EVALUATING PRIVATELY FUNDED PUBLIC RESEARCH: AN EXAMPLE WITH POULTRY AND EGGS

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Abstract

A procedure is described for evaluating poultry and egg research projects. A peer review questionnaire and benefit-cost analysis are utilized incorporating elasticities from an econometric model for poultry and eggs. Production, cost, and price changes are used to calculate changes in producer surplus and net economic surplus for a set of privately funded publicly conducted research projects.

Key words: poultry, research evaluation, economic surplus, benefit-cost analysis.

The private sector has become increasingly involved in funding research at public institutions. As a result, questions are being raised both by the private sector about the benefits from these investments and by the public sector about returns to society. Over the past 30 years, several studies have estimated the returns to public investments in agricultural research (Peterson; Bredahl and Peterson; Evenson et al.). In most cases, the estimated returns have been very high, typically 30 to 70 percent on an annual basis. Little is known, however, about the returns to either private research conducted by private firms or to public research supported by private funds. While the former is essentially impossible to estimate due to an absence of data, the latter may be possible to assess because data are available on privately funded research at public institutions.

Recently, one private organization, the Southeastern Poultry and Egg Association (SEPEA), requested a study of the returns to research projects conducted at public institutions and funded by that Association. Most of the poultry and eggs in the United States are produced by growers and processors who are members of SEPEA. The SEPEA was interested not only in a one time evaluation, but in the development of a procedure for conducting on-going evaluations of realized and potential benefits of completed projects. This procedure will provide SEPEA with an indication of the merits of funding additional research and will indicate which types of research appear to generate the greatest returns. Because the potential beneficiaries of poultry and egg research are consumers as well as producers, information which leads to more optimal allocation of poultry research funds can have widespread benefits to society. This study also will provide an opportunity to examine the benefits of privately funded poultry and egg research at public institutions and to compare those benefits with previous estimates of returns to aggregate public poultry and egg research published by Peterson, Bredahl and Peterson, and Smith et al.

The purpose of this article is to summarize the procedures developed for evaluating research projects funded by SEPEA and provide conclusions based on an example of privately funded publicly conducted research. The evaluation procedures themselves are conceptually simple, but they did require preliminary work in estimating supply and demand elasticities for poultry and eggs. The latter econometric effort is only briefly summarized in the paper and additional information on the poultry and egg model is available from the authors.

METHODS

An evaluation of projected impacts of a research project must answer three questions: (1) what is the scientific merit of the re-

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search? (2) what will be the demand for the new knowledge or technology?, and (3) what will be the value of the research information to the private sector and to society as a whole? Scientists familiar with the particular research area must help answer the first question while persons familiar with the production side of the industry must answer the second question. The third question requires specification of criteria against which the evaluation will be made, for example, income and employment generation. The evaluation procedures described subsequently are designed to provide information which contributes to the knowledge about these three questions for each project being evaluated. They include two major steps: peer review of project reports and an applied welfare analysis of projected direct impacts from the first step. Currently, the SEPEA evaluates projects by having its Technical Committee comprised of industry and university personnel read the final reports of the scientists completing the research projects. The additional peer review and benefit-cost procedures developed in this paper are an attempt to provide additional systematically developed information to the Technical Committee which decides about future project funding.

Peer Review of Projects

Only persons familiar with the research procedures employed and with the problems of the industry are in a position to judge the likely direct impacts of research projects for which benefits have not yet been realized. Even for those persons, the assessment task is very difficult. Direct impacts on production, cost reductions, or quality changes along with likely geographical spread and time rates of adoption must be estimated. To facilitate this, research proposals, final reports, and publications resulting from a set of SEPEA projects were obtained and sent to scientists familiar with the scientific area of work and to an extension worker familiar with poultry and egg production at the firm level. These research and extension scientists were interviewed and asked to render their opinions of the projects. Different researchers evaluated each project although the extension workers were asked to evaluate more than one project. The rationale for this difference is that the technical knowledge needed to assess the scientific merit of a project is more specialized than the knowledge needed to assess the usefulness of the results to producers.

Based on responses generated in these interviews, a standardized questionnaire was developed and tested on another set of research projects in an attempt to produce an inexpensive procedure for subsequent use by SEPEA in eliciting information on direct project impacts.[1] The questionnaire contains seven basic questions designed to obtain both projected quantitative direct impacts and the respondent's degree of confidence in his or her answers. It seeks opinions about the usefulness of the research project for future research (i.e., the degree to which the project produced useful basic rather than applied research results) and why nonsuccessful projects did not succeed.

The questionnaire asks the respondents to focus on per bird effects. Information from previous studies on adoption rates and research depreciation are provided as a point of reference and the respondent's beliefs are elicited about projected adoption rates for the results of the project being reviewed. The questionnaire asks where the research results are likely to be adopted in the United States and it provides the respondent with an opportunity to provide other non-quantitative information.

