Transactions of the American Fisheries Society

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t927035360

Expert Opinions on Critical Production Factors for Sustained Growth of the Hybrid Striped Bass Industry

Catherine K. Halbrendt[a]; Rhonda Aull-Hyde[a]; Dee A. Dunkers[a]
[a] Department of Food and Resource Economics College of Agricultural Sciences, University of Delaware, Delaware Agricultural Experiment Station, Newark, Delaware, USA

First published on: 09 January 2011

To cite this Article Halbrendt, Catherine K. , Aull-Hyde, Rhonda and Dunkers, Dee A.(1994) 'Expert Opinions on Critical Production Factors for Sustained Growth of the Hybrid Striped Bass Industry', Transactions of the American Fisheries Society, 123: 1, 94 — 100, First published on: 09 January 2011 (iFirst)

To link to this Article: DOI: 10.1577/1548-8659(1994)1232.3.CO;2

URL: http://dx.doi.org/10.1577/1548-8659(1994)1232.3.CO;2

Transactions of the American Fisheries Society 123:94–100, 1994

Expert Opinions on Critical Production Factors for Sustained Growth of the Hybrid Striped Bass Industry

CATHERINE K. HALBRENDT, RHONDA AULL-HYDE, AND DEE A. DUNKERS

Delaware Agricultural Experiment Station, Department of Food and Resource Economics
College of Agricultural Sciences, University of Delaware
Newark, Delaware 19717-1303, USA

Abstract.—Aside from regulatory or technological impediments, economic factors can inhibit sustained growth of the aquaculture industry. Expert opinions were solicited regarding economic constraints within the production infrastructure of the emerging U.S. aquaculture industry for hybrid striped bass (progeny of crosses between striped bass *Morone saxatilis* and other *Morone* species) that are potential impediments to sustained growth of the industry. Respondents' experience levels and response variability were considered in the interpretation of survey responses. Closed high-density production systems, insurance coverage, and public and private financing were judged by experts as those production factors that are most prohibitively expensive, under current economic conditions, for sustained growth of the hybrid striped bass industry.

The potential for aquaculture in the face of static wild-stock fisheries is evident from statistics on fish consumption. Though the U.S. per capita consumption of seafood declined slightly in recent years, domestic production increased because of declining imports and stagnant domestic landings. In recent years, U.S. consumers have been eating less red meat and more poultry, pork, and finfish. Among the aquacultural finfish, production of hybrid striped bass (HSB: Crosses of striped bass *Morone saxatilis* and other *Morone* species) is growing rapidly, although still considered small relative to the production of other species. From 1990 to 1992, production of HSB increased about 460% from 0.7 million kilograms to about 3.2 million kilograms (USDA 1992).

Such early surges in an industry's growth do not necessarily dictate long-term sustained growth. The enthusiasm of aggressive entrepreneurs to enter and expand production in fast-growing industries can often surpass the ability of input markets and production infrastructures to respond effectively to newly created demand. Relative to the industry for channel catfish *Ictalurus punctatus*, which has experienced a sustained growth rate of 14% during the last 5 years, the HSB aquaculture industry is not mature and is not well established. This newly emerging industry is at a potentially critical growth junction point. Present constraints within the industry's production infrastructure can impede long-term continual sustained growth of the industry.

This study focused on the identification of economic factors, rather than regulatory or technological factors, that potentially constrain sustained growth of the emerging HSB aquaculture industry. Specifically, we addressed the question of which production inputs and support services essential to an aquaculture enterprise are not economically feasible given the current technologies or financial resources. Identification of such items will help both producers and policy makers remove economic barriers to the continued growth of the HSB aquaculture industry.

Data Collection and Survey Administration

A survey was designed and conducted to elicit opinions from experts concerning 32 essential production input and support services vital to the growth of four aquaculture industries: catfish, trout, HSB, and tilapia. This study focused on HSB aquaculture, although the survey covered four species, because it is an emerging growth industry, unlike those for catfish and trout. Tilapia production in the United States is an emerging industry; however, the number of respondents reporting on tilapia was extremely low. The 32 items on the survey were selected based on knowledge of HSB production and a review of past studies on aquaculture. Restricted or limited access to any one of these 32 production items could inhibit sustainable growth of the industry. The 32 items were subdivided into the following nine categories: land, production systems, production inputs, maintenance and information services, marketing services, leases and permits, financing, research and agricultural extension services, and industrial organizations. A complete categorization of all 32 items is given in the Appendix. A copy of the complete survey is available upon request.

