PATTERNS AND IMPACTS OF PRODUCTION INCREASING AGRICULTURAL RESEARCH AT THE STATE AGRICULTURAL EXPERIMENT STATIONS

by

MARK ALLEN JAMISON

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Major Professor

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CHAPTER I

IMPACTS OF AGRICULTURAL RESEARCH

The agricultural industry continues to be the single largest sector of income and employment in Kansas. Past analyses indicate that returns to research in support of this broad-based industry in the U.S. are stable and high, in the range of 35 to 40 percent annually. Moreover, future expansion in agricultural production will be needed to improve world-wide living standards and to feed a rapidly increasing world population. Such production expansion must rely on a base of timely and effective agricultural research. In addition, key research is needed to effectively address both important firm-level and important policy issues relating to (1) use and management of natural resources, particularly land and water, (2) rural and community development in both declining and growing areas, (3) human resource development, particularly in rural areas, and (4) problems of excess capacity and low resource earnings in the agricultural sector.

Despite the demonstrated importance of past agricultural and related research, the public and its decision making representatives (including those in the State Legislatures, the Federal Congress and elsewhere) are increasingly concerned about the increasingly high level of public expenditures and rightfully demand improved information on the payoff for expanded research expenditures. Research administrators have a continuing need for improved information on the expected payoff

from alternative research investments in order to guide their decisions relative to the allocation of funding and other research support. And, members of the general public have a need to be better informed about the expected payoff from a wide range of agricultural and related research. It is to the general public (as final consumers of food and fiber products) that most of the benefits of research accrue in the form of expanded product supplies and lower product prices.

The need is keen, therefore, for more and better information and analysis on the expected size and incidence of payoff from a wide range of publicly (and, in some cases, privately supported research through the State Agricultural Experiment Stations. Still another major need is the one of effectively disseminating results on the expected payoffs from research funding requests to users in State Legislatures, as well as in the Executive and Legislative branches of the Federal government and among members of the general public.

Objectives and Procedure

The major objective of this study is to improve the capacity to analyze the impact of agricultural research expenditures or investment on different sectors of Kansas agriculture and thus facilitate decision making for future agricultural research. A more specific objective of this study is to develop, evaluate, and test improved methodology, data and presentational formats for analyzing and supporting agricultural research program requests in Kansas.

Generally, studies of this nature fall into two main categories: ex post and ex ante. Ex post studies attempt to estimate and quantify returns to past agricultural research. Ex ante studies do the same for

research whose results are not yet known. From a policy standpoint, the ex ante studies are most desirable; but their current methodologies lack objectivity, something easily obtained in ex post studies. For the purpose of assisting policy decisions, it would seem desirable to develop ex post methodologies which could be adapted to ex ante.

Ex post studies use two basic approaches to quantify returns--the index number approach and the production function approach. The index number approach was poineered by Griliches in 1958 (25). In that first study, Griliches estimated the rate of return of hybrid corn development to be at least 700 percent (25, p. 419).

The approach uses the concepts of consumer and producer surpluses. Consumer surplus is a measure of the amount of utility received by consumers, but not paid for. It is measured as the area between the portion of the demand curve which lies above price line, and the price line. In figure 1, consumer surplus is the area ABC. Producer surplus is a measure of profit. It is measured as the area between the portion of the supply curve which lies below the price line, and the price line. In figure 1, producer surplus is the area CBD.

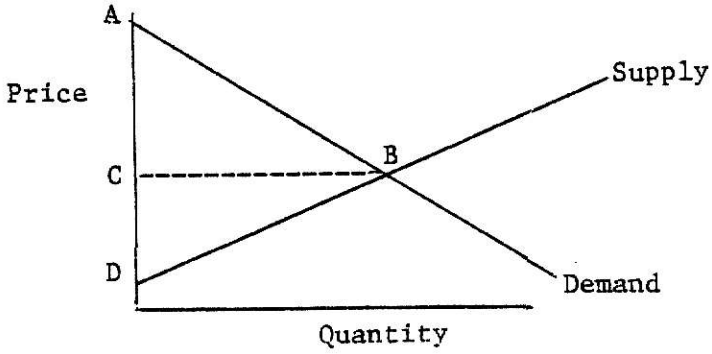

Fig. 1. Consumer and producer surplus

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In the index number approach the effect of agricultural research is assumed to be a shift in the supply curve. The shift causes changes in both consumer and producer surpluses. Benefit is seen as the gain in consumer surplus, plus the gain in producer surplus, minus any losses. For example, in figure 2 the effect of agricultural research was to shift the supply curve from S_1 to S_2. The old consumer surplus was ABC and the new is AB'C'; therefore, the gain in consumer surplus was CBB'C'. The old producer surplus was CBD and the new is C'B'D'; therefore, the loss was CBEC' and the gain was DEB'D'. Adding the two gains and subtracting the loss leaves the area DBB'D' as the measure of benefit.

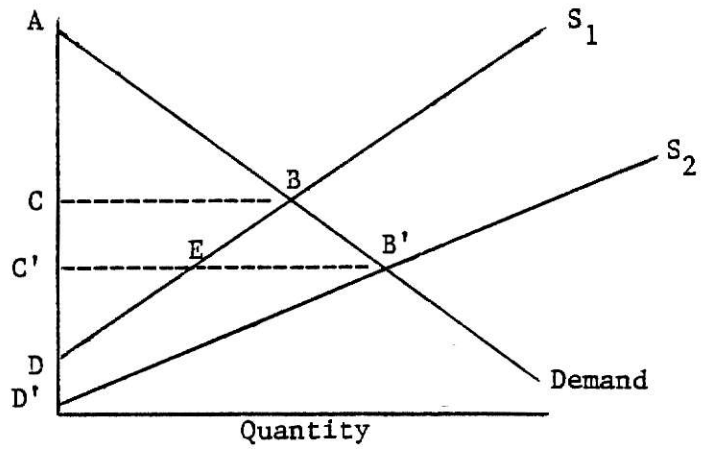

Fig. 2. Changes in consumer and producer surpluses

The index number approach was also the approach used by Schmitz and Seckler (40) to answer critics of the mechanized tomato harvester. The mechanized tomato harvester was researched and developed in the 1950s and early 60s through joint efforts by several land grant universities and private businesses. The adoption of the harvester displaced many migrant workers and necessitated the development of harder tomatoes which would not be easily bruised by the harvester. Hightower (26) felt

the purpose of the tomato harvester was to increase corporate agribusiness profits. He viewed the unemployed workers and harder fruit as social costs, but saw no social benefits. Schmitz and Seckler (40), however, calculated a gross social rate of return (including no social costs) to the harvester's development of 1000 percent (40, p. 569). Even after subtracting the social cost of unemployed migrant workers, the rate of return still exceeded 700 percent (40, 575).

The index number approach is useful for purposes such as Schmitz and Seckler's, but it is not satisfactory from a policy standpoint. The study of resource allocation requires marginal analysis, something not easily accomplished by the index number approach. The production function approach, on the other hand, is better designed to accomodate marginal analysis.

Like the index number approach, the production function approach was pioneered by Griliches (24). In 1964 he calculated an aggregate U.S. agricultural production function including research and extension (R&E) expenditures as one of the explanatory variables. By differentiating the function with respect to R&E, Griliches found the marginal product of one dollar of R&E to be $13 per year.

Since Griliches' original study (24), the production function approach has changed little. Most studies using this approach have used the value of the whole of or some part of agricultural output as the dependent variable (where the value was determined using constant prices as weights); conventional farm inputs, as well as, some form of R&E have usually been used as independent variables; and a distributed lag has normally been applied to the R&E variable. With this data set, the

researcher would statistically fit a production function. After statistical estimation of the function, the marginal product was calculated by differentiating the function with respect to R&E and applying appropriate values to the variables. This approach was also used in this study.

The basis for this study is the research results developed by Bredahl and Peterson (8). For this reason, their research effort is discussed in greater detail.

Bredahl and Peterson (8) estimated production functions for four types of Census of Agriculture farms in the U.S. The farm types were cash grain, poultry, livestock and dairy. Their study was cross sectional and used data from the 1969 Census of Agriculture. Each state was considered as one observation.

The functional form used by Bredahl and Peterson was a simple Cobb-Douglas production function of the type:

$$Y_i = A_i \prod_{j=1}^{\rho} X_{ij}^{\alpha_{ij}} R_i^{\beta_i}$$

where Y_i was the value of output for farm type i, using constant prices as the weights (8, p. 686); A_i was a constant; X_{ij} was the jth conventional input for farm type i; R_i was the research variable; and α and β were the estimated regression coefficients. The values for the research variable were obtained from the Inventory of Agricultural Research, FY 1969-1970 (8, p. 685). Figures used were the "Total Funds" entries for the relevant commodity groups. Using fiscal year 1969-1970 research expenditures assumed no lags, but Bredahl and Peterson felt this would not bias the estimated coefficients (8, p. 685).

Bredahl and Peterson divided their final marginal products by three to help account for the effects of private research and extension education (8, p. 690).

The Bredahl and Peterson study had several shortcomings. Besides not estimating a distributed lag for research expenditures, variables for private research, extension education and farmer managerial ability should have been included. Their study also ignored the spill-over effects of the movement of research results across state lines. Despite these shortcomings, this study builds on the Bredahl and Peterson results because it permits comparison of results between commodity groups and states, albeit less accurately than would be desired.

A major shortcoming of the production function studies, including the study by Bredahl and Peterson, is the assumption of constant prices. While this assumption may or may not be realistic, it does make it impossible to directly calculate marginal value products needed for research investment decisions and policy analysis.

To rectify that shortcoming is the main objective of this study. The production function results derived by Bredahl and Peterson will be modified by inclusion of research effects on prices. It is hoped that the final results will be more useful in policy decision making.

CHAPTER II

METHODOLOGY

This study examines three areas of interest to the study of impacts of agricultural research--farm input productivity, returns to agricultural research and research funding patterns. The examination is limited to production increasing research--i.e., even though other production research costs were included in research expenditure measurements, increases in production were the only impacts specifically quantified.

The section on the returns to research is the section which fulfills the study's specific objective--that of extending the current methodology used to estimate returns to research. The other sections are only supportive.

The procedure used to analyze farm resource productivity is taken from Babb and Pratt (4). This procedure is chosen because its measurement units conform with those used by Bredahl and Peterson (8) whose results are used in the returns to research section. Using input and production data from the Census of Agriculture (53) for four farm types (cash grain, poultry, livestock and dairy), this present study compares changes in farm inputs, outputs and input-output ratios for Kansas and U.S. farms. The years considered are the three most recent census years--1964, 1969 and 1974. The Babb and Pratt study made the same calculations, but included Indiana farms instead of Kansas farms.

As has already been stated, the returns to research section is an extension of the Bredahl and Peterson study (8) and its purpose is to calculate marginal value products (MVP) for research. The coefficients estimated by Bredahl and Peterson are research elasticities of production (percentage change in production over percentage change in research). Those elasticities are combined with price elasticities of demand (percentage change in quantity demanded over percentage change in price) to measure the effects of research on prices and total value product. The resulting figures are used to estimate MVPs of research to demonstrate what the returns to research were in 1969.

Productivity

Census of Agriculture (53) data for Kansas and U.S. cash grain, poultry, livestock and dairy farms are used in this section. Data are expressed on a per farm basis to conform with Bredahl and Peterson (8, p. 686). This also helped illustrate changes which have occured on farms (4, p. 21).

