Economic and Social Returns to Technology and Investment

Eighth Work Plan, Marketing and Economic Analysis Research 1 (MEAR1)

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Introduction

The Pond Dynamics/Aquaculture CRSP is a global research activity directed toward improving the sustainability and efficiency of pond aquaculture production. The benefits of this effort will be the economic and social returns to farmers who have adopted new technologies developed by the PD/A CRSP.

Technical progress has been modeled as a lagged function of research expenditures by Chavas and Cox (1992). This study identified and measured the length of time required to fully translate public research expenditures into economic benefits and estimated internal rates of return for research expenditures. In the Chavas and Cox model, there were no restrictions on substitution possibilities among inputs, joint estimation of the production technology, technical change, and the effects of research on technical progress using disaggregate inputs. This approach required only a standard linear programming algorithm. Ardito-Barletta (1971), Ayer and Schur (1972), and others estimated social rates of return to the investment in public research.

White (1985), in a study valuing research as an intangible capital in agriculture using Tobin's q theory, estimated the market value of public research capital to be 8.6 times higher than conventional assets. Private research capital was valued 5.2 times higher than conventional assets.

Fischer et al. (1996) used a random-effects model within a Bayesian framework to analyze the effect of the adoption of new wheat varieties in South Australia. Results showed that not all pieces of information added equally to knowledge about the innovation. The random effects model also provided a more accurate simulation of the speed of acquisition of information, which previous models over-estimated, and was able to take into account partial adoption of innovation.

Huang and Sexton (1996) developed a general, imperfect competition model to evaluate returns to a cost-reducing innovation. In an imperfectly competitive market structure, this study showed that farmers' incentives to adopt a mechanical harvester for tomatoes in Taiwan were attenuated because the benefits were reduced due to the oligopsonistic power of processors.

Dorfman (1996) used a multinomial probit model to simulate adoption decisions faced by farmers when there are multiple technologies available to be used in varying combinations. Results showed that the decision to adopt potentially sustainable production technology bundles was significantly influenced by off-farm labor supply.

Fuglie (1995) developed a multimarket model to explore equity and efficiency implications of improving crop storage technologies. The rate of return on research on potato storage in Tunisia was estimated to be between 44 and 74%.

Methods and Materials

Theoretical Model

The section entitled "Model Development and Data Requirements" mentions the theoretical considerations and describes the model developed for the analysis of data from this study. Supply and demand equations will be estimated to identify the areas in the graphs labeled as "Consumer Surplus" and "Producer Surplus". Research that leads to the development and adoption of new technologies reduces the cost of production which further causes

a reduction in the cost to the producers. The combined changes in the net gain to producers and the net gain to consumers are the social gain from research. Therefore, this study hypothesizes that new technologies produced from CRSP-funded research result in a net increase in economic surplus.

Data

The "Model Development and Data Requirements" section also lists the parameters to be estimated to conduct impact analysis for both shrimp and tilapia growers in Honduras. Specific CRSP technologies that will be evaluated include feeding recommendations for shrimp growers and sex-reversal technologies for tilapia growers. Data will be collected through surveys of shrimp and tilapia growers. Survey instruments have been designed and are currently under review. After review the instrument will be translated into Spanish, pre-tested, and then administered. The Asociacion Nacional de Acuicultores de Honduras (ANDAH) and the Federacion de Agroexportadores de Honduras (FPX) have been contacted for support in administering the survey. A follow-up trip to finalize data collection is planned for September 1997.

Data will be coded and entered into a LOTUS 1-2-3 spreadsheet for summarization and cross-tabulation. The model presented above will perform simulations for each set of survey data and estimate the net social gain from CRSP-developed technology.

Model Development and Data Requirements

Economic and production relationships are used as the basis for modeling technical progress in fish farming technologies. Following Chavas and Cox (1992), technical progress is modeled as a lagged function of research expenditures. The advantages of such an approach are:

1. substitution possibilities among inputs are not restricted;

2. it allows for the use of very disaggregate inputs, joint estimation of the production technology, technical change, and the effects of research on technical progress;

3. the investigation of the length and shape of the lag distribution between research and productivity is flexible; and

4. only a standard linear programming algorithm is required.