The targeted survey group consisted of aquaculture producers, academics, state and federal administrators, and industry analysts, all from the United States. Their names were published in membership listings of fisheries trade or professional associations. Initially, 950 people were contacted to solicit their willingness to participate in the study. This initial solicitation also requested information on years of experience, degree of familiarity with the four aquacultural species, years of education, and occupation. Of the 950 people contacted, 184 agreed to participate in the study. Because the membership listing did not identify the person's specialty area, nonrespondents may not have been familiar with the species of the study or with aquaculture in general.

Of the 184 people who agreed to participate, only those reporting to be most familiar or somewhat familiar with a particular species were selected to participate. Seventy-four of those willing to participate were either most familiar or somewhat familiar with the HSB industry, and these respondents were selected to participate in the HSB study. Of the 74 surveys sent, 61 were returned. Respondents were distributed regionally as follows: 22 were from the Northeast, 6 from the North-Central, 32 from the South, and 1 from the Western region. Northeastern respondents averaged 5.7 years of experience, North-Central respondents averaged 9.8 years, Southern respondents averaged 6 years, and the lone respondent from the Western region had 15 years of experience. The states comprising each region were based on the U.S. Department of Agriculture regional Aquaculture Center delineation. Forty respondents had postgraduate education, seven had some college training, and two had completed high school (not all respondents provided these data). Occupations of the respondents were diverse: geneticists, pathologists, disease specialist, marketing specialists, engineers, extension personnel, administrators, wholesalers, retailers, bankers, producers, and economists.

In the survey, respondents were asked to evaluate the 32 production and service items according to the degree to which they felt the items were economically feasible for producing HSB. Specifically, the respondents were asked to rate, on a 1-to-9 scale, the economic feasibility of each item. The survey specifically defined economic feasibility of an item as feasibility of obtaining or using an item, given available financial resources. Economic infeasibility can occur due to excessive costs of either procurement or operation. For example, land may be too expensive to purchase. Closed high-density production systems may be affordable but too expensive to operate. The survey also provided standardized interpretations for each rating. For example, a rating of 1 was defined as "definitely obtainable, usable with available financial resources." A rating of 3 was "costly to obtain or use with available financial resources." A rating of 5 was "very costly to obtain or use with available financial resources." A rating of 7 was "nearly impossible to obtain or use with available financial resources." A rating of 9 was "too costly to obtain or use with current financial resources."

Given the 61 completed surveys, responses were analyzed by considering two factors: (1) experience level of each respondent and (2) variability of each item's ratings across all respondents. These two factors were considered simultaneously to assess the economic feasibility of each item. The rationale for considering respondents' experience levels and rating variability and the methodologies used to incorporate these two factors are presented in the next section.

Analytical Methods

Raw survey data can be misleading due to varying experience levels of respondents and high variability within respondents' ratings. First, in the case of this survey, respondents' levels of expertise varied dramatically although each respondent had reported to be at least somewhat familiar with HSB. Thus, opinions from respondents with more expertise received more consideration (more weight) than opinions from respondents with less expertise. Second, variability of respondents' ratings of a particular item reflected the degree of consensus among respondents regarding the economic feasibility of that item. Because respondents encompassed diverse professions, respondents' perceptions regarding economic feasibility of items were subject to high degrees of variability. For example, a banker's opinion regarding the economic feasibility of private financial sources for HSB production may differ substantially from a producer's opinion regarding this item. Conceptually, a mean rating of an item with low rating variability should be viewed as a more credible assessment (i.e., has more group consensus) of that item's actual economic feasibility than a mean rating of an item with a higher rating variability.

Derivation of the Experience-Based Weighting Function

Adjustment of survey responses for respondents' experience levels was incorporated through the derivation of an experience-based weighting function. We assumed that years of experience with HSB is a suitable proxy for expertise level, and we derived a weighting function that adjusts each rating according to the respondent's years of experience:

$$W_i = F(X_i), \quad 0 \leq W_i \leq 1, \tag{1}$$

where W_i specified the weight given to the response of respondent i and X_i denoted years of experience for respondent i with HSB aquaculture. The $F(X_i)$ was specified such that $W_i = 0$ indicated that respondent i had absolutely no expertise with HSB aquaculture and $W_i = 1$ indicated that respondent i had maximum expertise with HSB aquaculture.