Expressing data on a per farm basis could result in biases if the number of small-acreage, part-time farmers increased or decreased significantly during the time period. As it turned out, the number of very small farmers increased relative to the number of larger farmers. (Farms with sales of less than $2500 comprised only 6.9 percent of total farm numbers in Kansas during 1964, but increased to 13.8 percent by 1974. At the same time, their sales as a percent of total sales in Kansas declined from 2.3 percent in 1964 to 0.5 percent by 1974). Because of this problem, only farms of sales greater than $2500 were considered.

Farm inputs and outputs are quantified using 1974 prices as weights. Doing this gives uniform units for aggregation purposes and the time period considered, 1964 through 1974, is short enough that no serious distortions should result. Prices and procedures being used to form specific indexes are given in the relevant footnotes of appendix tables 1 through 8.

Feed data does not reflect feedstuffs grown and fed on the same farm (except for some silages, hay and pasture). This could cause productivity changes to be underestimated if farms became more specialized during the period (4, p. 22).

Data on numbers of dairy cows, land and value of equipment are multiplied by 0.15 (4, p. 26). In addition, yields on cash grain farms are adjusted by using a three year average centering on the census year (4, p. 22). This is done to help neutralize weather effects; however, 1974 adjusted yields are still relatively low.

These data and procedures used for measuring productivity may be considered crude; yet they should be useful for measuring relative changes in resource productivity over a short period of time.

Research expenditure and scientist-year data are obtained from the Inventory of Agricultural Research (49) and Babb and Pratt (4). The indexes used to convert the current dollar expenditure figures to constant dollars are from Business Statistics (52, p. 5) and the Survey of Current Business (54, p. S-2). The indexes used are 1969 = 68.4, 1974 = 100 and 1976 = 115.5.

Returns to Research

The purpose of this section is to illustrate the methodology used to calculate marginal value products (MVPs) and marginal internal

rates of return (MIRR) for agricultural research. The section is broken into four parts. The first determines what information is needed to calculate MVPs and MIRRs; the second shows how that information was obtained; the third discusses some of the assumptions made; and the fourth demonstrates the actual calculations performed.

Marginal value products are calculated at both the farm and retail levels. At the farm level, they represent the change which occured for farm level total value product (TVP). At the retail level, they represent the change in TVP at food stores.

Derivation of Marginal Internal Rate of Return and Marginal Value Product-- Algebraic Considerations

Determination of MIRR and MVP form the basis of this study. The approach that follows shows step by step how MVPs and MIRRs are calculated at the farm and retail levels.

Four farm types, identified by the commodity group produced, are considered--cash grain, poultry, livestock and dairy.

In general, MIRR is the rate of return which makes the future MVP equal to the marginal research expenditure spent to produce it. The general formula used for calculating the present value of some future cash flow is:

$$\text{present value} = \frac{\text{future value}}{(1 + \text{IRR})^n}$$

where IRR is the internal rate of return and n is the lag denoting the number of years between when the investment is made and when the payoff is received. Solving for IRR:

$$\text{IRR} = \left(\frac{\text{future value}}{\text{present value}}\right)^{1/n} - 1.$$

In the case of MIRR, the present value is the marginal expenditure on research (one dollar) and the absolute value of MVP is the future value of the marginal expenditure. Therefore, to calculate MIRR the equation is written as:

$$MIRR = (MVP)^{1/n} - 1. \tag{1}$$

As can be seen from equation (1), all that is needed to calculate MIRR is MVP and an assumed time lag, n.[1]

The next step is the calculation of MVP.

The MVP of research for the commodities produced on farm type i can be written as:

$$MVP_i = \frac{\partial TVP_i}{\partial R_i} \tag{2}$$

where TVP_i is the total value product from farm type i and R_i is the relevant research expenditures. Because multiplying an expression by one does not change the value of that expression, the right-hand side of equation (1) can be multiplied by $\frac{R}{TVP} \cdot \frac{TVP}{R}$ and obtain:

$$\begin{aligned} MVP_i &= \frac{\partial TVP_i}{\partial R_i} \cdot \frac{R_i}{TVP_i} \cdot \frac{TVP_i}{R_i} \\ &= \left(\frac{\partial TVP_i}{\partial R_i} \cdot \frac{R_i}{TVP_i}\right) \frac{TVP_i}{R_i} \\ &= E_{R.TVP_i} \cdot AVP_i \end{aligned} \tag{3}$$

where $E_{R.TVP_i}$ is the research elasticity of production of commodity group i (percentage change in total value product over percentage change in research expenditures).

The AVP_i can be calculated as $\frac{TVP_i}{R_i}$, but to obtain $E_{R.TVP_i}$ the following transformations are needed:

Since TVP is equal to price (P) times quantity (Q), $E_{R.TVP_i}$ can be written as:

$$E_{R.TVP_i} = \frac{\partial P_i . Q_i}{\partial R_i} \cdot \frac{R_i}{P_i . Q_i} .$$

Differentiating $P_i . Q_i$ provides:

$$E_{R.TVP_i} = \left(P_i \frac{\partial Q_i}{\partial R_i} + Q_i \frac{\partial P_i}{\partial R_i} \right) \frac{R_i}{P_i . Q_i}$$

$$= \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} + \frac{\partial P_i}{\partial R_i} \cdot \frac{R_i}{P_i} .$$

Expanding the terms on the right-hand side of the plus sign, it follows that:

$$E_{R.TVP_i} = \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} + \left(\frac{\partial P_i}{\partial Q_i} \cdot \frac{\partial Q_i}{\partial R_i} \right) \left(\frac{R_i}{Q_i} \cdot \frac{Q_i}{P_i} \right)$$

$$= \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} + \left(\frac{\partial P_i}{\partial Q_i} \cdot \frac{Q_i}{P_i} \right) \left(\frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} \right)$$

$$= \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} \left(1 + \left(\frac{\partial Q_i}{\partial P_i} \cdot \frac{P_i}{Q_i} \right)^{-1} \right)$$

$$= E_{R.Q_i} \left(1 + E_{P.Qd_i}^{-1} \right) \qquad (4)$$

where $E_{R.Q_i}$ is the research elasticity of production for commodity group i and $E_{P.Qd_i}$ is the price elasticity of demand for commodity group i.

As can be seen from equations (3) and (4), all that is needed to calculate MVP are AVP, $E_{R.Q}$ and $E_{P.Qd}$. All of these equations hold true for both farm level and retail level MVPs.

Derivation of AVP, Research Elasticities and Demand Elasticities

As stated earlier, AVP is TVP divided by research expenditures. For retail level calculations, AVPs are calculated in that manner. For

farm level calculations, AVPs are obtained from Bredahl and Peterson (8, p. 690).

Research elasticities are more difficult to calculate than AVP; yet the following demonstrates that the research coefficients estimated by Bredahl and Peterson (8, pp. 687-688) are actually research elasticities of production $\left(\frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i}\right)$.

Bredahl and Peterson's production function was of Cobb-Douglas form:

$$Y_i = A_i \prod_{j=1}^{\rho} X_{ij}^{\alpha_{ij}} R_i^{\beta_i}$$

where Y_i was the value of output for farm type i, using constant prices as weights (8, p. 686); A_i was a constant; X_{ij} was the jth conventional input for farm type i; R_i was the research expenditure variable; and α and β were the estimated regression coefficients (8, pp. 684-685). To prove that $\beta = \frac{\partial Y_i}{\partial R_i} \cdot \frac{R_i}{Y_i}$, the following transformations are made:

$$\frac{\partial Y_i}{\partial R_i} = \beta_i A_i \prod_{j=1}^{\rho} X_{ij}^{\alpha_{ij}} R_i^{\beta_i - 1}$$

$$= \beta_i \frac{A_i \prod_{j=1}^{\rho} X_{ij}^{\alpha_{ij}} R_i^{\beta_i}}{R_i}$$

$$= \beta_i \cdot \frac{Y_i}{R_i}$$

$$\beta_i = \frac{\partial Y_i}{\partial R_i} \cdot \frac{R_i}{Y_i} . \qquad (5)$$

Bredahl and Peterson defined Y_i as the price of commodity group i (P_i) times the quantity of commodity group i (Q_i), equation (5) can be rewritten as:

$$\beta_i = \frac{\partial P_i . Q_i}{\partial R_i} \cdot \frac{R_i}{P_i . Q_i} \qquad (5')$$

And, because prices were held constant, we can rewrite equation (5') as:

$$\beta_i = P_i \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{P_i . Q_i}$$

$$= \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i}$$

$$= E_{R.Q_i} \qquad (6)$$

Therefore, the research coefficients calculated by Bredahl and Peterson are actually farm level research elasticities of production because Y_i represented farm level output.

Equivalent research elasticities of production for retail are not available and so have to be estimated; however, estimation without extensive research poses a severe problem because the functional relationship between farm output for commodity group i, Q_i, and its respective retail output, Q_i', is not known. Therefore, it is assumed that for a given year the ratio between Q_i and Q_i' is constant so that:

$$\frac{Q_i}{Q_i'} = k$$

where k is some constant. Therefore:

$$Q_i = kQ_i' .$$

Since Q_i is a function of research expenditures R_i, and Q_i' is a function of Q_i, the equation can be differentiated with respect to R_i so that:

$$\frac{\partial Q_i}{\partial R_i} = \frac{\partial kQ_i'}{\partial R_i} .$$

Multiplying both sides of the equation by the equivalent of $\frac{R_i}{Q_i}$ gives:

$$\frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} = \frac{\partial kQ_i'}{\partial R_i} \cdot \frac{R_i}{kQ_i'}$$

$$= k \frac{\partial Q_i'}{\partial R_i} \cdot \frac{R_i}{kQ_i'}$$

$$= \frac{\partial Q_i'}{\partial R_i} \cdot \frac{R_i}{Q_i'}$$

$$E_{R.Q_i} = E_{R.Q_i'} \tag{7}$$

where $E_{R.Q_i'}$ is the research elasticity of production at the retail level.

Therefore, if the assumption of a constant ratio is legitimate, the estimates for $E_{R.Q_i}$ can also be used for $E_{R.Q_i'}$. Making this assumption, the estimates for $E_{R.Q_i}$ are considered to be the values needed for $E_{R.Q_i'}$.

The next step is to find estimates for the price elasticity of demand for commodity group i.[2]

If it were legitimate to ignore all other influences (on quantity purchased) other than price, the price elasticity of demand for m commodities in commodity group i could be estimated as:

$$E_i = \frac{\dfrac{\sum_{t=1}^{m} P_{t1} (Q_{t2} - Q_{t1})}{\sum_{t=1}^{m} P_{t1} Q_{t1}}}{\dfrac{\sum_{t=1}^{m} Q_{t1} (P_{t2} - P_{t1})}{\sum_{t=1}^{m} P_{t1} Q_{t1}}} \tag{8}$$

which reduces to:

$$E_i = \frac{\sum_{t=1}^{m} P_{t1} (Q_{t2} - Q_{t1})}{\sum_{t=1}^{m} Q_{t1} (P_{t2} - P_{t1})} \tag{9}$$

where E_i is the estimate of the aggregated elasticity, Q_{tj} is the jth observation of the quantity of commodity t, P_{tj} is the jth observation of the price of commodity t, j=1 is the base year and j=2 is the next year. (When the actual calculations were made, 1969 was the base year and 1970 was, of course, the next year.)

Of course, other influences (such as income and taste) on the quantity purchased cannot be ignored. However, if the numerator of equation (9) were calculated from raw data and E_i were known, then it would be possible to find what the denominator would had to have been to have obtained E_i. Conversely, if the denominator of equation (9) were calculated from raw data and E_i were known, then it would be possible to find what the numerator would had to have been to have obtained E_i. That is roughly what is done.

