theory of resource use. The operative principle in this theory is that resources are allocated optimally when the return on the last dollar spent on each project is equal.

There are, of course, many serious difficulties in estimating the marginal returns (and the total returns) from research investigations and these difficulties are greatest with fundamental research projects (stressed also by Attwood 1963). Even with applied research, the returns will typically accrue over a long period of time in a manner determined by the organization of extension services, the availability of capital required to exploit research innovations, further investments in research, the education and social structure of farming communities, future market conditions, and many other influences.

One most important factor is the inherent riskiness of investment in research.' Research may fail completely to develop worthwhile technologies or to provide useful information. Governmental research organizations are able to accept failures in investigations. On the other hand, consequences of success or failure for private firms engaged in research will usually justify formal analysis of the risky investment using the concepts of statistical decision theory such as detailed by Cramer and Smith (1964). Of course, in some business organizations research may play essentially a public relations role.

Much of the evaluation of research submissions is inevitably subjective. Experienced research administrators should be proficient in estimating the likelihood of success in investigations and the worth of advances which may be made. With increasing specialization in research there is need for a systematic framework in which to assess research allocations. The allocation of funds can only be improved as more is known about the economic value of research work.

(c) Product Demand as an Indicator for Research Priorities

Useful expectations of markets for animal products can be one economic guide for research administration because research projects often take many years to complete, and consequent benefits take even longer to accrue. Gruen (1967) has prepared a comprehensive series of projections for animal (and other agricultural) product markets for 1965-1980, which could be valuable in formulating expectations.

Given the current and expected demand, it is probable that the production of beef can be expanded without reversing the present upward price trend. Although prices for wool will probably decline with increases in production, because synthetics are such close substitutes, it is unlikely that the fall in prices will be sufficient to reduce total revenue. This means that research directed at increasing the output of these major animal products is likely to be very profitable. It is therefore good sense for producers to support such research. However, consumers also benefit from such research through their consequent greater capacity to purchase imports, so that Australian society also can rationally support this research. This situation differs markedly from the U.S.A. experience in respect to production research for many agricultural products (Heady 1962).

The butter industry illustrates some further aspects. The size of the market for Australian butter is virtually fixed. Without further governmental protection, increased output from use of research innovations would probably decrease the total revenue to butter producers. In this industry we can see perhaps more clearly

(a) The Economic Approach in Experimental Design

While economic analysis of livestock experiments is not new, the last two decades have seen considerable interest in co-operation between economists and animal production researchers develop in the U.S.A. (Hoglund *et al.* 1959) and elsewhere (O.E.C.D. 1965). Economists have urged scientists to plan experiments so that results are amenable to economic analysis (Lloyd 195 8; Dillon 1966b)

It is not intended to reiterate these pleas except to note that the call has generally been for (1) use of more levels of treatments, (2) incorporating more factors rather than conducting numerous single-variable experiments (Dillon and Burley 1961) and- (3) embedding experiments in situations which have direct relevance to commercial farming (Davidson and Martin 1965). Because using more factors usually implies rather more costly experiments, there has been a concomitant appeal (Heady and Dillon 196 1) to employ efficient experimental designs in exploring response surfaces, such as those developed for industrial experimentation. However, such designs have not solved the problems of time-dependency and variability inherent in animal production processes. Sometimes the economist's preconceived notions of which factors are really important have been incorrect-for instance, he has tended to think of quantity, of say feed proteins, to the exclusion of quality.

The difficulties which have arisen have not been due solely to the production function approach itself but rather the result of dealing with complex production problems. It is suggested that with trivial sacrifice to his technical interest in an experiment, the animal production researcher might often profitably incorporate the economic approach so that the bonus of useful information will outweigh the additional costs incurred. Of course, in any joint research programme, the objectives of the researchers must be sufficiently complementary to justify an integrated approach.

On the other hand, it is not claimed that all small experiments of simple design are devoid of interest and value to economists. To be able to apply economic principles in analysing experimental data has obvious merit; but where this is impossible these data may still be useful in other empirical work such as farm planning. Economists should also give more attention to developing models in which the many experiments not of a production-function type can be viewed in an economic framework.

(b) Optimal Investment in Experiments

Diminishing marginal returns will eventually characterise any experiment if its size is increased sufficiently. Experimenters need continually to estimate the best size (in terms of animals and/or areas) for experiments. However, there is no well developed theory of the economics of agricultural experimentation and economists should give this subject urgent attention. Only one book on experimental design (Finney 1960) deals with the subject at all.

Many animal production experiments are designed to compare alternative procedures and may lead to recommendations for practice. For these situations the unexploited approach of Bayesian statistics (as exemplified by Raiffa and Schaifer 1961) holds considerable promise. In this approach prior information is

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