Applied Welfare Analysis

The direct impacts obtained from scientists answering the questionnaire are used to calculate the present value of changes in net economic surplus and in producer surplus. They also are used to calculate internal rates of return to research, both to society and producers. The validity of utilizing the concepts of consumer and producer surplus to measure welfare changes has been debated in the economics literature for many years (Currie et al.; Willig; Hause; Chipman and Moore; McKenzie and Pearce). Willig and Just et al. show conditions under which the surplus measures are valid approximations to welfare changes. Currie et al. (p. 791) conclude their review of the concepts by saying, *"While it is easy to raise objections, it is difficult to find any workable alternatives."* The current paper, while recognizing that

[1] A copy of the questionnaire is available from the authors upon request.

consumer and producer surplus have shortcomings as measures of welfare changes, follows the convention of previous research evaluation studies (see for example the list of studies provided in Ruttan) and utilizes these concepts. The error due to utilizing consumer and producer surplus as opposed to alternative measures is likely to be small when compared to errors arising from inaccurate estimation of the magnitude of the supply curve shift due to research.

The following equations (1) through (5), based on Figure 1 and on Rose, are used to calculate net economic surplus and producer surplus changes for a particular year resulting from research induced supply shifts.[2]

$$(1)\ CTS = kP_0Q_0 + .5kP_0\ (Q_1 - Q_0) = kP_0Q_0 + .5kP_0Q_0\ (ken/(e + n))$$

because, as shown by Pinstrup-Anderson et al.,

$$Q_1 = Q_0\ (1 + ken/(e + n)).$$

If $z = ke/(e+n)$, then:

$$(2)\ CTS = kP_0Q_0\ (1 + .5zn).$$

If $z = ke/(e+n)$, then:

$$- P_1)/P_0]\ P_0Q_0\ [ken/(e + n)].$$

Since, as shown by Pinstrup-Anderson et al., $P_1 = P_0\,[1 - ke/(e + n)]$, $P_1 - P_0 = P_0\,[-ke/(e + n)]$, and $P_0 - P_1 = P_0\,[ke/(e + n)]$, therefore:

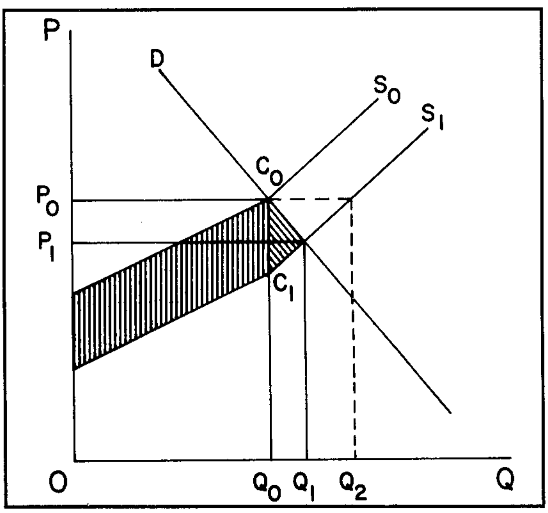

Figure 1. Changes in Net Economic Surplus Due to Agricultural Research.

$$(4)\ CCS = zQ_0P_0\ (1 + .5zn)\ \text{and}$$

$$(5)\ CPS = CTS - CCS = kP_0Q_0\ (1 + .5zn) - zP_0Q_0\ (1 + .5zn),$$

where: CTS = change in net economic surplus,

CCS = change in consumer surplus,

CPS = change in producer surplus,

k = proportionate vertical shift in the supply curve $(C_0 - C_1)/P_0$ due to a cost reduction,

e = supply elasticity,

n = demand elasticity (absolute value),

P_0 = equilibrium price before supply shift,

Q_0 = equilibrium quantity before supply shift,

P_1 = equilibrium price after the supply shift, and

Q_1 = equilibrium quantity after the supply shift.

In cases where direct impacts are described as production increases rather than cost reductions, equations (2), (4), and (5) are used after calculating k as follows: $k = K/e$ where $K = (Q_2 - Q_0)/Q_0$, $Q_2 - Q_0$ is the change in projected output due to a particular research project and Q_0 and e are as previously defined.

