Poultry O.S.

THE BENEFITS FROM SUCCESSFUL AUSTRALIAN POULTRY RESEARCH

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CHAPTER 1

INTRODUCTION

Research resources available to agricultural research are scarce and the resources available for poultry production research in particular are scarce. The various agricultural industries therefore compete for scarce research funds. The major source of funds is Government Consolidated Revenue, and the allocation of these funds will increasingly be based on various benefit/cost criteria.

Administrators make quick decisions about the likely benefits from various new and continuing research projects when allocating funds. The time and cost involved in making a benefit/cost analysis of all projects is forbidding. However, some rule of thumb for benefits can be provided: a revenue equation and set of 'ready reckoner tables' allows administrators to quantify the expected monetary benefits from competing projects. This approach values successful projects. Administrators will still have to gauge the likelihood of success.

This bulletin presents a parametric budgeting model which was developed to measure the potential economic benefits of innovations in the poultry industry. Real monetary benefits in relation to real monetary cost can be used to rank various research activities which could be expected to produce the innovations.

The innovations evaluated here are a reduction in laying hen mortality, an increase in hen housed egg production, a decrease in hen housed feed consumption and a reduction in rearing costs. These innovations were budgeted out to show how the cost of producing a dozen eggs can be reduced. The innovations were then valued by varying the parameters, level of acceptance (the percentage of the industry taking up the innovation) and lag in adoption (the number of years to elapse before the industry takes up an innovation). Also the expected life of each innovation was altered to obtain a range of economic benefits for administrators to use when ranking projects.

A detailed description of the model and its place in the poultry industry is given in Chapter 2. This section can be passed over by the reader who is not interested in economic detail. Worked examples of each part of the model and finally of the whole model are provided in Chapter 3. The results are summarized in the tables which follow the text of this bulletin.

CHAPTER 2

METHODOLOGY

The major aim of research conducted by poultry institutions is to increase the productivity in Australian poultry industries by lowering costs of production per unit of output. For example, research into modifying the rearing management of restricted fed pullets in the egg producing industry has achieved the production of more eggs at a lower cost. Consequently the average cost of production has been lowered in the Australian egg producing industry.

Ideally the monetary benefits from research should include external benefits. However, it is not a practical operation. In the analysis below only those measurable benefits accruing to society are considered. Benefits realised by society at large from research (for example, behavioural, biochemical or chemical research) must result in a reduction in the average cost of producing a dozen eggs to be included in the analysis. Thus, the research must affect one of the following: hen housed egg production, hen housed feed consumption, mortality, pullet rearing costs and finally the cost of producing a dozen eggs.

The estimate of monetary benefits is based on the size of the industry and the reduction in the average cost of production per unit of output. The size of benefits depends in part on the level of acceptance of the innovation and the lag in adoption by farmers. One can gauge both the level and the lag in adoption by interviewing extension officers and representatives of farmer organisations, surveying industry opinion and trends; or by conducting a Delphi exercise {8,12} with a small group of experts.

2.1 Model

Estimates of the monetary benefits from research project innovations were provided by the following revenue equation*:

$$EMB = \sum_{t=1}^{n} \frac{P_t (K \cdot P \cdot Q) T_t}{(1 + r)^t}$$

where EMB = estimated monetary benefits;

P_t = probability that the innovation will be available to industry in year t;

K = expected percentage reduction in the average cost of production due to the innovation;

P = equilibrium level of price;

**The revenue equation was based upon work by Duncan {2} and Logan {7}. It was then used as a parametric budgeting model to obtain a range of results {8,9}.*

Q = equilibrium level of quantity (that is, the quantity or expected 'market size' without the influence of the innovation);

T_t = percentage of industry taking up the innovation in year t;

r = rate of interest (the denominator of the equation discounts future benefits to present values);

n = the number of years until the innovation is superseded.

All values were expressed in real terms (constant 1975 prices). Estimates of the per unit reduction in the average cost of production (K) were based on the latest available estimates of prices, yield increases, and cost reductions. Estimates of K were measured at the margin and were assumed to be the same for both infra-marginal and marginal production.*

Simple gross margin budgeting of a representative egg producing enterprise is used for calculating the reduction in cost per dozen eggs. Prices and quantities were average 1975 values. Problems can arise by using these constant values in gross margin budgets. The relationship between gross income and variable costs is assumed to remain the same; their main components being egg prices and feed cost. In reality the relationship may change, for instance the egg price to feed cost ratio may decline and so innovations which might reduce hen housed feed consumption will increase in value relative to other innovations. However, the 1975 value estimates remain fixed over the number of years until the innovation is superseded or through to the year 2000. This step avoids the problem of estimating historical values for these variables given the limits of available data. Further, it is not necessary to predict prices and costs of alternative management strategies.

This approach defines the benefits in real terms, i.e. in constant (1975) prices. The actual benefits accruing in the future will be much higher in money terms mainly due to inflation.