The specific functional form for equation (1) was specified by modifying the traditional learning curve function to determine the functional form for W_i. The general specification of the traditional unit learning curve (also known as an experience curve) equation was

$$Z_i = C(i)^{\frac{\log_e b}{\log_e 2}}, \quad i \geq 1, \tag{2}$$

where C is the time (cost) required to produce the first unit, i is the unit number, b is the rate of learning as a percentage, and Z_i is the time (cost) required to produce the ith unit. Equation (2) is a monotonically decreasing function of i. Without loss of generality, we can assume $C = 1$ such that $Z_1 = 1$.

Given the functional form defined in equation (2), Z_i (time or cost) decreases by $(1 - b)$% as cumulative production output doubles. This specification of a learning curve has been used extensively to model overall organizational learning as well as time and cost reductions associated with production of homogenous units (Chase and Aquilano 1989:516). Meredith and Camm (1989) justified the use of the learning curve for measuring overall learning effects associated with the implementation of advanced manufacturing technologies. They emphasized that learning occurs throughout all supporting operations and technologies within an industry due to synergistic effects. This synergistic theory of Meredith and Camm (1989) suggests that experience curves are appropriate in modeling learning effects not only within production operations of aquaculture but also within other support operations such as financing, marketing, and agricultural extension services. It is for this reason that the above form of the learning curve is used as the basis for developing the experience-based weighting function to adjust respondents' ratings for varying expertise levels. Due to an assumed relationship between knowledge and experience of respondents in aquacultural enterprises, the functional form for the learning curve Z_i in equation (2) was modified under the following conditions: (1) if $X_i = 0$, then $F(0) = A$, indicating that ratings for a respondent with zero years of HSB aquacultural experience were given weight A, where $0 \leq A < 1$; (2) if $i = m$, then $F(X_m) = 1$, indicating that respondent m had the maximum number of years of experience in the HSB industry among all respondents in the respondent pool.

Enforcement of condition (1) generated the following modified form of equation (2):

$$\begin{aligned} W_i &= F(X_i) \\ &= A + 1 - (X_i + 1)^{\frac{\log_e b}{\log_e 2}}, \quad X_i \geq 0. \end{aligned} \tag{3}$$

From equation (3), the learning percentage rate parameter b was derived by enforcing the second condition. Setting $F(X_m) = 1$ and solving for b yields

$$b = \exp\left[\frac{(\log_e 2)(\log_e A)}{\log_e(X_m + 1)}\right]. \tag{4}$$

With equation (4), equation (3) was expressed as

$$W_i = F(X_i) = A + 1 - (X_i + 1)^{\frac{\log_e A}{\log_e(X_m+1)}}. \tag{5}$$

The final experience-based weighting function was defined by equation (5).

Condition 1 implies that ratings for respondents with no experience in aquaculture received weight A $(0 \leq A < 1)$. For this study, the value of A was assumed to be 0.40. The rationale for this assumption lies in a study reported by Rogers and Shoemaker (1971:130). The opinions of a survey respondent claiming zero years of direct experience with HSB aquaculture production were not completely discounted (i.e., not assigned a weight of zero). Rogers and Shoemaker (1971) reported that even personnel in agricultural support operations who had no actual direct experience in agricultural production still displayed some degree of awareness and knowledge of agricultural production. The value of $A = 0.40$ is estimated from