Incorporated in equations (2), (4), and (5) are the assumptions that the supply curve is linear and kinked (following Rose) and that the supply shift is parallel. A parallel shift is consistent with the assumption that the poultry and egg projects affect high marginal cost firms the same as low marginal cost firms (Lindner and Jarrett). This assumption may not be correct and the above equations can be easily modified to incorporate alternative assumptions on the type of shift. For example, a pivotal or proportional supply shift would result in a .5 replacing the 1 in equation (2) and the first 1 in equation (5). An important result of assuming a parallel (as opposed to a pivotal) supply shift is that the change in producer surplus (CPS) is always greater than or equal to zero. Further-

[2] Several other formulas have been employed in the literature to calculate economic surplus gains. Norton and Davis provide a review of those formulas and indicate how they relate to each other (although the upper case K's in equations 15, 16, 17, and 19 in Norton and Davis should have been lower case and a demand elasticity, n, is missing in the numerator of the last term in equation 19).

more, the change in total surplus is almost twice as large for a parallel as for a pivotal shift.

Empirical Data

Information from the questionnaire is used to estimate the rates of adoption and geographical spread of research results. The projected cost reductions and production increases thus estimated are used along with information on current prices and production to calculate k for the peak year impact and for years before and after the peak impact.

The supply and demand elasticities are obtained from econometric models. Several broiler, egg, and turkey models have been estimated over the past 15 years. Some utilized annual data (Heien; Thompson et al.), others used quarterly data (Chavas and Johnson, 1981 and 1982; Roy and Johnson), and one used monthly data (Malone and Reece). Given the length of time required to produce chickens, broilers, and turkeys (less than 1 year), the number of production stages involved, and the difficulty of obtaining adequate data on less than a quarterly basis, a quarterly model was the most appropriate for capturing response to changing profitability in the industry.

Chavas and Johnson (1981 and 1982) used quarterly data from 1965 to 1976 to estimate supply models for broilers and turkeys and both supply and demand models for eggs. Because these models used quarterly data and are relatively recent, they were examined in detail to determine whether some of the elasticities needed for the current study could be obtained without further estimation. The factors considered in making this decision were: (1) apparent appropriateness of the Chavas and Johnson model specification with respect to the poultry and egg production process, (2) appropriateness of estimation procedures employed, (3) the consistency of the signs on important variables with economic theory, (4) information provided by Chavas and Johnson on model fit and variable significance, and (5) the amount of structural change that has occurred in the poultry and egg industry since 1976. Upon examining these factors, it was concluded that despite a few problems with sign and significance levels of particular estimated coefficients, the Chavas and Johnson model was basically sound and could be used in the current study.

Broiler and Turkey Demand Models

Chavas and Johnson (1981 and 1982) did not provide a quarterly model of the demand for broilers and turkeys in the United States. Consequently, this component of the poultry and egg model was developed and estimated so that the equations could be combined with the supply side from Chavas and Johnson (1981) and the analytically derived reduced forms for the entire system were then calculated.

The estimated demand equations for broilers and turkeys are shown in Table 1. The model contains 8 behavioral equations and 4 identities. The broiler (turkey) wholesale price equation is specified as a function of broiler (turkey) production, the index of intermediate goods and services, lagged ending stocks of broilers (turkeys), retail beef price, a time trend, and broiler exports. Broiler exports are hypothesized to be a function of wholesale broiler price, world gross domestic product, and the value of poultry exports from Brazil. Turkey exports are specified as a function of the wholesale turkey price, turkey exports lagged one quarter, world gross domestic product, and the value of French poultry exports. Broiler and turkey margins are specified as functions of wholesale prices, processing cost indices, and a time trend. Civilian broiler (turkey) consumption is specified as a function of retail broiler (turkey) price, per capita income, and retail beef price. Changes in ending stocks identities are included that specify that the difference between ending stocks last quarter and this quarter equals production minus both domestic consumption and exports. A second set of identities specifies that retail price equals wholesale price plus the margin. Each behavioral equation contains dummy variables to capture seasonal effects. All price and income variables are in current dollars to be consistent with Chavas and Johnson's supply equations.

Quarterly data from 1970 to 1982 are used in the model. The broiler consumption and export equations and the turkey margin and wholesale price equations were corrected for first-order serial correlation using generalized differences. Most of the model is recursive, except for the wholesale price and export demand equations for broilers and turkeys. The latter equations were estimated using two-stage least squares. As in Chavas and Johnson (1981 and 1982), it is argued that

TABLE 1. STRUCTURAL EQUATIONS FOR QUARTERLY U.S. BROILER AND TURKEY DEMAND MODELS, 1970-1982[a]