The quantities (Q) of eggs in the Australian market place remains constant (1975 values) for the 1975-2000 time period. There is an adjustable laying hen quota for each farming enterprise aimed at fixing the quantity of eggs entering the market, and also the per capita consumption of eggs is declining slowly, and the population is increasing slowly. As a result, it is reasonable to assume that there is a constant quantity of eggs in the market.

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* *Under conditions of free competition and a perfectly inelastic demand curve, K would equal $(P_1 - P_2)/P_1$, which is equilibrium price before the innovation less the price after the innovation divided by the price before the innovation. In the egg producing case, it is equivalent to a reduction in unit costs divided by the price per unit of output, multiplied by 100 to bring it to percentage terms {8}. It is an advantage to express K in percentage terms as it can be related to prices and quantities in the future, prior to the introduction of the innovation, if the relationship between input costs and output prices remains the same.*

It is assumed the probability that innovations will be available to industry in year t to be 1. Actually there is a multiplicity of probabilities, and administrators must weigh up a number of these when allocating funds, not the least the reputation of the researcher. They will, of course, adjust the results in the light of their experiences.

The innovations were selected because they covered most egg producing functions and applied research project areas; that is they will show up in a gross margin budget. For example, veterinary research into competitive exclusion will bring forth innovations which will lower mortality in laying hens, lower rearing costs or increase hen housed egg production.

The percentage of industry taking up the innovation in year t indicates the level of acceptance of the innovation. Some innovations are taken up quickly, and in the poultry industry could be assumed to be immediate and constant until the innovation is superseded. The 'ready reckoner tables' show this and the implications are explored in Chapter 4. Slow or unusual adoption rates can still be accounted for by having a different level of acceptance for each year the innovation is in use.

The discount factor (r) is introduced in recognition of the fact that from the community's point of view, a dollar benefit received now is preferable to a dollar received at a later point in time. Because it reflects the alternative uses of the community's resources, discounting enables costs and benefits to be compared at a common point in time. Monies invested in poultry research projects could have been invested in other agricultural research or in public works, and the returns from poultry research are therefore required to match the rate of return in these alternative investments.

A 10 per cent rate of discount is used, bearing in mind that the benefits are expressed in real terms and are not influenced by future rates of inflation. The discount rate also allows the results to be compared with results obtained from other studies {4,11}.

The uncertainty that the benefits from each innovation will be realised can be accounted for by always using conservative assumptions regarding technical coefficients and levels of acceptance. Where the benefits are used in some form of benefit cost analysis and where competing projects are ranked, a cut-off point or benchmark can be used. For example, only innovations with an internal rate of return of greater than 20% will be considered, and subjected to further scrutiny.

2.2 Adjustments for the Poultry Industry

The Egg Industry Stabilisation Act and adjustable hen quota are dominant features of the egg producing industry. The Act allows for the quantity of eggs entering the market place to be controlled by a quota on the number of laying hens permitted on each farm. Because of this, the most limiting resources on many farms has become the laying hen, causing a change in emphasis in farm management and applied research.

The model used here is applicable to both output increasing and input reducing innovations. In the egg producing industry with its Stabilisation Act, there can be a difference in the effect of innovations which is worth noting here. The Act is used to limit the number of laying hens in order to limit the number of eggs coming onto the market. But, innovations which increase egg production will finally cause a decrease in laying hen numbers if the quantity of eggs on the market is to remain constant; innovations which reduce mortality affect both output and input and so to keep egg numbers constant, there will be a period of adjustment; on the other hand, innovations which reduce feed consumption do not cause an increase in egg number and so there is no adjustment needed to the number of laying hens.

Innovations which increase total egg number can initially affect the shape of the supply curve before the industry can adjust the number of laying hens to the increased egg output per hen. Innovations that do not affect egg number and consequently the number of laying hens do not cause industry adjustment problems and so a parallel shift in the supply curve can be assumed. However, in both cases, while the analysis is restricted to comparing the change in gross margins per dozen eggs, it can be assumed that when the industry adopts an innovation it will cause a parallel shift in the supply curve.*

The model accounts for innovation which alter the gross income or variable costs of production. And so, in the egg producing industry, the assumption is that innovations which reduce the cost of production per unit of output, equally affect costs of production at the margin and infra-marginally for all producers. The assumption is sound as the industry has a uniform structure of variable costs due to such factors as the same breed crosses of laying hens, the same commercial feedstuffs and lately a more uniform environment for the laying hens.

The model is less reliable if it is used to estimate benefits from innovations which cause major changes in the underlying structure of the farm, but it is still useful for ranking like projects.

For ease of analysis various studies {4,11} assume that the innovations which reduce costs per unit of output cause a parallel shift in the supply curves {2}. Another study {6,5} has shown that if the supply curves do not move in parallel the estimation of monetary benefits can be too high.

