EXERCISES IN THE ECONOMIC ANALYSIS OF AGRONOMIC DATA*

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* A workbook to accompany Perrin <u>et al</u>, 1976. "From Agronomic Data to Farmer Recommendations".

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Introduction

The following set of exercises were initially developed for the benefit of in-service production agronomy trainees at CIMMYT headquarters in Mexico. They augment and complement materials found in the CIMMYT Economics Manual (Perrin _et al_, 1976) for instructing these trainees in the use of partial budgets. We believe this set of complementary exercises will help them to confidently conduct their own economic analyses.

The exercises present the elements of partial budgets in a step-by-step manner. Before each exercise, an explanation of the underlying concepts is given. They begin with elementary concepts and end with analytical complications that researchers must face in practice. Consequently, the exercises are best used in the sequence in which they are presented.

The concept of the recommendation domain pervades all of the exercises and is therefore best explained in this introduction. A recommendation domain is a group of farmers with similar practices and circumstances, for whom a unique recommendation will be roughly appropriate. Delineation of domains in a target area is nothing more than the stratification of farmers into a few roughly homogeneous groups. The use of domains stems from the practical recognition that (1) it is not feasible to make individual recommendations for each farmer, and (2) a global, general recommendation for a whole study area will probable not be appropriate for many of the farmers in the area.

The concept of the recommendation domain is made operational in economic analysis by means of analysis of pooled data. Given that a single recommendation is to be formulated for a given domain, the results of all experiments planted in the domain, and for the domain, should be included in the analysis. Pooling should be undertaken across years as well as across sites, within one domain. The specific techniques for analysis of pooled data are presented in the exercises.

This set of exercises uses, for the most part, data from experiments on maize. The concepts and procedures can easily be applied to experiments on other crops.

Thanks are due to many people for their help in developing these exercises. I would like to express special gratitude to Derek Byerlee, CIMMYT economist; Federico Kocher, A.F.E. Palmer and Alejandro Violic, CIMMYT agronomists; and the in-service production agronomy trainees with whom it has been such a pleasure to work.

SECTION 1) FIELD PRICE OF THE PRODUCT

A key concept in the CIMMYT Economics Manual is that of the field price of the product, eg. maize or wheat. It is defined as "the value to the farmer of an additional unit of production in the field, prior to harvest ....." (Perrin *et al*, 1976, p 7).

The field price of the product is calculated by subtracting from the sales price of the product (*where* the farmer sells it, *when* he sells it and in the *form* in which he sells it) those costs which are roughly *proportional to yield*. These frequently include such costs as harvesting, shelling, transport from field to point of sale, and farmers' storage costs. (When the farmer does not sell, an opportunity field price should be used, equal to the money price incurred to acquire an additional unit of the product for consumption.)

The "field price" concept is used for three purposes: 1) To insure that the costs mentioned above are included in the analysis. (These costs are frequently overlooked by researchers but must nonetheless be faced by farmers.) 2) To simplify the succeeding steps in partial budgeting. (Once these costs are handled via the field price, they do not have to be individually estimated for each treatment.) 3) To exclude harvest and post-harvest costs from marginal analysis, because the farmer's capital invested in these activities will be recuperated almost immediately.

Exercise No. 1 - Field Price of Maize

Calculate the field price of maize for the following cases:

a) The farmer sells his maize in his house to a trader for $5.50/kg. He also has the following costs: harvesting = $0.40/kg; shelling = $0.60/kg; transport from field to house = $0.20/kg.

Field price of maize = $ ______ /kg.

b) The farmer sells his maize in his house to an intermediary for L15/quintal, abbreviated "qq" (1 qq = 100 lbs. = 45 kg.). He must also pay the following costs: maize harvest = L 1.20/qq; shelling = L 1.40/qq; transportation from field to house = L 2.50/"carga" (1 carga = 4 qq = 400 lbs. = 180 kg.).

Field price of maize = L ______ /kg.

SECTION 2) GROSS FIELD BENEFITS

Gross field benefits are defined as "Net yield times field price for all products from the crop. In general, this may include money benefits or opportunity benefits, or both." (Perrin, et al, p 7). Gross field benefits are estimated for each treatment to be evaluated.

"Field price" was defined in section (1). "Net yield" is defined as "The measured yield per hectare in the field, minus harvest losses and storage losses where appropriate." (Perrin, et al, p 6).

The concept of "net yield" stems from the recognition that farmers often do not receive the same yield as researchers, even when they apply the "same" treatment. This has several causes:

1) Management: Researchers can often be more precise and timely than farmers in applying a given treatment, e.g. plant spacing, timing of planting, fertilization, and weed control, etc.

2) Harvest date: Researchers often harvest fields at "physiological maturity" whereas farmers tend to let their crop dry in the field. Even when the yields of both researchers and farmers are adjusted to a constant moisture (eg. 14%), the researchers' yield is higher -- because of fewer yield losses to insects, birds, rats, ear rots, or shattering.

3) Form of harvest: At times, mechanized harvest by farmers leads to heavy field loss if the crop has lodged or if the rows were planted unevenly. In these cases, a careful manual harvest by researchers will lead to yield levels that farmers cannot obtain.

4) Storage losses: If the farmer stores his harvest for home consumption or for later sale, and thereby incurs insect or rat damage, his effective production is less than that predicted by researchers on the basis of experimental data. (Note: storage losses should not be

counted if they were already included in the "storage cost" used to calculate field price.)

5) Plot Size: Even when researchers are careful to use harvesting techniques that reduce border effects, yields estimated from small plots tend to be higher than yields taken from an entire field.

Exercise No. 2 - Gross Field Benefits

Calculate gross field benefits for the following nitrogen by density (N x D) treatments. It is estimated that researchers obtain higher yields than farmers (for the same levels of N and density) due to management (10%) and harvest date (10%). Farmers sell their maize immediately after harvest.

The farmer receives $6.00/kg for his shelled maize. Transport cost from the field to place of sale = $0.40/kg., shelling cost = $0.30/Kg., and harvest cost = $1.10/kg.

VARIABLE	T R E A T M E N T								
	N0[1/] D25	N0 D50	N0 D75	N50 D25	N50 D50	N50 D75	N100 D25	N100 D50	N100 D75
Average yield (kg/ha)	1360	1040	940	1070	1180	1200	1180	860	910
Adjusted Yield (Kg/ha)									
Gross Field Benefit ($/ha)									

1/ N0 = 0 Kg/ha N, etc.
D25 = 25,000 plants/ha, etc.

SECTION 3) ADJUSTING FOR "LOST SITES"

Researchers at times discard experimental data (or do not even harvest the experiment) when yields are extraordinarily low due to such natural factors as drought, frost or flooding. Insofar as these natural factors must also be faced by farmers, these cases of "Zero Response" should be accounted for. If the data on these lost sites are available, yields per treatment from "lost sites" should be included when averaging to obtain average treatment means for yield, for the recommendation domain under study (see Introduction). If the data from lost sites are not available, suitable uniform low yields per treatment should be estimated and used. Often an estimate of "zero yield" for all treatments is most accurate. It should be noted that any minor errors in estimating the uniformly low yield for treatments in a "lost site" are much less serious than the errors introduced by ignoring the problem.

Exercise No. 3 - Adjusting for Lost Sites

Calculate gross field benefits for the following weed control treatments. It is considered that researchers obtain higher yields than farmers (for the same weed control practice) due to an earlier harvest date (10%) and a more painstaking manual harvest (5%). The farmer receives B1.80/kg for his shelled maize. Harvest cost = B0.30/kg; this includes shelling. The government pays transport cost from the field to location of sale. Farmers sell their maize immediately after harvest.

The results of three experiments are available, all of which were planted for the same recommendation domain. A fourth experiment for the same domain was abandoned due to drought - it was not harvested. No response to improved weed control is expected under drought conditions, so a uniform yield of 500 kg/ha was estimated for all treatments.

Variable	TREATMENT			
	Manual Control	Gesaprim	Prowl	2,4-D
Yield-Experiment 1 (kg/ha)	2500	2800	3100	2600
Yield-Experiment 2 (kg/ha)	2000	2500	2600	2200
Yield-Experiment 3 (kg/ha)	2700	3500	3700	2900
Yield-Experiment 4 (Kg/ha)	(Not harvested - drought)			
Average yield (kg/ha)				
Adjusted yield (kg/ha)				
Gross Field Benefits (B/ha)				

Field price of maize = B______________/ kg..

SECTION 4) INCLUDING THE VALUE OF BYPRODUCTS

Frequently, maize or wheat grain is not the only product with economic value that comes from maize or wheat fields. Leaves, tassels, stover and straw may all have value to the farmer. (When a market for these byproducts exists, it is usually easy to calculate a sales price, from which a field price may be estimated by subtracting costs that are proportional to yield. (See section 1). Gross field benefits for byproducts should be added to gross field benefits for grain in order to obtain total gross field benefits.

Exercise No 4 - Value of Byproducts

Calculate total gross field benefits for the following experiment on the response of wheat to levels of N. Farmers sell their wheat immediately after harvest for $4.00/kg. Harvesting and threshing cost $0.30/kg., and transport to place of sale costs $0.20/kg. Wheat straw is baled and sold as animal feed for $5.50 per 18 Kg. bale. The purchaser of the straw, not the farmer, pays transport cost. The farmer does pay, however, the cost of baling of $0.60 per bale.