Broiler:											
Wholesale price (2SLS)											
1. WPB	= 106.114 −	.008IIGS −	.000049PBC −	$.00045ESB_{t-1}$ +	.000064BX +	1.017TR +	.166RBP +	6.372DV2 +	7.275DV2 −	4.356DV4	$\bar{R}^2$ = .8743
	(16.405)	(.0072)	(.0000088)	(.00012)	(.00004)	(.120)	(.030)	(1.546)	(1.507)	(1.332)	DW = 1.42
Foreign demand (2SLS)											
2. BX	= -38623.4 −	3386.480WPB +	38.068WI −	.321EXPORT +	7881.884DV2 +	9154.635DV3 −	1752.86DV4				$\bar{R}^2$ = .9038
	(30498.17)	(1115.538)	(5.573)	(.107)	(7143.995)	(8298.202)	(7736.809)				DW = 2.05
Price margin (OLS)											
3. MARB	= 7.164 +	.165WPB +	.0097AVG +	.046TR −	.291DV2 +	.493DV3 +	1.575DV4				$\bar{R}^2$ = .9107
	(1.612)	(.054)	(.0025)	(.064)	(.068)	(.6334)	(.645)				DW = 1.46
Domestic demand (OLS)											
4. CCB	= 416962 −	6184.296RPC +	166.405PCI +	1621.519RPB +	174086DV2 +	167755DV3 −	26130.377DV4				$\bar{R}^2$ = .9102
	(30093.435)	(1852.481)	(28.371)	(1096.038)	(15224.576)	(18212.505)	(17035.428)				DW = 1.74
5. $ESB_t - ESB_{t-1}$ = PBC − CCB − BX											
6. RPC = WPB + MARB											
Turkey:											
Wholesale price (2SLS)											
7. WPT	= 35.525 −	.033IIGS −	.000056TP −	$.000075EST_{t-1}$ +	.00094TEX +	.700TR +	.178RPB +	5.0142DV2 +	25.521DV3 +	39.510DV4	$\bar{R}^2$ = .8047
	(10.479)	(.0321)	(.00002)	(.000026)	(.0012)	(.594)	(.096)	(.3671)	(8.905)	(12.736)	DW = 1.84
Foreign demand (2SLS)											
8. TEX	= -3328.08 +	98.805WPT +	.042WI +	.0016TEXPORT +	$531TEX_{t-1}$ +	1502.984DV2 +	5828.469DV3 +	6584.543DV4			$\bar{R}^2$ = .4863
	(3329.88)	(94.875)	(.962)	(.014)	(.291)	(2074.084)	(2523.767)	(1702.326)			DW = 1.84
Price margin (OLS)											
9. MART	= 14.140 −	.650WPT +	.168LAB −	.162PACK +	.357TR +	.299DV2 +	.531DV3 +	.535DV4			$\bar{R}^2$ = .6049
	(1.750)	(.103)	(.070)	(.075)	(.359)	(1.068)	(1.279)	(1.187)			DW = 1.23
Domestic demand (OLS)											
10. CCT	= 145724 −	1887.579RPT +	30.269PCI +	630.535RPB +	51587.368DV2 +	198597DV3 +	620807DV4				$\bar{R}^2$ = .9874
	(29294.363)	(754.35)	(8.674)	(355.707)	(11910.741)	(11919.876)	(12274.602)				DW = 1.86
11. $EST_t - EST_{t-1}$ = TP − CCT − TEX											
12. RPT = WPT + MART											

[a] Standard errors are in parentheses; t−1 indicates a lag of 1 quarter; and variable definitions are found in the Appendix. Equations (1), (3), (4), and (9) are in the inconclusive area with respect to serial correlation.

price determination occurs at the wholesale level.

Twenty of the 31 nonseasonal variables in the broiler and turkey demand models were significant at the 5 percent level and all had expected signs except the wholesale price and French exports in the turkey export equation and the wholesale price and packing cost index in the turkey margin equation. Adjusted R^2's were relatively high except for the turkey margin and export equations. Alternative specifications, particularly on the margin and export equations, were evaluated and the results are summarized in Martinez.

Supply and Demand Elasticities

Reduced form equations were analytically derived from the structural equations of the turkey, broiler, and egg models. These were then used to calculate long-run supply and demand elasticities which relate endogenous to endogenous variables. This procedure required shifting exogenous variables on the demand side to obtain the supply differential ($\partial PBC/\partial WPB$ for broilers) and exogenous variables on the supply side to obtain the demand differential ($\partial CCB/\partial WPB$ for broilers). After calculating these relationships, elasticities were determined by $(\partial PBC/\partial WPB) \bullet WPB^*/PCC^*$ and $(\partial CCB/\partial WPB) \bullet WPB^*/CCB^*$ where WPB^*, PCC^*, and CCB^* were average values from 1978-1982.

The number of exogenous variables shifted to obtain the differentials and the amounts of the shifts can affect the magnitude of the elasticities (Chavas and Johnson, 1981). It seems reasonable to calculate elasticities by shifting all exogenous variables by their average shifts over the past 5 years. Doing this, the estimated supply elasticities (e) were .13 for eggs, .47 for broilers, and 1.05 for turkeys and the estimated demand elasticities (n) were −.22 for eggs, −.19 for broilers, and −.20 for turkeys.[3] Chavas et al. discussed the procedure for calculating elasticities between endogenous variables. Except in special cases, an *ad hoc* decision on the number of exogenous variables to shift must be made and, therefore, it is useful to evaluate the sensitivity of the results to that decision. When only one exogenous variable is shifted and by only one unit on the demand side, the supply elasticities range up to .71 for eggs, down to .40 for broilers, and up to 1.89 for turkeys. When only one exogenous variable is shifted on the supply side and by one unit, the demand elasticities decrease to −.09 for eggs, −.12 for broilers, and −.07 for turkeys. The importance of these elasticity differences to changes in benefits is in the following discussion.