CHAPTER 3

ANALYSIS AND RESULTS

The impact of various innovations on the laying phase of a representative farm were budgeted, and the reductions in the cost of production per unit of output were used in a revenue equation to estimate the expected benefits. The innovations were: 1 per cent reduction in laying hen mortality; 5 extra eggs hen housed and the same feed conversion ratio; 5 extra eggs hen housed; 2.5 kg decrease in hen housed feed consumption; 10 per cent reduction in rearing costs; 0.2 per cent reduction in the cost of producing a dozen eggs; and 1 cent reduction in the cost of producing a dozen eggs.

3.1 Budgeting

The budgets for a representative farm gave a gross margin before the innovation and a simulated gross margin after the innovation. Averaged information from the continuing farm management survey - The Farm Management Records Study (Eggs) for N.S.W.* - was used, together with costs and prices for 1975 {3,10}. All budgets were for 10,000 pullets housed at 18 weeks of age in conventional sheds and replaced at the optimal replacement age of 15 periods of lay or 60 weeks of lay.

Separate gross margin budgets were drawn up for each innovation (see Appendices A-G). The results (differences in gross margin per dozen eggs) were used to calculate the percentage reduction in the average cost of producing a dozen eggs (K) according to the following formula: K = (reduction in unit costs)/(price per unit of output) x 100. The results from these exercises are summarised in Table 1. For example, K for the innovation reducing the laying hen mortality by 1 per cent was K = 0.12636/71.37 x 100 = 0.1770491 per cent. It is necessary to quote a number of digits after the decimal point in the initial calculation as results are traditionally quoted on a per dozen eggs basis.

3.2 Revenue Equation

After obtaining gross margins from the budgeting exercise and calculating K, the necessary information is at hand to use the revenue equation to estimate the benefits expected from an innovation.

An example of the application of the revenue equation to an innovation reducing laying hen mortality by 1 per cent follows. From the budgeting results it was found that the innovation reduced the cost of producing a dozen eggs by 0.1770491 per cent. The equilibrium price

The computerised farm management survey is run by District Poultry Officers from the Poultry Research Station, Seven Hills. Egg producers keep daily records of their activities and each month receive averaged data on how comparable flocks are performing. There are 32 flocks in this scheme.

for an average dozen eggs, including a cull hen value allowance, was 71.37 cents a dozen and the quantity of eggs on the Australian market was 190,000,000 dozen a year. Annual revenue was treated as an annuity; this simplified matters as prices and quantities were assumed constant through time together with the percentage of industry taking up the innovation. The innovation was taken up immediately by the whole industry and it was expected to be superseded in ten years time; in this case the innovation lifetime was 10 years. The discount rate was 10 per cent per annum.

Applying the revenue equation:

$$\text{EMB} = \sum_{t=1}^{n} \frac{P_t(K \cdot P \cdot Q)T_t}{(1+r)^t}$$

$$\text{EMB} = \sum_{t=1}^{10} \frac{1.0(0.001770491 \times 0.7137 \times 190{,}000{,}000)1.0_t}{(1+.10)^t}$$

$$= \$1{,}475{,}219$$

The estimated total monetary benefits from an innovation causing an average 1 per cent reduction in laying hen mortality in Australian flocks would be, in real present value terms, $1.5 million.

The budgeting results for the various innovations were used in the revenue equation to obtain a benefit for each innovation reported in Table 2. In this table, the innovations were ranked in order of total benefits. In this case, with everything else being equal, the research project or innovation aiming to cause a 2.5 kg decrease in hen housed feed consumption would be favoured. While the extent of the innovations are arbitrary, the results and ranking show the power of each innovation. The implications of this on competing innovations is discussed in Chapter 4.

3.3 Parametric Results

Three parameters of the revenue equation were varied to obtain a range of results for the 'ready reckoner tables' (Tables 3 to 9). The parameters were the level of acceptance, the lag in adoption and the expected lives of the innovations. The industry acceptance levels for the innovations were 100 per cent, 60 per cent, 40 per cent, and 20 per cent; the lags in industry adoption of the innovations were 0 years, 3 years, 5 years, 8 years, and 10 years; the expected lives of the innovations were 5 years, 10 years, and 25 years.

The results from this exercise are shown in Tables 3 to 9. In Table 3, for example, the innovation which was expected to have a lifetime of 5 years and adopted in 10 year's time by egg producers producing 20 per cent of the total Australian output would have a value of $70,000. If the innovation lifetime was 10 years, the value would be $110,000; and 25 years, $160,000.

3.4 Costs

While this paper is concerned with estimating benefits, for completeness, some notice must be given to the cost of research. Cost figures are not generally available for individual research projects. However, average figures are available, or can be calculated, for both laboratory-based and research station-based research workers. Some cost figures are shown in Table 10. For example, the total cost in present value terms would be $242,000 for a station-based poultry research worker costing $97,000 per year and working full-time for three years on one project. In most cases, research workers are involved with several projects at the one time. Thus, to any one project, his time could be valued at say $25,000 per year - in this case, the total cost over 3 years would be $62,000.