Writing the price elasticity of demand for commodity t, E_t, as:

$$E_t = \frac{\frac{(Q_{t2} - Q_{t1})}{Q_{t1}}}{\frac{(P_{t2} - P_{t1})}{P_{t1}}}$$

$$= \frac{P_{t1} (Q_{t2} - Q_{t1})}{Q_{t1} (P_{t2} - P_{t1})} . \tag{10}$$

Obtaining estimates of E_t from Brandow (7, pp. 17 and 59) and using raw data to estimate the numerator, the estimate of the denominator

is obtained by:

$$Q_{t1}\ (P_{t2} - P_{t1})^{*} = E_t^{-1}\ P_{t1}\ (Q_{t2} - Q_{t1}), \tag{11}$$

Conversely, obtaining estimates of E_t from Brandow and using raw data to estimate the denominator of equation (10), the estimate of the numerator is obtained by:

$$P_{t1}\ (Q_{t2} - Q_{t1})^{*} = E_t\ Q_{t1}\ (P_{t2} - P_{t1}). \tag{12}$$

Raw data and the results of equation (11) or (12) could be used to approximate equation (9). However, since the individual elements of the numerator of equation (9) must be of the same sign as must the elements of the denominator if reasonable results are to be obtained, equations (11) and (12) are rewritten as:

$$Q_{t1}\ (P_{t2} - P_{t1})^{*} = E_t^{-1}\ P_{t1}\ |Q_{t2} - Q_{t1}| \tag{11'}$$

and

$$P_{t1}\ (Q_{t2} - Q_{t1})^{*} = E_t\ Q_{t1}\ |P_{t2} - P_{t1}|. \tag{12'}$$

Therefore, using equation (11') to approximate equation (9):

$$E_i^{*} = \frac{\sum_{t=1}^{m} P_{t1}\ |Q_{t2} - Q_{t1}|}{\sum_{t=1}^{m} Q_{t1}\ (P_{t2} - P_{t1})^{*}} \tag{13}$$

and using equation (12') to approximate equation (9):

$$E_i^{**} = \frac{\sum_{t=1}^{m} P_{t1}\ (Q_{t2} - Q_{t1})^{*}}{\sum_{t=1}^{m} Q_{t1}\ |P_{t2} - P_{t1}|} \tag{14}$$

where E_i^{*} is the first estimate of E_i (the aggregated elasticity) and E_i^{**} is the second.

Either equation (13), equation (14) or their average should be a close approximation of the price elasticity of demand for the time period considered. (In this study, the average is used.) These price elasticities of demand, of course, assume a particular product mix and a particular point in time, so they are relevant only for the year considered, 1969.

This procedure for estimating price elasticities of demand is relevant for both farm and retail level estimates.

Research elasticities of price

While the information thus far presented in this subsection is all that is needed to estimate MVPs and MIRRs, the methodology used makes it possible to calculate research elasticities of price (percentage change in price over percentage change in research expenditures) as well.

Writing the research elasticity of price for commodity group i, $E_{R.P_i}$, as:

$$E_{R.P_i} = \frac{\partial P_i}{\partial R_i} \cdot \frac{R_i}{P_i}$$

the following transformations are made:

$$E_{R.P_i} = \frac{\partial P_i}{\partial Q_i} \cdot \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} \cdot \frac{Q_i}{P_i}$$

$$= \left(\frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i}\right)\left(\frac{\partial P_i}{\partial Q_i} \cdot \frac{Q_i}{P_i}\right)$$

$$= E_{R.Q_i} \cdot E^{-1}_{P.Qd_i} \cdot \qquad (15)$$

Therefore, $E_{R.P_i}$ can be estimated using the same information used

to estimate $E_{R.TVP_i}$. This relationship would be true at both farm and retail levels.

We have now shown that: (1) to calculate marginal internal rate of return (MIRR), all that is need is marginal value product (MVP) and an assumed lag period between research expenditure and the payoff; (2) to calculate MVP, all that is needed is average value product (AVP), the research elasticity of production ($E_{R.Q}$) and the price elasticity of demand ($E_{P.Qd}$); (3) AVP is obtainable from Bredahl and Peterson for farm level estimates and calculated as retail total value product (TVP) divided by research expenditures (R) for retail level estimates; (5) Bredahl and Peterson's research coefficients are actually estimates of farm level $E_{R.Q}$; (6) under specific assumptions concerning the appropriate structural model of the food processing industry, estimates for $E_{R.Q}$ can be used for retail level research elasticities of production, $E_{R,Q'}$; and (7) estimates of $E_{P.Qd}$ are obtainable from available data.

Assumptions and Qualifications

The methodology used for determining MVPs and MIRRs depends on a number of assumptions and other qualifications.

First, this analysis considers only the effects of production increasing research. Despite the fact that the estimates for research expenditures include all expenditures for the commodities of interest, the only impact quantified is the impact on output.

Second, the model considered is static. The elasticities used assume a given product mix, the relationship assumed between farm and retail outputs assumes a given state of technology for some nonfarm sectors of the economy, and the prices used assume a given demand curve.

Third, the study considers Bredahl and Peterson's results as given; therefore, any errors in their study are transfered to this one.

Fourth, a bias emerges during the derivation of Kansas research elasticities of total value product and price. When the expression $\frac{\partial P_i}{\partial R_i} \cdot \frac{R_i}{P_i}$ is expanded to $\frac{\partial P_i}{\partial Q_i} \cdot \frac{\partial Q_i}{\partial R_i} \cdot \frac{R_i}{Q_i} \cdot \frac{Q_i}{P_i}$, the expansion assumes that the two ∂Q_is were equal and the two Q_is were equal. However, when price elasticities of demand are calculated for Kansas, national commodity price elasticities of demand are used. Therefore, the ∂Q_i in the denominator and the Q_i in the numerator are national figures (but assume the Kansas product mix for Kansas calculations), whereas the ∂Q_i in the numerator and the Q_i in the denominator are Kansas figures. This discrepency causes the Kansas research elasticities of total value product and price, and the Kansas marginal value products to be biased downwards; thus the estimated Kansas returns to research may be overestimated.

Fifth, $Q_i = kQ_i'$ used for obtaining retail research elasticities may not be a realistic assumption. To illustrate, assume the structural model of the food processing sector is such that a reduced form of the relationship between farm level output, Q_i, and its respective retail level output, Q_i', can be written as:

$$Q_i' = f(Q_i, \text{others}).$$

Also assume that Q_i can be solved for such that:

$$Q_i = g(Q_i', \text{others}).$$

Since Q_i is a function of research expenditures, R_i, Q_i' is also a function of R_i. Therefore, if each side of the equation is differentiated with respect to R_i:

$$\frac{\partial Q_i}{\partial R_i} = \frac{\partial g(Q_i', \text{ others})}{\partial Q_i'} \cdot \frac{\partial Q_i'}{\partial R_i} .$$

Thus it can be seen that in order for the assumption that farm level and retail level research elasticities of output are equal to be true, $\frac{\partial g(Q_i', \text{ others})}{\partial Q_i'}$ would have to equal one which would be a special case rather than the general case.

Sixth, using 1969 research expenditures to calculate the retail average value product assumes no lags. This, of course, is not realistic; however, earlier research figures are not readily available. Also, using 1969 expenditures conforms with Bredahl and Peterson's study (8, p. 685), so the bias should not be great.

Seventh, only livestock, poultry and dairy commodity groups are considered for retail level calculations. This is because many of the commodities classified as cash grain are not directly marketed at the retail level.

Eighth, no Kansas retail level estimates are calculated. Doing so would require carefully following Kansas products from farm to retail. Such a task is unreasonable for this study.

Derivation of Price Elasticities, Research Elasticities, Marginal Internal Rates of Return and Marginal Value Products--Applied Considerations

The format in this subsection is necessarily the reverse of the algebraic subsection. This subsection begins with the calculation of price elasticities of demand. Those elasticities are then combined with Bredahl and Peterson's research elasticities of production to obtain research elasticities of price and total value product. The estimates of

research elasticities of price and total value product are combined with estimates of average value product to obtain the marginal value products. Finally, the marginal value products calculated are then combined with time lags obtained from Bredahl and Peterson to obtain marginal internal rates of return.

As stated earlier, the resulting averages of equations (13) and (14) were used as estimates for price elasticities of demand. At the farm level for Kansas, the commodity elasticities, 1969 prices, 1969 production and 1970 production, Kansas data, appendix table 9, are used in equation (13) to obtain E_i^*, the first price elasticity of demand estimate. The same commodity elasticities, 1970 prices, 1969 prices and 1969 production, from appendix table 9, are used in equation (14) to obtain E_i^{**}, the second price elasticity of demand estimate. The average of E_i^* and E_i^{**} for each farm type is reported in table 7 as the estimated farm level price elasticity of demand for Kansas. U.S. farm level price elasticities of demand are estimated in the same manner, but the commodity elasticities, production and prices are based on U.S. data (see appendix table 10). The U.S. farm level results are also reported in table 7. Retail price elasticities of demand estimates use the same procedure, but the basic information is from appendix table 11. These retail elasticities are shown in table 10.

Using the price elasticities of demand just estimated and the research coefficients shown in table 6, research elasticities of price and total value product are estimated using equations (4) and (15). For example, in the case of Kansas cash grain farms, the farm level price elasticity of demand found in table 7, -0.1240, and the research elasticity of production found in table 6, 0.041, are combined in equation (15)

to obtain the Kansas farm level research elasticity of price shown in table 8, -0.3306. The same figures are used in equation (4) to obtain the Kansas farm level research elasticity of total value product, -0.2896, which is also shown in table 8. The same procedure is used for estimating the U.S. farm level elasticities shown in table 8, and the retail level elasticities shown in table 11.

Marginal value products were estimated using average value products and research elasticities of total value product equation (3). Again using Kansas cash grain farms as an example, the research elasticity of total value product from table 8, -0.2896, and the average product[3] from table 5, 91.46, are combined in equation (3) to obtain the marginal value product shown in table 9, -26.49. The same procedure and tables are used for U.S. farm level marginal value products.

In the case of retail marginal value products, average value products are not available and so have to be estimated. The total value products are obtained from appendix table 11 using 1969 prices and production. Research expenditures for 1969 are obtained from table 14, but current dollars are used. The quotients of total value product and research expenditures are used as average value product.

From here, the procedure for estimating retail level marginal value product is the same as for estimating farm level MVP. The research elasticities of total value product from table 11 and the retail average value products estimated above were combined in equation (4). The results are shown in table 12.

Given the marginal value products just calculated, the marginal internal rates of return were calculated using equation (1) and assuming lags of five years for cash grain, six years for poultry and dairy, and seven years for livestock (8, p. 688).

FOOTNOTES: CHAPTER II

1. Lags used are five years for cash grain, six years for poultry and dairy, and seven years for livestock (8, p. 688). These lags closely conform with those calculated by Evenson (19, p. 1422).

2. A special thanks goes to Dr. John Nordin for his help in obtaining the price elasticity of demand equation.

3. Bredahl and Peterson's average product is equivalent to average value product because they used prices as weights.

CHAPTER III

RESULTS

Productivity

Historically, the productivity gains of U.S. agricultural inputs have been impressive. Since 1910, agricultural output has increased 179 percent while inputs have increased 20 percent (13, p. 4). Studies such as those by Cline and Lu (10) and Evenson (18) have shown that agricultural research made significant contributions to those gains.

Recent productivity gains in Kansas have been impressive. In terms of gross productivity since 1950, Kansas ranks sixth among all states (18, p. 16). However, that information could be misleading because of the short time period considered and because recent gains could have been made possible by relatively small productivity gains earlier (18, p. 16).

