88.2 | 0.0 | 45.0 | 163.6 |
| | 60,000 | 127,561 | 169.2 | 62.6 | 117.5 | 0.0 | 50.7 | 133.0 |
| | 50,000 | 124,083 | 169.2 | 33.7 | 141.7 | 0.0 | 55.4 | 58.1 |
| | 40,000 | 115,825 | 153.0 | 0.0 | 175.8 | 0.0 | 71.2 | 26.4 |
| | 30,000 | 100,815 | 118.1 | 0.0 | 144.5 | 0.0 | 137.4 | 20.7 |

Table 4. Efficient MOTAD Solutions (Income, Deviations, and Organization) For Short-Term Capital-Real Capital Charge Setting.

| | Deviations | Income | Organization | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Beets (acre) | Beans (acre) | Silage (acre) | Corn (acre) | Alfalfa (acre) | Steers (unit) |
| (LP) | 159,016 | 170,785 | 167.1 | 212.4 | 0.0 | 3.7 | 0.0 | 500.0 |
| | 150,000 | 169,724 | 164.5 | 211.9 | 0.0 | 15.8 | 0.0 | 465.8 |
| | 140,000 | 168,106 | 164.9 | 208.0 | 0.0 | 14.5 | 12.4 | 428.4 |
| | 130,000 | 165,492 | 169.2 | 184.5 | 15.4 | 0.0 | 30.9 | 410.1 |
| | 120,000 | 162,456 | 169.2 | 161.9 | 34.3 | 0.0 | 34.5 | 390.0 |
| | 110,000 | 159,119 | 169.2 | 146.7 | 47.0 | 0.0 | 37.0 | 350.7 |
| | 100,000 | 155,783 | 169.2 | 131.5 | 59.7 | 0.0 | 39.5 | 311.4 |
| | 90,000 | 152,446 | 169.2 | 116.3 | 72.5 | 0.0 | 42.0 | 272.1 |
| | 80,000 | 149,110 | 169.2 | 101.2 | 85.2 | 0.0 | 44.4 | 232.8 |
| | 70,000 | 145,773 | 169.2 | 86.0 | 97.9 | 0.0 | 46.9 | 193.5 |
| | 60,000 | 140,634 | 169.2 | 62.6 | 117.5 | 0.0 | 50.7 | 133.0 |
| | 50,000 | 134,278 | 169.2 | 33.7 | 141.7 | 0.0 | 55.4 | 58.1 |
| | 40,000 | 124,511 | 153.0 | 0.0 | 175.8 | 0.0 | 71.2 | 26.4 |
| | 30,000 | 108,123 | 118.1 | 0.0 | 144.5 | 0.0 | 137.4 | 20.7 |

Table 5. Efficient MOTAD Solutions (Income, Deviations, and Organization) For Full Cost-Nominal Capital Charge Setting.

| | | | Organization | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Deviations | Income | Beets (acre) | Beans (acre) | Silage (acre) | Corn (acre) | Alfalfa (acre) | Steers (unit) |
| (LP) | 134,308 | 10,808 | 167.1 | 0.0 | 0.0 | 0.0 | 0.0 | 500.0 |
| | 130,000 | 10,631 | 167.8 | 0.0 | 0.0 | 0.0 | 0.0 | 484.6 |
| | 120,000 | 10,215 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 448.9 |
| | 110,000 | 9,758 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 413.0 |
| | 100,000 | 9,302 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 377.1 |
| | 90,000 | 8,845 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 341.2 |
| | 80,000 | 8,388 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 305.3 |
| | 70,000 | 7,932 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 269.4 |
| | 60,000 | 7,475 | 169.2 | 0.0 | 0.0 | 0.0 | 0.0 | 233.5 |
| | 50,000 | 6,868 | 167.8 | 0.0 | 0.0 | 0.0 | 0.0 | 188.7 |
| | 40,000 | 5,494 | 134.3 | 0.0 | 0.0 | 0.0 | 0.0 | 151.0 |
| | 30,000 | 4,121 | 100.7 | 0.0 | 0.0 | 0.0 | 0.0 | 113.2 |