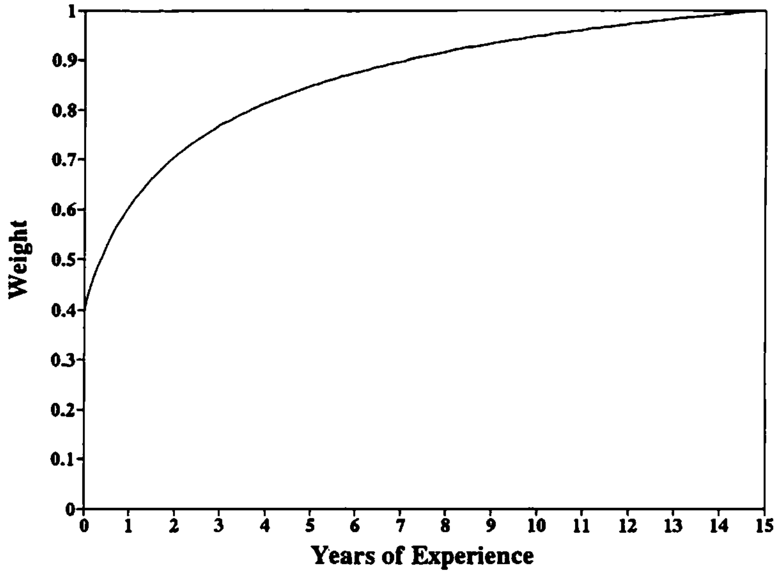

FIGURE 1.—The weighting function for $A = 0.4$ and $X_m = 15$.

a "rate of awareness knowledge" curve reported by Rogers and Shoemaker (1971). Figure 1 illustrates the weighting function, W_i, for input parameters $A = 0.40$ and $X_m = 15$ years.

Let R_{ij} denote the actual rating of item j by respondent i and M_j denote the experience-weighted mean rating, across all respondents, for item j. With experience-based weights (W_i) determined by equation (5), M_j is defined as

$$M_j = \frac{\sum_i W_i R_{ij}}{\sum_i W_i}. \quad (6)$$

Equation (6) determined a weighted mean rating for each item, averaged over all survey respondents, each respondent's rating being adjusted according to years of experience in HSB aquaculture.

Derivation of the Mean–Variance Function

Rating variability of an item reflects the degree of similarity of the respondents' ratings. Low variability indicates similar opinions among the respondent pool (i.e., more consensus) regarding economic feasibility of an item; high variability indicates divergent opinions (less consensus). For example, suppose item A had a weighted mean rating of 6.0 and an associated rating variability of 1.5. Item B had a weighted mean rating of 6.5 and an associated rating variability of 2.5. Although item B had the higher weighted mean rating, item A had lower variability. Essentially, group consensus regarding the mean rating of item A was stronger than group consensus regarding the mean rating for item B. How does a survey analyst systematically assess both the weighted means and variability of ratings for each item to ultimately determine the more economically constraining item?

Simultaneous consideration of an item's weighted mean rating and the item's rating variability was facilitated through a mean–variance function. Let var_j denote the variance of the respondents' actual ratings (i.e., the variance of the R_{ij} values). From equation (6), a mean–variance function for item j, denoted MV_j, was defined as

$$\text{MV}_j(\lambda) = \text{M}_j - \lambda \text{var}_j, \quad (7)$$

where λ represented the relative importance of rating variability (i.e., the importance of consensus within the respondent pool relative to the weighted mean rating) as judged by a survey analyst. The second term in equation (7) ($-\lambda \text{var}_j$) penalized those items with high rating variability (i.e., wide diversity of opinion) about the weighted mean rating. High MV measures, therefore, implied a high potential for economic infeasibility.

Lambda (λ) represented a subjective weight, as assigned by a survey analyst, that indicated the analyst's judgment concerning the importance of rating variability relative to the weighted mean rating. That is, λ represented the degree of importance, as judged by the analyst, of nonconsen-

TABLE 1.—Mean–variance values for production inputs and support services judged to be economically constraining to the hybrid striped bass industry. Parentheses denote the item's ranking in the list of top 10 critical items.

Item	Consideration of rating variability			
	Zero $\lambda = 0$	Low $\lambda = 0.2$	Medium $\lambda = 0.6$	High $\lambda = 0.8$
Closed production systems	5.51 (1)	4.61 (1)	2.81 (2)	1.91 (3)
Insurance	5.22 (2)	4.32 (3)	2.52 (5)	1.62 (7)
Processing plants	5.16 (3)	4.29 (4)	2.55 (4)	1.68 (6)
Public financing	5.16 (4)	4.36 (2)	2.76 (3)	1.96 (2)
Private financing	4.89 (5)	4.22 (5)	2.88 (1)	2.21 (1)
Closed system equipment	4.52 (6)	3.71 (6)	2.09 (10)	1.28 (10)
Harvest, shipping services	4.33 (7)	3.55 (8)	1.99	1.21
Skilled labor	4.28 (8)	3.56 (7)	2.12 (9)	1.40 (9)
Leases	4.24 (9)	3.49 (9)	1.99	1.24
Buyers, brokers, wholesalers	4.00 (10)	3.38 (10)	2.14 (8)	1.52 (8)
Engineering, construction	3.68	3.19	2.21 (6)	1.72 (5)
Equipment, repair services	3.35	2.96	2.18 (7)	1.79 (4)