CHAPTER 4

DISCUSSION

Maintaining research stations is a costly venture running into millions of dollars a year. It may be argued that to justify this expenditure on research, the benefits must be many times higher. The expected benefits reported in Table 2 of $16 million, $14 million, $11 million, etc. from various innovations indicate the enormous potential to Australian society.

The value of an industry's output largely determines the size of the benefits from research. The magnitude of potential benefits is likely to be quite small if an innovation is only applicable to a small section of the industry. This implies that the value of production is an important determinant of research priorities, but it does not imply that it is the sole determinant. By relating costs to benefits the administrator is concerned with the productivity of research expenditure rather than the (absolute) magnitude of monetary benefits.

Foregone benefits from a prolonged lag in an industry adopting an innovation has some major implications for extension effort. If innovations are not adopted quickly by the egg producing industry the potential loss is enormous. For instance, if the industry takes 3 years instead of nil years to adopt an innovation, then there is a 25 per cent reduction in potential benefits while for 5 years the reduction could be as high as 40 per cent. If the extension effort was slow to get started (or the potential of the innovations was not being quickly realised by producers) and the maximum acceptance level was achieved in 5 years instead of 3 years, then reduction in potential benefits can be as high as 17 per cent.

In the above discussion concerning the loss of potential benefits from the slow adoption of innovations, it has been assumed that the innovation lifetime remains unaltered. However, some innovations can be quickly superseded. If this is combined with an extension effort which is slow to start, the innovation lifetime can be shortened. For example, suppose an innovation with a lifetime of 5 years is not adopted as quickly as expected and takes another 2 years. Because of the slow adoption the actual innovation lifetime is shortened by 2 years. Thus instead of an innovation lifetime of 5 years the actual lifetime becomes 3 years. In this case the shortening of the lifetime of the innovation could result in a 45 per cent loss of potential benefits. Similarly, the loss could be as high as 19 per cent if the innovation lifetime is shortened from 25 to 23 years.

The time lag from experiment completion (and also commencement) to eventual maximum adoption by producers, and the potential income foregone because of the time lag, should concern administrators. The critical timing areas would be the time from project approval and funding to the commencement of experimentation, the time taken to disseminate results at the completion of experimentation and the implications for releasing results before publication in scientific journals. In related fields there are the economic pressures for the early release of various vaccines and new genetic material.

The innovation adoption rate has not been explored. The assumption has been that the maximum industry level of acceptance would be immediate and constant. Thus, in practice, the benefits can be under or over estimated depending on when it is assumed the industry takes up the innovation, because time can be measured from the initial adoption or from the maximum level of acceptance. Also the benefits shown in the 'ready reckoner tables' could be underestimated if the level of acceptance continues to climb instead of levelling off at a constant maximum. Innovations have to be looked at separately; for example, genetics innovations could be expected to be taken up simultaneously by all poultry breeders and remain at a constant maximum while farm management innovations would have a slower acceptance level per unit time but would then continue to rise slowly for a long time.

Competing research projects are normally ranked according to the benefits expected from the project innovations (see Table 2). However, the possibility of producing various innovations is not always the same. Thus, innovations that are necessary to achieve equal monetary benefits could be considered. With competing projects exhibiting constant relativity, the magnitude of each innovation coefficient can be altered to show an equal benefit. In the cases in the insert below, administrators would be indifferent towards the projects if each project had an equal potential benefit. For example, administrators would be indifferent towards a project showing a 2.5 kg decrease in hen housed feed consumption or a project showing a 11.32 per cent reduction in laying hen mortality.

<u>Equivalent Benefits from Innovations</u>

Research projects aimed at achieving these innovations have a potential for generating equal monetary benefits.

2.5 kg decrease in hen housed feed consumption.

11.75 per cent reduction in rearing costs.

1.43 cents reduction in cost of producing a dozen eggs.

7.689 extra eggs hen housed.

17.343 extra eggs hen housed with same feed conversion ratio.

2.004 per cent reduction in cost of producing a dozen eggs.

11.32 per cent reduction in uniform laying hen mortality.

To rank or separate the competing projects the administrator would consider such things as the ease of achieving the innovation, the possibility of publishing quickly, the likely rate of industry adoption, and the professional reputation of the project supervisor.

To reiterate, economic benefits from innovations must be related to the cost of doing research work. The tables of results (Tables 3 to 9) cover the real monetary benefits of innovations expected to flow from most egg industry research projects. By using the 'ready reckoner tables', administrators will be able to quickly obtain an estimate of the benefits expected from the project proposals placed before them.