The present study concentrated on productivity for four types of farms: cash grain, poultry, livestock and dairy. Tables 1 through 4 contain the results.

Kansas Farms

As can be seen in table 1, production on Kansas farms increased significantly during the time period considered. Input use increased also, with labor being the only exception.

Poultry farms were the only farms which did not show labor inputs decreasing relative to all other inputs. Labor use actually decreased

TABLE 1

PERCENTAGE CHANGES IN PRODUCTION AND INPUTS USED PER KANSAS FARMS WITH SALES OF $2500 OR MORE, BY TYPE OF FARM, 1964 TO 1969, 1969 TO 1974 AND 1964 TO 1974

	1964-69	1969-74	1964-74
Cash Grain Farms (Ave. per Farm)			
Production (1974 Dollars)	54.8	16.1	79.7
Harvested Acres	12.8	7.7	21.5
Labor (Man-days)	-5.5	5.1	-0.7
Machinery Services (1974 Dollars)	9.0	35.2	47.3
Purchased Fertilizer, Seed and Chemicals (1974 Dollars)	103.0	43.4	191.1
Poultry Farms (Ave. per Farm)			
Production (1974 Dollars)	125.0	35.0	203.7
Land and Buildings (1974 Dollars)	27.1	9.6	39.3
Labor (Man-days)	14.9	42.1	63.2
Purchased Feed and Poultry[1] (1974 Dollars)	160.3	22.5	219.0
Livestock Farms (Ave. per Farm)			
Production (1974 Dollars)	12.2	81.2	103.4
Land and Buildings (1974 Dollars)	-9.5	14.1	3.3
Labor (Man-days)	-8.4	7.7	-1.3
Breeding Stock (1974 Dollars)	-13.2	117.6	88.7
Feed[1] (1974 Dollars)	14.3	80.1	105.8
Dairy Farms (Ave. per Farm)			
Production (1974 Dollars)	59.9	54.6	147.2
Land and Buildings (1974 Dollars)	19.9	172.0	226.0
Pasture Land (Acres)	-12.7	22.2	6.7
Labor (Man-days)	10.6	4.1	15.1
Milking Cows (Numbers)	26.3	29.6	63.7
Feed[1] (1974 Dollars)	47.4	28.6	89.6

SOURCE: Appendix Tables 1, 2, 3 and 4. All weights were 1974 prices. Where more than one input or output is represented, the percentage change is a weighted average.

[1]Figures exclude some feedstuffs grown and fed on the same farm.

TABLE 2

PERCENTAGE CHANGES IN PRODUCTION AND INPUTS USED PER U.S. FARMS WITH SALES OF $2500 OR MORE, BY TYPE OF FARM, 1964 TO 1969, 1969 TO 1974 AND 1964 TO 1974

	1964-69	1969-74	1964-74
Cash Grain Farms (Ave. per Farm)			
Production (1974 Dollars)	24.0	11.2	37.9
Harvested Acres	6.0	1.0	7.1
Labor (Man-days)	1.5	-2.9	-1.4
Machinery Services (1974 Dollars)	6.1	20.6	28.0
Purchased Fertilizer, Seed and Chemicals (1974 Dollars)	63.4	27.4	108.2
Poultry Farms (Ave. per Farm)			
Production (1974 Dollars)	63.9	46.6	140.3
Land and Buildings (1974 Dollars)	8.2	-1.7	6.4
Labor (Man-days)	20.4	18.1	42.3
Purchased Feed and Poultry[1] (1974 Dollars)	85.5	35.0	150.5
Livestock Farms (Ave. per Farm)			
Production (1974 Dollars)	-2.3	25.6	22.7
Land and Buildings (1974 Dollars)	-20.9	8.2	-14.5
Labor (Man-days)	-12.7	-4.0	-16.1
Breeding Stock (1974 Dollars)	1.3	6.1	7.5
Feed[1] (1974 Dollars)	2.4	22.6	25.5
Dairy Farms (Ave. per Farm)			
Production (1974 Dollars)	34.9	41.8	91.3
Land and Buildings (1974 Dollars)	6.8	10.8	18.3
Pasture Land (Acres)	8.7	6.8	16.1
Labor (Man-days)	5.7	4.5	10.5
Milking Cows (Numbers)	15.8	29.8	50.3
Feed[1] (1974 Dollars)	63.4	25.3	104.8

SOURCE: (4, p. 25). Appendix Tables 5, 6, 7 and 8. All weights were 1974 prices. Where more than one input or output is represented, the percentage change is a weighted average.

[1]Figures exclude some feedstuffs grown and fed on the same farm.

0.7 percent on cash grain farms and 1.3 percent on livestock farms. That information seemed to indicate a substitution of other inputs for labor.

In livestock farms, feed increased more than all other inputs. This could have been due to data not considering some feedstuffs grown and fed on the same farm or an increase in feeders striving for rapid turnover.

U.S. Farms

As can be seen in table 2, U.S. farms also showed productivity gains, but the gains were not as impressive as those for Kansas farms.

Again, only on poultry farms did labor not decrease relative to other inputs. Poultry farm labor increased 42.3 percent while, on the other extreme, livestock farm labor decreased -16.1 percent.

Comparison of Kansas and U.S. Farms

As can be seen in table 3, except on dairy farms Kansas productivity gains were superior to those of the country as a whole. Most of the Kansas gain came during the 1964-1969 period. On all farms, Kansas production and Kansas input use increased more than for the rest of the country.

Table 4 compares the levels of productivity on Kansas versus U.S. farms. Kansas input productivity was consistently superior on cash grain and livestock farms, and consistently inferior on poultry and dairy farms. This seems reasonable because Kansas agriculture is predominantly livestock and cash grain.

Returns to Research

Societal benefits from agricultural research can take many forms. If the research increases farm resource productivity or increases farm use of renewable resources relative to norenewable resources, society

TABLE 3

PERCENTAGE CHANGES IN VALUE OF PRODUCTION AND INPUTS USED PER KANSAS AND U.S. FARMS WITH SALES OF $2500 OR MORE, BY TYPE OF FARM, 1964 TO 1969, 1969 TO 1974 AND 1964 TO 1974

	1964-69		1969-74		1964-74	
	KS	US	KS	US	KS	US
	Cash Grain Farms (Ave. per Farm)					
Production	54.8	24.0	16.1	11.2	79.7	37.9
Inputs	15.0	11.4	17.3	8.0	34.9	20.3
Prod/Inputs	34.6	11.2	-1.1	3.0	33.2	14.6
	Poultry Farms (Ave. per Farm)					
Production	125.0	63.9	35.0	46.6	203.7	140.3
Inputs	102.9	62.6	21.8	28.6	147.2	109.1
Prod/Inputs	10.9	0.8	10.8	14.0	22.8	14.9
	Livestock Farms (Ave. per Farm)					
Production	12.2	-2.3	81.2	25.6	103.4	22.7
Inputs	-5.1	-10.5	58.1	9.3	50.1	-2.2
Prod/Inputs	18.2	9.1	14.6	14.3	35.5	24.6
	Dairy Farms (Ave. per Farm)					
Production	59.9	34.9	54.6	41.8	147.2	91.3
Inputs	22.9	24.2	80.6	16.3	121.9	44.4
Prod/Inputs	30.1	8.6	-14.4	21.9	11.4	32.5

SOURCE: Appendix tables 1 through 8. U.S figures were obtained from Babb and Pratt (4, p. 26). Labor was valued at $18.64 per day (47). Land was valued on the basis of value per acre for the respective farm type in 1974 and multiplied times 0.15. Land and buildings was also multiplied by 0.15. Dairy cows were valued at $500 per head and multiplied times 0.15 (4, p. 26).

TABLE 4

PERCENTAGE DIFFERENCE IN TOTAL PRODUCTIVITY OF KANSAS FARMS OVER U.S. FARMS, BY TYPE OF FARM, 1964, 1969 AND 1974[1]

	Year		
Type of Farm	1964	1969	1974
Cash Grain	14.5	38.5	33.4
Poultry	-32.1	-25.4	-27.4
Livestock	19.3	29.4	29.8
Dairy	-26.6	-12.2	-38.3

[1]Percentage difference is calculated by (KS/U.S. productivity - 1) * 100.

benefits because nonrenewable resources would be conserved or put to other uses. If the research improved the quality of old products or created new products, society would be the ultimate beneficiary. If the research increased agricultural production or lowered food prices, societal benefits would be twofold. First, increased production would lead to a more secure food supply. Second, lower food prices would allow for the purchase of more luxeries. It is the latter two benefits--increased production and lower prices--that are considered by this study.

The measure of benefit used is the marginal increase in production and the marginal decrease in price which have resulted from the investment of the last research dollar spent. The marginal increase in production and the marginal decrease in price combine to form marginal value product, MVP.

A negative MVP interprets as a decrease in total value product (TVP) at the level considered--either farm or retail. The decrease in TVP would mean that society would be receiving more product but paying less for it.

Conversely, a positive MVP interprets as an increase in TVP. The increase in TVP would mean that, even though society would be receiving more, it would also be paying more.

Kansas Returns--Farm Level

The Bredahl and Peterson results are shown in tables 5 and 6. If the marginal products and MIRRs shown in table 5 were considered as the measure of social benefit from agricultural research, it would appear that, economically speaking, Kansas should decrease expenditures on poultry research and increase expenditures in the other three areas. However, the

TABLE 5

AVERAGE AND MARGINAL PRODUCTS AND MARGINAL INTERNAL RATES OF RETURN REPORTED BY BREDAHL AND PETERSON FOR TYPES OF FARMS, KANSAS AND U.S., 1969

Type of Farm	Average Product	Marginal Product	Marginal IRR(%)[1]
		Kansas	
Cash Grain	91.46	3.75	30.26
Poultry	13.93	0.85	-2.67
Livestock	176.40	17.64	50.69
Dairy	41.36	2.23	14.33
		U.S.[2]	
Cash Grain	114.55	4.70	36.20
Poultry	106.99	6.53	36.70
Livestock	140.61	13.92	45.70
Dairy	160.06	8.64	43.20

SOURCE: (8, p. 690). Figures were divided by three in order to reflect the effects of public research only.

[1]Lag times assumed were 5 years for cash grain, 6 years for poultry, 7 years for livestock and 6 years for dairy (8, p. 688).

[2]U.S. figures for average and marginal products and marginal internal rates of return were obtained form Babb and Pratt (4, p. 30).

TABLE 6

REGRESSION COEFFICIENTS OBTAINED BY INSTRUMENTAL VARIABLE TECHNIQUE AS REPORTED BY BREDAHL AND PETERSON BY TYPE OF FARM, 1969

	Type of Farm			
Inputs	Cash Grain	Poultry	Livestock	Dairy
Research	0.041	0.061	0.099	0.054
Fertilizer				
Southeast	0.038			
Corn Belt	0.137			
Other	0.102			
Labor	0.251	0.185	0.067	0.632
Land	0.192			
Chemicals	0.081			
Seed	0.132			
Machinery	0.447			
Feed		0.530	0.547	0.151
Poultry Purchased		0.282		
Land and Buildings		0.123	0.261	0.077
Livestock			0.137	
Dairy Cattle				0.177
Pasture				0.046

SOURCE: (8, pp. 687-8).

TABLE 7

ESTIMATED FARM LEVEL PRICE ELASTICITIES OF DEMAND FOR SELECTED COMMODITY GROUPS, KANSAS AND U.S., 1969

	Commodity Group			
	Grain[1]	Poultry[2]	Livestock[3]	Dairy[4]
Kansas	-0.1240	-0.2849	-0.6379	-0.1500
U.S.	-0.1626	-0.5173	-0.6626	-0.1500

[1]Includes wheat, rye, corn, oats, barley, soybeans and sorghum.