The length of time required to fully translate public research expenditures into economic benefits will be estimated along with internal rates of return for the research expenditures. Following Ayer and Schur (1972) and Ardito-Barletta (1971), social rates of return will be estimated and both supply-shifting (cost-reducing) and demand-lifting (quality improvement) effects of new technologies will be assessed.

Given the collaborative nature of the PD/A CRSP projects, it is necessary to evaluate the net social welfare resulting from the implementation of these projects. Welfare economics are concerned with policy recommendations; however, they can also be used as an evaluation tool to determine the social impact of a given project. In a attempt to measure PD/A CRSP impact, a function describing the net social benefits can be estimated. The different groups involved in these projects are usually not mutually exclusive, and in conjunction with the compensation criterion, social welfare can be measured as follows:

$$w = \Pi_Q = CS_Q + PS_X + E - G$$

where

w = net social benefits (positive or negative),

Π_Q = the profit or rent accruing to PD/A CRSP researchers,

CS_Q = consumers' surplus in the host country which can be measured as surplus for final consumers plus all forward rents,

PS_X = producers' surplus measured as rent inputs plus all backward rents plus surplus for raw materials,

E = external benefits/costs,

G = the social overhead cost for PD/A CRSP programs.

As suggested by Alston et al. (1995), methods of production economics can be used to evaluate the effects of aquacultural research. However, the evaluation should progress beyond a simple estimation of the input-output relationship. Consequently, the framework suggested by Masters et al. (1996) was adopted to evaluate past research investment (see Appendix).
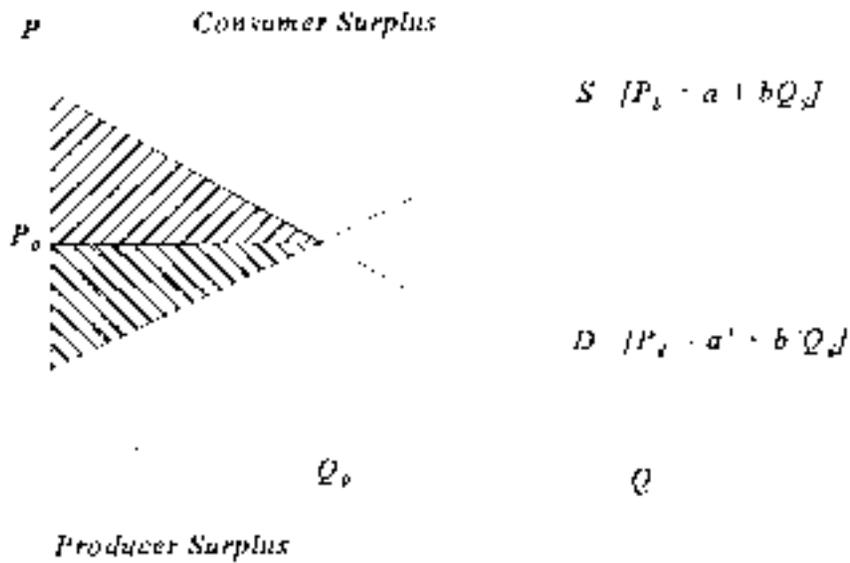
ANTICIPATED BENEFITS

Results of this study will provide justification for the continued funding of PD/A CRSP research through quantification of the program's benefits and impacts. This study will provide the first estimates of the social and economic returns generated by the PD/A CRSP over time.
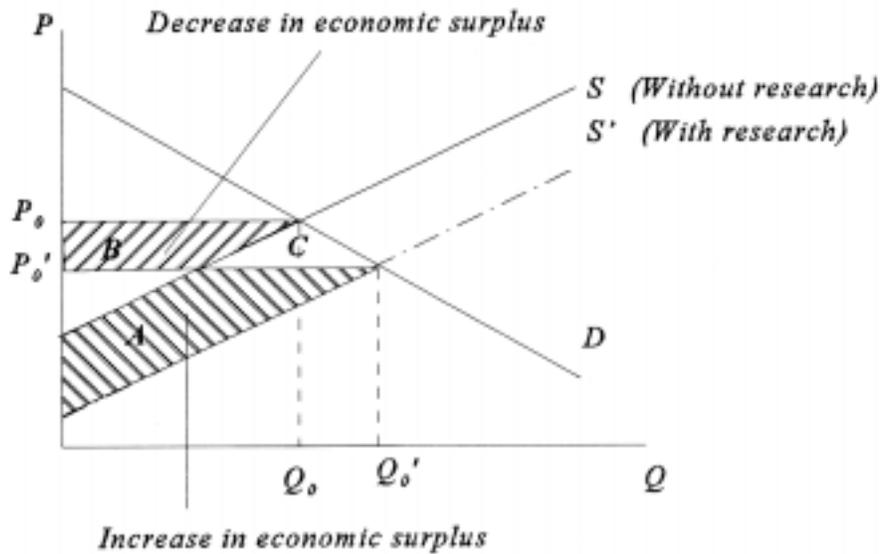
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APPENDIX: A FRAMEWORK TO EVALUATE PAST RESEARCH EFFORT