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TABLE 1

A SUMMARY OF GROSS MARGIN BUDGETING RESULTS OF INNOVATIONS IN THE EGG PRODUCING INDUSTRY

BEFORE INNOVATIONS	
Gross margin (GM)/hen	$2.61
Gross margin (GM)/dozen eggs	14.72508 cents
AFTER INNOVATIONS	
a) 1% reduction in laying hen mortality:	
GM/hen	$2.65
GM/dozen eggs	14.85144 cents
Difference/dozen eggs	0.12636 cents
% reduction in average costs of production	0.1770491%
b) 5 extra eggs hen housed and same feed conversion ratio:	
GM/hen	$2.75
GM/dozen eggs	15.13754 cents
Difference/dozen eggs	0.41246 cents
% reduction in average costs of production	0.5779178%
c) 5 extra eggs hen housed:	
GM/hen	$2.84
GM/dozen eggs	15.65521 cents
Difference/dozen eggs	0.93013 cents
% reduction in average costs of production	1.3032506%
d) 2.5 kg decrease in hen housed feed consumption:	
GM/hen	$2.86
GM/dozen eggs	16.1556 cents
Difference/dozen eggs	1.43052 cents
% reduction in average costs of production	2.0043715%
e) 10% reduction in rearing costs:	
GM/hen	$2.82
GM/dozen eggs	15.94209 cents
Difference/dozen eggs	1.21701 cents
% reduction in average costs of production	1.7052122%
f) 0.2% reduction in cost of producing a dozen eggs:	
GM/hen	$2.63
GM/dozen eggs	14.86782 cents
Difference/dozen eggs	0.14274 cents
% reduction in average costs of production	0.2%
g) 1 cent reduction in cost of producing a dozen eggs:	
GM/hen	$2.79
GM/dozen eggs	15.72508 cents
Difference/dozen eggs	1.00000 cents
% reduction in average costs of production	1.4011489%

Budgets shown in Appendices A-G.

TABLE 2

INNOVATIONS RANKED IN ORDER OF GREATEST BENEFIT

Innovation†	Percentage reduction in A.C.** (%)	Benefits* ($m)
2.5 kg decrease in hen housed feed consumption	2.0043715	16.7
10% reduction in rearing costs	1.7052122	14.2
1c reduction in cost of producing a dozen eggs	1.4011489	11.7
5 extra eggs hen housed	1.3032506	10.8
5 extra eggs hen housed and same feed conversion ratio	0.4008687	4.8
0.2% reduction in cost of producing a dozen eggs	0.2	1.7
1% reduction in laying hen mortality	0.1770491	1.5

† The innovations were budgeted for a representative egg producing farm of 10,000 layers over 15 periods of lay (see Appendices A to G).

** The average cost of production (A.C.) includes normal profit and is equal to the return per unit of output - in this case, the average price per dozen eggs plus an allowance for cull layers.

* The real monetary benefits (1975 values) were for innovations taken up immediately by the whole industry and lasting 10 years. The discount rate was 10%.

TABLE 3

ESTIMATED TOTAL BENEFITS OF A UNIFORM 1% REDUCTION IN LAYING HEN MORTALITY OVER 15 PERIODS OF LAY

($ million)

a) *The innovation lifetime was 5 YEARS and the discount rate was 10% per annum*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	0.91	0.68	0.56	0.42	0.35
60%	0.54	0.41	0.33	0.25	0.21
40%	0.36	0.27	0.22	0.16	0.14
20%	0.18	0.13	0.11	0.08	0.07

b) *The innovation lifetime was 10 YEARS and the discount rate was 10% per annum*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	1.47	1.10	0.91	0.68	0.56
60%	0.88	0.66	0.54	0.41	0.34
40%	0.59	0.44	0.36	0.27	0.22
20%	0.29	0.22	0.18	0.13	0.11

c) *The innovation lifetime was 25 YEARS and the discount rate was 10% per annum*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	2.17	1.63	1.35	1.01	0.84
60%	1.30	0.98	0.81	0.60	0.50
40%	0.87	0.65	0.54	0.40	0.33
20%	0.43	0.32	0.27	0.20	0.16

TABLE 4

ESTIMATED TOTAL BENEFITS OF 5 EXTRA EGGS HEN HOUSED AND SAME FEED CONVERSION RATIO OVER 15 PERIODS OF LAY

($ million)

a) The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	2.97	2.22	1.84	1.38	1.14
60%	1.78	1.33	1.10	0.89	0.68
40%	1.18	0.89	0.73	0.55	0.45
20%	0.59	0.44	0.36	0.27	0.22

b) The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	4.81	3.61	2.98	2.24	1.85
60%	2.88	2.16	1.79	1.34	1.11
40%	1.92	1.44	1.19	0.89	0.74
20%	0.96	0.72	0.59	0.44	0.36

c) The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	7.11	5.34	4.41	3.31	2.74
60%	4.26	3.20	2.64	1.98	1.64
40%	2.84	2.13	1.76	1.32	1.09
20%	1.41	1.06	0.88	0.66	0.54