Table 6. Efficient MOTAD Solutions (Income, Deviations, and Organization) For Full Cost-Real Capital Charge Setting.

| | | | Organization | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Deviations | Income | Beets (acre) | Beans (acre) | Silage (acre) | Corn (acre) | Alfalfa (acre) | Steers (unit) |
| (LP) | 159,016 | 92,867 | 167.1 | 212.4 | 0.0 | 3.7 | 0.0 | 500.0 |
| | 150,000 | 91,583 | 168.1 | 198.3 | 10.1 | 3.9 | 6.2 | 479.0 |
| | 140,000 | 89,917 | 169.2 | 185.8 | 17.7 | 0.0 | 18.6 | 451.3 |
| | 130,000 | 88,168 | 169.2 | 174.7 | 24.8 | 0.0 | 28.2 | 422.9 |
| | 120,000 | 86,332 | 169.2 | 152.3 | 42.3 | 0.0 | 36.1 | 400.5 |
| | 110,000 | 84,383 | 169.2 | 114.1 | 74.3 | 0.0 | 42.3 | 386.4 |
| | 100,000 | 82,434 | 169.2 | 75.9 | 106.3 | 0.0 | 48.5 | 372.3 |
| | 90,000 | 80,485 | 169.2 | 37.7 | 138.3 | 0.0 | 54.7 | 358.1 |
| | 80,000 | 78,524 | 169.2 | 0.0 | 169.9 | 0.0 | 60.9 | 343.4 |
| | 70,000 | 75,717 | 169.2 | 0.0 | 169.9 | 0.0 | 60.9 | 287.5 |
| | 60,000 | 72,389 | 169.2 | 0.0 | 169.9 | 0.0 | 60.9 | 221.3 |
| | 50,000 | 66,581 | 169.2 | 0.0 | 169.9 | 0.0 | 60.9 | 105.6 |
| | 40,000 | 59,363 | 153.0 | 0.0 | 175.8 | 0.0 | 71.2 | 26.4 |
| | 30,000 | 49,251 | 118.1 | 0.0 | 144.5 | 0.0 | 137.4 | 20.7 |

activities, regardless of type of capital input used, can be directly compared. Further, it employs real interest rates for capital, the proper rate for economic analysis.

The comparisons between cost settings are presented in Fig. 1 starting at 50,000 deviations to the LP point for each adjusted frontier. A common frontier occurs whenever solutions are identical between settings. This occurs for two areas when comparing full costed-nominal capital charge and short-term costed-real capital charge. One area of commonality is at the lower portion of the frontier and the other at the upper end. Otherwise, all four setting differ.

The results demonstrate some interesting comparisons. The real-nominal difference is much wider under short-term costing conditions compared to the full costing setting. Only a small difference in frontiers exist between the full costed-real and the full costed-nominal setting.

The distinction between short-term costing and full costing is generally much wider under nominal costing compared to real capital charges. Only a portion of the short-term-real frontier departs from the full costed-nominal frontier. The full costed-nominal frontier lies close to the full costed-real frontier throughout the map. However, when the short-term costed-real frontier departs from the full costed-nominal frontier, it is a significant difference.

Summarizing the results of these comparisons from this study: 1) costing at real or nominal rates does not lead to major differences when all costs are considered, 2) very major differences in short-term costed frontiers result when a real vs. nominal costing is employed, 3) when real costing is employed, the short-term vs. full costed distinction was important for part of the frontier but much less significant for other portions of the frontiers.

## Summary and Conclusions

By alternative costing assumptions it was demonstrated that the choice of asset fixity assumptions and the use of real vs. nominal capital charges results in different risk-income frontiers. These differences are not simply differences in the level of the frontier caused simply by different units of return criteria. Rather, these are different organizational results resulting in true frontier differences when directly compared in the same return unit.

The authors contend that for almost all economic analyses of risk in agriculture, biased results will occur unless a fully costed analysis is used employing real interest rates. The use of full costing appears more important than the real-nominal costing issue. That is, if risk analyses utilize full costing, whether such capital requirements are costed at real vs. nominal rates, while technically leading to different results, is not seen to have major impacts on results.