It is estimated that researchers obtain higher wheat and straw yields than farmers even with the same N levels, due to management precision (10%) and earlier harvest that leads to fewer losses to shattering (5% for wheat only). No experimental sites were lost.

Variable	TREATMENT			
	N0[1]	N50	N100	N150
Grain yield (Kg/ha)	1500	2100	2400	2500
Straw yield (Kg/ha)	1800	2520	2880	3000
Adjusted grain yield (Kg/ha)				
Adjusted straw yield (Kg/ha)				
Gross field benefits-wheat ($/ha)				
Gross field benefits-straw ($/ha)				
Total gross field benefits ($/ha)				

Field price of wheat = $ ________

Field price of straw = $ ________

[1] N0 = 0 Kg/ha N, etc.

SECTION 5) NET BENEFITS

Net benefits are defined by Perrin et al as "total gross field benefits minus total variable costs" (p.9). "Gross field benefits" were discussed in section (2). "Total variable costs" are defined as "the sum of field costs for all inputs which are affected by the choice... Variable costs can consist of either money costs or opportunity costs or both" (p. 9). That is, costs can reflect either a cash payment by the farmer (monetary cost) or the value of a farmer owned resource (opportunity cost).

Net benefits should not be confused with "profits". Recall that only costs that vary over treatments need be included in the net benefit calculation, i.e. Costs that do not vary need not be taken into account. It should be noted, however, that the inclusion of costs that do not vary over treatments will not make the economic analysis incorrect. In fact, the rate of return to investment capital (the measure of profitability used here) will not change at all if non-varying costs are included.

There is one cost that should not be included in "costs that vary over treatments". This is the "cost of investment capital", of which interest is usually a major element. This is because rates of return to capital are compared with this "cost of capital" when a recommendation is formulated (see sections (9) and (10)).

In the exercise that follows, data is given from three insect control experiments. All experiments were planted with the same recommendation domain in mind. So the calculation of an average yield for each treatment is the first step in the analysis which leads sequentially to the calculation of net yields, gross field benefits, total costs that vary, and net benefits.

Exercise No. 5 - Net Benefits

Calculate the net benefits for each treatment, using the average maize yields for several insect control experiments. Yields for each treatment can be averaged over experiments because all experiments were located in a single recommendation domain. No experiments were abandoned.

VARIABLE	NO CONTROL	BIRLANE 1 X	BIRLANE[1/] 2 X	BIRLANE[2/] + FURADAN
Yield (kg/ha) Experiment 1	3000	2900	3100	3600
Yield (kg/ha) Experiment 2	2400	2500	2700	3000
Yield (kg/ha) Experiment 3	2750	2505	2950	3100
Average Yield (kg/ha)				
Adjusted Yield (kg/ha)				
Gross Benefits (L/ha)				
Birlane (kg/ha)	0	8	16	8
Furadan (kg/ha)	0	0	0	4
Insecticide Cost (L/ha)				
Application Cost (L/ha)				
Total Costs that Vary (L/ha)				
Net Benefits (L/ha)				

1/ Birlane two times, 8 kg/ha each application.

2/ Birlane and Furadan are not applied together. Furadan is placed in the hole at planting but Birlane is used in a foliar application.

Cont'n. Exercise No. 5

Here are the data needed to complete the calculation:

Sales price of maize	=	L 14.50/qq
Harvesting cost	=	L 1.50/qq
Shelling cost	=	L 1.00/qq
Transport - field to sales point	=	L 1.60/qq
Wage in Market	=	L 6.00/day
Price of Birlane	=	L 1.70/kg
Price of Furadan	=	L 4.30/kg
Application cost:		
Birlane	=	1 man-day/application
Furadan	=	0.5 man-day/application
Yield adjustment	=	20%
1 qq	=	45 kg

SECTION 6) FIELD PRICE OF BULKY PURCHASED INPUTS

The calculation of total costs that vary and net benefits is at times complicated by transport charges for bulky purchased inputs, eg. fertilizer and seed. This can have a large impact on treatment costs where transport costs are high. For example, consider the following calculation of the field price of N:

	\$ 5.00/kg	price of urea in store
+	3.50/kg	transport to field
	\$ 8.50/kg	price of urea in the field

$$\$\ \frac{8.50}{.46} = \$\ 18.48 =$$ price of N in the field, in the form of urea (46% N)

To find the cost of N for a given N dose, one only has to multiply this field price by the dose (eg. \$ 18.48/kg x 100 kg/ha = \$ 1848/ha).

Exercise No. 6 - Field Price of Fertilizer

Calculate the field price of N and P, and the cost of the N P dose, for each treatment in the following N P experiment.

TREATMENTS

	N0P0 1/	N0P40	N50P0	N50P40	N100P0	N100P40
N Cost ($/ha)						
P Cost ($/ha)						
Fertilizer Cost ($/ha)						

1/ Numbers refer to kg/ha of N and P element

Data:

ammonium nitrate (33.5% N)	$ 4.80/kg
triple super phosphate (46% P)	$ 7.50/kg
transport of fertilizer	$ 3.00/kg

N field price = $ ____________ /kg N

P field price = $ ____________ /kg P

SECTION 7) DOMINANCE ANALYSIS AND THE NET BENEFIT CURVE

The calculation of net benefits for each treatment is only an intermediate step in the economic analysis of agronomic data. That is, the treatment with the highest net benefit does not always make the best recommendation. Such factors as capital scarcity and risk aversion have yet to be included in the analysis.

Net benefits and "costs that vary" are used to calculate "marginal rates of return to investment capital" as one moves from a less expensive to a more expensive treatment (sections (8) and (10)). This "marginal analysis", however, can be made more efficient by an intermediate step -- "dominance analysis" -- in which clearly unprofitable treatments are discarded. (See Perrin _et al_, p 18).

A "dominated" treatment has lower net benefits _and_ higher costs that vary, than some other treatment in the experiment. Dominated treatments need not be considered further in the analysis.

Dominance analysis can be seen graphically in the "net benefit curve". The net benefit curve "shows the relation between the variable costs ... and the net benefits ..." (see Perrin _et al_, p 16, for an example). To construct a net benefit curve, each treatment is plotted on a graph, the vertical axis representing net benefits and the horizontal axis representing costs that vary. The net benefit curve is formed by connecting these points with a solid line having a positive or upward slope.

That is, beginning with the point that corresponds to the least expensive treatment, a line is drawn to a point that represents the next most expensive treatment -- but only an _upward_ sloping line is allowed. Undominated treatments will be _on_ the net benefit curve but dominated treatments will be _below_ the net benefit curve.

EXERCISE NO.7 - DOMINANCE ANALYSIS AND THE NET BENEFIT CURVE

Based on five N by density experiments, all from one recommendation domain, the following data were obtained. Perform a dominance analysis and draw the net benefit curve.

TREATMENT	NET BENEFIT ($/HA)	TOTAL COST THAT VARIES ($/HA)
NO DO	3670	670
NO D1	4963	830
NO D2	5870	990
N1 DO	3984	1373
N1 D1	4877	1533
N1 D2	4717	1693
N2 DO	3174	2074
N2 D1	4758	2234
N2 D2	4075	2444

SECTION 8) THE MARGINAL RATE OF RETURN

After dominated treatments have been discarded, marginal analysis can begin. The purpose of marginal analysis "is to reveal just how the net benefits from an investment increase as the amount invested increases." (Perrin et al, p 17).

Marginal analysis is based on the "marginal rate of return", which is defined as the increment in net benefits divided by the increment in costs that vary, as one moves from one treatment to the next more expensive treatment. This is usually expressed as a percentage.

$$MRR = \frac{\text{increment NB}}{\text{increment TCV}} \times 100$$

The marginal rate of return can be fruitfully interpreted as the percent return on investment capital, after that capital has been repaid. For example, if a farmer receives a MRR of 50% on an investment of $100, then that $ 100 investment has not only been recovered but a further return of $ 50 has also been earned.

It should be stressed that the MRR does not measure the returns corresponding to a single treatment, but rather to the returns that correspond to a change from a less expensive to a more expensive treatment. It follows from this that the slope of the net benefit curve is a measure of the MRR: the flatter the net benefit curve (small increment in net benefits compared to the increment in costs that vary), the lower the MRR.

This section only deals with the calculation of the MRR. The use of the MRR in the formulation of farmer recommendations must be left to a later section (10) because the topic of the cost of investment capital must first be addressed.

EXERCISE NO. 8 - MARGINAL RATE OF RETURN

Based on the following data you should obtain, for recommendation domain one, marginal rates of return and the net benefit curve.