TABLE 5

ESTIMATED TOTAL BENEFITS OF 5 EXTRA EGGS HEN HOUSED OVER 15 PERIODS OF LAY

($ million)

a) *The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	6.69	5.02	4.15	3.12	2.57
60%	4.01	3.01	2.49	1.86	1.54
40%	2.67	2.00	1.66	1.24	1.03
20%	1.33	1.00	0.83	0.61	0.51

b) *The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	10.85	8.15	6.73	5.06	4.18
60%	6.51	4.88	4.04	3.03	2.51
40%	4.34	3.26	2.69	2.02	1.67
20%	2.17	1.62	1.34	1.00	0.83

c) *The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	16.03	12.04	9.95	7.47	6.18
60%	9.62	7.22	5.96	4.48	3.70
40%	6.41	4.81	3.98	2.98	2.47
20%	3.20	2.40	1.98	1.49	1.23

TABLE 6

ESTIMATED TOTAL BENEFITS OF A 2.5 kg DECREASE IN HEN HOUSED FEED CONSUMPTION OVER 15 PERIODS OF LAY

($ million)

a) The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	10.30	7.73	6.39	4.80	3.96
60%	6.18	4.64	3.83	2.87	2.37
40%	4.12	3.09	2.55	1.91	1.58
20%	2.06	1.53	1.27	0.95	0.79

b) The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	16.69	12.54	10.35	7.78	6.43
60%	10.01	7.51	6.21	4.66	3.86
40%	6.67	5.01	4.14	3.11	2.56
20%	3.33	2.50	2.07	1.55	1.27

c) The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	24.66	18.53	15.31	11.50	9.50
60%	14.79	11.11	9.18	6.89	5.70
40%	9.86	7.40	6.12	4.59	3.80
20%	4.92	3.70	3.05	2.29	1.90

TABLE 7

ESTIMATED TOTAL BENEFITS OF A 10% REDUCTION IN REARING COSTS OF HEN HOUSED PRODUCTION OVER 15 PERIODS OF LAY

($ million)

a) *The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	8.76	6.57	5.44	4.08	3.37
60%	5.25	3.94	3.26	2.44	2.02
40%	3.50	2.62	2.17	1.62	1.34
20%	1.75	1.30	1.08	0.80	0.67

b) *The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	14.20	10.67	8.81	6.62	5.47
60%	8.52	6.39	5.28	3.96	3.28
40%	5.68	4.26	3.52	2.64	2.18
20%	2.84	2.12	1.76	1.31	1.08

c) *The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	20.98	15.76	13.03	9.78	8.09
60%	12.58	9.45	7.81	5.86	4.85
40%	8.38	6.29	5.21	3.91	3.23
20%	4.18	3.14	2.60	1.95	1.61

TABLE 8

ESTIMATED TOTAL BENEFITS OF A 0.2% REDUCTION IN THE COST OF PRODUCING A DOZEN EGGS ($ million)

a) *The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	1.02	0.77	0.63	0.47	0.39
60%	0.61	0.46	0.38	0.28	0.23
40%	0.41	0.30	0.25	0.19	0.15
20%	0.20	0.15	0.12	0.09	0.07

b) *The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	1.66	1.25	1.03	0.77	0.64
60%	0.99	0.75	0.62	0.46	0.38
40%	0.66	0.50	0.41	0.31	0.25
20%	0.33	0.24	0.20	0.15	0.12

c) *The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	2.46	1.84	1.52	1.14	0.94
60%	1.47	1.10	0.91	0.68	0.56
40%	0.98	0.73	0.61	0.45	0.37
20%	0.49	0.36	0.30	0.22	0.18

TABLE 9

ESTIMATED TOTAL BENEFITS OF A 1 CENT REDUCTION IN THE COST OF PRODUCING A DOZEN EGGS

($ million)

a) *The innovation lifetime was 5 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	7.20	5.40	4.47	3.35	2.77
60%	4.32	3.24	2.68	2.01	1.66
40%	2.88	2.16	1.78	1.33	1.10
20%	1.44	1.07	0.89	0.66	0.55

b) *The innovation lifetime was 10 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	11.67	8.76	7.24	5.44	4.49
60%	7.00	5.25	4.34	3.26	2.69
40%	4.66	3.50	2.89	2.17	1.79
20%	2.33	1.74	1.44	1.08	0.89

c) *The innovation lifetime was 25 YEARS and the discount rate was 10% per annum.*

Level of acceptance	Lag in adoption of innovation (years)				
	0	3	5	8	10
100%	17.24	12.95	10.70	8.04	6.64
60%	10.34	7.77	6.41	4.82	3.98
40%	6.89	5.17	4.28	3.21	2.65
20%	3.44	2.58	2.13	1.60	1.32

TABLE 10

TOTAL COST OF RESEARCH†

($'000)

Annual cost per research worker	Number of years working on an innovation			
	3 years	5 years	8 years	10 years
97**	242	369	520	599
90*	225	344	484	557
60	149	227	320	368
50	124	189	266	307
25	62	94	133	153
10	24	37	53	61

† Cost per research worker was treated as an annuity accruing at the end of each year. The total cost therefore is the present value of this annuity discounted at 10% per annum.