RESULTS

The peer review and benefit-cost procedures previously described were applied to a set of eleven research projects. Four of the eleven projects were projected to have measurable direct impacts on production or cost, Table 2. The first of these focused on optimal feeding schedules and other procedures for forced molting of breeder hens. The second concerned maternal immunological response to early vaccination for infectious bursal disease virus (IBDV) and the transfer of immune response to progeny. The third examined management technologies in caged layer houses which could provide an environment suitable for soldier fly larvae. Soldier fly larvae compete with and destroy house fly lar-

TABLE 2. SUMMARY OF DIRECT IMPACTS OF POULTRY AND EGG RESEARCH PROJECTS FUNDED BY SEPEA FROM 1975 TO 1982

Project number	Type of impact expected	Distribution of impact
1	Cost savings in broiler industry	\$320,000 saved per year and continue thereafter
2	Cost savings in broiler industry	\$36,700 saved in first year, \$73,300 saved in second year, \$110,000 saved in third year, and continue thereafter.
3	Cost savings in egg industry	\$1,030,000 saved in first year, \$2,060,000 saved in second year, \$3,090,000 saved in third year, \$4,120,000 saved in fourth year, \$5,150,000 saved in fifth year, \$6,180,000 saved in sixth year, \$7,210,000 saved in seventh year, \$8,240,000 saved in eighth year, \$9,270,000 saved in ninth year, \$10,300,000 saved in tenth year, and continue thereafter.
4	Egg production increase	11.875 million dozen in first year, 23.75 million dozen in second year, 35.62 million dozen in third year, 47.5 million dozen in fourth year, and 59.375 million dozen in fifth year.

[3] These differences in supply elasticities reflect historical differences in the production systems for the commodities. Recent structural changes in the turkey industry may not be fully captured in this elasticity making the 1.05 an overestimate.

vae, helping to minimize the house fly population. Investigators of project four studied Avian Mycolplasmosis (MG) to determine interactions of host and mycolplasma with respect to cell-mediated and antibody-mediated immunity and attempted to develop a vaccine to prevent respiratory infections, egg transmission, and loss of egg production caused by MG. Some of the other projects had no direct impacts but scientists believed the projects provided useful information for further research. Three of these resulted in journal articles which tends to indicate that the results may be useful to other researchers. The projected time distributions of benefits were interesting in that scientists did not believe that 3 of the 4 research projects with direct benefits would experience a decline in benefits over the first 10 years. The fourth project, however, was projected to have sizable impacts in the first 5 years but to become useless by the sixth year because an expected technological breakthrough would render the results obsolete.

These impacts were combined with the elasticity estimates to calculate gross revenue changes, net economic surplus changes for society, and producer surplus changes. Gross revenue changes were negative because demand was inelastic and their magnitudes were not reported to save space. Net surplus gains to society and to producers were substantial, however, and are reported in Table 3 in present value form discounted at 10 percent. Internal rates of return vary from several hundred to several thousand percent for these projects.

Caution must be exercised when interpreting these results. Most of these privately funded projects were able to build on basic and applied research supported by public funds. These calculated surpluses and rates of return are *marginal* gains realized because of SEPEA funding. The assumption is that existing public research would not have realized the benefits identified for the projects without the additional SEPEA funding. Because the returns are marginal and not average gains and because the costs of unsuccessful projects are not included, they are not comparable to the results presented in more aggregate returns to poultry research studies (e.g. Peterson; Bredahl and Peterson; Smith et al. who estimated returns of up to 60 percent).

To put this point in perspective, Project 1 involved improving biological efficiency in poultry production. In 1981, the public sector spent about $14 million in that research area. Projects 2 and 4 involved control of disease and the public sector spent $12 million in 1981. Project 3 involved control of insects and the public sector spent $500 thousand. The public sector has supported these and related basic research areas for many years. Therefore, a true cost accounting to arrive at average net benefits to society would include much higher costs and probably be impossible to calculate on a project basis. Consequently, the above results may only be useful to SEPEA for cross-project comparisons. In this case, the returns based only on producer benefits may be the most relevant for their purposes because the proportion of total benefits which accrue to producers varies by commodity. Producer benefits for projects 1 and 2 (broilers) are approximately 28 percent of the aggregate benefits while producer benefits for projects 3 and 4 (eggs) are approximately 62 percent of the total. Furthermore, the results lead one to wonder if the scientists answering the peer review questionnaire were overly optimistic, particularly for project 4. This is a potential danger in any peer review process although such a review is essential in research projects evaluation unless one relies solely on general knowledge of the decisionmaking committee.