Consumer and Producer Surpluses (Economic Surplus)

P   Consumer Surplus

$S \ [P_b \cdot a \ I \ bQ]$

P_0

$D \ [P_t \cdot a' \cdot b \ Q]$

Q_0 Q

Producer Surplus

Research Impact

P   Decrease in economic surplus

S   (Without research)
S'   (With research)

P_0
P_0' B   C

A   D

Q_0 Q_0' Q

Increase in economic surplus

Research reduces cost of production and price to producers.
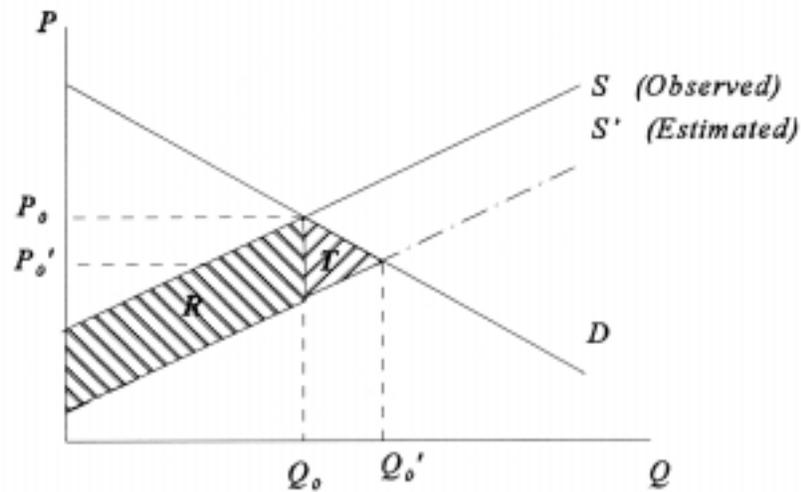
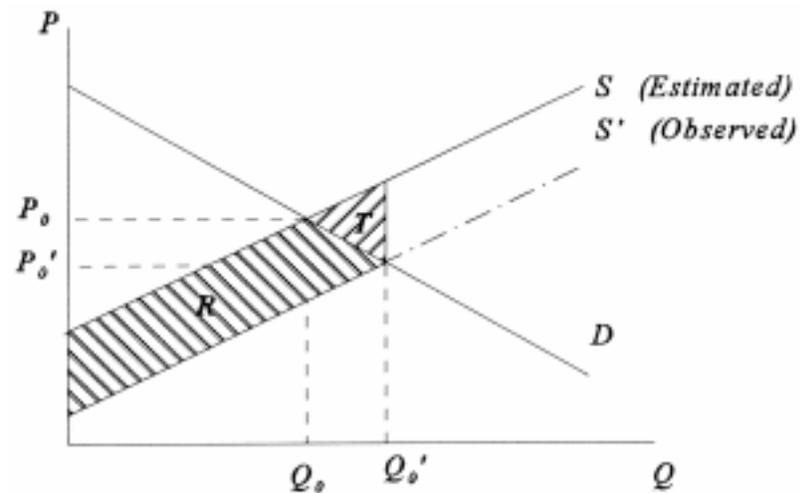Producers net gain (PNG) = (A - B).

Consumer net gain (CNG) = (B + C).

(A + C) can be viewed as social gain for research.