** Represents the Net Allocation (1975) for a research worker plus on costs, at a State Government Poultry Research Station.

* Represents the Net Allocation (1975) for a research worker at a State Government Poultry Research Station.

APPENDIX A

LAYING HEN BUDGET, 1% REDUCTION IN MORTALITY OVER 15 PERIODS OF LAY

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age, and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had a uniform reduction of laying mortality of 1% through the laying period. Costs and prices were for 1975.

PRODUCTION AND RETURNS

		Before innovation		*After innovation*
		$		$
Egg sales : 213 eggs/hen housed		124,736.61	214.16 eggs/HH	125,417.30
60g: 30.1% @ 77.4c/doz =	$41,352.80		$41,578.48	
55g: 30.8% @ 73.3c/doz	40,073.11		$40,291.79	
50g: 23.3% @ 70.3c/doz	29,074.32		$29,232.97	
45g: 8.5% @ 64.3c/doz	9,701.26		$ 9,754.20	
second: 4.7% @ 35c/doz	2,919.87		$ 2,935.80	
pullet: 2.6% @ 35c/doz	1,615.25		$ 1,624.06	
Cull sales: 8,080 x 2.3 kg @ 10.48c		1,947.60		1,971.70
Gross Income		$126,684.21		$127,389.00
Gross Income/Hen		$12.66		$12.73
VARIABLE COSTS		$		$
Pullets 10,000 @ $2.06		20,600		20,600.00
Feed 410.6 tonnes @ $97.57		40,062	412.79 tonnes	40,276.65
CEMAA cost @ 89c/hen housed		8,900	@ 89.5c/HH	8,953.53
Board charges @ 17.4c/doz (includes pool levy @ 9.94c/doz)		30,885		31,053.51
Total Variable Costs		$100,547		$100,883.69
Variable Costs/Hen		$10.05		$10.08
GROSS MARGIN				
Gross Margin		$26,137.21		$26,505.31
Gross Margin/Hen		$ 2.61		$ 2.65
Gross Margin/doz Eggs		14.72508c		14.85144c

DIFFERENCE in gross margin/doz eggs 0.12626c

APPENDIX B

LAYING HEN BUDGET, 5 EXTRA EGGS HEN HOUSED AND SAME FEED CONVERSION RATIO OVER 15 PERIODS OF LAY

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their hen housed production increased by 5 eggs a hen with the same feed conversion ratio. Costs and prices were for 1975.

PRODUCTION AND RETURNS

		Before innovation $		*After innovation* $
Egg sales : 213 eggs/hen housed		124,736.61	218 eggs/HH	127,664.69
60g: 30.1% @ 77.4c/doz =	$41,352.80		$42,323.54	
55g: 30.8% @ 73.3c/doz	40,073.11		$41,013.79	
50g: 23.3% @ 70.3c/doz	29,074.32		$29,756.81	
45g: 8.5% @ 64.3c/doz	9,701.26		$ 9,928.98	
second: 4.7% @ 35c/doz	2,919.87		$ 2,988.41	
pullet: 2.6% @ 35c/doz	1,615.25		$ 1,653.16	
Cull sales: 8,080 x 2.3 kg @ 10.48c		1,947.60		1,947.60
Gross Income		$126,684.21		$129,612.29
Gross Income/Hen		$12.66		$12.96

VARIABLE COSTS

	$		$
Pullets 10,000 @ $2.06	20,600		20,600
Feed 410.6 tonnes @ $97.57	40,062	420.2 tonnes	41,002.42
CEMAA cost @ 89c/hen housed	8,900		8,900
Board charges @ 17.4c/doz (includes pool levy @ 9.94c/doz)	30,885		31,609.99
Total Variable Costs	$100,547		$102,112.41
Variable Costs/Hen	$10.05		$10.21

GROSS MARGIN

Gross Margin	$26,137.21	$27,499.88
Gross Margin/Hen	$ 2.61	$ 2.75
Gross Margin/doz Eggs	14.72508c	15.13754c

DIFFERENCE in gross margin/doz eggs 0.41246c

APPENDIX C

LAYING HEN BUDGET, 5 EXTRA EGGS HEN HOUSED OVER 15 PERIODS OF LAY

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their hen housed production increased by 5 eggs a hen. Costs and prices were for 1975.