[2]Includes chickens, turkeys and eggs.

[3]Includes cattle, calves, hogs, sheep and lambs.

[4](54, p. 33).

marginal values in table 5 are not complete measures of benefit because they ignore the effects of research on price.

The marginal value products in table 9 do take price effects into account. The Kansas figures in that table indicate that society receives a positive MIRR on Kansas poultry research. Since the MIRRs for Kansas are all at high or very high levels, it would seem socially desirable for Kansas to increase all of its production research expenditures--especially in the areas of cash grain and dairy (ignoring possible effects on other research benefits and costs).

U.S. Returns--Farm Level

As in the case of Kansas figures, the marginal values for U.S. farms shown in table 5 are misleading. Those figures would seem to indicate that the U.S. as a whole should increase expenditures on livestock research relative to expenditures in other areas. However, in light of the U.S. farm level marginal value products shown in table 9, livestock research expenditures should decrease relative to others.

In general, U.S. MIRRs in table 9 are higher than those for Kansas. Economically speaking, this indicates that Kansas had a more optimal level of research investment in 1969 than did the rest of the U.S. as a whole.

U.S. Returns--Retail Level

The dollars society saved at the farm level because of agricultural research were used for basically two purposes: First, they were used to more completely process the raw farm products so that the retail products were more appealing, sanitary, convenient, etc. Second, they were used to purchase luxeries in other segments of the economy. Retail level MVPs

TABLE 8

ESTIMATED FARM LEVEL RESEARCH ELASTICITY OF PRICE AND RESEARCH ELASTICITY OF TOTAL VALUE PRODUCT FOR KANSAS AND ALL U.S. STATE AGRICULTURAL EXPERIMENT STATIONS BY TYPE OF FARM, 1969

Type of Farm	Kansas		U.S.	
	$E_{R \cdot P}$	$E_{R \cdot TVP}$	$E_{R \cdot P}$	$E_{R \cdot TVP}$
Cash Grain	-0.3306	-0.2896	-0.2522	-0.2122
Poultry	-0.2141	-0.1531	-0.1179	-0.0569
Livestock	-0.1552	-0.0562	-0.1494	-0.0504
Dairy	-0.3600	-0.3060	-0.3600	-0.3060

TABLE 9

FARM MARGINAL VALUE PRODUCTS AND MARGINAL INTERNAL RATES OF RETURN FOR KANSAS AND ALL U.S. STATE AGRICULTURAL EXPERIMENT STATION RESEARCH BY TYPE OF FARM, 1969

	Kansas		U.S.	
	MVP	MIRR(%)	MVP	MIRR(%)
Cash Grain	-26.49	92.59	-24.19	89.11
Poultry	-2.13	13.46	-6.09	35.14
Livestock	-9.91	38.78	-7.09	32.28
Dairy	-12.66	52.66	-48.98	91.28

are indicators of how much of the farm level savings goes to processing and how much goes to other segments of the economy.

As can be seen in table 12, the MVP for poultry at the retail level was positive. This was because demand at the retail level was elastic. The positive MVP indicates that all of the farm level savings for poultry were used in processing.

Of the other two commodity groups shown in table 12, dairy makes most significant contribution to retail level savings.

Implications

If it were the desire of the society to increase demand in the nonagricultural sectors, expenditures on dairy research would be the most productive. If the goal were to increase resources committed to processing, poultry research expenditures would be the most productive. If the desire were to not decrease farm level TVP, production increasing agricultural research would not be undertaken.

If the benefits from agricultural research which accrue to a particular state were defined as increasing the total revenue brought in by that state, it is clear that a state composed primarily of agricultural producers would not have been the beneficiary of agricultural research. In fact, the state that would have received the benefit would have been the state composed primarily of food processors and other industries which had experienced increases in demand because of decreases in societal expenditures on food.

Research Funding Patterns

During the period from 1969 to 1976, constant dollar research expenditures in Kansas decreased (see table 14). This is contrary to what

TABLE 10

ESTIMATED RETAIL PRICE ELASTICITIES OF DEMAND FOR SELECTED GROUPS, U.S., 1969

Commodity Group		
Poultry[1]	Livestock[2]	Dairy[3]
-1.0528	-0.9780	-0.6030

[1]Includes chickens, turkeys and eggs.

[2]Includes beef, veal, pork and lamb.

[3]Includes fluid milk and cream, evaporated milk, cheese, ice cream and butter.

TABLE 11

ESTIMATED RETAIL LEVEL RESEARCH ELASTICITY OF PRICE AND RESEARCH ELASTICITY OF TOTAL VALUE PRODUCT BY COMMODITY, U.S., 1969

	Commodity Group		
	Poultry[1]	Livestock[2]	Dairy[3]
$E_{R \cdot P}$	-0.0579	-0.1012	-0.0896
$E_{R \cdot TVP}$	0.0031	-0.0022	-0.10356

[1]Includes chickens, turkeys an eggs.

[2]Includes beef, veal, pork and lamb.

[3]Includes fluid milk and cream, evaporated milk, cheese, ice cream and butter.

TABLE 12

ESTIMATED RETAIL LEVEL AVERAGE VALUE PRODUCTS, MARGINAL VALUE PRODUCTS AND MARGINAL INTERNAL RATES OF RETURN BY COMMODITY GROUP, U.S., 1969

Commodity Group	AVP[1]	MVP	MIRR(%)[2]
Poultry[3]	478.77	1.465	6.57
Livestock[4]	948.68	-2.113	11.28
Dairy[5]	996.09	-135.413	81.22

[1]Total value product was taken from Appendix table 11 and research expenditures were taken from table 14, but in 1969 dollars.

[2]Lag times used were six years for poultry, seven years for livestock and six years for dairy (8, p. 688).

[3]Includes chickens, turkeys and eggs.

[4]Includes beef, veal, pork and lamb.

[5]Includes fluid milk and cream, evaporated milk, cheese, ice cream and butter.

TABLE 13

DIFFERENCES IN MARGINAL VALUE PRODUCTS BETWEEN FARM AND RETAIL LEVEL FOR SELECTED COMMODITY GROUPS, U.S., 1969

	Commodity Group		
	Poultry	Livestock	Dairy
MVP	7.56	4.98	13.57
MIRR(%)[1]	40.08	25.77	54.44

[1]Lag time was six years for poultry and dairy, and seven years for livestock (8, p. 688).

marginal analysis recommends. However, research expenditures for cash grain and livestock did increase both in real terms and in relative terms.

For the U.S. as a whole, real research expenditures increased from 1969 to 1976 (see table 14). As with Kansas, U.S. expenditures increased in the areas of cash grain and livestock. Yet unlike Kansas, U.S. expenditures increased for dairy research.

TABLE 14

REAL RESEARCH EXPENDITURES (1974 DOLLARS) FOR SELECTED COMMODITIES AT KANSAS, ALL NORTH CENTRAL REGION AND ALL U.S. STATE AGRICULTURAL EXPERIMENT STATIONS, 1969, 1974 AND 1976

	Expenditures ($1000)				
Kansas	Crops[1]	Livestock[2]	Dairy	Poultry	Total[3]
1969	1,775	1,448	806	636	13,442
1974	2,569	2,128	674	417	9,288
1976	3,871	2,660	706	413	11,629
N.C. Region					
1969	13,141	18,764	11,157	5,344	129,320
1974	15,966	23,089	9,897	4,326	122,621
1976	19,055[4]	24,415	10,181	4,710	133,922
U.S.					
1969	24,453	48,224	28,543	22,032	427,777
1974	29,876	54,523	27,013	19,157	423,983
1976	36,932	60,528	29,315	19,559	457,648
	Percent of Total Expenditures (%)				
Kansas					
1969	13.2	10.8	6.0	4.7	
1974	27.7	22.9	7.3	4.5	
1976	33.3	22.9	6.1	3.6	
N.C. Region					
1969	10.2	14.5	8.6	4.1	
1974	13.0	18.8	8.1	3.5	
1976	14.2	18.2	7.6	3.5	
U.S.					
1969	5.7	11.3	6.7	5.2	
1974	7.0	12.0	6.4	4.5	
1976	8.3	13.5	6.6	4.4	

SOURCE: Cooperative State Research Service, Inventory of Agricultural Research, U.S. Department of Agriculture (49). Except for crops, unadjusted U.S. and regional figures were obtained from Babb and Pratt (4, p. 35). Expenditures were adjusted with the implicit price deflater for government purchases of goods and services, 1974 = 100 (Business Statistics, 52).

TABLE 14-Continued

[1]Includes corn, wheat, grain sorghum and soybeans.

[2]Includes beef, swine and sheep.

[3]All research, not just those itemized here.

[4]Regional figures for grain sorghum research were not available for 1976; therefore, they were estimated assuming the percentage change from 1974 expenditures would be the average of the percentage changes in Kansas and U.S. expenditures.

CHAPTER IV

SUMMARY

Interest in the studies of the allocation and productivity of resources devoted to agricultural research has received a new impetus in recent years. As demands for scarce research funds increase, the accountability of their use to the voters and thus their allocation becomes very important, not only for legislators, but for those administering funds as well.

Studies of this type fall into two broad categories: ex post and ex ante. Ex ante studies examine the prospective returns to agricultural research not yet done. Ex post studies examine the returns to research which has already been put in practice.

Ex post studies are generally one of two approaches: the production function approach or the index number approach. The index number approach measures changes in consumer and producer surpluses that result from agricultural research. That approach is difficult to use in policy analysis.

The approach that does lend itself to policy analysis, the production function approach, is able to do so because marginal analysis (the analysis needed for allocation decisions) is readily acheived. That approach normally develops a production function to explain agricultural output, and includes research as an explanatory variable.

A major shortcoming of the production function approach has been the assumption of constant prices. Because of that assumption, the approach does not calculate the research marginal value porducts needed for allocation decisions. This study developed a methodology which can be applied to existing production function results to calculate marginal value products of research at both the farm and retail levels.

The methodology demonstrates that all that was necessary to calculate marginal value products was the average value product (total value of considered production divided by considered research expenditures), the research elasticity of production (percentage change in the physical units of considered production divided by the percentage change in the considered research expenditures) and the price elasticity of demand (the percentage change in the physical units of the considered production divided by the percentage change in the relevant prices). The methodology further demonstrates that average value products can be calculated from existing data or obtained from production function results, estimates for research elasticity of production are provided by the production function studies, and estimates for price elasticity of the demand are obtainable from existing information.

To demonstrate the methodology, this study uses farm level average value products and research elasticities of production from Bredahl and Peterson (8), farm and retail level price elasticities of demand from Brandow (7), and estimated retail level average value products to calculate marginal value products for production increasing research in the areas of poultry, cash grain, livestock and dairy.

By using constant prices, previous production function approach studies have only been able to calculate marginal products for research.

The value of estimating marginal value products over marginal products is evident from the results of this study. Bredahl and Peterson calculated a marginal product of $0.85 for Kansas poultry research. Since the marginal expenditure was one dollar, this would appear to indicate overinvestment in this area. However, the marginal value product found in this study for Kansas poultry research was $-2.13 which means that society saved $2.13 in expenditures on poultry at the farm level. Spending one dollar on research to save $2.13 on total expenditures for poultry would seem to indicate that more rather than less research dollars should be spent in this area.

Estimation of both retail and farm level marginal value products permitted the examination of the forms research returns have taken. For example, in the case of U.S. poultry research the farm level marginal value product was $-6.09 while the retail level marginal value product was $7.56. That means that farm level expenditures for poultry products decreased while retail level expenditures increased. Therefore, all the returns to poultry research were in the form of increased processing of poultry products.