RECOMMENDATION DOMAIN	EXPERIMENT NO.	TREATMENT[1/] N0	N50	N100	N150
1	1	1000	1850	2200	2250
1	2	900	1860	2100	2400
2	3	1900	2400	2500	2600
1	4	1300	2200	2400	2500
2	5	2000	2600	2600	2700
1	6	1100	2100	2400	2500
1	7	1400	2050	2600	2600
2	8	1700	2200	2100	2200
2	9	(abandoned - drought)			

Data:

Yield adjustment	=	15%
Maize sales price	=	$ 6.50/kg
Shelling cost	=	$ 0.50/kg
Harvest cost	=	$ 1.00/kg
Transport cost (maize)	=	$ 0.75/kg
Wage	=	$ 150/day
Urea (46% N)	=	$ 4.00/kg
Transport (urea)	=	$ 0.30/kg

Fertilizer application:

2 man-days/ha

[1/] Numbers refer to kg/ha N

SECTION 9) COST OF INVESTMENT CAPITAL

Consider a farmer who invests $100 in fertilizer. If the increased value of production (due to fertilizer use) were exactly $100, the farmer would undoubtedly be sorry he bought the fertilizer. In order to willingly invest, he would require that both the $ 100 be repaid and that a "minimum rate of return" be earned. If his minimum required rate of return were 50%, he would have to expect a return of $150 ($ 100 + 50%) before investing. Any investment expected to earn a rate of return lower than this minimum would be rejected; likewise, any investment expected to earn a rate of return higher than this minimum would be accepted (risk aside for the moment). The problem lies in estimating this "minimum required rate of return".

In a few areas, the minimum rate of return required to induce investment can be estimated directly. In one area, for example, a common rule of thumb for farmers was "2 to 1"; i.e. an expected return of $ 2 was required by farmers for each $ 1 invested. This is equivalent to a minimum rate of return of 100% ($ 1 + 100% = $ 2).

Usually, however, no such rule of thumb exists and the minimum rate of return must be inferred from an estimate of the cost of borrowed capital. (This is usually easier to estimate than the opportunity cost of the farmer's own capital.)

Suppose, for example, that a farmer borrows $ 1000 for 8 months, at an 18% annual interest rate, and that he pays a $ 30 service charge and $ 70 in personal expenses in order to obtain the loan. His cost of capital is estimated as follows:

$\$ 1000 \times .18 = \$ 180$	annual interest
$\$ 180 \times \frac{8}{12} = \$ 120$	interest for loan period
$\$ 120 + \$ 30 + \$ 70 = 220$	loan costs
$\$ 220/\$1000 = 22\%$	cost of borrowed capital for 8 months

The minimum rate of return that is requested to induce investment will usually be above this "cost of borrowed capital". Perrin et al suggest adding 20 percentage points ("risk premium") onto the cost of borrowed capital to estimate the minimum required rate of return. They further suggest that a 40% minimum rate of return "rule of thumb" is roughly appropriate for many areas.

In Perrin et al, "cost of capital" and "minimum rate of return" are used interchangeably. In the following exercises, references will only be made to "cost of capital".

Exercise No. 9 - Cost of Capital

a) A farmer borrows $3000 for eight months, at an annual interest rate of 20%. Besides interest, he must pay a service charge of $60 and he has $140 in personal expenses related to obtaining the loan. He also has to pay a crop insurance premium of $90. What is his cost of borrowed capital? What is his cost of capital (minimum rate of return) when a 20% "risk premium" is added?

b) A farmer borrows $2000 from the village money-lender. He does not have to pay any service charge, insurance premium or personal expenses. But the money-lender charges him 10% per month interest. What is his cost of borrowed capital if the loan runs for seven months? What is his cost of capital (minimum rate of return) including a 20% "risk premium"?

SECTION 10) RECOMMENDATIONS AND THE MARGINAL RATE OF RETURN

In the previous exercises, emphasis was placed on calculation and estimation of field price, gross field benefits, net benefits, cost of capital, etc. Now these calculations and estimations must be interpreted in order to formulate a farmer recommendation.

Researchers have used several incorrect criteria for the formulation of recommendations: highest yield, highest net benefit, or highest marginal rate of return. All of the above are likely to give incorrect and misleading results. The correct way to interpret partial budget calculations is a bit more complicated, involving a series of comparisons between marginal rates of return and the cost of capital.

Consider a net benefit curve, in which undominated treatments are joined. Beginning with the least expensive treatment (lowest TCV), calculate the marginal rate of return that is earned when moving to the next treatment on the net benefit curve. If this marginal rate or return is greater than the cost of capital, the change (or investment) is accepted as profitable (risk aside). Each succeeding change is evaluated in the same way. In summary, researchers are asked to consider each increment in cost separately; they should keep increasing costs until the marginal rate of return approaches (but does not fall below) the cost of capital. (See Perrin et al, Chapter 4, for further information.)

Exercise No. 10 - Recommendations and the MRR

Based on the following data, conduct dominance analysis and marginal analysis (MRR). What should be recommended if the cost of capital is 30%? If the cost of capital is 60%? Draw the net benefit curve.

a) N x P Experiment

TREATMENT		NET BENEFIT ($/HA)	COSTS THAT VARY ($/HA)
N0	P0	500	0
N0	P40	480	91
N50	P0	610	99
N50	P40	520	178
N100	P0	650	186
N100	P40	580	265
N150	P0	420	273
N150	P40	350	352

b) Insect Control Experiment

TREATMENT	NET BENEFIT ($/HA)	COSTS THAT VARY ($/HA)
Without control	450	0
Birlane 1 X	475	30
Birlane 2 X	480	45
Birlane + Furadan	460	42

Cont'n. Exercise No. 10

c) Verification Trial

	TREATMENT	NET BENEFIT ($/HA)	COSTS THAT VARY ($/HA)
1)	Farmer practice	350	50
2)	(1) + new variety	320	58
3)	(1) + chemical weed control	380	35
4)	(2) + chemical weed control	375	43
5)	(3) + fertilizer	450	135
6)	(4) + fertilizer	440	143

SECTION 11) PARTIAL BUDGETS AND FIXED COSTS

In section (5) it was asserted that the results of economic analysis using partial budgets would be identical whether or not "fixed costs" (costs that do not vary due to treatments) were included in the analysis. Many researchers find this difficult to believe -- that so many costs can be safely ignored in economic analysis.

The following exercise demonstrates that marginal rates of return to investment capital do not change when fixed costs are excluded from economic analysis using partial budgets.

Exercise No. 11 - Partial Budgets and Fixed Costs

To demonstrate the value of partial budgets, perform dominance analysis and marginal analysis on the following two data sets. Data set 1 includes only those costs that vary due to treatment changes. Data set 2 also includes some fixed costs. Yields and gross benefits are identical for both data sets.

DATA SET 1 N x P EXPERIMENT

VARIABLE	TREATMENT			
	N0 P0	N0P40	N50P0	N50P40
Yields (kg/ha)	2000	2100	2500	2600
Adjusted yield[1/] (kg/ha)				
Gross Benefits[2/] ($/ha)				
Cost of N[3/] ($/ha)	0	0	350	350
Cost of P[3/] ($/ha)	0	300	0	300
Application cost ($/ha)	0	150	150	150
Total - TVC ($/ha)				
Net Benefits ($/ha)				

1/ 20% adjustment

2/ Field price of maize = $ 3.50/kg

3/ Transport cost already included

Cont'd. Exercise No. 11

DATA SET 2 - N x P EXPERIMENT

VARIABLE	TREATMENT			
	N0 P0	N0P40	N50P0	N50P40
Yields (kg/ha)	2000	2100	2500	2600
Adjusted Yield[1/] (kg/ha)				
Gross Benefits[2/] ($/ha)				
Tillage Cost ($/ha)	1200	1200	1200	1200
Planting Cost ($/ha)	400	400	400	400
Cost of Seed ($/ha)	75	75	75	75
Weeding Cost ($/ha)	1600	1600	1600	1600
Cost of N[3/] ($/ha)	0	0	350	350
Cost of P[3/] ($/ha)	0	300	0	300
Application Cost ($/ha)	0	150	150	150
Total - TVC ($/ha)				
Net Benefits ($/ha)				

1/ 20% adjustment

2/ Field Price of Maize = $ 3.50/kg

3/ Transport cost already included

SECTION 12) ECONOMIC ANALYSIS OF VERIFICATION TRIALS

As improved production practices are developed through on-farm research, a need arises to measure the consistency with which those improved practices prove to be economically superior to the current farmer practice. This measurement is performed via "verification trials" in which the farmer practice is compared with the improved practice in many locations, within a recommendation domain. The economic analysis of verification trials is crucial, profitability and risk being the major criteria for comparison. Put bluntly, if economic analysis of verifications is not performed, it is probably not worth while to plant them.

Verification trials present special problems for economic analysis. It is usual to find many factors changing simultaneously, as one moves from one treatment to another. Specification of "costs that vary" must be conducted very carefully to insure that all costs that vary are included.

As with other experiments, economic analysis of verification trials is best performed on the average yields (over many experiments) for each treatment, within a given recommendation domain.

Exercise No. 12 - Verifications

Perform an economic analysis of the following set of verification trials for recommendation domain two. Include marginal analysis and the net benefit curve. What is the proper recommendation for RD 2?