One of the advantages of the procedure presented in this paper is that it presents and analyzes the results of the peer review for the decisionmakers. They in turn review these results and are free to disagree with the projections and ask for the implications of altering projected cost or production shifts, price elasticities, adoption rates, geographical distribution, etc. All of the assumptions and formulas are incorporated in a computer spreadsheet program and can be quickly changed.

Research project returns also are high in Table 3 compared to previous studies because the cost of the unsuccessful research projects are not included. When one includes these costs which totaled approximately $100,000, the returns are still several thousand percent, particularly because of the influence of Project 4. That project may demonstrate the danger of obtaining opinions for only a few (in the case of Project 4, two) experts. There is a tradeoff, however, in bal-

TABLE 3. SUMMARY OF PROJECTED BENEFITS TO POULTRY AND EGG PRODUCERS AND TO U. S. SOCIETY AS A WHOLE 1982 - 1997[a]

Year	Project 1		Project 2		Project 3		Project 4	
	Producer gains	Societal gains	Producer gains	Societal gains	Producer gains	Societal gains	Producer gains	Societal gains
1	$82,719	$287,223	$ 9,535	$33,317	$ 565,349	$ 901,854	$ 34,977,959	$ 55,646,652
2	75,199	261,111	17,442	60,578	1,027,274	1,636,497	63,767,469	101,429,560
3	68,363	237,374	23,739	62,608	1,408,436	2,239,192	90,831,826	144,474,900
4	62,148	215,795	21,581	75,098	1,807,480	2,814,475	109,210,880	173,779,070
5	56,498	196,177	19,619	68,271	2,014,497	3,204,635	124,661,100	196,803,305
6	51,362	178,343	17,836	62,064	2,110,973	3,359,443		
7	46,493	162,130	16,214	56,422	2,376,690	3,700,928		
8	42,448	147,391	14,740	51,293	2,470,119	3,845,277		
9	38,589	133,991	13,400	46,630	2,382,641	3,788,584		
10	35,081	121,810	12,182	42,391	2,404,729	3,826,152		
11	31,892	110,737	11,075	38,537	2,186,117	3,478,320		
12	28,992	100,670	10,068	35,034	1,987,379	3,162,109		
13	26,357	91,518	9,152	31,849	1,806,708	2,874,645		
14	23,961	83,198	8,320	28,953	1,642,462	2,613,313		
15	21,782	75,635	7,564	26,321	1,493,147	2,375,739		
Project Funding		$ 10,000		$14,763		$ 17,883		$ 8,452
IRR	910%	3,159%	92%	321%	3,539%	5,645%	455,290%	724,323%

[a] Present value with 10% discount rate. Benefits begin in 1982 for Projects 1 and 4 and in 1983 for Projects 2 and 3.

ancing off the quality of the information with the cost of obtaining additional reviews.[4]

The sensitivity of the results to changes in elasticity assumptions also was tested. For example, the larger supply elasticity and smaller demand elasticity for eggs resulted in considerably smaller producer benefits, larger consumer benefits, but similar aggregate benefits. This supports the often cited fact that the level of aggregate benefits to research are primarily a function of the magnitude of the supply shift while the benefit distribution depends on the relative size of the demand and supply elasticities.

CONCLUSIONS AND IMPLICATIONS

The primary criterion employed in this study to approximate private benefits of privately funded public research is the present value of producer surplus change. The primary criterion used to approximate social benefits is the present value of net economic surplus which includes the benefits to both producers and consumers. The procedures suggested for SEPEA are crude but add a means of quantifying some information in the research project evaluation process. The quantitative results do not place a value on basic research which does not directly lower costs or increase production, but the peer review form does provide information on potential usefulness of basic research projects.

The response to the question on reasons for unsuccessful research can prove useful in future research funding decisions. One of the projects was deemed unsuccessful because it essentially rediscovered the fact that a liquid flows faster downhill than uphill. Another, once the technical jargon was removed, found that flies like manure. A third project failed due to poor design. Knowing the reasons for lack of success (i.e. discovered the obvious, poor project design, etc.) can prove useful to decisionmakers.

The validity (or non-validity) of the procedure developed in this study will only become evident in future years. Most of the benefits of the projects deemed successful are yet to be realized. In turn, it may be possible to reassess these projects to determine if in fact all the projected benefits occurred.