APPENDIX

APPENDIX TABLE 1

PRODUCTION AND INPUTS USED PER FARM ON KANSAS CASH GRAIN FARMS
WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Wheat (Bushels)[1]	3,745.4	5,569.8	6,633.5
Sorghum (Bushels)[2]	2,037.8	3,020.3	2,687.9
Corn (Bushels)[3]	852.3	1,835.9	2,805.0
Soybeans (Bushels)[4]	217.4	320.6	354.8
Value of Production, 1974 Dollars[5]	25,935.5	40,140.5	46,596.3
Inputs Used Per Farm			
Harvested Acres	286.4	323.1	347.9
Operator Labor (Days)[6]	205.0	186.1	194.8
Hired Labor (Days)[7]	38.6	44.0	47.0
Total Labor (Days)	243.6	230.1	241.8
Fertilizer Purchased, 1974 Dollars[8]	1,079.7	2,324.3	3,445.7
Chemicals Purchased, 1974 Dollars[9]	223.3[15]	324.2	699.0
Seed Purchased, 1974 Dollars[10]	427.5	864.4	892.9
Petroleum Products Purchased 1974 Dollars[11]	1,564.8	1,731.3	2.118.5

APPENDIX TABLE 1-Continued

Inputs Used Per Farm	1964	1969	1974
Custom Work Purchased, 1974 Dollars[12]	510.9[16]	718.2	890.3
Value of Equipment, 1974 Dollars[13]	21,111.3[17]	21,749.7	31,414.4
Value of Equipment Service, 1974 Dollars[14]	5,242.4	5,712.0	7,721.0

SOURCE: Census of Agriculture (53).

[1]Wheat production was adjusted by a three year average yield centered on the census year. Census production was multiplied by 1.1333 in 1974, 0.9677 in 1969 and 1.0152 in 1964.

[2]Sorghum production was handled the same as wheat. Census production was multiplied by 1.15 in 1974, 0.8571 in 1969 and 1.2051 in 1964.

[3]Corn was handled the same as wheat and sorghum. Census production was multiplied by 1.1181 in 1974, 325 in 1969 and 1.1111 in 1964.

[4]Soybean production was treated the same as the others. Census production was multiplied by 1.05 in 1974, 0.913 in 1969 and 0.9907 in 1964.

[5]Prices in 1974 in Kansas were $4.23 per bushel for wheat, $3.08 per bushel for sorghum, $2.85 per bushel for corn and $6.38 per bushel for soybeans (28).

[6]Days of operator labor was calculated from days of work off the farm data assuming 260 days labor for a full-time operator and multiplying work done by operators over 65 years of age by 0.6 (4, p. 62).

APPENDIX TABLE 1-Continued

[7]Days of hired labor was calculated using a daily wage rate of $18.64 in 1974, $13.50 in 1969 and $10.10 in 1964 (7).

[8]The fertilizer price index used was obtained from Babb and Pratt (4, p. 62). Expenditures were divided by 1.00 in 1974, 0.521 in 1969 and 0.611 in 1964.

[9]The chemical price index was obtained from Babb and Pratt (4, p. 62). Expenditures were divided by 1.00 in 1974, 0.8403 in 1969 and 0.8151 in 1964.

[10]The seed price index was obtained from Babb and Pratt (4, p. 62). Expenditures were divided by 1.00 in 1974, 0.493 in 1969 and 0.4152 in 1964.

[11]The petroleum price index was obtained from Babb and Pratt (4, p. 62). Net custom work purchased was divided by 1.00 in 1974, 0.6415 in 1969 and 0.6101 in 1964.

[12]The custom work price index was obtained from Babb and Pratt (4, p. 62). Net custom work purchased was divided by 1.00 in 1974, 0.6894 in 1969 and 0.559 in 1964.

[13]The equipment price index was obtained from Babb and Pratt (4, p. 62). The market value was divided by 1.00 in 1974, 0.6894 in 1969 and 0.559 in 1964.

[14]Value of equipment service equals petroleum plus custom work plus 0.15 times value of equipment.

[15]The value of chemicals was not available for 1964, so it was estimated by multiplying the 1964-1969 ratio for Indiana (4, p. 62) by 1969 expenditures for Kansas.

[16]Income from custom work sold was not available for 1964, so the expenditures for 1964 were multiplied by the ratio of custom work sold to custom work purchased for 1969 as an estimate.

[17]Value of equipment was not available for 1964, so it was estimated by multiplying the ratio of 1964-1969 values from Indiana (4, p. 62) by the 1969 Kansas value.

APPENDIX TABLE 2

PRODUCTION AND INPUTS USED PER FARM ON KANSAS POULTRY FARMS WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Value of Broilers Sold, 1974 Dollars[1]	438.6	246.7	2,087.4
Value of Turkeys Sold, 1974 Dollars[2]	14,086.4[9]	8,854.3	1,908.6
Value of Eggs Sold, 1974 Dollars[3]	8,979.3	43,784.3[10]	67,380.5
Value of Poultry Products Sold, 1974 Dollars	23,504.3	52,885.3	71,376.5
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars[4]	81,270.7	103,256.3	113,183.0
Operator Labor (Days)[5]	224.1	187.3	197.7
Hired Labor (Days)[6]	101.7	186.9	334.0
Total Labor (Days)	325.8	374.2	531.7
Poultry Purchased, 1974 Dollars[7]	4,810.4	14,402.2	18,734.5
Feed Purchased, 1974 Dollars[8]	20,640.3	51,846.9	62,440.7

SOURCE: Census of Agriculture (53).

APPENDIX TABLE 2-Continued

[2]The 1974 Kansas broiler price 23.2 cents per pound was multiplied times the average weight of broilers in Kansas which, in turn, was multiplied times the number of broilers per farm. The average weight of broilers in Kansas was 3.9 pounds in 1974, 3.3 pounds in 1969 and 3.3 pounds in 1964 (47).

[3]Turkeys were treated the same as broilers. The 1974 price was 36.8 cents per pound. The average weights were 25 pounds in 1974, 20.7 pounds in 1969 and 17.8 pounds in 1964 (47).

[4]The 1974 Kansas egg price of 39.4 cents per dozen was multiplied times the lay rate per hen divided by 12. This was multiplied times the number of hens. The Kansas lay rate for 1974 was 227 eggs per hen, 226 eggs per hen for 1969 and 210 eggs per hen for 1964 (47).

[5]The value per farm was multiplied times 1.00 in 1974, 1.5999 in 1969 and 2.2031 in 1964 (47).

[6]Days of operator labor was calculated the same as it was for cash grains farms.

[7]Days of hired labor was calculated the same as it was for cash grain farms.

[8]The price index for poultry purchased was obtained from Babb and Pratt (4, p. 64). Purchases per farm were divided by 1.00 in 1974, 0.82 in 1969 and 0.85 in 1964.

[9]The price index for feed was obtained from Babb and Pratt (4, p. 64). Purchases were divided by 1.00 in 1974, 0.5224 in 1969 and 0.5651 in 1964.

[10]Census data for turkeys sold on Kansas poultry farms in 1964 was not available. It was estimated taking the turkeys on Kansas farms in 1964 times the ratio of turkeys sold in 1969 to total turkeys in 1969 (47).

[11]The number of eggs in 1969 was obtained directly from the census.

APPENDIX TABLE 3

PRODUCTION AND INPUTS USED PER FARM ON KANSAS LIVESTOCK FARMS
WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Number of Cattle Sold	74.0	79.7	172.2
Number of Calves Sold	29.2	34.9	17.9
Number of Hogs and Pigs Sold	58.9	82.6	107.9
Number of Sheep and Lambs Sold	15.2	8.6	5.0
Value of Livestock Sold, 1974 Dollars[1]	35,258.6	39,575.5	71,726.9
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars[2]	175,099.2	158,497.0	180,832.0
Operator Labor (Days)[3]	210.9	189.3	178.9
Hired Labor (Days)[4]	58.1	57.2	86.7
Total Labor (Days)	269.0	246.5	265.6
Value of Beef Breeding Stock[5]	10,118.2	11,239.7	14,664.4
Value of Hog Breeding Stock[6]	297.3	456.2	496.8
Value of Sheep Breeding Stock[7]	199.1	139.4	69.1
Livestock Purchased[8]	16,192.0	13,653.6	31,281.8
Value of Breeding Stock, 1974 Dollars[9]	17,785.2	15,428.9	33,566.3

APPENDIX TABLE 3-Continued

Inputs Used Per Farm	1964	1969	1974
Feed Purchased, 1974 Dollars[10]	7,712.2	10,425.2	24,101.3
Hay Produced, 1974 Dollars[11]	2,912.1	3,230.6	2,760.2
Corn Silage Produced, 1974 Dollars[12]	1,056.1	1,334.8	1,355.5
Sorghum Silage Produced, 1974 Dollars[13]	2,658.6	1,395.4	1,297.8
Value of Feed, 1974 Dollars[14]	14,339.0	16,386.0	29,514.8

SOURCE: Census of Agriculture (53).

[1]Livestock prices used were those reported by farmers in the 1974 census. The prices were $357 per head for cattle, $147.74 per head for calves, $69.11 per head for hogs and $30 per head for sheep.

[2]Land and building values were estimated the same as they were for poultry farms.

[3]Days of operator labor was calculated the same as it was for cash grain farms.

[4]Days of hired labor was calculated the same as it was for cash grain farms.

[5]Beef breeding stock was valued at $357 per head.

[6]Hog breeding stock was valued at $69.11 per head.

[7]Sheep breeding stock was valued at $30 per head.

[8]The price index for livestock purchased was calculated as follows: $I_j = \sum_{i=1}^{3} \frac{P_{j74}}{P_{ij}} \cdot PR_{ij}$.

for year j. P_{i74} is the price of livestock i (beef, hogs, or sheep) in 1974. P_{ij} is the dollar proportion of breeding stock i in year j. The index was multiplied times livestock purchased per farm. The index was 1.00 in 1974, 2.0274 in 1969 and 0.9101 in 1964.

[9]The value of breeding stock was estimated by multiplying 0.15 times the breeding stock and adding livestock purchased (4, p. 66).

[10]The price index for feed purchased was obtained from Babb and Pratt (4, p. 66). The index divided into feed purchased per farm was 1.00 in 1974, 0.516 in 1969 and 0.506 in 1964.

[11]The price of hay used was $47 per ton (47).

[12]The price of corn silage was $20.20 per ton in 1974 (28). For 1974 and 1964, acres of corn not harvested for grain was multiplied by 9 tons per acre for 1974 and 8.5 tons per acre for 1964 (28). Tons of corn silage for 1969 was obtained from the census.

[13]The price of sorghum silage in 1974 was $16.20 per ton (28). For 1974 and 1964, acres of sorghum not harvested for grain was multiplied times 9.6 tons per acre for 1974 and 7.6 tons per acre in 1964 (28). Tons of sorghum silage for 1969 was obtained from the census.

[14]This does not include the value of some feedstuffs grown and fed on the same farm.