sus among survey respondents on item j relative to the experience-weighted mean rating of item j in identifying item j as a potentially economically constraining item. For example, suppose a survey analyst selected $\lambda = 0.5$ to reflect his or her judgment concerning the importance of rating variability relative to the weighted mean rating. Because in equation (7) the implied weight on the weighted mean rating (M_j) is 1, variability would carry a relative percentage weight of $\lambda/(\lambda + 1) = 33\%$ and the weighted mean rating would carry a relative percentage weight of 67%. Likewise, if a survey analyst chose $\lambda = 1$, variability would carry a relative percentage weight of 50%, implying that variability of ratings was equal in importance to the weighted mean rating in determining economically constraining items. In the ranking of economically constraining items, if variability of respondents' actual ratings was deemed more important than experience-weighted averages, then $\lambda > 1$.

In this study, rankings of items were initially performed with six λ values between 0 and 1 (λ = 0, 0.2, 0.4, 0.6, 0.8, 1.0). Lambda was bounded above by 1 so that the variability of respondent ratings would, at most, be deemed equally important to the experience-weighted average ratings in identifying the most economically constraining items. If $\lambda = 0$, variability of respondent ratings would receive absolutely no consideration in identifying the most economically constraining items. Relative rankings of the items were not significantly different for similar λ values. Thus, results will be reported for $\lambda = 0$ (no consideration of variability), $\lambda = 0.2$ (low consideration of variability), $\lambda = 0.6$ (medium consideration of variability), and $\lambda = 0.8$ (high consideration of variability). Those items having a mean rating of 3 or less will not be discussed; a rating of less than 3 implied that the item is obtainable given current available financial resources.

Results and Discussion

Table 1 shows the mean–variance values for the four λ values. With considerations of varying experience level and diverse penalty weights for rating variability, the following five production items or services consistently ranked among the top eight as most economically constraining: closed high-density production systems, insurance, processing plant services, public (federal, state) financing sources, and private financing services (banks, venture capitalists). These eight production items or services consistently included the top five most economically constraining items (out of 32 items) for λ values of at least 0.6 (i.e., even when relatively strong penalties for rating variability were considered). This result strongly suggests that there was a consensus among the experts that the aforementioned items were in general the most economically constraining factors to sustained growth of the HSB industry. Regional rankings varied just slightly from those reported in Table 1, generally reflecting the development stage of regional aquaculture industries. Nevertheless, each of the 8 highest-ranked items in Table 1 were among the top 10 most economically constraining, regardless of the λ value.

Closed high-density production systems for HSB were consistently rated the most economically constraining production input item for small to moderate λ values. Closed systems allow production to continue throughout the seasons in which the climate would normally prohibit outdoor production. The result implies that current technology to support closed systems, which allow for year-round production of HSB, is still economically constraining. Comments from survey respondents indicated that the current closed-system technology is technically efficient but not economically feasible given current market conditions. This constraint might not apply to pond-produced HSB. However, to provide a year-round supply of HSB, the current closed system technology is still preferred. Given the upper Mid-Atlantic and Northeast regions' close proximity to large consumption areas, economically feasible closed high-density production systems are preferable in these regions to pond production, because the warmer season is not long enough for fish to mature to market size in 1 year. If this technology becomes economically feasible, widespread adoption of closed systems within these regions will soon follow.

The high cost of insurance was also cited as a barrier to sustained growth of industry. High insurance costs reflect financial analysts' views that aquaculture ventures are still risky. These views were also apparent in respondents' ratings on the economic feasibility of public and private financing sources; both items were cited as impediments to industry growth. In particular, private financing became the most economically constraining item for $\lambda > 0.4$. This result indicated that consensus on this item varied among experts. In the Northeast region where HSB is an emerging industry, the costs of insurance and financing could be much greater than in other regions.