The technical board of SEPEA has not yet decided to implement the evaluation procedure for all its projects. Those on the board supporting the evaluation concept strongly desire additional expert opinion. Those opposed believe that the information may be misused and lead to a bias toward future funding of more applied projects for which benefits are easily quantified to the detriment of important basic research. It appears to the authors that one option for SEPEA is to make a policy decision on what proportion of its research budget it wants to devote to research that may pay off only after additional research builds on the results of that work (i.e., basic research) and how much it desires to devote to research aimed at providing results with immediate payoff. The questionnaire could be administered for both sets of projects but benefits quantified only for the latter grouping.

One implication from this evaluation project is that the estimated benefits from such a procedure will inevitably be marginal and not average benefits because it is impossible to allocate preceding nonproject costs to the project. As a result, the procedure is most useful for making cross-project comparisons on the part of SEPEA rather than for estimating the social rates of return. Furthermore, a number of other factors described in the results section can lead to overestimation of benefits. Therefore, the use of the formulas in sensitivity analysis is likely to be quite important. It is argued in this paper that the estimation of direct production or cost impacts need to be separated from the evaluation of these impacts on the poultry and egg industry. Direct impact estimation can be better made by technical poultry and egg scientists while valuation of those impacts can be better handled by economists. This does not preclude, however, testing the sensitivity of the results derived from scientists' projections and economists' assumptions.

The results of the econometric modelling effort indicate the need for future analysis of the determinants of turkey demand, particularly foreign exports. The results of the estimated turkey equations were not entirely satisfactory despite several attempts to improve the equations.

[4] It also should be noted that Project 4 resulted in a production increase and the benefits are somewhat overestimated because the formulas based on the kinked supply curve and the relation $k = K/e$ overestimate benefits when supply is inelastic and vice versa when supply is elastic. The egg supply elasticity is very inelastic. This bias does not occur when impacts are measured as cost decreases.

Another implication from this study is that consumers are the primary beneficiaries of this privately funded public research, although producers do gain, at least if one accepts the parallel supply shift assumption. In general, the demand for a number of agricultural commodities in the United States has become more elastic over time as export markets have become more important. This may provide increased incentives for producers, perhaps operating through private associations such as SEPEA, to fund research in the future because producers are able to capture a greater share of the benefits. The increased use of check-off schemes in the last few years to support research on a number of agricultural commodities may be evidence of this.

Implications follow for public agricultural research systems. Privately supported public research will be strongly directed by the funding source. Private groups have an incentive to fund applied research making it more important for publicly supported research efforts to concentrate on more basic research.

REFERENCES

Bredahl, M. and W. Peterson. "The Productivity and Allocation of Research: U.S. Agricultural Experiment Stations." *Amer. J. Agr. Econ.*, 58,4(1976): 684-92.

Chavas, J. P., Z. A. Hassan, and S. R. Johnson. "Static and Dynamic Elasticities and Flexibilities in System of Simultaneous Equations." *J. Agr. Econ.*, 32(1981):177-87.

Chavas, J. P. and S. R. Johnson. "An Econometric Model of The U.S. Egg Industry." *Applied Econ.*, 13(1981): 321-35.

Chavas, J. P. and S. R. Johnson. "Supply Dynamics: The Case of U.S. Broilers and Turkeys." *Amer. J. Agr. Econ.*, 64,3(1982): 558-64.

Chipman, J. S. and J. C. Moore. "Compensating Variation, Consumer Surplus, and Welfare." *Amer. Econ. Rev.*, 70(1980): 933-49.

Council of Economic Advisors. *Economic Indicators*, various issues.

Currie, J. S., J. A. Murphy, and A. Schmitz. "The Concept of Economic Surplus and its Use in Economic Analysis." *The Econ. J.*, 81(1971): 741-98.

Evenson, R. E., V. W. Ruttan, and P. E. Waggoner. "Economic Benefits From Research: An Example from Agriculture." *Science*, 205(1979): 1,101-7.

Food and Agriculture Organization of the United Nations (FAO). *FAO Production Yearbook*, various issues.

Hause, J. C. "The Theory of Welfare Cost Measurement." *J. Pol. Economy*, 83(1975): 1,145-82.

Heien, D. "An Economic Analysis of the U.S. Poultry Sector." *Amer. J. Agr. Econ.*, 58,3(1976): 311-6.

Just, R. C., D. Hueth, and A. Schmitz. *Applied Welfare Analysis*. Prentice Hall, Inc., Englewood Cliffs, N.J., 1982.

Lindner, R. K. and F. G. Jarrett. "Supply Shifts and the Size of Research Benefits." *Amer. J. Agr. Econ.*, 60,1(1978): 48-56.

Malone, G. W. and J. Reece. "Estimating Broiler Supply and Demand as a Simultaneous System." *Poultry Sci.*, 55(1976): 414-8.

Martinez, S. W. *Procedure for Evaluating Poultry and Egg Research Projects*, M.S. Thesis, Virginia Polytechnic Institute and State University, 1984.