PRODUCTION AND RETURNS

		Before innovation		*After innovation*
		$		$
Egg sales : 213 eggs/hen housed		124,736.61	218 eggs/HH	127,664.69
60g: 30.1% @ 77.4c/doz =	$41,352.80		$42,323.54	
55g: 30.8% @ 73.3c/doz	40,073.11		$41,013.79	
50g: 23.3% @ 70.3c/doz	29,074.32		$29,756.81	
45g: 8.5% @ 64.3c/doz	9,701.26		$ 9,928.98	
second: 4.7% @ 35c/doz	2,919.87		$ 2,988.41	
pullet: 2.6% @ 35c/doz	1,615.25		$ 1.653.16	
Cull sales: 8,080 x 2.3 kg @ 10.48c		1,947.60		1,947.60
Gross Income		$126,684.21		$129,612.29
Gross Income/Hen		$12.66		$12.96

VARIABLE COSTS

	$	$
Pullets 10,000 @ $2.06	20,600	20,600
Feed 410.6 tonnes @ $97.57	40,062	40,062
CEMAA cost @ 89c/hen housed	8,900	8,900
Board charges @ 17.4c/doz (includes pool levy @ 9.94c/doz)	30,885	31,609.99
Total Variable Costs	$100,547	$101,171.99
Total Variable Costs/Hen	$10.05	$10.11

GROSS MARGIN

Gross Margin	$26,137.21	$28,440.30
Gross Margin/Hen	$ 2.61	$ 2.84
Gross Margin/doz Eggs	14.72508c	15.65521c

DIFFERENCE in gross margin/doz eggs 0.93013c

APPENDIX D

LAYING HEN BUDGET, 2.5 kg DECREASE IN HEN HOUSED FEED CONSUMPTION OVER 15 PERIODS OF LAY

STRUCTURE

Laying hens: The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their hen housed feed consumption decreased by 2.5 kg a hen. Costs and prices were for 1975.

PRODUCTION AND RETURNS

	Before innovation		*After innovation*
	$		$
Egg sales : 213 eggs/hen housed	124,736.61		124,736.61
Cull sales : 8,080 x 2.3 kg @ 10.48c	1,947.60		1,947.60
Gross Income	$126,684.21		$126,684.21
Gross Income/Hen	$12.66		$12.66

VARIABLE COSTS

	$		$
Pullets 10,000 @ $2.06	20,600		20,600
Feed 410.6 tonnes @ $97.57	40,062	385.6 tonnes	37,622.99
CEMAA cost @ 89c/hen housed	8,900		8,900
Board charges @ 17.4c/doz (includes pool levy @ 9.94c/doz)	30,885		30,885
Total Variable Costs	$100,547		$98,007.99
Variable Costs/Hen	$10.05		$ 9.80

GROSS MARGIN

Gross Margin	$26,137.21	$28,676.22
Gross Margin/Hen	$ 2.61	$ 2.86
Gross Margin/doz Eggs	14.72508c	16.1556c

DIFFERENCE in gross margin/doz eggs 1.43052c

APPENDIX E

LAYING HEN BUDGET, 10% REDUCTION IN REARING COSTS ON HEN HOUSED FIGURES OVER 15 PERIODS OF LAY

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their rearing costs decreased by 10%. Costs and prices were for 1975.

PRODUCTION AND RETURNS

	Before innovation		*After innovation*
	$		$
Gross Income	$126,684.21		$126,684.21
Gross Income/Hen	$ 12.66		$ 12.66

VARIABLE COSTS

	$		$
Pullets 10,000 @ $2.06	20,600	@ $1.854	18,540
Feed 410.6 tonnes @ $97.57	40,062		40,062
CEMAA cost @ 89c/hen housed	8,900		8,900
Board charges @ 17.4c/doz (includes pool levy @ 9.94c/doz)	30,885		30,885
Total Variable Costs	$100,547		$98,387
Variable Costs/Hen	$ 10.05		$ 9.83

GROSS MARGIN

Gross Margin	$26,137.21		$28,297.21
Gross Margin/Hen	$ 2.61		$ 2.82
Gross Margin/doz Eggs	14.72508c		15.94209c

DIFFERENCE in gross margin/doz eggs 1.21701c

APPENDIX F

LAYING HEN BUDGET, 0.2% REDUCTION IN THE COST OF PRODUCING A DOZEN EGGS

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their cost of producing a dozen eggs reduced by 0.2%. Costs and prices were for 1975.

GROSS MARGIN

	Before innovation	*After innovation*
Gross Margin	$26,137.21	$26,390.38
Gross Margin/Hen	$ 2.61	$ 2.63
Gross Margin/doz Eggs	14.72508c	14.86782c

DIFFERENCE in gross margin/doz eggs 0.14274c

APPENDIX G

LAYING HEN BUDGET, 1 CENT REDUCTION IN THE COST OF PRODUCING A DOZEN EGGS

STRUCTURE

Laying hens : The 10,000 pullets were housed in conventional sheds at 18 weeks of age and replaced at 15 periods (60 weeks) of lay. The pullets, due to an innovation, had their cost of producing a dozen eggs reduced by 1 cent/dozen. Costs and prices were for 1975.

PRODUCTION

	Before innovation	*After innovation*
Egg sales : 213 eggs hen housed		

GROSS MARGIN

Gross Margin	$26,137.21	$27,912.19
Gross Margin/Hen	$ 2.61	$ 2.79
Gross Margin/doz Eggs	14.72508c	15.72508c

DIFFERENCE in gross margin/doz eggs 1.0c

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