RECOMMENDATION DOMAIN	EXPERIMENT NUMBER	TREATMENT YIELDS (KG/HA) 1	2	3	4	5	6
1	1	1200	1150	1500	1510	2000	2000
2	2	900	910	1100	1000	1500	1400
2	3	700	500	900	700	1100	1100
1	4	1500	1550	2100	2150	2460	2600
2	5	1500	1700	2100	2300	2700	2800
2	6	1400	1350	1800	1900	2550	2600

TREATMENTS:

1) Criollo Seed
   Density = (12 kg/ha seed)
   No fertilizer
   No insecticide
   Conventional tillage and weed control

2) Same as (1) but with improved seed

3) Criollo Seed
   Density = (12 kg/ha seed)
   No fertilizer
   No insecticide
   Zero tillage with chemical weed control

Cont'd. Exercise No. 12

4) Same as (3) but with improved seed

5) Criollo Seed

Density = (20 kg/ha seed)

50 kg/ha N

Birlane applied once

Zero tillage with chemical weed control

6) Same as (5) but with improved seed

DATA:

-	Yield adjustment	=	20%
-	Farm Gate Price of Maize	=	$ 6.50/kg
-	Harvesting Cost	=	$ 1.50/kg
-	Shelling Cost	=	$ 0.30/kg
-	Transport Cost (field to location of maize sale)	=	$ 0.60/kg
-	Transport Cost (store to field)	=	$ 0.40/kg
-	Criollo Seed	=	$ 7.00/kg
-	Improved Seed	=	$ 25.00/kg
-	Increased Planting Cost (due to density increase)	=	1 man-day/ha
-	Increased Harvesting Cost (due density increase)	=	0
-	Conventional Tillage Cost	=	$ 1400/ha
-	Conventional Weed Control Cost	=	$ 800/ha
-	Zero Tillage Uses:		
	2.5 lt/ha Gramoxone at	=	$ 300/lt
	3.0 kg/ha Gesaprim 50 at	=	$ 240/kg
-	Sprayer Rental	=	$ 50/ha
-	Herbicide application takes		4 man-days

Cont'd. Exercise No. 12

- Hauling water for herbicide application takes		2 man-days
- Wage	=	$ 150/day
- Birlane treatment uses 12 kg/ha Birlane at	=	$ 32/kg
- Urea (at store) costs	=	$ 4.20/kg
- N application takes		2 man-days/ha
- Cost of capital	=	55%
- Birlane application takes		1 man-day/ha

SECTION 13) MINIMUM RETURNS ANALYSIS

Farmers normally wish to earn more income -- but will often insist that this increased income be accompanied by a reasonably low level of risk. Perrin et al note that "farmers want to avoid the possibility of occasional high losses as they seek higher average net benefits" (p 20). These "occasional high losses" can be attributed to yield variability and price variability.

"Minimum returns analysis" is used to look at the effects of yield variability on net benefits, especially the effects of "disaster". This analysis merely entails the examination of the net benefits for each treatment for the worst cases.

Consider a set of ten identical experiments conducted in one recommendation domain. Marginal analysis leads to the selection of one of the treatments as a farmer recommendation. However, researchers should compare the net benefits earned with this treatment in the two or three worst cases (roughly 20% of the total number of experiments) with the net benefits earned by alternative treatments in these worst cases. If the recommended treatment demonstrates "worst-case" net benefits that are much lower than those of some reasonable alternative, researchers may wish to re-consider their recommendation.

For minimum returns analysis to be valid, all experiments of a given kind that are planted in a given domain (except those lost to researcher mismanagement) should be included in the analysis. Specifically, those experiments that are due to natural causes (flooding, drought, etc.) that farmers must face must be included in minimum returns analysis. Otherwise, the riskiness of selected treatments will be under-estimated.

Minimum returns analysis is especially important for experiments with high cost treatments in areas of substantial yield variability.

Exercise No. 13 - Minimum Returns Analysis

Conduct a minimum returns analysis and a marginal analysis on the following data. If cost of capital = 40%, what is the recommendation if we do not consider risk? Might this recommendation be re-considered due to yield variability? Why?

Net Benefits by Site, Nitrogen Experiments in RD= 1

SITE	TREATMENT			
	N0	N50	N100	N150
	($/HA)			
1	2000	3000	1200	- 1000
2	5000	7500	10000	10500
3	3000	6500	8000	8100
4	4000	5000	2000	3000
5	4500	7000	9000	10000
6	2500	4000	1000	- 500
7	5000	8000	11640	13700
8	6000	7000	9000	9000
Average net benefits	4000	6000	6480	6600
TCV	0	1000	2000	3000

SECTION 14) SENSITIVITY ANALYSIS

As noted in the previous section, farmers face two primary sources of risk: yield variability and price variability. The effects of yield variability are examined through minimum returns analysis. The effects of price variability are examined through "sensitivity analysis".

At times, researchers have difficulty estimating some input or product prices. In these cases, the researcher can examine the stability of his recommendation by conducting the economic analysis twice: once using a high (but likely) price and once using a low (but likely) price. Similarly, researchers can study the effect of input subsidies or recommendations by constructing budgets with and without the subsidy.

A stable recommendation (one that does not change given likely price variability) can be extended with much more confidence than an unstable one. If a recommendation is not stable, farmers must be given more information on needed adjustments in technology as prices change.

Exercise No. 14 - Sensitivity Analysis

Perform, with the following data, marginal analysis of the tillage and weed control experiments for recommendation domain No. 1. First, use the subsidized price, then use the non-subsidized price for herbicides. Which is the correct recommendation for the farmers at present, given subsidies? Which would be the effect on recommendations if the herbicide subsidy were removed (ignore the possible effect on the maize price)?

RECOMMENDATION DOMAIN	EXPERIMENT NUMBER	YIELDS BY TREATMENTS (KG/HA) FARMERS PRACTICE	ZERO TILLAGE 1	ZERO TILLAGE 2
1	1	2000	1900	2400
1	2	1800	2100	2200
2	3	1200	1400	1500
2	4	1000	1300	1700
1	5	2200	2300	2600

DATA:

Cost of capital	=	40%
Yield adjustment	=	20%
Maize field price	=	$ 5.00/kg
Farmer practice cost	=	$ 2000/ha
Machete chopping, zero till 1 and 2	=	4 man-days/ha
Herbicide application	=	2 man-days/ha
Hauling water for herbicide applic.	=	2 man-days/ha
Wage	=	$ 120/day

Cont'n Exercise No. 14

Gramoxone (subsidized price)	=	$ 250/lt
Gramoxone (non-subsidized price)	=	$ 360/lt
Gesaprim 50 (subsidized price)	=	$ 200/kg
Gesaprim 50 (non-subsidized price)	=	$ 340/kg
Sprayer rental	=	$ 50/ha
Farmer practice	=	Land preparation with animal traction, one weeding with hoe
Zero tillage 1	=	Machete chopping followed by 1.0 lt/ha of Gramoxone and 2.0 kg/ha of Gesaprim 50
Zero tillage 2	=	Machete chopping followed by 2.5 lt/ha of Gramoxone and 3.0 kg/ha of Gesaprim 50

SECTION 15) COMBINING STATISTICAL AND ECONOMIC ANALYSIS: 2 FACTORIAL EXPERIMENTS

The 2^4 experiment has become increasingly popular in on-farm agronomic experimentation, in part due to the efforts of CIMMYT's maize training program. This experiment is used to examine main effects and interactions for four different factors, each of which is set at two levels. If the two levels for each factor are respectively set at the farmer's level and at a high, non-limiting level, the experiment is useful in identifying those factors that limit crop yield. If the levels are respectively set at the farmer's level and at a higher level that appears to be possible for target farmers, the experiment can also serve as a basis for formulating recommendations for farmers.

However, the very characteristic that makes this experiment useful -- the simultaneous testing of multiple factors -- creates complications in the economic analysis of results. The major complication is that not all treatments in a given experiment are necessarily included in the partial budget used in economic analysis. Sometimes data from individual treatments are used in analysis; at other times averages for main effects are used, depending on the results of statistical analysis.

In the partial budgeting, increased "costs that vary" are compared with increased "net benefits" to calculate a "marginal rate of return". Clearly, the analysis assumes that net benefits and gross benefits are calculated on the basis of yield changes that really exist, and that are really due to treatment effects, i.e., not due to random variation. If yield changes do not exist (or are not due to treatment effects), then the procedures for partial budgets do not entirely apply. In the absence of yield changes (and hence, in the absence of change in gross benefits) preference is normally given to the least-cost treatment.[1/]

1/ This follows classical statistics in guarding against accepting a difference that does not exist. At times, however, it may be less costly to do the reverse: guard against rejecting a difference that does exist.

Whether or not yield changes really exist is determined by statistical analysis. Perrin et al, (p.4) however note two cautions.

"Most statistical tests are geared to the 0.05 or 0.01 levels of significance. But farmers may be willing to accept evidence that is much less persuasive than this. For instance if variety A yields 3 tons in an experiment, while variety B yields 4 tons, farmers may be quite happy to choose variety B even though this difference is statistically significant at, say only the 0.10 level.

Furthermore, it is quite possible that two treatment means are not significantly different at any of five trial sites, but the treatment means are different at the 0.01 level of significance when the data are pooled. Because of these considerations, we suggest that both statistical and economic analysis be conducted. If only one experiment is available, little can be said of the desirability of the treatment for farmers in the area, unless the results are overwhelming. When several experiments are available (from different sites or year or both), a statistical analysis of the pooled data should be conducted. The analysis of variance should include treatments, sites, and site-by-treatment interaction as sources of variation".