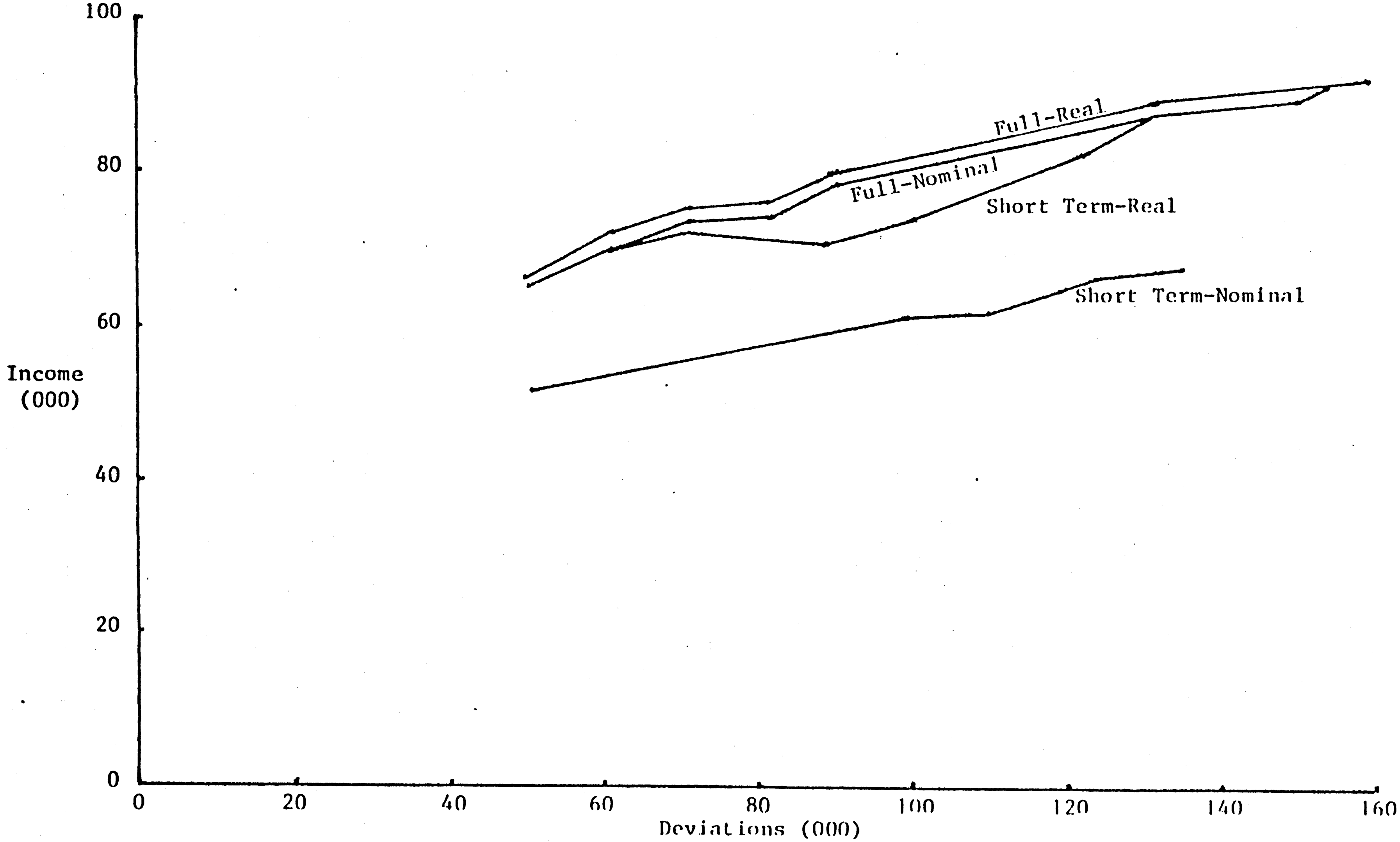


Fig. 1 Adjusted E-A Frontiers Formed By Forcing Solutions From Alternative Cost Settings Into Full Costed-Real Capital Charge Space.

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