The economic feasibility of processing plant services was also perceived as a barrier to the growth of the HSB industry. For $\lambda \leq 0.4$, the costs of processing plant services were considered by the respondents as more economically constraining. Hybrid striped bass production has been increasing rapidly. For example, in 1987 only 12 fish producers were located in Maryland, but by 1991 that number had increased to about 200, a 16-fold increase. The cost of processing plant services may not be as critical in the South as in the Northeast region, due to the established southern catfish industry. In 1989, the Northeast region had 443 processing plants compared with 657 processing plants in the Southern region (NMFS 1991). This difference was reflected in the lack of consensus on this item as an economically constraining factor.

Other factors consistently found to be somewhat economically constraining to the expansion of the HSB industry were skilled labor and buyer, broker, or wholesaler services. Most respondents believed that agricultural research stations and extension services were providing sufficient research services. Also, many physical inputs common to any aquacultural enterprise were rated as economically obtainable or usable. These inputs included feed, liquid oxygen, chemicals, fertilizers, energy or utilities, pond equipment, and unskilled labor.

Generally, the most economically constraining production inputs and services within the U.S. HSB industry were closed high-density production systems, insurance, processing plant services, and public and private financing. Depending upon the region, the relative degrees of economic constraint posed by these items varied slightly. However, regardless of region, these items were consistently rated in the 10 most economically constraining items from the 32 essential production inputs and services. Financing and insurance were cited as costly because aquaculture has not proven to be as profitable as previously predicted. In particular, for an emerging aquaculture industry such as HSB, competition is very keen not only from other species but also from improved harvest from wild fish stocks.

This study found that inputs specific to HSB production are more economically constraining than inputs currently used for other aquacultural enterprises. If the demand for HSB continues at the current rate, financing should be forthcoming and processing plant services should expand. Hybrid striped bass, like catfish, are more popular in some regions than in others. To ensure continued growth in the industry, broad-based education of and advertising to potential buyers and consumers are essential. This study indicates that economic factors, as well as technological and regulatory factors, should receive emphasis in the design of future aquacultural research efforts. As the demand for HSB continues to increase, identification of economically constraining production factors is critical to sustained growth of the HSB aquaculture industry. Perhaps the next logical step is to conduct an economic analysis to evaluate the impact on profitability of eliminating production constraints.

Acknowledgments

We thank the anonymous referees for their many perceptive and invaluable comments. We thank the Delaware Agricultural Experiment Station for support of this project which will be published as miscellaneous paper 1498 of the Delaware Agricultural Experiment Station.

References

Chase, R., and N. Aquilano. 1989. Production and operations management, 5th edition. Irwin, Homewood, Illinois.

Meredith, J., and J. D. Camm. 1989. Modeling synergy and learning under multiple advanced manufacturing technologies. Decision Sciences 20:258–271.

NMFS (National Marine Fisheries Service). 1991. Fisheries of the United States, 1990. U.S. Department of Commerce, Washington, D.C.

Rogers, E. M., and F. F. Shoemaker. 1971. Communication of innovations. Macmillan, New York.

USDA (U.S. Department of Agriculture). 1992. Situation and outlook report, September 1992. USDA, Commodity Economics Division, Economics Research Service, AQUA-7, Washington, D.C.

Received May 29, 1992
Accepted July 27, 1993

Appendix: Production Services Vital to the Hybrid Striped Bass Industry

TABLE A.1.—Production items and services listed in the survey.

(1) Land for ponds and raceways
(2) Production systems
(a) Closed high-density systems
(b) Cages and pens
(3) Production inputs
(a) Suitable water
(b) Fingerlings
(c) Feed
(d) Liquid oxygen
(e) Chemicals to maintain water quality
(f) Fertilizer
(g) Energy, utilities
(h) Skilled labor
(i) Unskilled labor
(j) Pond equipment (aerators, feeders)
(k) Closed system equipment (tanks, filters)
(l) Equipment for cages (netting, flotation)
(4) Maintenance and information services
(a) Engineering, construction services
(b) Equipment, repair services
(c) Insurance
(d) Disease diagnostics
(e) Production consulting
(5) Marketing services
(a) Processing plants
(b) Buyers, wholesalers, brokers
(c) Harvesting, shipping services
(d) Marketing information, consulting
(6) Leases and permits
(a) Government permits
(b) Leases
(7) Financing
(a) Public sources (federal, state)
(b) Private sources (banks, venture capitalists)
(8) Research and agricultural extension services
(a) Teaching
(b) Research
(c) Extension
(9) Industry organizations