The above two points refer to ways in which the search for "significance" may be facilitated. Nonetheless, research programs frequently find themselves forced to analyze one or few experiments, to focus future experimental work and/or make preliminary farmer recommendations. Such is the case when research is begun in a new study area. In these cases, "significance" may be elusive for some factors. Even in those cases where researchers have access to several cycles of data, not even pooled analysis will lead to "significant" differences between treatment means if none exist in the universe under study.

Researchers must be ready, then, to deal with situations in which some factors demonstrate "significant" differences between treatment means while other factors do not. This possibility creates special complications in such multiple-factor experiments as 2^4 factorials.

In the procedures and examples used by Perrin et al, experimental treatments are analyzed one by one. In the case of the 2^4 factorials, each of the sixteen treatments included in a given experiment would be analyzed: net benefits calculated, dominated treatments excluded, etc. This treatment by treatment analysis of 2^4 factorials is complex due to the large number of treatments included in the budgets, and can be misleading due to the relative difficulty of combining statistical and economic results.

An alternative to a treatment by treatment approach to economic analysis is to pool data, using yield averages for main effects. Further disaggreagation would only be needed in the presence of significant interactions. Thus, instead of a single budget with 16 treatments, there may be several budgets, each with two or possibly four treatments. The exact form of the budgets, however, depends on the results of statistical analysis.

15.1) Case I - No Significance

At times, statistical analysis indicates that there is no significant difference in yields for either main factors or interactions. As noted, the required level of significance is up to the researcher and may range from the .01 level (large cost increase with a marginal rate of return just above the cost of capital) to the .20 level (small cost change with an excellent MRR). In this case, there is no need to use partial budget analysis because yields (and therefore gross benefits) are the same for all treatments. A comparison of costs is all that is needed to select a recommendation: the least-cost treatment. This may be performed on a factor by factor basis.

15.2) <u>Case II - Some Main Effects Significant - No Significant Interactions</u>

Normally, some of the factors in a 2^4 experiment will demonstrate significant yield differences between the selected levels. This is especially the case when the selected factors are serious limitations to increased production by representative farmers, when the two levels for each factor are set "far apart", and when the experiment is reasonably precise.

When some main effects are significant -- but there are no significant interactions -- it is possible to conduct economic analysis by means of separate budgets for each significant factor. (Factors without significant yield differences between the two chosen levels are treated as in section 15.1 -- the least-cost level is chosen for each such factor.)

15.3) <u>Case III - Some Main Effects and Some Interactions Significant</u>

When some main effects and some interactions are significant, the factor-by-factor approach discussed in Section 15.2 is no longer valid. Nonetheless, it is not necessary to return to the long, complicated treatment-by-treatment approach. A middle ground does exist, in which budgets are constructed for significant main factors <u>and</u> factors with which a significant interaction exists. (In the same experiment if a main factor is <u>not</u> significant and does <u>not</u> interact with other factors, choose the least-cost treatment. If a main factor <u>is</u> significant but does <u>not</u> interact with other factors, construct a budget with two treatments).

The 2^4 factorial experiment has become more popular in on-farm agronomic research, but the economic analysis of these experiments is somewhat complicated. The purpose of this section was to describe a method of economic analysis that focuses on factors, not on individual treatments, and that uses the result of statistical analysis to help plan economic analysis.

Exercise No. 15 Combining Economic and Statistical Analysis - 2^4 Factorials

Using the following data analyze the 2^4 experiment in the simplest way using the statistical analysis to plan the economic analysis. For simplicity, use the .05 level of significance ($F > 4.60$).

STATISTICAL ANALYSIS

SOURCE OF VARIATION 1/	OBSERVED F 2/
A	135.27
B	0.44
C	1.61
D	0.29
AB	4.84
AC	1.04
AD	2.30
BC	0.29
BD	0.02
CD	2.43
ABC	2.18
ABD	1.40
ACD	0.11
BCD	0.33

1/

A0 = 0 N		A1 =	100 kg/ha N
B0 = 0 P		B1 =	80 kg/ha P
C0 = 0 Boron		C1 =	1 kg/ha Boron
D0 = 0 Zinc		D1 =	2 kg/ha Zinc

2/ Tabular F for 0.05 significance level 4.60

Cont'd. Exercise No. 15

DATA:

Cost of capital	=	50%
Yield adjustment	=	20%
Maize Field Price	=	$ 10.00/qq
Urea Price	=	$ 34.00/qq
TSP	=	$ 39.00/qq
Hauling of fertilizer	=	$ 3.00/qq
Fertilizer application	=	1 man-day/ha
Wage	=	$ 6.00/day
1 qq	=	45 kg

YIELDS

A B C D	
0 0 0 0	2.03
1 0 0 0	3.66
0 1 0 0	2.48
1 1 0 0	3.68
0 0 1 0	1.98
1 0 1 0	3.30
0 1 1 0	1.52
1 1 1 0	3.69
0 0 0 1	2.42
1 0 0 1	3.20
0 1 0 1	2.13
1 1 0 1	3.61
0 0 1 1	2.41
1 0 1 1	3.28
0 1 1 1	2.05
1 1 1 1	3.77

SECTION 16) PARTIAL BUDGETS FOR PLANNING EXPERIMENTS

The previous sections have focused on the use of partial budgets for the economic analysis of experimental data. These budgeting concepts can also be used, however, in the planning of experiments.

Researchers should use several criteria in the selection of experimental treatments, when the purpose of the research is the formulation of near-term recommendations useful to farmers. Specifically, high priority should be given to experimented treatments that researchers expect to be profitable, not too risky, and that mesh well with the current farming system (e.g. cropping calendar, labor supply, cash flow, consumption needs, etc.).

An estimate of the likely profitability of a treatment may be obtained by calculating the minimum yield increase needed to pay the increment in cost that is incurred. Agronomists can then assess (through intuition or judgement) the likelihood of obtaining this minimum required response.

Consider, for example, a case where weeds are limiting maize production. Farmers currently control weeds through horse cultivation but researchers are considering chemical weed control as an alternative. The increment in costs that vary (when changing from horse cultivation to chemical weed control) is \$500/ha. Is this change likely to be profitable?

The minimum yield increase needed to pay the increment in costs may by found as follows:

$$\Delta Y = \frac{\Delta TCV \times (1 + C)}{P}$$

where ΔY = minimum required yield increase, per ha

ΔTCV = increment in costs that vary, per ha

C = cost of capital (%)

P = field price of product

with a cost of capital of 40% and a maize field price of $ 2.00/kg, the minimum required yield increase for our example is:

$$\Delta Y = \frac{500 \times 1.4}{2} = 350 \text{ kg/ha}$$

Agronomists consider a 600 kg/ha yield increase to be likely (averaging over good and bad crop cycles), so chemical weed control emerges as a priority practice for on-farm testing, at least from the viewpoint of expected profitability. (Note that it still be screened, however, for riskiness and consistency with the farming system).

Exercise No. 16 - Partial Budgets for Planning Experiments

Researchers in one recommendation domain conclude that N deficiency is a major limiting factor in the maize crop. They feel that 150 kg/ha N would overcome this deficiency, and would lead to a yield increase of one ton/ha. Is this level likely to be profitable for local farmers? (If not, researchers might wish to set N treatment levels a bit lower).

DATA:

Fertilizer application	$ 100/ha
Price of urea (in the store)	$ 7.00/kg
Transport of urea (store to field)	$ 3.00/kg
Cost of capital	60%
Maize sales price	$ 3.00/kg
Shelling cost	$ 0.20/kg
Harvesting cost	$ 0.70
Transport (for maize, from field to place of sale)	$ 0.30/kg

ANSWERS TO EXERCISES

Exercise No. 1 - Field Price of Maize

a)

Sales price	=	\$ 5.50/kg
Harvest cost	=	\$ 0.40/kg
Shelling cost	=	\$ 0.60/kg
Transport cost	=	\$ 0.20/kg
Field price	=	\$ 4.30/kg

b)

Sales price	=	L 15.00/qq
Harvest cost	=	L 1.20/qq
Shelling cost	=	L 1.40/qq
Transport cost	=	L 0.63/qq
Field price	=	L 11.77/qq
	or	L 0.26/kg

Exercise No. 2 - Gross Field Benefits

VARIABLE	TREATMENT								
	NO D25	NO D50	NO D75	N50 D25	N50 D50	N50 D75	N100 D25	N100 D50	N100 D75
Average Yield (kg/ha)	1360	1040	940	1070	1180	1200	1180	860	910
Adjusted Yield[1/] (kg/ha)	1088	832	752	856	944	960	944	688	728
Gross Field Benefit[2/] ($/ha)	4570	3494	3158	3595	3965	4032	3965	2890	3058

1/ Yield adjustment = 20%

2/ Field price of maize = $ 4.2/kg

Exercise No. 3 - Adjusting for Lost Sites

Variable	TREATMENT Manual Control	Gesaprim	Prow	2,4D
Yield 1 (Kg/ha)	2500	2800	3100	2600
Yield 2 (Kg/ha)	2000	2500	2600	2200
Yield 3 (Kg/ha)	2700	3500	3700	2900
Yield 4 (abandoned) (Kg/ha)	500	500	500	500
Average yield (Kg/ha)	1925	2325	2475	2050
Adjusted yield[1/] (Kg/ha)	1636	1976	2104	1742
Gross Field Benefits (B/ha)	2454	2964	3156	2614

Field price of maize = B 1.50/Kg.