McKenzie, G. W. and I. F. Pearce. "Welfare Measurement - A Synthesis." *Amer. Econ. Rev.*, 72(1982): 669-82.

Norton, G. W. and J. S. Davis. "Evaluating Returns to Agricultural Research: A Review." *Amer. J. Agr. Econ.*, 63,4(1981): 685-99.

Office of Economic Cooperation and Development (OECD). *Main Economic Indicators*, various issues.

Peterson, W. "Returns to Poultry Research in the United States." *J. Farm Econ.*, 49(1967): 656-69.

Pinstrup-Anderson, P., N. Ruiz de Londono, and E. Hoover. "The Impact of Increasing Food Supply on Human Nutrition: Implications for Commodity Priorities in Agricultural Research and Policy." *Amer. J. Agr. Econ.*, 58,1(1976): 131-42.

Pridicasts, Inc. *World Product Casts*, various issues.
Rose, F. "Supply Shifts and the Size of Research Benefits Comment." *Amer. J. Agr. Econ.*, 62,4(1980): 834-7.
Roy, S. K. and P. N. Johnson. "Econometric Models for Quarterly Shell Egg Prices." *Amer. J. Agr. Econ.*, 55,2(1973): 209-13.
Ruttan, V. W. *Agricultural Research Policy*, University of Minnesota Press, Minneapolis. 1982.
Smith, B. L., G. W. Norton, and J. Havlicek, Jr. "Impacts of Public Research Expenditures on Agricultural Value-Added in the U.S. and the Northeast." *J. Northeastern Agr. Econ. Council*, (Fall 1983): 109-14.
Thompson, R. G., J. M. Sprott, and R. W. Callen. "Demand, Supply, and Price Relationships for the Broiler Sector with Emphasis on the Jack-Knife Method." *Amer. J. Agr. Econ.*, 54,2(1972): 245-8.
United States Department of Agriculture, Economics Research Service (a). *Agricultural Outlook.* Washington, D. C., various issues.
__________________(b). *Livestock and Meat Situation.* Washington, D. C., various issues.
__________________(c). *Livestock and Poultry Situation.* Washington, D. C., various issues.
__________________(d). *Poultry and Egg Situation.* Washington, D. C., various issues.
__________________(e). *Poultry and Egg Statistics.* Washington, D. C., various issues.
__________________(f). *Working Data for Demand Analysis.* Washington, D. C., various issues.
United States Department of Commerce. *Survey of Current Business.* Washington, D. C., various issues.
Willig, R. D. "Consumer Surplus Without Apology." *Amer. Econ. Rev.* 66(September 1976): 589-97.

APPENDIX

Variable Definitions and Data Sources for Structural Equations in Table 1

Variable definitions with data source are as follows:

AVG = weighted average of labor, energy, and packaging indices.
BX = exports of broilers, thousand lbs. (USDA (c) and (d)).
CCB = civilian consumption of broilers, thousands lb. (USDA (c) and (d)).
CCT = civilian consumption of turkey, thousand lb. (USDA (c) and (d)).
DVj = dummy variable for j-th quarter, first quarter = reference quarter.
ESB = ending stocks of broilers, thousand lb. (USDA (c), (d), and (e)).
EST = ending stocks of turkeys, thousand lb. (USDA (c), (d), and (e)).
EXPORT = value of poultry exports by Brazil (FAO).
IIGS = index of intermediate goods and services (USDA (a)).
LAB = index of hourly earnings of production workers in food manufacturing (USDA (a); OECD)
MARB = RPC-WPB where RPC is the retail price of chicken, cents/lb. (USDA (c), (d), and (e)).
MART = RPT-WPT where RPT is the retail price of turkey, cents/lb. (USDA (b), (c), (d), and (e)).
PACK = index of packaging and containers purchased by food marketing firms (USDA (a); U. S. Department of Commerce).
PBC = production of broilers, thousand lb. (USDA (b), (c), and (d)).
PCI = per capita disposable income, current $/person (U. S. Department of Commerce; USDA (f)).
RPB = retail price of choice grade beef, cents/lb. (USDA (b) and (c)).
RPC = retail price of frying chicken, cents/lb. (USDA (a), (d), and (e)).
RPT = retail price of turkey, cents/lb. (USDA (a), (c), (d), and (e)).
TEX = turkey exports, thousand lb. (USDA (c) and (d)).
TEXPORT = value of poultry exports by France; (FAO).
TP = production of turkeys, thousand lb. (USDA (b), (c), (d), and (e)).

TR = time trend.
WI = gross domestic product for the world, billion U.S. $'s (Predicasts, Inc.).
WPB = wholesale price of broilers, cents/lb. (USDA (c) and (d)).
WPT = wholesale price of turkey, cents/lb. (USDA (b), (c), and (d)).