<center>**APPENDIX:** continued</center>

Ex-Ante Evaluation of the Impact

Ex-Post Evaluation of the Impact

Let $\Delta Q = Q_0' - Q_0$ denote the change in total quantity observed due to research, and let k denote the vertical movement factor of the supply curve.

Social gain (SG) can be expressed as:

$$SG = kQ_0 \pm \tfrac{1}{2} k \Delta Q$$

where

(+) is used for ex-ante and (–) for ex-post evaluations,

Q is known,

k and ΔQ are unknown and need to be estimated.

<center>**APPENDIX:** continued</center>

The following are the necessary parameters to be estimated and data requirements:

- Increase in productivity (ΔR) $(kg\,ha^{-1})$
- Adoption cost (ΔC) in terms of land area moved from one activity to new activity
- Adoption rate (t) in terms of % increase in acreage devoted to activity (or in terms of new entrants)
- Total area in production (S) (ha)
- Total production (Q) (kg or tons)
- Average production/productivity $(R = Q/S)$ (kg or tons)

To be estimated:

1. Let $J = \Delta R * t * S$

   J can be viewed as total increase in production due to technology adoption, holding cost, and prices that remain constant.

   Let j be the change in supply or coefficient by which the supply curve has moved with the new technology, $j = (\Delta R * t)/R = J/Q$

2. $I = \Delta C * t / R$

   I is the increase in cost of inputs per unit necessary to achieve J. I can be calculated proportionally to observed price (P) such that $c = I/P = (\Delta C * t)/(R * P)$

3. Let $K = (b * J) - I$

   b is the supply curve slope; K represents the net reduction in production cost due to technology (vertical movement of the supply curve). In fact, the coefficient b is not used, the supply elasticity (ϵ_s) is used instead.

   $$\epsilon_S = (\Delta Q / \Delta P) * (P / Q) = (1 / b)(P / Q)$$

   this leads to:

   $$\epsilon_S * b = P / Q$$
   $$b = (1 / \epsilon_S) * (P / Q)$$

   therefore,

   $$K = [(1 / \epsilon_S) * (P / Q) * J] - I = (P * J / \epsilon_S * Q) - I$$

   With respect to price (P),

   $$k = K / P = [(P * J / \epsilon_S * Q) - I] / P = (P * J / \epsilon_S * Q * P) - (I / P) = [(1 / \epsilon_S) * (P * J / Q * P)] - (I / P)$$
   $$k = (1 / \epsilon_S) * j - c$$

   When supply is inelastic $(\epsilon_S < 1)$, an increase in production due to research has a relatively high economic value $(k > j - c)$ possibly limited acreage. Elastic supply $(\epsilon_S > 1)$, possibly abundant acreage, ϵ_S reduces $k(k < j - c)$. In this latter case, it is easy to increase production and research gains have little economic value.

APPENDIX: continued

4. ΔQ depends on supply movement and response of supply to demand.

At equilibrium:

$$Q_s = Q_d$$
$$a + bP = a' - b'P$$
$$P = (a - a')/(b' - b)$$

with research, equilibrium corresponds to new supply curve which moved with price increase:

$$Q_s' = Q_d$$
$$a' - b'P' = a + bK + bP'$$
$$P' = (a - a' + bK)/(b' - b)$$

In terms of change in price (ΔP):

$$\Delta P = P' - P$$
$$\Delta P = -bK / (b' - b) = bK / (b' - b)$$
$$\Delta Q = b'\Delta P = b'bK / (b' - b)$$

Elasticity of demand (ϵ_d)

$$\epsilon_d = (\Delta Q / \Delta P)(P / Q) = b'(P / Q)$$
$$b' = \epsilon_d /(P / Q) = \epsilon_d (Q / P)$$

In terms of change in production (ΔQ):

$$\Delta Q = [(\epsilon_d (Q / P))(\epsilon_s (Q / P))K] / [(\epsilon_d (Q / P)) + (\epsilon_s (Q / P))]$$
$$\Delta Q = \epsilon_d \epsilon_s (Q^2 / P^2) / [(\epsilon_d + \epsilon_s)(Q / P)]$$
$$\Delta Q = Q \epsilon_d \epsilon_s k / (\epsilon_d + \epsilon_s)$$