APPENDIX TABLE 4

PRODUCTION AND INPUTS USED PER FARM ON KANSAS DAIRY FARMS
WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Milk Sold[1]	187,013.0	299,007.5	462,373.2
Value of Milk Sold, 1974 Dollars[2]	16,270.1	26,013.7	40,226.5
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars[3]	117,474.5	140,813.5	382,997.0
Acres of Pasture	117.2	102.3	125.0
Operator Labor (Days)[4]	225.1	225.0	226.0
Hired Labor (Days)[5]	51.0	80.3	91.9
Total Labor (Days)	276.1	305.3	317.9
Number of Cows Milked	28.9	36.5	47.3
Feed Purchased, 1974 Dollars[6]	6,534.0	10,927.8	14,773.4
Hay Produced, 1974 Dollars[7]	3,590.5	4,588.5	4,923.4
Corn Silage Produced, 1974 Dollars[8]	1,682.5	2,398.7	3,656.1
Sorghum Silage Produced, 1974 Dollars[9]	1,747.1	2,068.4	2,340.9
Value of Feed, 1974 Dollars[10]	13,554.1	19,983.4	25,693.8

APPENDIX TABLE 4-Continued

SOURCE: Census of Agriculture (53).

[1]Number of cows times pounds per cow. Milk per cow was 9,773 pounds in 1974, 8,189 pounds in 1969 and 6,480 pounds in 1964 (47).

[2]The price of milk in 1974 was $8.70 cwt. (47).

[3]Value of land and buildings was treated the same as it was for poultry farms.

[4]Days of operator labor was estimated in the same manner as it was for cash grain farms.

[5]Days of hired labor was estimated in the same manner as it was for cash grain farms.

[6]Feed price indexes were obtained from Babb and Pratt (4, p. 68). Feed purchased per farm was divided by 1.00 in 1974, 0.5107 in 1969 and 0.4955 in 1964.

[7]The price of hay used was $47 per ton (47).

[8]Corn silage was estimated in the same manner it was for livestock farms.

[9]Sorghum silage was estimated in the same manner it was for livestock farms.

[10]Does not include the value of some feedstuffs produced and fed on the same farm.

APPENDIX TABLE 5

PRODUCTION AND INPUTS USED PER FARM ON U.S. CASH GRAIN FARMS
WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Corn (Bushels)[1]	4,059.0	4,795.0	5,492.0
Soybeans (Bushels)[2]	1,094.0	1,692.0	1,762.0
Wheat (Bushels)[3]	2,022.0	2,138.0	2,455.0
Value of Production, 1974 Dollars[4]	27,833.0	34,508.0	38,381.0
Inputs Used Per Farm			
Harvested Acres	256.3	271.7	274.5
Days of Operator Labor[5]	192.6	190.4	192.8
Days of Hired Labor[6]	72.6	78.8	68.6
Total Days of Labor	265.2	269.2	261.4
Fertilizer Purchased, 1974 Dollars[7]	1,844.0	3,237.0	4,041.0
Chemicals Purchased, 1974 Dollars[8]	434.0	646.0	1,245.0
Seed Purchased, 1974 Dollars[9]	911.0	1,329.0	1,353.0
Petroleum Products Purchased, 1974 Dollars[10]	1,774.0	1,920.0	2,009.0
Custom Work Purchased, 1974 Dollars[11]	354.0	375.0	484.0

APPENDIX TABLE 5-Continued

Inputs Used Per Farm	1964	1969	1974
Value of Equipment, 1974 Dollars[12]	23,012.0	24,181.0	31,000.0
Value of Equipment Services 1974 Dollars[13]	5,580.0	5,922.0	7,143.0

SOURCE: (4, pp. 73-74).

[1]Corn yields during census years were adjusted to reflect three year average yields centered on the census year. Bushels produced on census farms were multiplied by 1.1615 in 1974, 0.9228 in 1969 and 1.0858 in 1964.

[2]Soybean yields were adjusted as for corn. Bushels produced on census farms were multiplied by 1.453 in 1974, 0.9828 in 1969 in 1.0483 in 1964.

[3]Wheat yields were adjusted as for corn. Bushels produced on census farms were multiplied by 1.0923 in 1974, 0.9804 in 1969 and 1.0012 in 1964.

[4]U.S. prices for 1974 were: $3.03 for corn, $6.64 for soybeans and $4.09 for wheat (47).

[5]Days of operator labor were based on number of days worked on the farm, with a weight of 0.6 placed on days worked by operators over age 65 (8, p. 24).

[6]Hired and contract labor expenditure divided by average daily wages for hired farm workers in the U.S.: $18.32 for 1974, $12.40 for 1969 and $8.64 for 1964.

[7]The price index for fertilizer was used to adjust expenditures for fertilizer and lime to 1974 prices (47). Fertilizer expenditures were divided by 1.00 for 1974, 0.521 for 1969 and 0.611 for 1964.

[8]The price index for agricultural chemicals was used to adjust expenditures to 1974 prices (47). Chemical expenditures were divided by 1.00 for 1974, 0.8403 for 1969 and 0.8151 for 1964.

APPENDIX TABLE 5-Continued

[9]The price index for seed was used to adjust seed purchases to 1974 prices (47). Seed expenditures were divided by 1.00 for 1974, 0.493 for 1969 and 0.4512 for 1964.

[10]The price index for petroleum products was used to adjust expenditures to 1974 prices (47). Petroleum expenditures were divided by 1.00 for 1974, 0.6414 for 1969 and 0.6101 for 1964.

[11]Net custom work purchased (purchased minus sold) adjusted by machinery price index (47). Net purchases were divided by 1.00 for 1974, 0.6894 for 1969 and 0.559 for 1964.

[12]The price index for farm machinery and equipment was used to adjust value of equipment to 1974 prices (47). Value of equipment was divided by 1.00 for 1974, 0.6894 for 1969 and 0.559 for 1964.

[13]Value of equipment multiplied by 0.15 plus expenditure for petroleum products and net custom work (8, p. 44).

APPENDIX TABLE 6

PRODUCTION AND INPUTS USED PER FARM ON U.S. POULTRY FARMS WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Value of Broilers Sold, 1974 Dollars[1]	18,554.0	32,140.0	47,146.0
Value of Turkeys Sold, 1974 Dollars[2]	6,645.0	9,323.0	14,682.0
Value of Eggs Sold, 1974 Dollars[3]	26,355.0	43,044.0	62,036.0
Value of Poultry Products Sold, 1974 Dollars	51,554.0	84,507.0	123,864.0
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars	91,022.0	98,507.0	96,846.0
Days of Operator Labor[4]	179.5	178.7	193.9
Days of Hired Labor[5]	188.3	264.2	329.3
Total Days of Labor	367.8	442.9	523.2
Poultry Purchased, 1974 Dollars[6]	7,228.0	14,475.0	24,073.0
Feed Purchased, 1974 Dollars[7]	37,466.0	68,445.0	87,897.0

SOURCE: (4, pp. 75-76).

[1]The 1974 U.S broiler price of 21.5 cents per pound was multiplied by the average weight of broilers: 3.78 pounds in 1974, 3.60 pounds in 1969 and 3.48 pounds in 1964 (47). The value per broiler sold was $0.81 in 1974, $0.77 in 1969 and $0.75 in 1964.

[2]The 1974 U.S. turkey price of 28 cents per pound was multiplied by the average weight of turkeys: 18.5 pounds in 1974, 19.0 pounds in 1969 and 18.1 pounds in 1964 (47). The value per turkey sold was $5.18 for 1974, $5.32 in 1969 and $5.07 in 1964.

APPENDIX TABLE 6-Continued

[3]The 1974 U.S. egg price of 53.3 cents per dozen was multiplied by the dozens of eggs per layer: 19.25 in 1974, 18.33 in 1969 and 18.08 in 1964 (47). The value of eggs per layer was $10.26 in 1974, $9.77 in 1969 and $9.64 in 1964.

[4]Days of operator labor were based on the number of days worked on the farm, with a weight of 0.6 placed on days worked by operators over age 65 (8, p. 24).

[5]Hired and contract labor expenditures were divided by average daily wages for hired farm workers in the U.S.: $18.32 in 1974, $12.40 in 1969 and $8.64 in 1964.

[6]Prices of turkey poults, layer chicks and broiler chicks changed by almost identical percentages among census years (47). The price index, which was divided into actual poultry purchases, was 1.00 for 1974, 0.82 for 1969 and 0.85 for 1964.

[7]The U.S. poultry feed price was used to adjust expenditures for feed to 1974 prices (47). Feed expenditures were divided by 1.00 for 1974, 0.526 for 1969 and 0.573 for 1964. Does not include the value of corn or other grains produced and fed on the same farm.

APPENDIX TABLE 7

PRODUCTION AND INPUTS USED PER FARM ON U.S. LIVESTOCK FARMS
WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Number of Cattle Sold	56.1	55.2	81.1
Number of Calves Sold	27.5	31.2	19.5
Number of Hogs and Pigs Sold	112.0	105.6	116.5
Number of Sheep and Lambs Sold	36.2	23.2	21.2
Value of Livestock Sold, 1974 Dollars[1]	31,903.0	31,169.0	39,147.0
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars	221,964.0	175,536.0	189,890.0
Days of Operator Labor[2]	200.3	180.1	177.0
Days of Hired Labor[3]	103.0	84.8	77.4
Total Days of Labor	303.3	264.9	254.4
Value of Beef Breeding Stock[4]	12,897.0	12,410.0	16,371.0
Value of Hog Breeding Stock[5]	665.0	660.0	606.0
Value of Sheep Breeding Stock[6]	907.0	571.0	518.0
Livestock Purchased[7]	13,928.0	14,266.0	14,684.0
Value of Breeding Stock, 1974 Dollars[8]	16,098.0	16,312.0	17,308.0

APPENDIX TABLE 7-Continued

Inputs Used Per Farm	1964	1969	1974
Feed Purchased, 1974 Dollars[9]	8,537.0	9,102.0	11,810.0
Hay Produced, 1974 Dollars[10]	3,800.0	3,523.0	3,503.0
Corn Silage Produced, 1974 Dollars[11]	1,173.0	1,209.0	1,645.0
Value of Feed, 1974 Dollars[12]	13,510.0	13,834.0	16,958.0

SOURCE: (4, pp. 77-78).

[1]The 1974 prices received by U.S. farmers in the census were used: $341 per head for cattle, $132 per head for calves, $70 per head for hogs and $36 per head for sheep and lambs.

[2]Days of operator labor were based on number of days worked on farm with a weight of 0.6 placed on days worked by operators over age 65 (8, p. 24).

[3]Hired and contract labor expenditure divided by average daily wages for hired farm workers in the U.S.: $18.32 in 1974, $12.40 in 1969 and $8.64 in 1964 (47).

[4]Number of beef cows and heifers that had calved times $341 per head.

[5]Number of hogs and pigs for breeding times $70 per head.

[6]Number of ewes one year old and over for breeding times $36 per head.

[7]A price index was constructed using prices of each class of animal from Agricultural Statistics, weighted by the proportion of cattle, hogs and sheep for breeding on census farms. The price index, which was divided into actual livestock purchases, was 1.00 for 1974, 0.6827 for 1969 and 0.435 for 1964.

[8]Value of livestock was 0.15 times value of breeding stock on farms plus the value of livestock purchased (8, p. 68).

APPENDIX TABLE 7-Continued

[9]The simple average price of cattle and hog feed for the U.S. was used to adjust expenditures for feed to 1974 prices (47). Feed expenditures were divided by 1.00 in 1974, 0.5109 in 1969 and 0.4612 in 1964.

[10]The 1974 U.S. hay price was $50.60 per ton (47).

[11]Yield of silage per acre was 9.7 tons in 1964, 12.6 tons in 1969 and 10.4 tons in 1974 (47). Value of silage was computed for 1974 as 6.35 times the price of corn plus $3.50 per ton or $22.74 per ton of silage.

[12]Does not include the value of corn or other grains produced and fed on the same farm.