[1/] Yield adjustment = 15%

Excercise No. 4 - Value of By-Products

Variable	TREATMENT			
	N0	N50	N100	N150
Grain yield (Kg/ha)	1500	3100	2400	2500
Straw yield (Kg/ha)	1800	2520	2880	3000
Adjusted grain yield[1/] (Kg/ha)	1275	1785	2040	2125
Adjusted straw yield[2/] (Kg/ha)	1620	2268	2592	2700
Gross field benefit-wheat ($/ha)	4463	6248	7140	7438
Gross field benefit-straw ($/ha)	437	612	700	729
Total gross field benefit ($/ha)	4900	6860	7840	8167

1/ 15% adjustment

2/ 10% adjustment

Field price of wheat = $3.50/kg.

Field price of straw = $0.27/kg.

-

Exercise No. 5 - Net Benefits

VARIABLE	TREATMENT NO CONTROL	BIRLANE 1X	BIRLANE 2X	BIRLANE + FURADAN
Average yield (kg/ha)	2717	2635	2917	3233
Adjusted yield 1/ (kg/ha)	2174	2108	2334	2586
Gross Benefits 2/ (L/ha)	502	485	537	595
Insecticide cost (L/ha)	0	13.6	27.2	30.8
Application Cost (L/ha)	0	6.0	12.0	9.0
TCV (L/ha)	0	19.6	39.2	39.8
Net Benefits (L/ha)	498	465	498	555

1/ Yield adjustment = 20%

2/ Field Price of Maize = L 0.23/kg

Exercise No. 6 - Field Price of Fertilizer

$$N \text{ field price} = \frac{4.8 + 3.0}{.335} = \$\ 23.3/kg$$

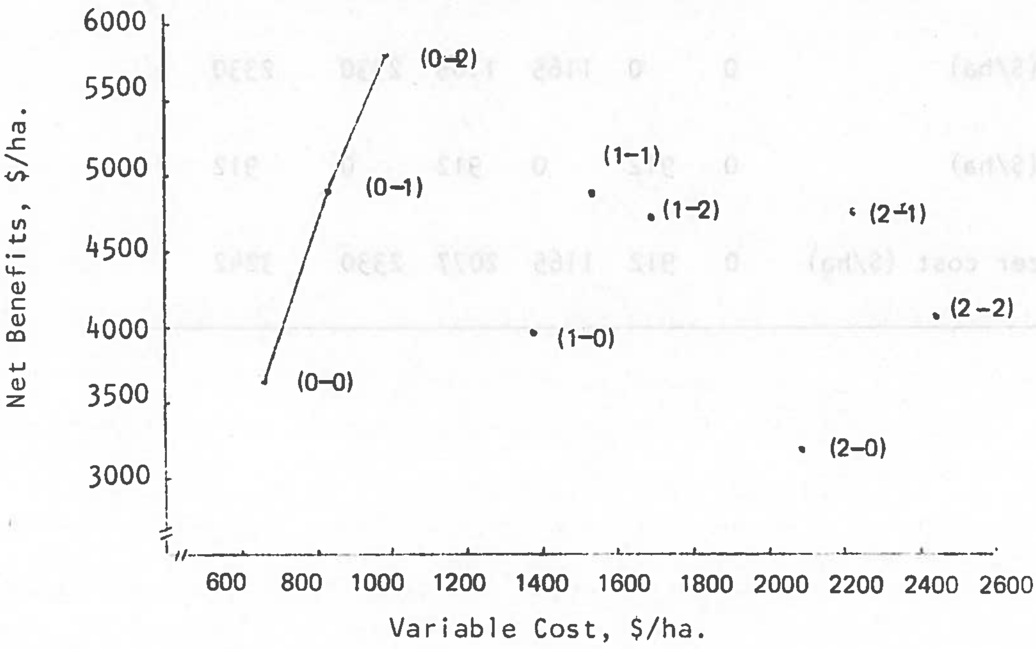
$$P \text{ field price} = \frac{7.5 + 3.0}{.46} = \$\ 22.8/kg$$

VARIABLE	TREATMENT					
	N0 P0	N0 P40	N50 P0	N50 P40	N100 P0	N100 P40
N cost ($/ha)	0	0	1165	1165	2330	2330
P cost ($/ha)	0	912	0	912	0	912
Fertilizer cost ($/ha)	0	912	1165	2077	2330	3242

Exercise no. 7 - Dominance Analysis and the Net Benefit Curve

TREATMENT	NET BENEFIT ($/HA)	TCV ($/HA)	
NO DO	3670	670	
NO D1	4963	830	
NO D2	5870	990	
N1 DO	3984	1373	D
N1 D1	4877	1533	D
N1 D2	4717	1693	D
N2 DO	3174	2074	D
N2 D1	4758	2234	D
N2 D2	4075	2444	D

All treatments marked "D" are dominated, in this example by a single treatment (NO D2).



Exercise No. 8 - Marginal Rate of Return

VARIABLE	TREATMENTS			
	N0	N50	N100	N150
Average yield-RD1 (kg/ha)	1140	2012	2340	2450
Adjusted yield[1/] (kg/ha)	969	1710	1989	2083
Gross benefits[2/] ($/ha)	4118	7268	8453	8850
Cost of N[3/] ($/ha)	0	468	935	1403
Application cost ($/ha)	0	300	300	300
TCV ($/ha)	0	768	1235	1703
Net Benefits ($/ha)	4118	6500	7218	7148

1/ Yield adjustment = 15%

2/ Maize field price = $ 4.25/kg

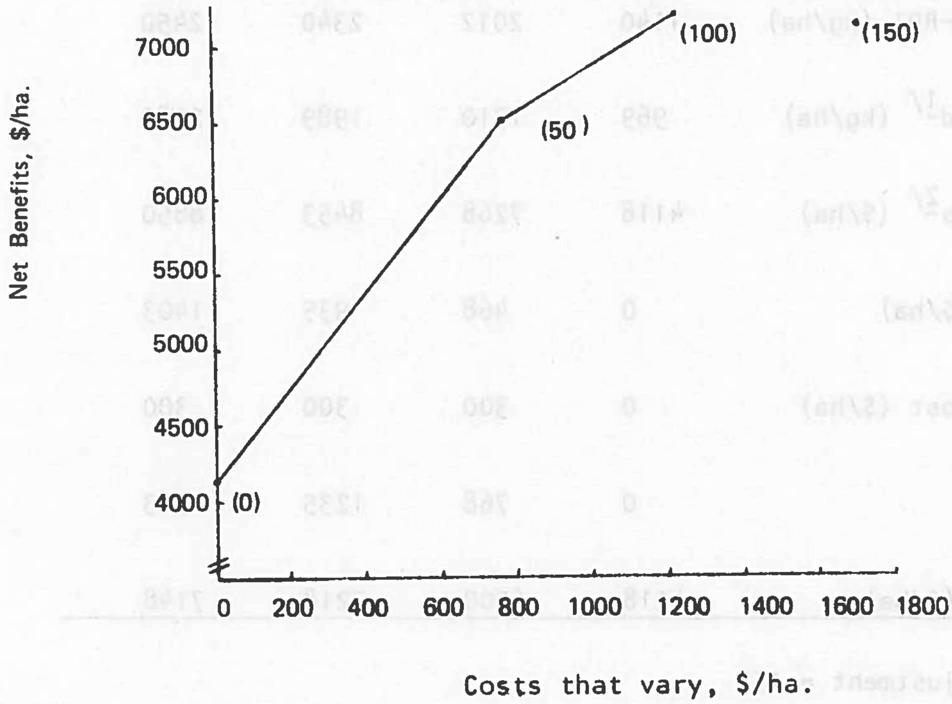
3/ Field price of N = $ 7.35/kg

MARGINAL ANALYSIS:

N150 is dominated

$$\text{MRR N0} \rightarrow \text{N50} = \frac{6500 - 4118}{768 - 0} \times 100 = 310\%$$

$$\text{MRR N50} \rightarrow \text{N100} = \frac{7218 - 6500}{1235 - 768} \times 100 = 154\%$$


Net Benefits, $/ha.
7000
6500
6000
5500
5000
4500
4000
(0)
(50)
(100)
(150)
0
200
400
600
800
1000
1200
1400
1600
1800
Costs that vary, $/ha.