APPENDIX TABLE 8

PRODUCTION AND INPUTS USED PER FARM ON U.S. DAIRY FARMS WITH SALES OF $2500 OR MORE, 1964, 1969 AND 1974

Production Per Farm	1964	1969	1974
Milk Sold (Cwt.)[1]	2,559.0	3,452.0	4,895.0
Value of Milk Sold, 1974 Dollars[2]	21,521.0	29,031.0	41,167.0
Inputs Used Per Farm			
Value of Land and Buildings, 1974 Dollars	115,801.0	123,654.0	136,954.0
Acres of Pasture	64.5	70.1	74.9
Days of Operator Labor[3]	218.6	218.0	225.6
Days of Hired Labor[4]	106.6	125.9	133.7
Total Days of Labor	325.2	343.9	359.3
Number of Cows Milked	31.6	36.6	47.5
Feed Purchased, 1974 Dollars[5]	6,427.0	10,328.0	13,810.0
Hay Produced, 1974 Dollars[6]	4,356.0	6.981.0	7,318.0
Corn Silage Produced, 1974 Dollars[7]	2,114.0	3,763.0	5,283.0
Value of Feed, 1974 Dollars[8]	12,897.0	21,072.0	26,411.0

SOURCE: (4, pp. 79-80).

[1]Milk production per cow times number of cows milked.

[2]1974 average milk price was $8.41 per hundredweight.

[3]Days of operator labor were based on number of days worked on farm, with a weight of 0.6 placed on days worked by operators over age 65. (8, p. 24).

[4]Hired and contract labor expenditures divided by average daily wages for hired farm workers in the U.S.: $18.32 in 1974, $12.40 in 1969 and $8.64 in 1964 (47).

APPENDIX TABLE 8-Continued

[5]The price of 16 percent dairy ration for the U.S. was used to adjust expenditures for feed to 1974 prices (47). Feed expenditures were divided by 1.00 for 1974, 0.5145 for 1969 and 0.5377 for 1964.

[6]The 1974 U.S. hay price was $50.60 per ton (47).

[7]Yield of silage per acre was 10.4 tons in 1974, 12.6 tons in 1969 and 9.7 tons in 1964 (47). Value of silage was computed for 1974 as 6.35 times the price of corn plus $3.50 per ton or $22.74 per ton of silage.

[8]Does not include the value of corn or other grains produced and fed on the same farm.

APPENDIX TABLE 9

FARM LEVEL PRICE ELASTICITIES OF DEMAND, PRICES AND PRODUCTION FOR SELECTED COMMODITIES, KANSAS, 1969 AND 1970

Commodity	Elasticity[1]	Prices[2]			Production[2]		
		1969	1970	Units	1969	1970	Units
Cattle	-0.6836	26.20	27.10	¢/lb.	3,375,900	3,462,120	1000 lb.
Calves	-1.0824	31.50	34.50	¢/lb.	11,655	16,920	1000 lb.
Hogs	-0.4578	22.10	22.30	¢/lb.	641,290	722,700	1000 lb.
Sheep & Lambs	-1.7820	26.95	23.94	¢/lb.	22,387	21,433	1000 lb.
Chickens	-0.7369	6.28	7.11	¢/lb.	20,081	21,317	1000 lb.
Turkeys	-0.9240	21.40	23.50	¢/lb.	7,411	6,881	1000 lb.
Eggs	-0.2332	31.30	28.60	¢/doz.	74,750	70,167	1000 doz.
Wheat	-0.0214	1.19	1.28	$/bu.	305,319	299,013	1000 bu.
Rye	-0.0377	0.88	0.84	$/bu.	1,121	1,892	1000 bu.
Corn	-0.0332	1.13	1.30	$/bu.	91,164	79,670	1000 bu.
Oats	-0.0070	0.71	0.71	$/bu.	6,080	10,250	1000 bu.
Barley	-0.0737	0.82	0.81	$/bu.	6,105	7,141	1000 bu.
Soybeans	-0.6000	2.22	2.70	$/bu.	19,596	15,075	1000 bu.

APPENDIX TABLE 9-Continued

Commodity	Elasticity[1]	Prices[2] 1969	Prices[2] 1970	Prices[2] Units	Production[2] 1969	Production[2] 1970	Production[2] Units
Sorghum[3]	-0.3800	0.99	1.09	$/bu.	182,896	145,960	1000 bu.

[1]Elasticities were from Brandow (7, p. 59).

[2]Prices and production were obtained from Agricultural Statistics (47).

[3]Elasticities for soybeans and sorghum were obtained from Schultz (38, p. 190).

APPENDIX TABLE 10

FARM LEVEL PRICE ELASTICITIES OF DEMAND, PRICES AND PRODUCTION FOR SELECTED COMMODITIES, U.S., 1969 AND 1970

Commodity	Elasticity[1]	Prices[2]			Production[2]		
		1969	1970	Units	1969	1970	Units
Cattle	-0.6836	26.20	27.10	¢/lb.	45,957,744	48,300,345	1000 lb.
Calves	-1.0824	31.50	34.50	¢/lb.	2,978,556	2,946,056	1000 lb.
Hogs	-0.4578	22.20	22.70	¢/lb.	20,489,443	21,850,813	1000 lb.
Sheep & Lambs	-1.7820	24.90	23.50	¢/lb.	1,037,076	1,082,268	1000 lb.
Chickens	-0.7369	13.03	14.60	¢/lb.	11,192,038	12,004,801	1000 lb.
Turkeys	-0.9240	22.40	22.70	¢/lb.	2,020,035	2,184,453	1000 lb.
Eggs	-0.2332	40.00	37.60	¢/doz.	5,757,167	5,859,333	1000 doz.
Wheat	-0.0214	1.24	1.36	$/bu.	1,460,187	1,378,465	1000 bu.
Rye	-0.0377	1.00	0.961	$/bu.	31,583	38,552	1000 bu.
Corn	-0.0332	1.16	1.34	$/bu.	4,582,534	4,109,732	1000 bu.
Oats	-0.0070	0.586	0.625	$/bu.	950,023	909,481	1000 bu.
Barley	-0.0737	0.874	0.92	$/bu.	423,547	410,445	1000 bu.
Soybeans[3]	-0.6000	2.35	2.84	$/bu.	1,126,314	1,135,769	1000 bu.

APPENDIX TABLE 10-Continued

Commodity	Elasticity[1]	Prices[2] 1969	Prices[2] 1970	Units	Production[2] 1969	Production[2] 1970	Units
Sorghum[3]	-0.3800	1.07	1.13	$/bu.	747,280	607,050	1000 bu.

[1]Elasticities were from Brandow (7, p. 59).

[2]Prices and production were obtained from Agricultural Statistics (47).

[3]Elasticities for soybeans and sorghum were obtained from Schultz (38, p. 190).

APPENDIX TABLE 11

RETAIL PRICE ELASTICITIES OF DEMAND, PRICES AND CONSUMPTION OF SELECTED COMMODITIES, U.S., 1969 AND 1970

Commodity	Elasticity[1]	Price			Consumption		
		1969	1970	Units	1969	1970	Units
Beef[2]	-0.9500	96.2	98.6	¢/lb.	20,953	21,487	mil. lb.
Veal[2]	-1.6000	110.8	124.3	¢/lb.	878	558	mil. lb.
Pork[2]	-0.7500	74.3	78.0	¢/lb.	12,953	13,434	mil. lb.
Lamb[2]	-2.3500	100.7	105.5	¢/lb.	550	551	mil. lb.
Chicken[3]	-1.1603	42.2[5]	40.8[5]	¢/lb.	8,110[6]	7,678[6]	mil. lb.
Turkey[3]	-1.4043	48.8[7]	55.9[7]	¢/lb.	1,605[8]	1,567[8]	mil. lb.
Eggs[3]	-0.3000	62.1	61.4	¢/doz.	4,851,510[9]	4,880,400[9]	1000 gal.
Fluid Mild and Cream[4]	-0.2850	110.2	114.8	¢/gal.	13,502	13,492	mil. gal.
Evaporated Milk[4]	-0.3000	19.4	20.6	¢/lb.	1,615	1,500	mil. lb.
Cheese[4]	-0.7000	94.0[10]	100.8	¢/lb.	2,195	2,332	mil. lb.
Ice Cream[4]	-0.5500	162.3	169.0	¢/gal.	766	765	mil. gal.
Butter[4]	-0.8500	84.6	173.2	¢/lb.	1,132	1,103	mil. lb.

APPENDIX TABLE 11-Continued

[1]Elasticities were obtained from Brandow (7, p. 17).

[2]U.S.D.A., Livestock and Meat Situation (50).

[3]U.S.D.A., Poultry and Egg Situation (51).

[4]U.S.D.A., Dairy Situation (48). Consumption figures were total domestic use.

[5]Frying chickens at retail stores in urban areas.

[6]Total slaughter.

[7]Ready-to-cook weight in retail stores in urban areas.

[8]Total slaughter.

[9]Balance.

[10]American cheese, processed and sliced.

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PATTERNS AND IMPACTS OF PRODUCTION INCREASING AGRICULTURAL RESEARCH AT THE STATE AGRICULTURAL EXPERIMENT STATIONS

by

MARK ALLEN JAMISON

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AN ABSTRACT OF A MASTER'S THESIS

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Studies considering the returns to past agricultural research have basically used two approaches: the production function approach and the index number approach. The latter of the two approaches measures changes in consumer and producer surpluses and, therefore, measures gross returns. On the other hand, production function approach studies develop some form of agricultural production using agricultural output as the dependent variable and agricultural inputs, including research and extension, as the independent variables.

The production function approach is well adapted to measuring marginal returns to research. Since it is estimates of the marginal returns to research which are needed for research resource allocation decisions, the production function approach is more useful than the index number approach in studying those decisions.

Past production function approach studies have used constant prices as weights for agricultural output; therefore, the results are expressed as marginal products, the marginal change in agricultural production. However, marginal value products, the marginal change in the value of agricultural production, is a more accurate measure of social benefit because it is the decrease in societal expenditures for farm products which constitutes social benefit. This study developed a methodology which can be applied to existing production function results to calculate marginal value products of research at both the farm and retail levels.

The methodology demonstrates that all that was necessary to calculate marginal value products was the average value product (total value of considered production divided by considered research expenditures), the research elasticity of production (percentage change in the physical units

of considered production divided by the percentage change in the considered research expenditures) and the price elasticity of demand (the percentage change in the physical units of the considered production divided by the percentage change in the relevant prices). The methodology further demonstrates that average value products can be claculated from existing data or obtained from production function results, estimates for research elasticity of production are provided by the production function studies, and estimates for price elasticity of demand are obtainable from existing information.

To demonstrate the methodology, this study uses farm level average value products and research elasticities of production from Bredahl and Peterson (8), farm and retail level price elasticities of demand from Brandow (7), and estimated retail level average value products to calculate marginal value products for production increasing research in the areas of poultry, cash grain, livestock and dairy.

The value of estimating marginal value products over marginal products is evident from the results of this study. Bredahl and Peterson calculated a marginal product of $0.85 for Kansas poultry research. Since the marginal expenditure was one dollar, this would appear to indicate overinvestment in this area. However, the marginal value product found in this study for Kansas poultry research was $-2.13 which means that society saved $2.13 in total expenditures for poultry at the farm level. Spending one dollar on research to save $2.13 to total expenditures for poultry would seem to indicate that more rather than less research dollars should be spent in this area.

Estimation of both retail and farm level marginal value products permitted the examination of the forms research returns have taken.

For example, in the case of U.S. poultry research the farm level marginal value product was $-6.09 while the retail level marginal value product was $7.56. That meant that farm level expenditures for poultry products decreased while retail level expenditures increased. Therefore, all the returns to poultry research were in the form of increased processing of poultry products.