Exercise No. 9- Cost of Capital

a) $3000 borrowed
x .20 annual interest rate
$600 annual interest charge

$$\$600 \times \frac{8}{12} = \$400 \text{ interest charge - 8 month loan}$$

60 service charge
\+ 140 personal expenses
90 crop insurance
$690 total expenses re loan

$$\frac{\$690}{\$3000} = 23\%$$ cost of borrowed capital
20% "risk premium"
43% cost of capital (minimum required rate of return)

b) $2000 borrowed
x .10 monthly interest rate
$200 monthly interest charge
x 7 months
$1400 interest charge - 7 month loan

$$\frac{\$1400}{\$2000} = 70\%$$ cost of borrowed capital
\+ 20% "risk premium"
90% cost of capital (minimum required rate of return)

Exercise No. 10 - Recommendations and the MRR

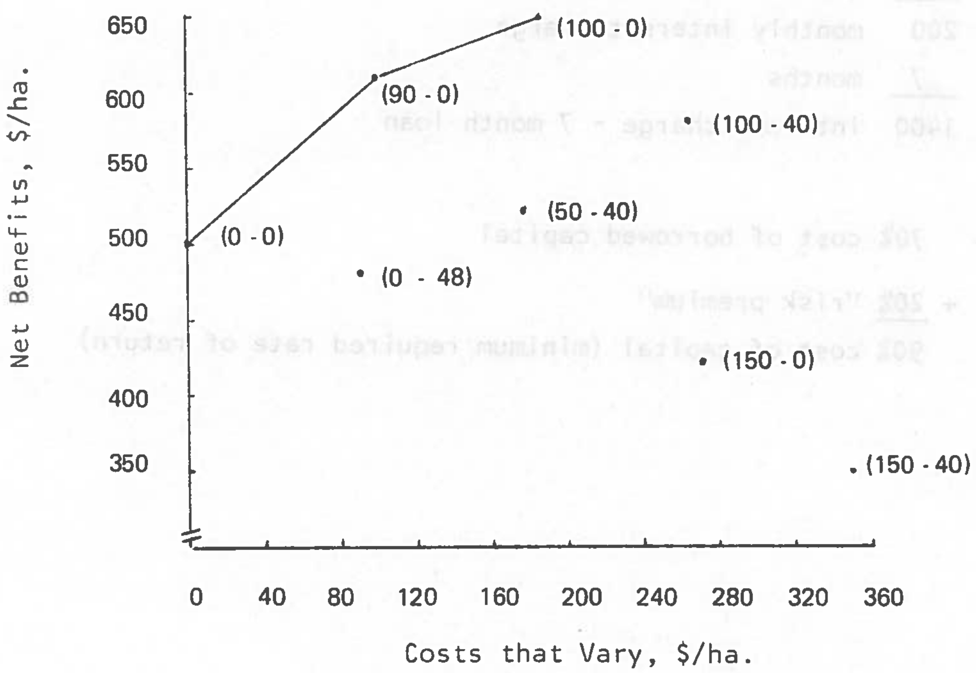
a) N x P Experiment

Dominated treatments:

N0P40, N50P40, N100P40, N150P0, N150P40

TREATMENT CHANGE	INCREMENT NET BENEFIT	INCREMENT TCV	MRR
N0P0 → N50P0	110	99	111%
N50P0 → N100P0	40	87	46%

If the cost of capital = 30%, recommend N100P0. If the cost of capital = 60%, recommend N50P0.

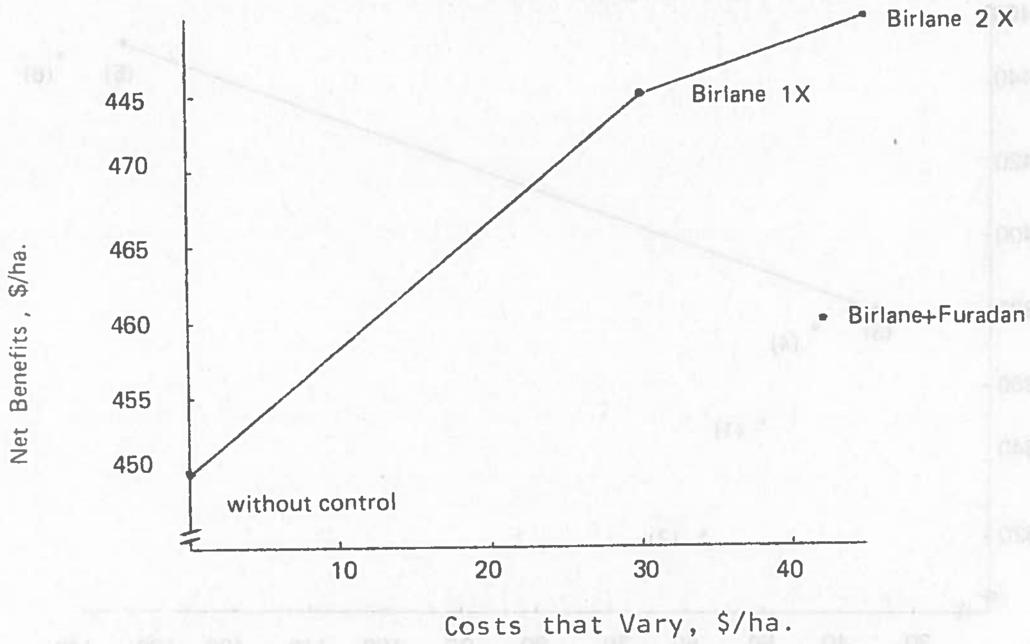


b) Insect Control Experiment

Dominated treatment: Birlane + Furadan

TREATMENT CHANGE	INCREMENT NET BENEFIT	INCREMENT TCV	MRR
No Control → Birlane 1X	25	30	83%
Birlane 1X → Birlane 2X	5	15	33%

If the cost of capital = 30%, recommend Birlane 2X. If the cost of capital = 60%, recommend Birlane 1X

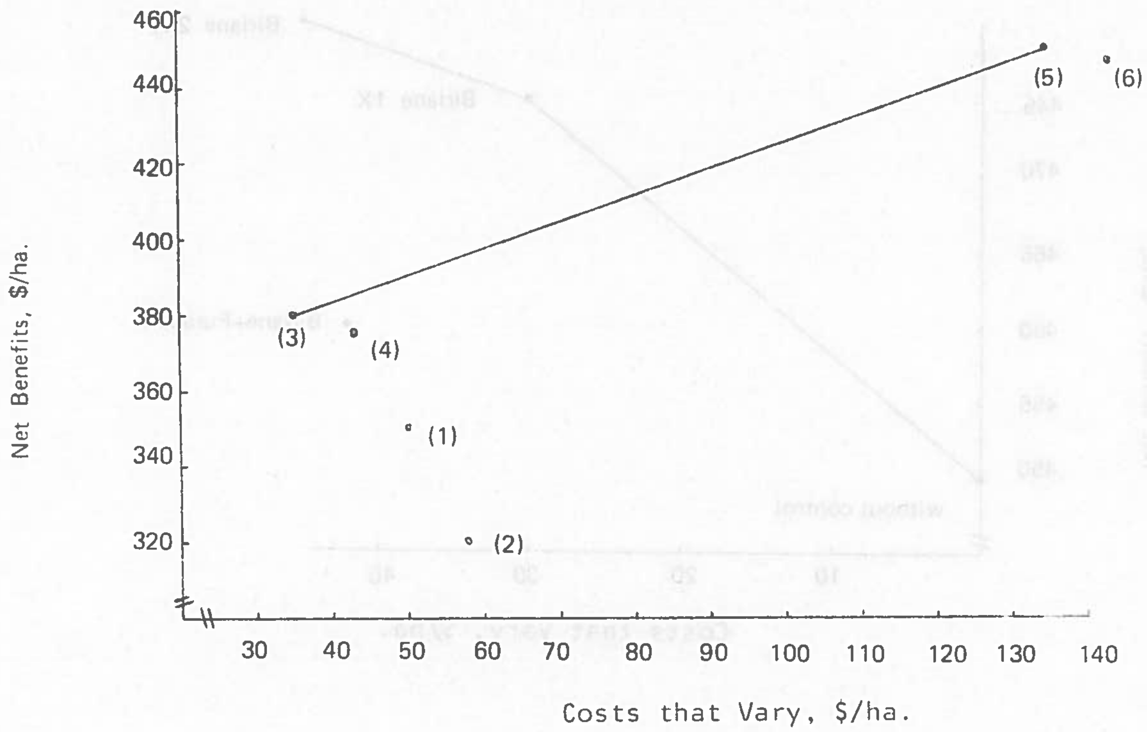


c) <u>Verification Trial</u>

Dominated treatments: 1, 2, 4, 6

TREATMENT CHANGE	INCREMENT NET BENEFIT	INCREMENT TCV	MRR
3 → 5	70	100	70%

If the cost of capital = 30% or 60%, recommend treatment (5).



Exercise No. 11 - Partial Budgets and Fixed Costs

VARIABLE	NOPO	NOP40	N50PO	N50P40
Data Set 1				
Yield (kg/ha)	2000	2100	2500	2600
Gross Benefits ($/ha)	5600	5880	7000	7280
TCV ($/HA)	0	450	500	800
Net Benefits ($/HA)	5600	5430	6500	6480
Data Set 2				
Yield (kg/ha)	2000	2100	2500	2600
Gross Benefits ($/ha)	5600	5880	7000	7280
TCV ($/ha)	3275	3725	3775	4075
Net Benefits ($/Ha)	2325	2155	3225	3205

(Columns NOPO, NOP40, N50PO, N50P40 are under the heading T R E A T M E N T.)

For both data sets:

NOP40 and N50P40 are dominated

TREATMENT CHANGE	INCREMENT NET BENEFITS	INCREMENT TCV	MRR
NOPO → N50PO	900	500	180%

Exercise No. 12 - Verification

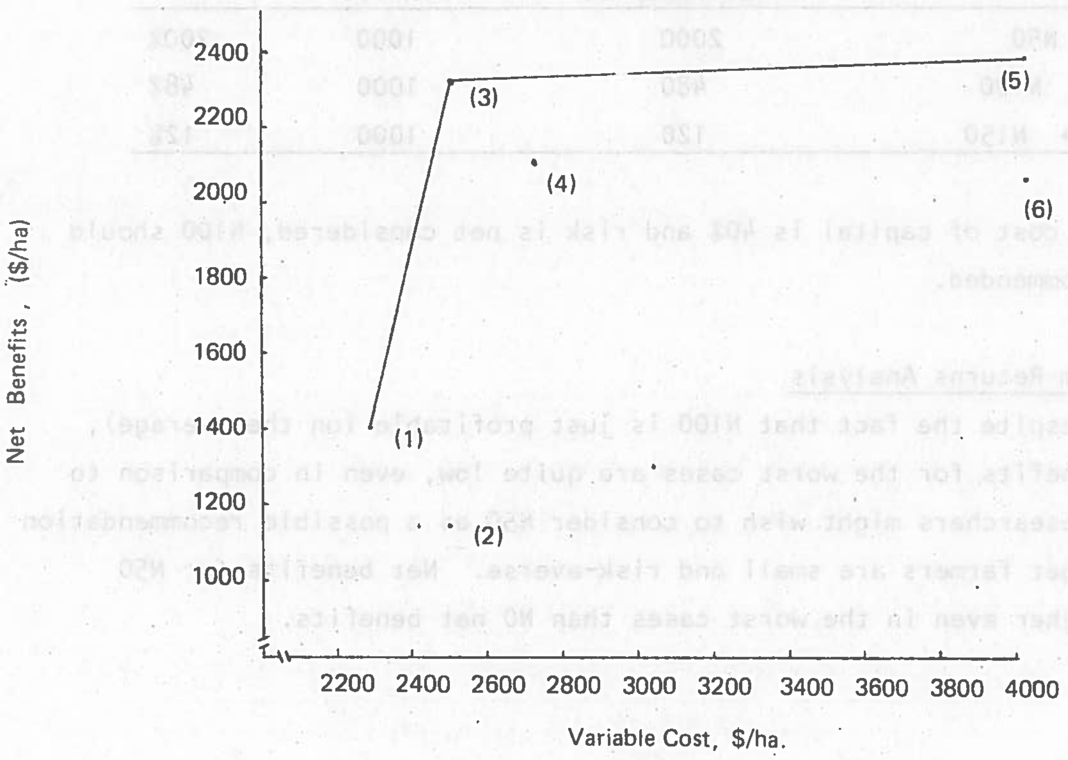
VARIABLE	TREATMENT 1	2	3	4	5	6
Average yield-RD2 (kg/ha)	1125	1115	1475	1475	1963	1975
Adjusted yield (kg/ha)	900	892	1180	1180	1570	1580
Gross benefits ($/ha)	3690	3657	4838	4838	6439	6478
Local seed ($/ha)	84	0	84	0	140	0
Improved seed ($/ha)	0	300	0	300	0	500
Increased planting ($/ha)	0	0	0	0	150	150
Conventional tillage and weed control ($/ha)	2200	2200	0	0	0	0
Gramoxone ($/ha)	0	0	750	750	750	750
Gesaprim 50 ($/ha)	0	0	720	720	720	720
Sprayer rental ($/ha)	0	0	50	50	50	50
Herbicide application and hauling water ($/ha)	0	0	900	900	900	900
Insecticides ($/ha)	0	0	0	0	384	384
Insecticide application ($/ha)	0	0	0	0	150	150
N ($/ha)	0	0	0	0	500	500
N Application ($/ha)	0	0	0	0	300	300
TCV ($/ha)	2284	2500	2504	2720	4044	4044
Net benefit ($/ha)	1406	1157	2334	2118	2395	2434

Dominated Treatments: 2, 4, and 6

Marginal analysis:

TREATMENT CHANGE	INCREMENT IN NET BENEFITS	INCREMENT IN TCV	MRR
1 → 3	928	220	422%
3 → 5	61	1540	4%

If cost of capital = 55%, treatment 3 should be recommended. (The only profitable change is from conventional to chemical tillage and weed control).



Net Benefits, ($/ha)
2400
2200
2000
1800
1600
1400
1200
1000
(1)
(2)
(3)
(4)
(5)
(6)
2200 2400 2600 2800 3000 3200 3400 3600 3800 4000
Variable Cost, $/ha.

Exercise No. 13 - Minimum Returns Analysis

	TREATMENT			
VARIABLE	NO	N50	N100	N150
TCV	0	1000	2000	3000
Net benefits (average)	4000	6000	6480	6600
Net benefits (average of two worst cases)	2250	3500	1100	- 500

Dominated Treatment: None

Marginal Analysis (risk not considered)

TREATMENT CHANGE	INCREMENT IN NET BENEFITS	INCREMENT IN TCV	MRR
NO → N50	2000	1000	200%
N50 → N100	480	1000	48%
N100 → N150	120	1000	12%

If the cost of capital is 40% and risk is not considered, N100 should be recommended.

Minimum Returns Analysis

Despite the fact that N100 is just profitable (on the average), net benefits for the worst cases'are quite low, even in comparison to NO. Researchers might wish to consider N50 as a possible recommendation if target farmers are small and risk-averse. Net benefits for N50 are higher even in the worst cases than NO net benefits.

Exercise No. 14 - Sensitivity Analysis

VARIABLE	FARMER PRACTICE	ZERO TILL 1 + SUBSIDY	ZERO TILL 1 - SUBSIDY	ZERO TILL 2 + SUBSIDY	ZERO TILL 2 - SUBSIDY
Average yield-RD 1 (kg/ha)	2000	2100	2100	2400	2400
Adjusted yield (kg/ha)	1600	1680	1680	1920	1920
Gross Benefits ($/ha)	8000	8400	8400	9600	9600
Farmer practice ($/ha)	2000	0	0	0	0
Machete chopping ($/ha)	0	480	480	480	480
Herbicide application ($/ha)	0	240	240	240	240
Hauling water ($/ha)	0	240	240	240	240
Sprayer ($/ha)	0	50	50	50	50
Gramoxone ($/ha)	0	250	360	625	900
Gesaprim ($/ha)	0	400	680	600	1020
TCV ($/ha)	2000	1660	2050	2235	2930
Net Benefits ($/ha)	6000	6740	6350	7365	6670

Marginal Analysis:

With the Subsidy on Herbicides

Dominated treatments: Farmer practice

TREATMENT CHANGE	INCREMENT N B	INCREMENT TCV	MRR
Zero till 1 → Zero till 2	625	575	109%

Without the Subsidy on Herbicide:

TREATMENT CHANGE	INCREMENT N B	INCREMENT TCV	MRR
Farmer practice → Z T 1	350	50	700%
Z T 1 → Z T 2	320	880	36%

If the subsidy on herbicides were to be dropped, zero tillage would remain profitable, but farmers should reduce their herbicide dose. Herbicide dose is sensitive to the herbicide subsidy.

Exercise No. 15 - combining Economic and Statistical Analysis - 2^4 Factorial

Factor A: (Significant, and with a significant interaction with factor B).

VARIABLE	A0 B0	A1 B0	A0 B1	A1 B1
	TREATMENT			
Average yield[1/] (kg/ha)	2210	3360	2045	3688
Adjusted yield (kg/ha)	1768	2688	1636	2950
Gross benefits ($/ha)	389	591	360	649
N cost ($/ha)	0	178	0	178
P cost ($/ha)	0	0	162	162
Application ($/ha)	0	6	6	6
TCV ($/ha)	0	184	168	246
Net Benefits ($/ha)	389	407	192	303

1/ The average yield for each noted combination (A0 B0 etc.) is found by averaging the four of sixteen individual treatment yield containing that combination.

Dominated treatments: A0 B1, A1 B1

Marginal Analysis: MRR for A0 B0 → A1 B0 = 10%

Recommendation: A0 B0

Factor B: (Interacts with factor A, included with factor A)

Factor C: (Not significant, no significant interaction, so recommend the least cost level, C0)

Factor D: (Not significant, no significant interaction, so recommend the least cost level: D0)

Recommendation: A0 B0 C0 D0

Exercise No. 16 - Partial Budgets for Planning Experiments

$$\text{Field price of N} = \frac{\$\ 7.00 + \$\ 3.00}{.46} = \$\ 21.74/\text{kg}$$

TCV Increment	=	$ 21.74/kg	N field price
		x 150 kg/ha	N dose
		$ 3261/ha	N cost/ha
	+	100/ha	N application/ha
		$ 3361	Increment TCV

Field price of maize = $ 1.80/kg

$$\Delta Y = \text{minimum yield increase required to pay costs} = \frac{3361 \times 1.6}{1.8} = 2988 \text{ kg/ha}$$

Almost a three ton yield increase is needed to pay treatment costs, but the treatment is only expected to give a one ton increase. This treatment should be re-considered.